Disclosure of enterprises' environmental violations: evidence from Chinese public supervision

Beibei Shi[1*], Fei Yang[2] and Rong Kang[1]

[1] School of Economics and Management, Northwest University, Xi'an, China and [2] School of Business, Northwest University of Political Science and Law, Xi'an, China

*Corresponding author. E-mail: shibeibei@nwu.edu.cn

ONLINE APPENDIX

Appendix A

Table A1. The distribution of pilot cities

Regional distribution	Eastern regions	Central regions	Western regions
The list of pilot cities	Shanghai, Dongguan, Zhongshan, Foushan, Baoding, Beijing, Beihai, Nanjing, Nanning, Nantong, Xiamen, Taizhou, Tangshan, Jiaxing, Dalian, Tianjin, Weihai, Ningbo, Changzhou, Guangzhou, Xuzhou, Yangzhou, Fushun, Wuxi, Rizhao, Benxi, Hangzhou, Zaozhuang, Liuzhou, Guilin, Shantou, Shenyang, Quanzhou, Taian, Jining, Zibo, Shenzhen, Wenzhou, Huzhou, Zhanjiang, Weifang, Yantai, Zhuhai, Yancheng, Fuzhou, Shaoxing, Suzhou, Handan, Jinzhou, Qingdao, Anshan, Shaoguan, LianYungang, ShiJiazhuang, QinHuangdao	Linfen, Jiujiang, Baotou, Nanchang, Hefei, Jilin, Datong, Daqing, Taiyuan, Anyang, Yichang, Yueyang, Changde, Kaifeng, Zhuzhou, Wuhai, Luoyang, Xiangtan, Jiaozuo, Wuhu, Jingzhou, Chifeng, Zhengzhou, Changchun, Changsha, Changzhi, Yangquan, HaErbin, DanJiangkou, PingDingshan, Hohhot, Ordos, Qiqihar, ZhangJiajie, MaAnshan	Lanzhou, Xianyang, Yibin, Boji, Yanan, ChengDu, Kunming, Qujing, Luzhou, Mianyang, Xining, Xi’an, Guiyang, Zunyi, Jinchang, Tongchuan, Yinchuan, Urumqi, Chongqing, PanZhihua, ShiZuishan, Karamay
Number	56	35	22

Table A2. Impact of public supervision on urban environmental pollution emissions

	Water	*Fog*	*Dust*	*So2*
	IV-DID	IV-DID	IV-DID	IV-DID
	(2)	(4)	(6)	(8)
PITI×Time	-0.1400	-0.3124	-0.2829	-0.4110
	(0.0736)	(0.0851)	(0.1088)	(0.2026)
Control variable	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Cragg-Donald Wald F statistic	358.39	358.39	357.78	358.39
LM Chi-sq (1) statistic	290.35	290.35	289.88	290.35
N	1999	1999	2035	1999
F	4.6562	5.2770	16.6619	126.3071
r2_a	0.0451	0.0538	0.1319	0.5584

Notes: (1) The values in brackets are robust standard errors of clustering at the prefecture level; (2) The tests of insufficient identification (LM Chi-sq (1) statistic) and weak identification (Cragg-Donald Wald F statistic) of instrumental variables significantly rejected the null hypothesis at the 1% confidence level, which indicates that the instrumental variable selected is effective.

Appendix B. Robustness tests

(1) Parallel trend hypothesis test

This study adopts DID methods to evaluate the impact of public supervision on the disclosure of enterprises' environmental violations. The parallel trend hypothesis is tested in two ways. First, we draw total quantity and percentage of enterprises with environmental violations before 2008 as shown in figure A1. Before policy implementation in 2008, the number of enterprises with environmental violations in the treatment group and control group had the same growth trend, which was even more obvious in the percentage of enterprises. Therefore, the parallel trend assumption is met in the present study.

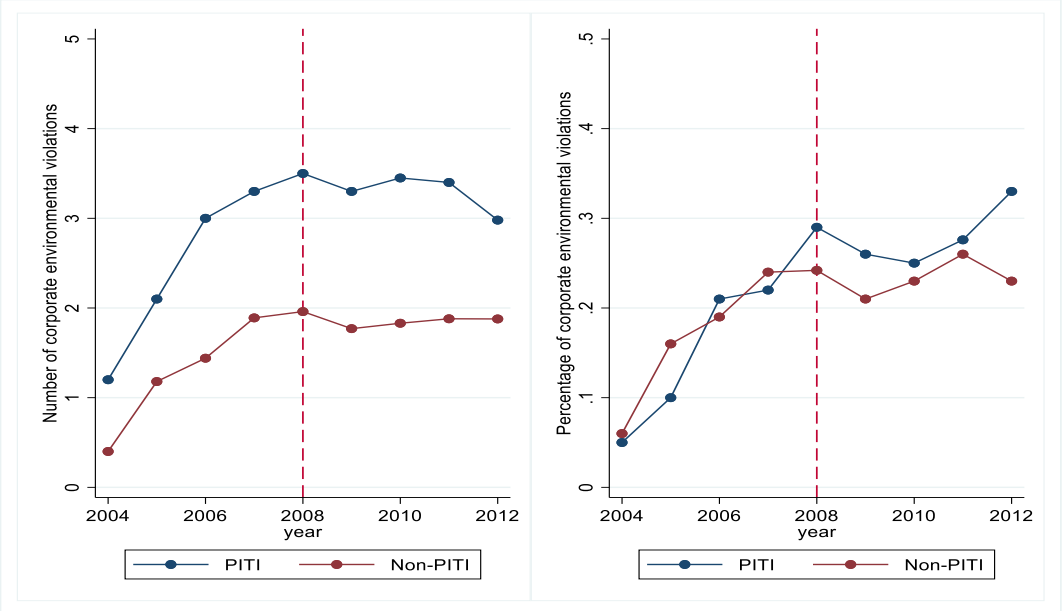

Figure A1. Trend changes of environmental violation in pilot and non-pilot areas.

Figure A1 only tests the parallel trends hypothesis in the way the data is presented. To further test it empirically, we performed a regression estimation on model (3). Besides, through dynamic effects, we can also know the dynamic changes of the disclosure number of

enterprises' environmental violations. The specific results are shown in table A3. Column (1) shows the effect of public supervision on total number of enterprises with environmental violations disclosure under different environmental standards, Column (3) shows the effect of public supervision on relative number of enterprises with environmental violation disclosure, and columns (2) and (4) are the regression results after excluding western cities. Before 2008, the impact of public supervision on number of enterprises with environmental violations disclosure was not significant. That is, without policy implementation, the number of disclosures of enterprises with environmental violations disclosure between treatment group and control group does not change significantly over time, so the parallel trend assumption is satisfied.

Table A3. Parallel trend and dynamic test

	Number of enterprises with environmental violations		Percentage of enterprises with environmental violations	
	(1)	(2)	(3)	(4)
$PITI \times year_{2004}$	-0.2816	-0.2384	-0.0267	-0.0381
	(0.1892)	(0.2173)	(0.0310)	(0.0365)
$PITI \times year_{2005}$	-0.2076	-0.0287	-0.0448	-0.0447
	(0.1911)	(0.1761)	(0.0321)	(0.0383)
$PITI \times year_{2006}$	0.2361	0.2670	0.0298	0.0172
	(0.1889)	(0.1929)	(0.0372)	(0.0362)
$PITI \times year_{2007}$	0.1334	0.1843	-0.0117	-0.0205
	(0.1720)	(0.1872)	(0.0384)	(0.0445)
$PITI \times year_{2008}$	0.3376	0.4579	0.0713	0.0809
	(0.1464)	(0.1612)	(0.0255)	(0.0293)
$PITI \times year_{2009}$	0.3811	0.4644	0.0510	0.0277
	(0.1384)	(0.1541)	(0.0314)	(0.0318)
$PITI \times year_{2010}$	0.3646	0.4200	0.0220	0.0197
	(0.1391)	(0.1606)	(0.0355)	(0.0409)
$PITI \times year_{2011}$	0.4249	0.4830	0.0391	0.0245
	(0.1122)	(0.1195)	(0.0374)	(0.0420)
Control variable	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
_cons	3.0085	6.2804	0.5504	0.8825
	(3.6991)	(4.5951)	(0.5918)	(0.7135)
N	2314	1892	2008	1731
r2_a	0.3472	0.3417	0.2224	0.2056

Note: The values in brackets are robust standard errors of clustering at the prefecture level.

Meanwhile, dynamic effects show that the pilot policy has a current effect on enterprises' environmental violation disclosure. From the evaluation coefficient, whether total number of enterprises with environmental violation disclosure or relative number, the policy effect has gradually increased over time. It fully demonstrates that public supervision has a significant long-term role in revealing enterprises' environmental violations. To show the dynamic effect more intuitively, according to the regression results in columns (1) and (3) in table A3, we plotted figure A2. It can be seen that before 2008, policy effect fluctuated around 0 and was not significant, which indicates that the parallel trend assumption is satisfied. In the long term, after 2008, the policy effect gradually increased, and was significantly positive.

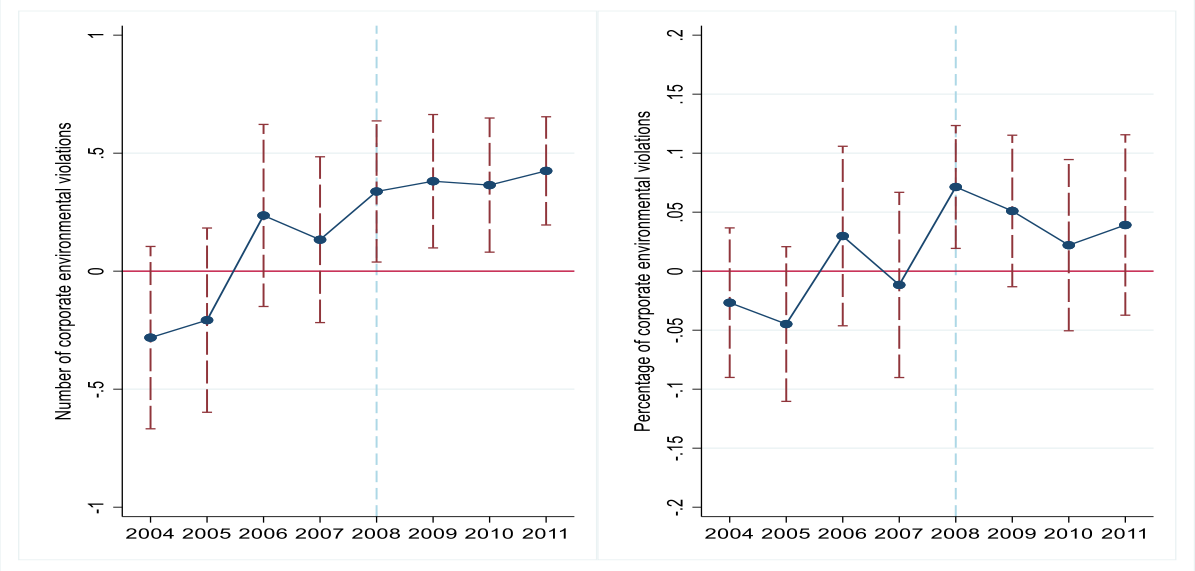

Figure A2. Dynamic effects of public supervision.

(2) Endogenous treatment

Given that endogeneity leads to biased estimates, it is necessary to conduct further analysis. First, cities that implement pilot policies may have poorer environmental quality, and the mutual causal relationship leads to endogeneity. Second, those important but

difficult-to-measure variables ignored in this study (e.g., institutional building, policy support, etc.) can also lead to endogeneity. In view of this, the number of public petitions on urban environmental issues (*petitions*) was set as the instrumental variable. On the one hand, the number of petitions can directly let the local government know people's current livelihood demands. The more serious the environmental pollution, the more the number of environmental petitions, the more likely to implement the disclosure policy of PITI, and vice versa. On the other hand, as a special political system implemented by the Chinese government, environmental petitions can directly reflect the public's demand for environmental issues. It is only related to the environmental factors of the city, but not to other economic factors, so it meets the basic requirements of the instrumental variables. The specific regression model is as follows:

The first stage: $$PITI_i \times Time_t = \rho + \varphi\, Petitions_{it} \times Time_t + \sum Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

The second stage: $$Corporate\ violation_{it} = \alpha_0 + \beta\, \overline{PITI_i \times Time_t} + \sum Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

Table A4 is the result of the two-stage least squares estimation using instrumental variables. It can be seen that after dealing with endogeneity, public supervision policies still significantly reveal enterprises' environmental violation. At the same time, the table on the instrumental variables of the statistical test also shows that the instrumental variable meets the corresponding requirements. Thus, the results in table A4 further illustrate that the endogeneity problems caused by missing variables and bidirectional causal effect are not serious, and the results obtained in this paper are still robust.

Table A4. Instrumental variables test

	Number of enterprises with environmental violations		Percentage of enterprises with environmental violations	
	(1)	(2)	(3)	(4)
PITI×Time	1.0254	1.1101	0.0816	0.1035
	(0.1560)	(0.1946)	(0.0326)	(0.0407)
Control variable	NO	YES	NO	YES
Individual fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
N	2037	1999	2037	1999
F	104.2958	55.1196	53.2569	29.4503
r2_a	0.2169	0.2120	0.0875	0.0937
First -Stage				
petitions	0.060	0.053	0.060	0.053
	（0.002）	（0.003）	（0.002）	（0.003）
Cragg-Donald Wald F statistic	655.14	430.99	655.14	430.99
LM Chi-sq(1) statistic	479.718	347.727	479.718	347.727

Notes: (1) The values in brackets are robust standard errors of clustering at the prefecture level; (2) The tests of insufficient identification (LM Chi-sq (1) statistic) and weak identification (Cragg-Donald Wald F statistic) of instrumental variables significantly rejected the null hypothesis at the 1% confidence level, which indicates that the instrumental variable selected is effective.

(3) Exclusion of important factors

Although the potential endogeneity problems in the regression model can be investigated as much as possible by using instrumental variables, it is clear that due to the complexity of the economic system and the strategic nature of policy implementation, many factors can cause the endogeneity in the model. Therefore, this study attempts to eliminate the endogeneity by the following methods:

(a) **City hierarchy.** Given that the choice of pilot cities may give priority to cities with better economic development, the city hierarchy may be a potential factor affecting policy implementation. In view of this, first-class cities (*first*) and eastern cities (*east*) were selected as independent variables to test whether cities with higher hierarchy are more likely to be a pilot city. The results of tests are shown in columns (1) and (2) in table A5. It can be seen that the city hierarchy did not significantly affect policy implementation.

(b) **Government-enterprise relationship.** Enterprises can influence policy implementation through affecting the decisions of local governments, so, according to the Government-enterprise Relationship Index, we constructed the government -enterprise collusion variables (*conspiracy*) to test whether government-enterprise collusion affects policy implementation. The results of the tests are shown in column (3) in table A5. It can be seen that the government-enterprise collusion did not significantly affect policy implementation.

(c) **Promotion in official careers.** As government officials in China play an important role in China's economic development, they may strive to have cities under their jurisdiction selected as pilot cities to increase the number of their "achievement projects" during their terms of office to enhance the probability of official promotion in their performance assessment. To test this, this study collects official promotion data and selects *promotion* as the explanatory variable to test its effect on the policy implementation. The regression results are shown in column (4) of table A5. They show that the promotion in official careers does not affect policy implementation, and the potential effect of this factor is thus eliminated.

(d) **Private networks.** Considering that the choice of pilot cities in China is often interfered with by private networks between government officials, a stronger private network between government officials will greatly increase the probability of the implementation of the pilot program in the jurisdiction, leading to the endogeneity problems caused by the omission of important variables in the model. To test this, this study uses whether government officials have been educated at the *Central Party School* and whether they have worked as an *office secretary* to measure the private networks.[1] The specific regression results are shown in columns (5) and (6) of table A5. They show that private networks do not affect policy implementation, and the potential effect of this factor is reduced.

(e) **Policy preference factor.** A large number of reforms or pilot programs are dominated by the central government, which often gives special consideration and offers preferential treatment to some old revolutionary base areas when making decisions. The existence of such factors may make the model potentially endogenous. To solve this problem, this study collects the *number of old revolutionary areas* in each prefecture-level city to measure the policy preference. The specific regression results are shown in column (7) of table A5. The results show that the policy implementation is not affected by the number of old revolutionary base areas. That is, the implementation of the policy is not affected by the policy preference. The elimination of the key factors above reduces the potential endogeneity of the model as much as possible and ensures the reliability of the evaluation results.

[1] In China's political officialdom, an education experience at the Central Party school and working experience as an office secretary enable government officials to meet more officials at the central and provincial levels and expand their political networks respectively, and thereby obtain more political resources.

Table A5. The exogenous test of PITI pilot city choice

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	PITI	*PITI*	*PITI*	*PITI*	*PITI*	*PITI*	*PITI*
first	0.2496						
	(1.2164)						
east		-0.5221					
		(0.3487)					
conspiracy			0.4196				
			(0.2780)				
promotion				-0.4058			
				(0.2714)			
Central Party School					0.1103		
					(0.1993)		
office secretary						-0.1033	
						(0.1862)	
number of old revolutionary areas							-0.0306
							(0.0284)
Control variable	YES	YES	YES	YES	YES	YES	YES
_cons	-11.7253	-11.2580	-11.7428	-11.6944	-11.8098	-12.8519	-11.4687
	(2.8525)	(2.9308)	(2.5653)	(2.7906)	(2.7062)	(2.5524)	(2.9579)
N	2314	2314	2314	2278	2267	1970	2267
Wald chi2(9)	160.59	208.07	164.02	118.97	115.98	117.58	239.58
Pseudo R2	0.3419	0.347	0.3467	0.3332	0.3287	0.3285	0.3441

Notes: (1) The values in brackets are robust standard errors of clustering at the prefecture level; (2) The explained variables of the above regression represent whether the city implements the PITI policy or not, if yes, it is 1, otherwise, it is 0.

(4) Counterfactual test

Is the effect of public supervision on environmental violations disclosure affected by other random factors? If there is interference from other factors, it also leads to biased estimation results. In view of this, this study mainly uses random sampling methods to conduct the counterfactual test. The specific results are shown in table A6.

Table A6. Counterfactual test

	Number of enterprises with environmental violations			Percentage of enterprises with environmental violations		
	(1)	(2)	(3)	(4)	(5)	(6)
Random3×Time	0.0237			0.0041		
	(0.0571)			(0.0111)		
Random1 ×Time		-0.0505			-0.0037	
		(0.0558)			(0.0095)	
Random2 ×Time			0.1315			0.0144
			(0.0860)			(0.0174)
Control variable	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
_cons	2.7286	2.7312	2.7311	0.5157	0.5188	0.5186
	(3.9295)	(3.9002)	(3.9247)	(0.6013)	(0.5995)	(0.6008)
N	2314	2314	2314	2008	2008	2008
F	67.1728	66.3113	86.2037	24.3770	22.3302	23.4991
r2_a	0.3368	0.3369	0.3377	0.2175	0.2175	0.2178

Note: The values in brackets are robust standard errors of clustering at the prefecture level.

Columns (1) and (4) are regression results by randomly selecting half of the cities in all samples as the hypothetical treatment group, columns (2) and (5) are regression results by randomly selecting half of the cities in the control group as the hypothetical treatment group, and columns (3) and (6) are regression results by randomly selecting half of the cities in the treatment group as the hypothetical treatment group. It can be seen that there is no significant effect that is the same as the actual results, which indicates that there are no other random factors that affect results of this study. It fully proves that an increase in the number of regional enterprises with environmental violation disclosure is not caused by other factors, but by public supervision.

(5) Elimination of policy interference

To ensure the robustness of the estimated results, this study excludes a series of policy shocks that affect enterprises' environmental violations disclosure, as shown in table A7. It specifically includes the following three parts. First, considering that the carbon pilot policy implemented by the central government in 2010 may affect evaluation results, we eliminate the carbon pilot samples, and the results after the removal have not changed significantly; see columns (1) and (4). Second, in November 2011, the central government implemented a carbon trading policy in Beijing, Shanghai, Chongqing, Tianjin, Shenzhen, Guangdong, and Hubei. Considering that this policy may affect enterprises' environmental violations, we re-performed the regression analysis after removing these cities. The results have not changed significantly; refer to columns (2) and (5). In addition, the most stringent environmental regulations are the "Regional Restricted Lots" and "Watershed Restricted Lots" implemented

by the State Environmental Protection Administration in some areas during the third "EIA Storm" in 2007.[2] Considering the policy enforcement and severe punishment and its effect on our study, we removed these samples in the regression. The specific results are shown in columns (3) and (6). The results are still significant. The results of table A7 show that even after excluding a series of policies, the disclosure effect of public supervision on enterprises' environmental violations remains significant, thus further illustrating robustness of the above results.

Table A7. Elimination of policy interference

	Number of enterprises with environmental violations			Percentage of enterprises with environmental violations		
	(1)	(2)	(3)	(4)	(5)	(6)
PITI×Time	0.3315	0.2879	0.3190	0.0598	0.0508	0.0561
	(0.1348)	(0.1347)	(0.1448)	(0.0277)	(0.0282)	(0.0279)
Control variable	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
_cons	1.8690	3.7845	3.6024	0.3700	0.2122	0.6028
	(5.0110)	(4.0321)	(4.1671)	(0.9184)	(0.6175)	(0.6372)
N	1786	1998	2105	1545	1699	1840
F	41.3764	179.6367	121.4939	16.0384	35.0644	25.2549
r2_a	0.3860	0.3299	0.3445	0.1575	0.2286	0.2170

Note: The values in brackets are robust standard errors of clustering at the prefecture level.

[2]The pilot samples of "Regional Restricted Lots" and "Watershed Restricted Lots" mainly come from the research results of Long and Wan (2017), and the difference is that this paper mainly analyzes at the city level, so even if only one county in a city implements "Regional Restricted Lots" and "Watershed Restricted Lots", the city is eliminated. Specifically include: Tangshan, Luliang, Liupanshui, Laiwu, Chaohu, Wuhu, Baiyin, Lanzhou, Bayannaoer, Weinan, Hejin, Linfen, Zhoukou, Bengbu, Handan, Liyang, Liaocheng, Shengzhou, Jinzhou, Shijiazhuang, Hengshui, Xinxiang, Kaifeng, Shanghai, Beijing, Huozhou, Changzhi, Yuncheng, Fenyang, Liaoyang, Qingyuan, Maoming.

(6) Adding covariates test

To further control factors at the regional level, referring to the approach of Moser and Voena (2012), this study added the regional change trend variables over time and the interaction terms of regional dummy variable and year dummy variable (*district-by-year*) based on model (1). However, considering the degrees of freedom, this study did not deal directly with the prefecture level; instead, it investigates the regional categories at the provincial level. Specifically, we add the first-order term ($\gamma_p \times t$), quadratic term ($\gamma_p \times t^2$) of the province's trend over time in the model and interaction term of the province dummy variable and year dummy variable ($\gamma_p \times \delta_t$) to control the non-linear trend changes of enterprises with environmental violations in different regions; the results of the DID estimation are more convincing. The specific results are shown in table A8. Columns (1) and (3) are mainly regression results obtained by adding the first-order term of regional changes trend over time, while columns (2) and (4) are mainly regression results obtained by adding the interaction term of regional and time terms. It can be seen that after considering regional and time factors, public supervision still promotes enterprises' environmental violation disclosure.

(7) Two-phase difference-in-difference test

In order to control potential impact of serial correlation between variables on assessment results, we only use a two-phase difference-in-difference method to re-evaluate the role of public supervision in revealing enterprises' environmental violation. First, we averaged data from different years before and after environmental information publicity in 2008 to generate data for two years before and after policy implementation for evaluation. The specific results are shown in columns (5)–(6) of table A8. Second, we only retain data for the two years before and after environmental information publicity policy implementation, that is, we use data from 2007 and 2008 to assess the role of public supervision in revealing enterprises'

environmental violation. The specific results are shown in columns (7)–(8) of table A8. From the specific regression results, it can be seen that after eliminating serial correlation between variables, public supervision still improves environmental violations disclosure, and the effect is still significant.

Table A8. Adding covariates test and Two-phase difference-in-difference test

	Number of enterprises with environmental violations		Percentage of enterprises with environmental violations		Number of enterprises with environmental violations		Percentage of enterprises with environmental violations	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PITI×Time	0.3392	0.3730	0.0527	0.0601	0.3154	0.2520	0.0786	0.0793
	(0.1171)	(0.1261)	(0.0236)	(0.0251)	(0.1103)	(0.1333)	(0.0367)	(0.0272)
Control variable	YES	YES	YES	YES	YES	YES	YES	YES
$\gamma_p \times t$	YES	NO	YES	NO	NO	NO	NO	NO
$\gamma_p \times t^2$	YES	NO	YES	NO	NO	NO	NO	NO
$\gamma_p \times \delta_t$	NO	YES	NO	YES	NO	NO	NO	NO
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
_cons	-2.3165	-2.0899	-0.3086	0.0746	6.1351	-6.7982	0.1880	-9.5213
	(3.2547)	(3.3119)	(0.5024)	(0.3986)	(3.8673)	(12.0850)	(1.2199)	(3.6979)
N	2314	2314	2008	2008	525	491	422	391
r2_a	0.4192	0.4916	0.2680	0.3794	0.5219	0.0570	0.1188	0.1120

Note: The values in brackets are robust standard errors of clustering at the prefecture level.

(8) Enterprise migration effects test

Although the above methods have been used to test the reliability, as one of environmental regulation methods, public supervision may affect enterprises' migration decision. Therefore, we can't help wondering whether strengthening of environmental regulations caused by public supervision leads to enterprises' cross-regional transfers, and further affects enterprises' environmental violation disclosure by affecting the number of enterprises among regions. In order to eliminate impact of the mechanism, this study uses a micro-enterprise database to sum up number of various types of enterprises at each city level to obtain the number of new enterprises (*newfirm*), the number of enterprises with a history of one year (*firm*), and the total number of enterprises (*firmnumber*), to test impact of public supervision on enterprises' migration. The specific results are shown in table A9. It can be seen that public supervision does not cause enterprises' migration, that is to say, there is no environmental pollution-type enterprise moving from information disclosure areas to non-information disclosure areas, which indirectly proves that increase of number of enterprises with environmental violation disclosure is not caused by change in the number of enterprises, but is entirely due to public supervision.

Table A9. Enterprise migration effects test

	newfirm	*newfirm*	*firm*	*firmnumber*	*firm*	*firmnumber*
	(1)	(2)	(3)	(4)	(5)	(6)
PITI×Time	-0.0966	-0.0236	-0.1070	-0.0171	-0.0487	0.0167
	(0.1057)	(0.0989)	(0.0831)	(0.0236)	(0.0943)	(0.0143)
Control variable	NO	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
_cons	1.3311	-0.4529	-1.3035	0.7722	10.7882	9.7084
	(0.0600)	(2.0737)	(1.9069)	(0.5747)	(9.4593)	(2.3787)
N	2042	2001	2001	2001	478	478
F	17.8042	23.4526	83.9642	65.1327	9.6693	8.5779
r2_a	0.2283	0.2418	0.3290	0.3416	0.0420	0.2160

Note: The values in brackets are robust standard errors of clustering at the prefecture level.

References

Long X N and Wan W (2017) Environmental regulation, corporate profit margins and compliance cost heterogeneity of different scale enterprises. *Chinese Industrial Economy* **6**,155–174 (in Chinese).

Moser P and Voena A (2012) Compulsory licensing: evidence from the Trading with the Enemy Act. *American Economic Review* **102**, 396–427.