Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

Environmental information disclosure and firm export: evidence from China

Yu Xia, Najid Ahmad & Xian-Liang Tian

To cite this article: Yu Xia, Najid Ahmad & Xian-Liang Tian (2023) Environmental information disclosure and firm export: evidence from China, Economic Research-Ekonomska Istraživanja, 36:1, 2180060, DOI: 10.1080/1331677X.2023.2180060

To link to this article: https://doi.org/10.1080/1331677X.2023.2180060

Published online: 09 Mar 2023.

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2023, VOL. 36, NO. 1, 2180060
https://doi.org/10.1080/1331677X.2023.2180060

Environmental information disclosure and firm export: evidence from China

Yu Xia[a], Najid Ahmad[b] and Xian-Liang Tian[c]

[a]School of Law, Hubei University, Wuhan, Hubei, China; [b]School of Business, Hunan University of Science and Technology, Xiangtan, Hunan, China; [c]Wenlan School of Business, Zhongnan University of Economics and Law, Wuhan, Hubei, China

ABSTRACT

In this paper, we empirically investigate how a governmental environmental information disclosure (EID) program in China affects the extensive and intensive margins of export for a panel of Chinese industrial firms. The results show that stricter enforcement of environmental disclosure discourages firms' participation in export. However, the export volume of remaining exporting firms increases following more environmental disclosure. The results are robust to a battery of robustness checks as well as an IV estimation. Mechanism analysis reveals that firms' propensity of innovation increases after stricter enforcement of disclosure, lending support for the Porter hypothesis.

ARTICLE HISTORY
Received 5 April 2022
Accepted 7 February 2023

KEYWORDS
Environmental regulation; disclosure; export; intensive margin; Porter hypothesis

JEL CODES
F12; F18; Q50; Q57

1. Introduction

Environmental regulation is an important approach to address environmental problems in the world. However, some policymakers hesitate to adopt strict environmental regulation for fear that it might increase the costs of regulated firms and hence hurt their competitiveness in the world market. On the contrary, there are scholars arguing that properly designed environmental regulation can help firms overcome operational inefficiency and innovate, which then enhances their international competitiveness (Porter & van der Linde, 1995). To solve this controversy, a large literature has empirically investigates the relationship between environmental regulation and export at the country/sector level.[1] However, the results are generally inconclusive; and one reason behind the mixed results is that most of the research is at aggregate levels, without exploring micro mechanisms using firm-level data.[2]

To address this issue, this paper empirically investigates the impact of China's first governmental environmental information disclosure (EID) program on the extensive and intensive export margins of a panel of Chinese industrial firms. Using city-level pollution information transparency indexes (PITIs) and the annual surveys of industrial

CONTACT Xian-Liang Tian xianliangtian@gmail.com

firms (ASIF) in China between 2008 and 2010, we conduct the analysis with a firm fixed-effect specification. The empirical results are two-fold: on one hand, we find that stricter enforcement of environmental disclosure discourages firms' participation in export. On the other hand, the analysis of intensive export margin shows that remaining exporting firms can export more following stricter enforcement of environmental information disclosure. The results are robust to a battery of robustness checks as well as an instrumental-variable (IV) estimation. Mechanism analysis shows that firms' propensity of innovation increases with more environmental disclosure, which is compatible with predictions of the Porter hypothesis.

This paper is related to existing literature as follows:

First, this paper relates to a large literature on the impact of environmental regulation on firm competitiveness. Different from traditional view that environmental regulation hurts firm competitiveness, Porter and van der Linde (1995) argue that well-designed regulation fosters firm innovation (the *weak* Porter hypothesis) and even improves firm productivity/profitability when the benefits of innovation outweighs compliance costs (the *strong* Porter hypothesis). Empirical tests of the weak Porter hypothesis generally examine firms' R&D expenditure or patent applications/grants (e.g., Jaffe & Palmer, 1997; Brunnermeier & Cohen, 2003; Popp, 2006; Lanoie et al., 2011; Kneller & Manderson, 2012). Some research explores the relationship between environmental regulation policies and innovation in the context of a specific county, such as Netherlands (Leeuwen & Mohnen, 2017), Sweden (Weiss & Anisimova, 2019) and Germany (Bitat, 2018), whereas other studies test the weak Porter hypothesis in a cross-county context (e.g., Franco & Marin, 2017). The tests of the strong Porter hypothesis look into the link between environmental regulation and direct indicators of firm competitiveness, such as firm productivity and profitability (e.g., Gray & Shadbegian, 2003; Gollop & Roberts, 1983; Berman & Bui, 2001; Greenstone et al., 2012; Lanoie et al., 2008; Rassier & Earnhart, 2015). Nevertheless, the results are highly mixed (e.g., Jaffe & Palmer, 1997; Ambec et al., 2013; Rexhauser & Rammer, 2014). For example, Stoever and Weche (2018) find that German wastewater regulation cannot significantly affect firms' competitiveness, while Albrizio et al. (2017) find a short-run increase in productivity following tightening environmental regulation in advanced countries. Our analysis adds to this literature since we find that tighter environmental regulation can increase export volume of exporting firms.

Second, our research adds to an extensive literature on the relationship between environmental regulation and international trade. In this literature, many studies investigate the effects of environmental regulation on country-level trade flows, conditional on country characteristics (e.g., Xu, 2000; Harris et al., 2002), while some other scholars incorporate measures of regulation stringency into the Heckscher-Ohlin trade model and examine the effects of environmental regulation on export volume at the sector level (e.g., Levinson & Taylor, 2008; Ederington & Minier, 2003). The existing results are also inconclusive (Tsurumi et al., 2015).[3] This paper is among the scant literature investigating the link between the EID and firm export. This is an important topic since the effects of environmental regulation on firm performance depend on specific approaches of regulation (Brunel & Levinson, 2016).

Third, this research also contributes to the literature on the EID. As the third wave of environmental regulation, EID is a cost-saving but effective approach of pollution control, especially in developing countries that do not have enough institutional arrangements for the enforcement of traditional regulation (Tietenberg, 1998; Powers et al., 2011). There is a strand of management literature studying determinants of EID (Baldini et al., 2018), how EID affects firm risk and value (Benlemlih et al., 2018; Fatemi et al., 2018), and how firms use EID to greenwash their public image (Hassan & Guo, 2017). In environmental economics, existing literature on EID mainly focuses on the role of EID in pollution reduction (e.g., Powers et al., 2011; Dasgupta et al., 2007; Wang et al., 2004; Tian et al., 2016), while much less research has investigated the relationship between EID and firm competitiveness, which is nevertheless necessary for a comprehensive cost-benefit analysis before the implementation of an EID program. And this paper will fill this gap.

The remainder of this paper is organized as follows: Section 2 is about the data and empirical specification. In Section 3, we conduct the empirical analysis, the results of which are further discussed in Section 4; then, Section 5 concludes.

2. Data and empirical design

2.1. China's EID by local governments

EID is a specific way of environmental regulation that is widely used in the world. To combat the worsening environmental problems in China, in 2007, China's State Environmental Protection Administration passed the first nationwide program on EID—the Measures on Open Environmental Information for Trial Implementation (the Measures for short), which requires Chinese local governments to disclose firms' environmental information and stipulates in detail the scope of disclosure, procedures, responsibilities and supervision, etc.[4]

The main mechanism through which EID facilitates pollution reduction is that the disclosure of unsatisfying environmental information arouses complaints from NGOs and local communities against polluting firms which are forced to invest in pollution reduction. In addition, output/input markets respond to environmental disclosure which provides firms incentive to cut pollutant emissions in order to prevent negative market reactions. For example, disclosed bad environmental information leads to stock price decreases in the U.S. capital market (Konar & Cohen, 1997). In 2007, China's ministry of environmental protection and the central bank of China passed *Opinions on enforcing environmental laws to prevent credit risks*, which requires Chinese commercial banks to decrease credits allocated to disclosed environmental violators. Also, as international enterprises increasingly care about 'green' supply chains, they may terminate the cooperation with disclosed polluting suppliers.

Environmental disclosure also decreases information asymmetry among China's ministry of environmental protection, local governments and the public and thus improves traditional environmental regulation (Tian et al., 2016). On the one hand, Chinese local governments have more environmental information than the public and the latter will be more aware of local environmental problems under EID program. Then the bottom-up pressure from the public forces local governments to engage in traditional environmental regulation in a more active manner. On the other hand, local governments are also better informed of local environmental situation than the ministry of environmental protection. Environmental disclosure reduces the information asymmetry and offers local governments fewer opportunities to shirk in environmental regulation while not being detected.

Upon EID, the pressure for pollution reduction forces firms to invest in pollution abatement, which increases their marginal cost of production and therefore affects firm export. Below, we will empirically investigate how the EID in China affects the extensive and intensive margins of firm export.

2.2. Data

Because law enforcement in China usually differs a lot across regions as in other developing countries, the Institute of Public and Environmental Affairs (IPEA) and the Natural Resources Defense Council have jointly compiled the pollution information transparency indexes (PITI) of 113 Chinese cities since the year 2008, in order to evaluate the enforcement of the Measures across Chinese cities and years. The empirical part below will use the PITI indexes of a panel of Chinese cities to investigate the impact of China's EID program on firm export.

The construction of the PITI indexes is as follows: First, eight aspects of pollution information disclosure are defined according to the requirement of the Measures and for each aspect, each city is assigned a numeric score. The scoring is based on if the disclosure is timely, comprehensive, user-friendly, and systematic or not and higher scores mean better environmental disclosure performance. Second, the total of the scores of the eight aspects (the full scores of the eight aspects add up to 100) is the PITI index of the city that will be used in the analysis. Table 1 defines the eight aspects of disclosure and lists the average score of each aspect across cities at 2008.

The average scores in Table 1 are relatively low, indicating that the enforcement of the Measures at the beginning is rather inadequate. For example, the average score on 'response to public information requests' is only 5.38 (the full score is 18), consistent with the finding that Chinese governments often decline public requests of pollutant information, although the disclosure is required by the Measures (Tian et al., 2016). The PITI indexes also differ a lot across Chinese cities as shown in Figure 1, implying different enforcement of the Measures across regions. Note that coastal cities (such as Ningbo with the PITI index of 72.9 in 2008) generally have higher PITI indexes than inland cities (such as Xining with the PITI of only 10.2 that year), which can be interpreted by the difference in economic development and demand for environmental quality across Chinese regions (IPE & NRDC, 2008).

Then the PITI indexes at the city level are merged with firms' financial data drawn from the Annual Surveys of Industrial Firms in China (ASIF). The survey is annually compiled by China's national bureau of statistics and contains most statement-of-balance information of *all* state-owned manufacturing enterprises (SOEs) in China as well as the non-SOE manufacturers with annual operating incomes exceeding five million RMBs. One advantage of the surveys is their comprehensive coverage—in 2008, the surveyed manufacturers produced more than 95% of gross industrial output value in China. Because the way that the PITI index is compiled has been modified since 2012 and the

Table 1. Eight aspects of pollution information disclosure.

Aspects of Disclosure	Full score	Description	Average score (2008)
Disclosure of enterprise violations	28	Disclosure of records for various aspects of facility violations, including penalties and enforcement actions taken.	8.85
Results of 'enforcement campaigns'	8	Disclosure of results of environmental protection bureau enforcement campaigns.	4.33
Clean production audit information	8	Disclosure of firm lists that have been enforced clean production audits and their emission data.	2.24
Enterprise environmental performance ratings	8	Disclosure of firms' environmental performance ratings.	0.85
Disposition of verified petitions and complaints	18	Disclosure of environmental petitions and complaints, as well as their handling.	6.42
Environmental impact assessment (EIA) reports	8	Disclosure of EIA reports and project completion reports, including firms' emission data.	2.06
Discharge fee data	4	Disclosure of firms' discharge fees, including standards, collecting procedures, waivers or discounts, etc.	0.91
Response to public information requests	18	Whether local environmental protection bureau has established a standard and comprehensive system responding to public pollution information requests.	5.38

Notes: The table is drawn from Tian et al. (2016). The average scores at 2008 are calculated using the data provided by IPE and NRDC.
Source: created by the authors.

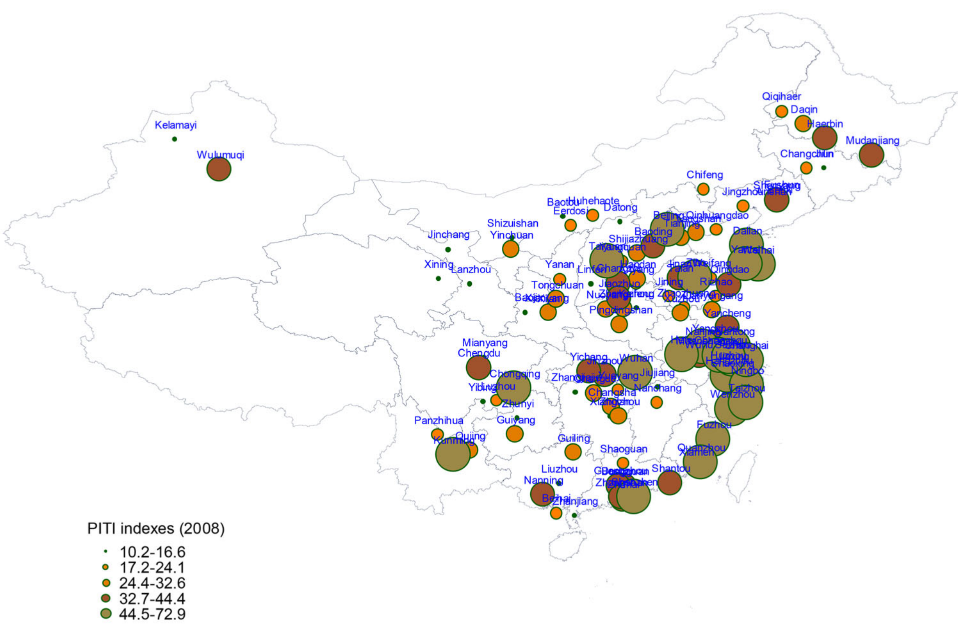

Figure 1. PITI indexes of 113 Chinese cities in 2008.
Source: created by the authors.

2011 ASIF data miss some key variables of interest, we use the merged panel data between 2008 and 2010 to conduct the empirical analysis.

During data management and cleaning, we follow the procedure of Brandt et al. (2012) to merge China annual surveys of manufacturing firms. We also delete abnormal observations as follows: First, following Cai and Liu (2009), we delete observations missing key variables (such as total assets, employment and sales, etc.). Second, the firms with reported employment less than 30 or those with reported total assets less than liquid assets are also deleted from the sample. Third, in light of Bai et al. (2009), we drop the firms with calculated gross profit rates greater than 99% or less than 0.1%.

2.3. Econometric specification

We estimate the impact of China's EID program on firm export using the econometric specification as follows,

$$\mathrm{Ex}_{csft} = \alpha_f + \alpha_0 PITI_{ct} + \alpha_1 \mathrm{PITI}_{ct} \times \mathrm{Poll\_inten}_s + \beta \mathbf{X_t} + \gamma_1 \mathrm{D}_c + \gamma_2 \mathrm{D}_Y + \gamma_3 \mathrm{D}_s + \varepsilon_{csft}, \quad (1)$$

where Ex_{csft} represents a dummy variable indicating if firm f in sector s of city c exports or not in year t; it also represents the logarithm of the firm's export value. $PITI_{ct}$ is city-level PITI index reflecting the extent of environmental disclosure in the city. The interaction term, $\mathrm{PITI}_{ct} \times \mathrm{Poll\_inten}_s$, is the variable of our interest that reflects the *de facto* stringency of regulation in sector s of city c. In the interaction term, $\mathrm{Poll\_inten}_s$ represents sectoral pollution intensities. Since such intensities are not readily available in the literature, we use the information on firms' pollution discharge fees in the 2004 ASIF data to construct sectoral pollution intensities. Specifically, we divide the sum of firms' pollution discharge fees within each 2-digit industrial sector by total value added in the sector and use the ratio as a proxy for the pollution intensity of the sector. The constructed pollution intensities of all 2-digit industrial sectors are listed in Table 2.[5]

Prior research on firm export finds that exporting firms tend to be older, bigger, more productive and capital intensive, and spend more on R&D, compared with other firms (e.g., Roberts & Tybout, 1997; Bernard & Jensen, 2004; Bernard et al., 2007a, 2007b). Thus, we include firm age, employment, labour productivity, the capital-labour ratio (all in logs), and firm ownership in the vector $\mathbf{X_t}$ of (1). Labour productivity is measured by a firm's total production value divided by its total employment; we use *real* capital stock calculated following the method of Brandt et al. (2012) when constructing the capital-labour ratio. Unfortunately, our panel data do not contain information on firms' R&D expenditures and instead, we use a firm's new-product production divided by its total production value to measure firm innovation. In addition, α_f is a set of firm fixed effects, which can control for unobserved and time-invariant firm heterogeneity. D_Y includes a set of year dummies, controlling for yearly macro shocks. Since some firms may change their reported city/sector during the period, we also include city and sector fixed effects (denoted by D_c and D_s, respectively) in (1).[6] Note that $\mathrm{Poll\_inten}_s$ is not separately included in (1), because it is absorbed in D_s. Finally, ε_{csft} is the error term. In the analysis below, we use robust standard errors clustered at the city level when estimating (1), and Table 3 reports descriptive statistics of main variables that will be used in the analysis.[7]

Table 2. Pollution intensities of all two-digit sectors.

2-digit code	Sectors	Pollution intensities (%)
16	Cigarette products	0.032
40	Computers, communication and other electronic equip.	0.035
39	Electric devices and apparatus	0.061
21	Furniture	0.075
18	Clothes, shoes and caps	0.076
36	Specialized equipment manufacturing	0.079
30	Plastic products	0.086
24	Educational and sports products	0.093
35	General equipment manufacturing	0.096
42	Craftwork products	0.101
37	Transportation equipment	0.101
29	Rubber products	0.105
23	Printing and record medium production	0.106
34	Fabricated metal products	0.118
32	Ferrous metal smelting and rolling	0.146
13	Agricultural product and by product processing	0.146
19	Leather, fur and feather products	0.146
20	Timber, bamboo, cane and straw products	0.151
41	Instruments, meters, cultural and office machinery	0.181
15	Beverage	0.183
14	Food	0.191
27	Pharmaceutical products	0.251
33	Non-ferrous metal smelting and rolling	0.259
25	Petroleum, coke and nuclear fuel processing	0.292
26	Chemical materials and products	0.311
31	Non-metallic mineral products	0.338
17	Textile	0.343
28	Chemical fibre manufacturing	0.364
43	Resources and waste materials recycling	0.385
22	Paper	0.71

Source: created by the authors.

Table 3. Descriptive statistics of main variables.

Variable	No. of Obs.	Mean	Std.	Min	Max
Firm-level variables					
Log(export value)	132,031	8.55	2.05	0	18.28
If export	619,179	0.213	0.409	0	1
Log age	615,985	1.972	0.741	0	4.12
Log productivity	619,179	5.931	0.973	−5.74	12.03
Log (capital/labour)	619,179	4.14	1.352	−8.7	11.77
Log employment	619,179	4.629	1.151	2.19	11.95
Innovation	595,554	0.03	0.131	0	1
SOE	619,179	0.046	0.211	0	1
Sector-level variables					
Pollution intensity	30	0.00185	0.00143	0.00032	0.0071
Energy intensity	30	0.00147	0.00167	0.000097	0.0058
Coal intensity	30	0.00095	0.0018	0.000018	0.0092
Electricity intensity	30	0.0019	0.0016	0.00014	0.0062
SO_2 intensity	30	0.00085	0.0012	0.000025	0.005
Log export	7943	11.747	2.536	0	19.443
City-level variables					
PITI	336	35.832	16.5	10.2	83.7
Log (punish/GDP)	336	0.4	1.24	−4.91	3.56
Log (GDP per capita)	336	10.468	0.551	9.164	12.07

Source: created by the authors.

Table 4. PITI and firm export.

Dependent variable	If export			Log(export value)		
W/o extreme sectors	No	No	Yes	No	No	Yes
Model No.	(1)	(2)	(3)	(4)	(5)	(6)
$PITI_{ct}$	0.012	0.012	0.013	0.031	0.031	0.027
	(0.21)	(0.21)	(0.19)	(0.029)	(0.029)	(0.33)
$PITI_{ct}$ × Pollution intensity$_s$	**−0.238***** **(0.02)**	**−0.054***** **(0.01)**	**−0.085***** **(0.027)**	**0.416*** **(0.23)**	**0.082***** **(0.023)**	**0.093***** **(0.035)**
Estimation method	OLS	Firm FE	Firm FE	OLS	Firm FE	Firm FE
Observations	592,372	592,372	442,153	129,344	129,344	90,857
R^2	0.27	0.06	0.05	0.51	0.22	0.23

Notes: City, sector and year fixed effects have been controlled for. In columns 2–3 and 5–6, firm fixed effects are also controlled for. In addition, we control for firm age, labour productivity, capital-labour ratio, employment (all in logs), and firms' new-product intensity. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

3. Results

3.1. Baseline results

Table 4 shows baseline results of investigating the impact of China's environmental disclosure on the extensive and intensive margins of firm export. As a tentative check, columns 1 and 4 report pooled OLS estimates without firm fixed effects; and the results using the full specification in (1) are presented in columns 2 and 5. The coefficients on the interaction term in columns 1 and 2 are significantly negative, indicating that stricter environmental disclosure discourages firms to participate in export. In columns 4 and 5, the coefficients on the interaction term are all positive, implying that remaining exporting firms experience an increase in export value following stricter disclosure. The results in these columns also indicate that the inclusion of firm fixed effects can make substantial difference in parameter estimation, suggesting the importance of controlling for unobserved firm heterogeneity in the analysis. To check if the results are driven by the firms in extreme sectors, in columns 3 and 6, we drop top four sectors in Table 2 with the highest pollution intensities and the bottom four sectors with the lowest intensities. Again, we find significantly negative impact of environmental disclosure on participation in export, and significantly positive impact on export value.

To evaluate economic significance of the above results, consider a representative firm in the sector of materials and products (ISIC = 26) and in a hypothetical city whose PITI index increases from 0 to 100. Then, it can be calculated that firms' likelihood of participation in export will decrease by 1.67%, amounting to 10.03% of the export participation rate (16.64%) in the sector.[8] If the firm continues to export after environmental disclosure, the estimates in column 5 imply that the firm's export value will increase by 2.86%, which is of high economic significance.

The estimated coefficients on other control variables are comparable with existing empirical evidence on firm export. Firms that are older, bigger, more productive, with higher capital-labour ratio, and more innovative are found to be more likely to export and export more.[9]

Table 5. Robustness check 1, with other city characteristics.

Dependent variable	If export				Log(export value)			
W/o extreme sectors	No	No	No	Yes	No	No	No	Yes
Model No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PITI_{ct}$ × Pollution intensity$_s$	**−0.052*****	**−0.08*****	**−0.079*****	**−0.094*****	**0.099*****	**0.062*****	**0.071*****	**0.089****
	(0.017)	**(0.017)**	**(0.017)**	**(0.02)**	**(0.023)**	**(0.023)**	**(0.023)**	**(0.035)**
$Punish_{ct}$ × Pollution intensity$_s$	**−0.58***		**−0.303**	**−0.775***	**−2.139*****		**−1.907*****	**−1.637****
	(0.307)		**(0.31)**	**(0.42)**	**(0.515)**		**(0.51)**	**(0.667)**
Log(gdp_p)$_{ct}$ × Pollution intensity$_s$		**9.14*****	**8.95*****	**5.43****		**11.60*****	**10.86*****	**15.35*****
		(1.53)	**(1.55)**	**(2.34)**		**(1.95)**	**(1.95)**	**(2.85)**
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	592,372	592,372	442,153	129,344	129,344	129,344	90,857
R^2	0.06	0.07	0.06	0.05	0.22	0.22	0.22	0.23

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity, $PITI_{ct}$, $Punish_{ct}$, and $Log(gdp\_p)_{ct}$. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

3.2. Robustness checks

3.2.1. With other city characteristics

One concern with the above analysis involves the interpretation of the PITI index. If the index is correlated with other city-level variables, then the above estimates simply reflect the influence of those variables. One variable that can be correlated with the PITI index is the stringency of traditional environmental regulation. We use the number of punishment cases against firms' environmental violation in a city divided by the GDP of the city (in logs) to measure the stringency (denoted by $Punish_{ct}$). Another city-level variable is economic development since wealthier coastal cities generally have higher PITI indexes as shown in Figure 1. We use the logarithm of cities' GDP per capita to measure the level of economic development. Then, we add the two variables and their interaction terms with sectoral pollution intensities in the econometric specification. Table 5 shows the main results of regression; the estimated coefficients on the interaction term of PITI index is quite stable across different specifications and are all statistically significant, implying that the above baseline results do not merely reflect the effects of traditional regulation and economic development. Table 5 also reveals that traditional environmental regulation decreases the export value of remaining exporters, different from the impact of environmental disclosure on the intensive margin of firm export. Therefore, different types of environmental regulation may have differentiated effects on firm export.

3.2.2. With different pollution intensities

Another concern is the measure of sectoral pollution intensities. In the literature, energy-usage intensities and SO_2 emission intensity at the sector level are usually used to evaluate the impact of pollution control policies on firm performance (e.g., Hering & Poncet, 2014). To test if our estimation results are sensitive to the pollution intensities used in baseline analysis. We construct four alternative intensities—sectors' energy-usage, coal, electricity and SO_2-emission intensities; then, we interact these intensities with the PITI index, traditional regulation stringency, and the logarithm of

Table 6. Robustness check 2, with other pollution intensities.

Dependent variable	If export			Log(export value)		
W/o extreme sectors	No	No	Yes	No	No	Yes
$PITI_{ct}$ ×Energy intensity$_s$	−0.065***	−0.085***	−0.074***	0.056**	0.028	0.023
	(0.016)	(0.017)	(0.018)	(0.024)	(0.024)	(0.026)
$Punish_{ct}$ ×Energy intensity$_s$		0.11	0.038		−1.086**	−0.649
		(0.26)	(0.26)		(0.46)	(0.49)
Log(gdp_p)$_{ct}$ ×Energy intensity$_s$		4.96***	2.2		6.615***	5.99***
		(1.36)	(1.4)		(1.99)	(2.10)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	592,372	442,153	129,344	129,344	90,857
$PITI_{ct}$ ×Coal intensity$_s$	−0.071***	−0.102***	−0.087***	0.064*	0.027	0.157
	(0.02)	(0.022)	(0.023)	(0.035)	(0.037)	(0.39)
$Punish_{ct}$ ×Coal intensity$_s$		−0.049	−0.01		−0.458	−1.57
		(0.29)	(0.29)		(0.642)	(6.9)
Log(gdp_p)$_{ct}$ × Coal intensity$_s$		6.13***	3.49**		7.687**	6.685**
		(1.7)	(1.75)		(3.08)	(3.18)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	592,372	442,153	129,344	129,344	90,857
$PITI_{ct}$ × Electricity intensity$_s$	−0.06***	−0.081***	−0.074***	0.082***	0.063***	0.059**
	(0.017)	(0.017)	(0.019)	(0.021)	(0.021)	(0.024)
$Punish_{ct}$ × Electricity intensity$_s$		0.146	−0.043		−1.69***	−1.18**
		(0.29)	(0.31)		(0.433)	(0.48)
Log(gdp_p)$_{ct}$ × Electricity intensity$_s$		7.16***	3.65**		8.187***	7.507***
		(1.44)	(1.6)		(1.72)	(1.94)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	592,372	442,153	129,344	129,344	90,857
$PITI_{ct}$ × SO_2 intensity$_s$	−0.084***	−0.114***	−0.103***	0.06*	0.022	0.064
	(0.021)	(0.022)	(0.025)	(0.034)	(0.035)	(0.39)
$Punish_{ct}$ × SO_2 intensity$_s$		0.108	0.2		−5.8	−3.36
		(0.38)	(0.4)		(6.4)	(7.22)
Log(gdp_p)$_{ct}$ × SO_2 intensity$_s$		6.37***	3.41*		8.489***	7.473**
		(1.72)	(1.85)		(2.93)	(3.11)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	592,372	442,153	129,344	129,344	90,857

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity, $PITI_{ct}$, $Punish_{ct}$, and Log$(gdp_p)_{ct}$. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

cities' GDP per capita, and add the interaction terms in the regression. As shown in Table 6, we always find a negative and significant effect of environmental disclosure on the extensive margin of firm export, regardless of the intensity measure used in the analysis. However, for the analysis of intensive export margin, only using the electricity intensity can yield significantly positive effects across different specifications.

3.2.3. The role of firm ownership

The role of ownership in the performance of Chinese firms has been widely discussed in the literature. On one hand, Chinese state-owned enterprises (SOEs) have more bargaining power than the firms with other ownership and thus are more favourably treated during regulation (Huang, 2003). To protect the SOEs, Chinese local governments even take direct price/quantity controls and market intervention to discriminate against private

Table 7. Robustness check 3, the role of firm ownership.

Dependent variable	If export	Log (export value)	If export	Log (export value)
Intensities	Pollution intensity		Pollution intensity	
W/o extreme sectors	No	No	Yes	Yes
$PITI_{ct} \times intensities_s$	−0.054***	0.089***	−0.085***	0.113***
	(0.017)	(0.023)	(0.027)	(0.035)
$PITI_{ct} \times SOE_{ft} \times intensities_s$	0.003	0.163*	−0.02	0.13***
	(0.03)	(0.088)	(0.06)	(0.04)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE
Observations	592,372	129,344	442,153	90,857
R^2	0.07	0.22	0.05	0.23

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), and firms' new-product intensity. $PITI_{ct}$, $PITI_{ct} \times SOE_{ft}$, $SOE_{ft} \times intensities_s$ are all controlled for. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

firms (World Bank, 2005). Thus, it is natural to predict that Chinese SOEs will be subject to more lenient environmental regulation. In addition, Chinese governments would provide extra supports and resources for the SOEs (Dollar & Wei, 2007), implying that compared to other firms, the SOEs' marginal costs will be affected less by the regulation even though they are equally regulated. On the other hand, Jiang et al. (2014) investigate the distribution of pollutant emissions across Chinese firms with different ownership and find that Chinese SOEs generally pollute more than public-listed, foreign-owned and private firms. Therefore, everything else constant, the SOEs in China will be affected more by the regulation.

To analyse how firm ownership influences the effects of China's EID program, we define a SOE dummy and add a triple interaction term, $PITI_{ct} \times intensities_s \times SOE_{ft}$, along with all the pairwise interaction terms in the regression. Table 7 presents the main results and we do not find a role of firm ownership in the effects on extensive margin of export. However, for the analysis of intensive export margin, the coefficients on the triple interaction term are significantly positive in all cases, implying that Chinese SOEs are affected more by increased environmental disclosure.

3.2.4. Sample attrition and city/sector sorting

The sample in this study is an unbalanced panel with firms exiting the sample each year. The last column in Tables 8 and A1 investigates the determinants of firm exit from the sample, and we find that stricter disclosure increases the likelihood of firm exit, with exporters' likelihood of exit being lower. This will bias the estimated effects since the exiting and surviving firms differ in their export performance. Note that about 0.08% of firms in the sample have changed their cities and 3.68% of them have changed sectors during the period. Although city and sector fixed effects are included in the specification, the estimation results can still be biased if the city/sector sorting is not random and instead correlated with omitted variables in the error term of (1). To check how our baseline results are influenced by sample attrition and city/sector sorting, in Tables 8 and A1, we re-estimate (1), excluding the firms exiting the sample before 2010, including only the firms that survive in the whole period, and excluding the firms that ever changed city/sector. For all the subsamples, we estimate significant and negative effects of environmental disclosure on the

Table 8. Robustness check 4, Sample attrition and city/sector sorting.

Dependent var.	If export		Log(export value)		If export		Log(export value)		If export		Log(export value)		If exit
W/o extreme sectors	No	No	No	No	No	No	No	No	No	No	No	No	No
Model No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
$PITI_{ct}$ × Pollution $intensity_s$	**−0.05****	**−0.087*****	**0.119*****	**0.088*****	**−0.043****	**−0.076*****	**0.125*****	**0.097*****	**−0.059*****	**−0.081*****	**0.097*****	**0.073*****	**0.022*****
	(0.02)	**(0.02)**	**(0.027)**	**(0.027)**	**(0.02)**	**(0.02)**	**(0.027)**	**(0.028)**	**(0.017)**	**(0.017)**	**(0.024)**	**(0.024)**	**(0.002)**
$Punish_{ct}$ × Pollution $intensity_s$		−0.024		−1.969***		−0.125		−1.757***		−0.193		−2.945***	
		(0.36)		(0.563)		(0.36)		(0.585)		(0.31)		(0.583)	
$Log(gdp\_p)_{ct}$ × Pollution $intensity_s$		12.23***		10.497***		10.96***		9.485***		8.767***		13.691***	
		(1.72)		(2.044)		(1.71)		(2.106)		(1.57)		(2.069)	
If export													**−0.0096*****
													(0.002)
Sample used	Excluding firms exiting before 2010				Including only firms surviving 2008–2010				Excluding firms changing city/sector				All
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Obs.	375,232	375,232	98,469	98,469	304,115	304,115	63,348	63,348	560,894	560,894	122,186	122,186	503,342

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity, $PITI_{ct}$, $Punish_{ct}$, and $Log(gdp\_p)_{ct}$. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively. In Model (13), we first track the last year when each firm is observed in the sample and only keep the last two years' observations. Then we assign 1 to the variable 'If exit' for the last-year × firm combination if the firm exits the sample before 2010. We assign 0 to 'If exit' for all other year × firm combination.
Source: created by the authors.

extensive margin of firm export, the magnitude of which is similar to that of baseline results. The estimated positive effects on firms' export value (intensive margin) are even greater.

4. Discussion

4.1. Does PITI reflect other city characteristics?

As discussed before, one problem with the interpretation of the results is that the PITI index might reflect other time-varying city characteristics. To preclude this possibility, in this subsection, we conduct further sensitivity check by adding more relevant city characteristics in the regression, based on existing literature.

The research on determinants of the PITI index shows that Chinese cities with higher GDP per capita and closer to the Hong Kong have higher PITI indexes. Cities with more pollution and bigger internet coverage also have higher PITIs. The mayors in Chinese cities with longer tenure are less willing to stimulate economic growth at the expense of environmental quality. Therefore, mayors' tenure is found to be positively correlated with the PITI index of a city (Tian et al., 2016). In addition, giant firms in a city are able to influence policy-making and thus hinder environmental disclosure that decreases their profits (Lorentzen et al., 2014). Based on these findings, we add a long list of city characteristics and their interaction terms with sectoral pollution intensities in the regression.[10] Tables 9 and A2 show the regression results, and we find that the negative effects of environmental disclosure on extensive margin of export and positive effects on export value are successfully estimated in all specifications, despite that a long list of PITI determinants have been controlled for. This implies that our estimation results do not merely reflect the influence of other city characteristics.

4.2. Environmental disclosure and firm innovation

Porter and van der Linde (1995) argue that properly designed environmental regulation forces polluting firms to break inefficient operational inertia and invest in new technologies and innovate in order to improve environmental performance. Meanwhile, the innovation can also bring about more efficient production and products of higher quality, which then increases the demand for goods of regulated firms. As a result, firms' intensive export margin could be increased upon stricter regulation. This subsection uses the information on firms' new-product production to investigate the impact of China's environmental disclosure on firm innovation. We use the 2009 and 2010 ASIF data to conduct the analysis; during the period, about 11.73% of the sample have positive new-product production.[11] As shown in Table 10, firms' participation in innovation has increased following stricter environmental disclosure, which is robust to the inclusion of a long list of city characteristics and the exclusion of extreme sectors. However, for the firms with positive new-product production, we do not find significant effects of environmental disclosure on their volume of innovation.

Table 9. Does PITI reflect other city characteristics?.

Dependent var.	If export					Log(export value)				
W/o extreme sectors	No	No	No	No	No	No	No	No	No	No
$PITI_{ct}$ × Pollution $intensity_s$	−0.079***	−0.069***	−0.047***	−0.043**	−0.064***	0.071***	0.088***	0.094***	0.136***	0.123***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)	(0.023)	(0.024)	(0.023)	(0.023)	(0.025)
$Log(gdp\_p)_{ct}$ × Pollution $intensity_s$	8.95***				5.39***	10.86***				12.97***
	(1.55)				(1.95)	(1.96)				(2.59)
$Punish_{ct}$ × Pollution $intensity_s$	−0.3				−0.58*	−1.907***				−1.96***
	(0.3)				(0.31)	(0.519)				(0.526)
$Log(SO_2)_{ct}$ × Pollution $intensity_s$		−2.31***			−1.808*		−6.83			2.144*
		(0.75)			(0.93)		(9.09)			(1.199)
$Log(distance)_{ct}$ × Pollution $intensity_s$		0.13			−0.47		11.92***			9.881**
		(2.31)			(2.34)		(4.61)			(4.94)
$Internet_{ct}$ × Pollution $intensity_s$			−3.14***		−3.06***			−1.731***		−4.51
			(0.405)		(0.42)			(0.408)		(4.4)
$Log(firm\ size)_{ct}$ × Pollution $intensity_s$			4.9***		2.73**			−16.55		−4.199**
			(1.3)		(1.37)			(17.45)		(1.95)
$Tenure_{ct}$ × Pollution $intensity_s$				−0.396***	−0.366**				−2.06***	−2.05***
				(0.15)	(0.15)				(0.241)	(0.241)
$Native_{ct}$ × Pollution $intensity_s$				−0.094	0.615				−3.805**	−3.615**
				(0.88)	(0.9)				(1.825)	(1.83)
PhD_{ct} × Pollution $intensity_s$				0.465	0.047				15.57***	14.35***
				(0.85)	0.85				(1.6)	(1.61)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	513,275	513,275	513,275	513,275	513,275	79,841	79,841	79,841	79,841	79,841

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity. $PITI_{ct}$ and other city characteristics are also controlled for. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

Table 10. PITI and firm innovation.

Dependent var.	If innovate				Log(new product value)			
W/o extreme sectors	No	No	No	No	No	No	No	No
Model No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PITI_{ct} \times$ Pollution $intensity_s$	**0.165*****	**0.137*****	**0.129*****	**0.138*****	**0.427**	**0.135**	**0.137**	**0.281**
	(0.032)	**(0.032)**	**(0.033)**	**(0.034)**	**(0.65)**	**(0.63)**	**(0.64)**	**(0.65)**
Firm controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
City controls (1)	No	No	Yes	Yes	No	No	Yes	Yes
City controls (2)	No	No	No	Yes	No	No	No	Yes
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Obs.	377,707	374,513	374,513	374,513	40,399	40,066	40,066	40,066
Dependent var.	**If innovate**				**Log(new product value)**			
W/o extreme sectors	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Model No.	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**
$PITI_{ct} \times$ Pollution $intensity_s$	**0.323*****	**0.278*****	**0.262*****	**0.237*****	**−0.02**	**−0.59**	**−0.59**	**−0.291**
	(0.052)	**(0.053)**	**(0.053)**	**(0.055)**	**(0.75)**	**(0.71)**	**(0.72)**	**(0.79)**
Firm controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
City controls (1)	No	No	Yes	Yes	No	No	Yes	Yes
City controls (2)	No	No	No	Yes	No	No	No	Yes
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Obs.	281,700	279,186	279,186	279,186	28,888	28,653	28,653	28,653

Notes: 'If innovate' is a dummy variable that equals 1 if the firm has positive new-product production and 0 otherwise. Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs). $PITI_{ct}$ and other city characteristics are also controlled for. City controls (1) include interaction terms in Table 5; and city controls (2) include interaction terms in Table 9. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

4.3. Endogeneity

One potential threat to our identification is endogeneity issue of the variable – $PITI_{ct}$ in (1). The PITI indexes are not randomly assigned to Chinese cities; instead, they might be correlated with some unobserved city characteristics and thus lead to biased estimates. For example, the PITI indexes tend to be higher in coastal cities that not only grow faster in economy but also thrive in export. Omitting cities' economic growth in the specification will lead to downward bias in the estimates of α_0, α_1 in (1). On the other hand, if the PITI indexes are positively correlated with other measures of environmental regulation and the latter hinders firm export, then neglecting these city-level regulation measures will result in upward bias in the estimated coefficients. We deal with the endogeneity issue in the following ways: 1) City dummies, D_c, are included in the specification (1) to control for time-invariant city characteristics. 2) In Section 4.1, a long list of time-varying city characteristics (such as cities' GDP and variables for other measures of environmental regulation, etc.) have been controlled for; and the estimated coefficients are not qualitatively different from the baseline results. 3) Further, we will try to solve the aforementioned endogeneity issue using an instrumental-variable (IV) estimation as below.

Specifically, we construct IV variables for the PITI indexes using environmental-impact disclosure indexes for cities' construction sector. In China, environmental-impact assessment is required by the MEP of China before the construction of any big projects, such as highways, bridges and large-scale residential complexes, etc. Since the disclosure of environmental-impact reports varies greatly across different Chinese cities,

Table 11. IV estimation.

W/o extreme sectors	No	No	Yes	Yes
Model No.	(1)	(2)	(3)	(4)
Panel A: First-stage estimation (dependent variable: PITI)				
IV	0.779***	0.779***	0.774***	0.774***
	(0.123)	(0.123)	(0.13)	(0.13)
IV × Poll_inten	−2.138	−2.138	−8.303	−8.303
	(4.95)	(4.95)	(6.53)	(6.53)
Panel B: First-stage estimation (dependent variable: PITI × Poll_inten)				
IV	−0.00037	−0.00037	−0.00029	−0.00029
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
IV × Poll_inten	0.859***	0.859***	0.816***	0.816***
	(0.174)	(0.174)	(0.163)	(0.163)
Panel C: Second-stage estimation				
Dependent var.:	If export	Log(export value)	If export	Log(export value)
PITI	0.015	0.037	0.023	0.026
	(0.32)	(0.41)	(0.35)	(0.39)
PITI × Poll_inten	**−0.074*****	**0.065****	**−0.089*****	**0.081****
	(0.025)	**(0.023)**	**(0.029)**	**(0.032)**
Weak instrument test				
Anderson-Rubin Wald test	(5.86)***	(4.16)***	(5.4)***	(4.46)***
Stock-wright LM S statistic	(15.02)***	(10.33)***	(16.09)***	(11.03)***
Observations	592,372	129,344	442,153	90,857

Notes: The instrument variable (IV) is cities' disclosure index for environmental-impact reports in the construction sector. Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity, $Punish_{ct}$, and $Log(gdp\_p)_{ct}$. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.
Source: created by the authors.

in 2008, the IPEA in China began to compile cities' environmental-impact disclosure indexes to reflect different extent of environmental disclosure in the construction sector of the cities. We argue that the index of environmental-impact disclosure will be a valid IV variable for the PITI index for the following reasons: on one hand, both indexes are determined by local governments' intent of disclosure and stringency of regulation; thus, they are expected to be positively correlated (i.e., the relevant condition is satisfied). On the other hand, although the disclosure of environmental-impact reports can affect the location and start-up cost of a new business, it will not influence everyday operation (such as export) of an existing firm. That is, the exclusion condition will be satisfied.

Then, we use the environmental-impact disclosure index as the IV variable for $PITI_{ct}$, and its interaction term with $Poll\_inten_s$ as the IV for $PITI_{ct} \times Poll\_inten_s$ in (1). Table 11 shows the results of IV estimation. The results of first-stage estimation are shown in Panels A and B; apparently, it shows that the relevant condition is satisfied for both IV variables. In Panel C, we list the results of second-stage estimation. Again, the estimated coefficient on $PITI_{ct}$ is insignificant; however, the coefficient on the interaction term, $PITI_{ct} \times Poll\_inten_s$, is significantly negative (positive) for the extensive (intensive) margin of export, which is compatible with the baseline results. Note that compared with the results in Table 5, the coefficient on $PITI_{ct} \times Poll\_inten_s$ using IV estimation is slightly smaller in magnitude for the analyses of both margins of export. This implies that some omitted variables in the error term of (1) result in a slight upward bias in the estimated effects using OLS estimation. In addition, the last two rows in Panel C of Table 11 show the results of weak-instrument tests, which indicate that weak instruments are not an issue for the IV estimation in this subsection.

5. Conclusion

This paper investigates the impact of China's governmental environmental disclosure programs on the extensive and intensive margins of export for a panel of Chinese industrial firms. Our findings are two-fold: on one hand, stricter enforcement of government environmental disclosure leads to decreased firm participation in export. On the other hand, we find that the export volume of remaining exporters increases following stricter enforcement of environmental disclosure, which is robust to a battery of robustness checks and an IV estimation. In addition, we find that firms' innovation propensity increases with more environmental disclosure.

Notes

1. See, for example, Harris et al. (2002), Jug and Mirza (2005), Xu (2000), Costantini and Crespi (2008) and Costantini and Mazzanti (2012) among others. In addition, some literature examines the impact of environmental regulation on other competitiveness measures, such as productivity (e.g., Jaffe et al., 1995; Berman & Bui, 2001; Telle & Larsson, 2007; Lanoie et al., 2008), innovation (e.g., Jaffe & Palmer, 1997; Brunnermeier & Cohen, 2003), and economic/financial performance (e.g., Khanna & Damon, 1999; Rassier & Earnhart, 2015).
2. Possible explanations for the different results regarding the link between environmental regulation and export volume include: First, Soest et al. (2006) argue that there is little consensus about appropriate and internationally comparable measures of the stringency of environmental regulation, resulting in different conclusions using different measurements. Second, Brunel and Levinson (2016) claim that environmental regulation is multi-dimensional and different approaches of regulation may have different impacts on firm performance, including export.
3. Detrimental effects of environmental regulation on international competitiveness are found by Van Beers and Van den Bergh (1997) and Jug and Mirza (2005) among others while beneficial effects of environmental regulation are found by Xu (2000), Costantini and Crespi (2008) and Tsurumi et al. (2015) among others. More recently, Ramzy and Zaki (2018) find that environmental regulation can stimulate innovation activities, and thus improve countries' trade competitiveness. Using a gravity model, Helble and Majoe (2017) find that the implementation of Energy Performance of Buildings Directive (EPBD) in the EU can bring about more trade in environmental goods.
4. Since the year 2003, China has passed several laws, some aspects of which involve EID, such as the 2003 Clean Production Promotion Law, the 2004 Clean Production Audit Methods (for trial implementation), and the 2005 State Council's Decision on Strengthening Environmental Protection among others. The Measures, however, are the first nationwide laws in China specialized in EID.
5. Note that China Pollution Source Census Office has compiled the Handbook of Pollutant Emission Intensity Coefficients of Industrial Pollution Sources, which includes various pollutants' emission intensities of 351 4-digit industrial sectors. However, those intensities cannot be directly used in this study since the types of emitted pollutants are different across sectors and thus the calculated emission intensities are not readily comparable between industrial sectors.
6. Around 0.08% of the firms in the sample have changed the city where they reside in and 3.68% of the firms have changed their reported sectors during the period.

7. We will not use the Probit or Logit model when analyzing firm participation into export since the interaction term in (1) is of our main interest and the interpretation of estimated coefficients of interaction terms in non-linear models (such as the Probit or Logit model) is quite complicated (Ai & Norton, 2003).
8. Note that the estimated effect on firm participation into trade may be under-estimated since the firms that exit the sample are more likely to be non-exporters, as discussed later on.
9. The results will be provided upon request.
10. Specifically, these variables include cities' GDP per capita (in logs), distance to Hong Kong (in logs), SO_2 emission per GDP (in logs), internet users as a fraction of population, average output value per firm (in logs, denoted by Log(firm size)), and mayors' tenure. We also include in the regression punishment cases against environmental violation per GDP (in logs, denoted by Punish), dummies indicating if mayors were born in locality (denoted by Native) and if they have a PhD degree or not.
11. The 2008 ASIF data are dropped because the information on new-product production is missing in that year.

Funding

Xian-Liang Tian is grateful for the financial support from the National Natural Science Foundation of China (Grant # 72074223), the Teaching Reform Fund and Fundamental Research Funds for the Central Universities, Zhongnan University of Economics and Law (Grant # YB202162). Yu Xia is grateful for the financial support from the 2021 Discipline Construction Project of School of Law, Hubei University (Project title: Evolution of Latin American regional governance and the Construction of the Rule of Law in China; Grant # 602017200).

References

Ai, C., & Norton, E. C. (2003). Interaction terms in logit and probit models. *Economics Letters*, *80*(1), 123–129. https://doi.org/10.1016/S0165-1765(03)00032-6

Albrizio, S., Kozluk, T., & Zipperer, V. (2017). Environmental policies and productivity growth: Evidence across industries and firms. *Journal of Environmental Economics and Management*, *81*, 209–226. https://doi.org/10.1016/j.jeem.2016.06.002

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? *Review of Environmental Economics and Policy*, *7*(1), 2–22. https://doi.org/10.1093/reep/res016

Bai, C.-E., Lu, J., & Tao, Z. (2009). How does privatization work in China? *Journal of Comparative Economics*, *37*(3), 453–470. https://doi.org/10.1016/j.jce.2008.09.006

Baldini, M., Maso, L. D., Liberatore, G., Mazzi, F., & Terzani, S. (2018). Role of country- and firm-level determinants in environmental, social and governance disclosure. *Journal of Business Ethics*, *150*(1), 79–98. https://doi.org/10.1007/s10551-016-3139-1

Benlemlih, M., Shaukat, A., Qiu, Y., & Trojanowski, G. (2018). Environmental and social disclosures and firm risk. *Journal of Business Ethics*, *152*(3), 613–626. https://doi.org/10.1007/s10551-016-3285-5

Berman, E., & Bui, L. T. M. (2001). Environmental regulation and productivity: Evidence from oil refineries. *The Review of Economics and Statistics*, *83*(3), 498–510. https://doi.org/10.1162/00346530152480144

Bernard, A. B., & Jensen, J. B. (2004). Why some firms export. *The Review of Economics and Statistics*, *86*(2), 561–569. https://doi.org/10.1162/003465304323031111

Bernard, A. B., Jensen, J. B., Redding, B. J., & Schott, P. (2007a). Firms in international trade. *The Journal of Economic Perspectives*, *21*(3), 105–130. https://doi.org/10.1257/jep.21.3.105

Bernard, A. B., Redding, S., & Schott, P. K. (2007b). Comparative advantage and heterogeneous firms. *Review of Economic Studies*, *74*(1), 31–66. https://doi.org/10.1111/j.1467-937X.2007.00413.x
Bitat, A. (2018). Environmental regulation and eco-innovation: The Porter hypothesis refined. *Eurasian Business Review*, *8*(3), 299–321. https://doi.org/10.1007/s40821-017-0084-6
Brandt, L., Biesebroeck, J. V., & Zhang, Y. (2012). Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. *Journal of Development Economics*, *97*(2), 339–351. https://doi.org/10.1016/j.jdeveco.2011.02.002
Brunel, C., & Levinson, A. (2016). Measuring the stringency of environmental regulations. *Review of Environmental Economics and Policy*, *10*(1), 47–67. https://doi.org/10.1093/reep/rev019
Brunnermeier, S. B., & Cohen, M. A. (2003). Determinants of environmental innovation in US manufacturing industries. *Journal of Environmental Economics and Management*, *45*(2), 278–293. https://doi.org/10.1016/S0095-0696(02)00058-X
Cai, H., & Liu, Q. (2009). Competition and corporate tax avoidance: Evidence from Chinese industrial firms. *The Economic Journal*, *119*(537), 764–795. https://doi.org/10.1111/j.1468-0297.2009.02217.x
Costantini, V., & Crespi, F. (2008). Environmental regulation and the export dynamics of energy technologies. *Ecological Economics*, *66*(2–3), 447–460. https://doi.org/10.1016/j.ecolecon.2007.10.008
Costantini, V., & Mazzanti, M. (2012). On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports. *Research Policy*, *41*(1), 132–153. https://doi.org/10.1016/j.respol.2011.08.004
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*. Edward Elgar.
Dollar, D., & Wei, S.-J. (2007). Das (wasted) Kapital: Firm ownership and investment efficiency in China. IMF Working Papers, 07/(9), 1. DDollar@imf.org. https://doi.org/10.5089/9781451865738.001
Ederington, J., & Minier, J. (2003). Is environmental policy a secondary trade barrier? An empirical analysis. *Canadian Journal of Economics/Revue Canadienne dEconomique*, *36*(1), 137–154. https://doi.org/10.1111/1540-5982.00007
Fatemi, A., Glaum, M., & Kaiser, S. (2018). ESG performance and firm value: The moderating role of disclosure. *Global Finance Journal*, *38*, 45–64. https://doi.org/10.1016/j.gfj.2017.03.001
Franco, C., & Marin, G. (2017). The effect of within-sector, upstream and downstream environmental taxes on innovation and productivity. *Environmental and Resource Economics*, *66*(2), 261–291. https://doi.org/10.1007/s10640-015-9948-3
Gollop, F. M., & Roberts, M. J. (1983). Environmental regulations and productivity growth: The case of fossil-fuelled electric power generation. *Journal of Political Economy*, *91*(4), 654–674. https://doi.org/10.1086/261170
Gray, W. B., & Shadbegian, R. (2003). Plant vintage, technology and environmental regulation. *Journal of Environmental Economics and Management*, *46*(3), 384–402. https://doi.org/10.1016/S0095-0696(03)00031-7
Greenstone, M., List, J. A., & Syverson, C. (2012). The effects of environmental regulation on the competitiveness of U.S. manufacturing. NBER Working Paper no.18392, September.
Harris, M. N., Konya, L., & Matyas, L. (2002). Modeling the impact of environmental regulations on bilateral trade flows: OECD, 1990-1996. *The World Economy*, *25*(3), 387–405. https://doi.org/10.1111/1467-9701.00438
Hassan, A., & Guo, X. (2017). The relationships between reporting format, environmental disclosure and environmental performance: An empirical study. *Journal of Applied Accounting Research*, *18*(4), 425–444. https://doi.org/10.1108/JAAR-06-2015-0056
Helble, M., & Majoe, A. (2017). How can environmental regulations spur international trade? The case of the EU performance of buildings directive and lessons for Asia. ADBI Working

Paper 769. *Asian Development Bank Institute*. https://www.adb.org/publications/how-can-environmental-regulations-spur-international-trade

Hering, L., & Poncet, S. (2014). Environmental policy and exports: Evidence from Chinese cities. *Journal of Environmental Economics and Management*, *68*(2), 296–318. https://doi.org/10.1016/j.jeem.2014.06.005

Huang, Y. (2003). One country, two systems: Foreign-invested enterprises and domestic firms in China. *China Economic Review*, *14*(4), 404–416. https://doi.org/10.1016/j.chieco.2003.09.011

IPE and NRDC. (2008). Breaking the ice on environmental open information: The 2008 pollution information transparency index (PITI), first annual assessment of environmental transparency in 113 Chinese cities. http://ipe.org.cn/Upload/Report-PITI-2008-EN.pdf.

Jaffe, A. B., & Palmer, K. (1997). Environmental regulation and innovation: A panel data study. *The Review of Economics and Statistics*, *79*(4), 610–619. https://doi.org/10.1162/003465397557196

Jaffe, A. B., Peterson, S. R., Portney, P. R., & Stavins, R. N. (1995). Environmental regulation and the competitiveness of USA manufacturing: What does the evidence tell us? *Journal of Economic Literature*, *33*, 132–163.

Jiang, L., Lin, C., & Lin, P. (2014). The determinants of pollution levels: Firm-level evidence from Chinese manufacturing. *Journal of Comparative Economics*, *42*(1), 118–142. https://doi.org/10.1016/j.jce.2013.07.007

Jug, J., & Mirza, D. (2005). Environmental regulations in gravity equations: Evidence from Europe. *The World Economy*, *28*(11), 1591–1615. https://doi.org/10.1111/j.1467-9701.2005.00748.x

Khanna, M., & Damon, L. A. (1999). EPA's voluntary 33/50 program: Impact on toxic releases and economic performance of firms. *Journal of Environmental Economics and Management*, *37*(1), 1–25. https://doi.org/10.1006/jeem.1998.1057

Kneller, R., & Manderson, E. (2012). Environmental regulations and innovation activity in UK manufacturing industries. *Resource and Energy Economics*, *34*(2), 211–235. https://doi.org/10.1016/j.reseneeco.2011.12.001

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. https://doi.org/10.1006/jeem.1996.0955

Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., & Ambec, S. (2011). Environmental policy, innovation and performance: New insights on the Porter Hypothesis. *Journal of Economics & Management Strategy*, *20*(3), 803–842. https://doi.org/10.1111/j.1530-9134.2011.00301.x

Lanoie, P., Patry, M., & Lajeunesse, R. (2008). Environmental regulation and productivity: Testing the porter hypothesis. *Journal of Productivity Analysis*, *30*(2), 121–128. https://doi.org/10.1007/s11123-008-0108-4

Leeuwen, G., & Mohnen, P. (2017). Revisiting the Porter hypothesis: An empirical analysis of Green innovation for the Netherlands. *Economics of Innovation and New Technology*, *26*(1-2), 63–77. https://doi.org/10.1080/10438599.2016.1202521

Levinson, A., & Taylor, M. S. (2008). Unmasking the pollution haven effect. *International Economic Review*, *49*(1), 223–254. https://doi.org/10.1111/j.1468-2354.2008.00478.x

Lorentzen, P., Landry, P., & Yasuda, J. (2014). Undermining authoritarian innovation: The power of China's industrial giants. *Journal of Politics*, *76*(1), 182–194. https://doi.org/10.1017/S0022381613001114

Popp, D. (2006). International innovation and diffusion of air pollution control technologies: The effects of NOx and SO_2 regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management*, *51*(1), 46–71. https://doi.org/10.1016/j.jeem.2005.04.006

Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment competitiveness relationship. *Journal of Economic Perspectives*, *9*(4), 97–118. https://doi.org/10.1257/jep.9.4.97

Powers, N., Blackman, A., Lyon, T., & Narain, U. (2011). Does disclosure reduce pollution? Evidence from India's Green Rating Project. *Environmental and Resource Economics*, *50*(1), 131–155. https://doi.org/10.1007/s10640-011-9465-y

Ramzy, M., & Zaki, C. (2018). Do environment regulations matter for EU-MENA trade? *Applied Economics*, *50*(39), 4197–4221. https://doi.org/10.1080/00036846.2018.1441519

Rassier, D. G., & Earnhart, D. (2015). Effects of environmental regulation on actual and expected profitability. *Ecological Economics*, *112*, 129–140. https://doi.org/10.1016/j.ecolecon.2015.02.011

Rexhauser, S., & Rammer, C. (2014). Environmental innovations and firm profitability: Unmasking the Porter Hypothesis. *Environmental and Resource Economics*, *57*(1), 145–167. https://doi.org/10.1007/s10640-013-9671-x

Roberts, M. J., & Tybout, J. R. (1997). The decision to export in Colombia: An empirical model of entry with sunk costs. *American Economic Review*, *87*(4), 545–564.

Soest, D., List, J., & Jeppesen, T. (2006). Shadow prices, environmental stringency, and international competitiveness. *European Economic Review*, *50*(5), 1151–1167. https://doi.org/10.1016/j.euroecorev.2005.02.002

Stoever, J., & Weche, J. (2018). Environmental regulation and sustainable competitiveness: Evaluating the role of firm-level green investments in the context of the Porter Hypothesis. *Environmental and Resource Economics*, *70*(2), 429–455. https://doi.org/10.1007/s10640-017-0128-5

Telle, K., & Larsson, J. (2007). Do environmental regulations hamper productivity growth? How accounting for improvements of plants' environmental performance can change the conclusion. *Ecological Economics*, *61*(2–3), 438–445. https://doi.org/10.1016/j.ecolecon.2006.03.015

Tian, X.-L., Guo, Q. G., Han, C., & Ahmad, N. (2016). Different extent of environmental information disclosure across Chinese cities: Contributing factors and correlation with local pollution. *Global Environmental Change*, *39*, 244–257. https://doi.org/10.1016/j.gloenvcha.2016.05.014

Tietenberg, T. (1998). Disclosure strategies for pollution control. *Environmental and Resource Economics*, *11*(3/4), 587–602. https://doi.org/10.1023/A:1008291411492

Tsurumi, T., Managi, S., & Hibiki, A. (2015). Do environmental regulations increase bilateral trade flows? *The B.E. Journal of Economic Analysis & Policy*, *15*(4), 1549–1577. https://doi.org/10.1515/bejeap-2014-0164

Van Beers, C., & Van den Bergh, J. (1997). An empirical multi-country analysis of the impact of environmental regulations on foreign trade flows. *Kyklos*, *50*(1), 29–46. https://doi.org/10.1111/1467-6435.00002

Wang, H., Bi, J., Wheeler, D., Wang, J., Cao, D., Lu, G., & Wang, Y. (2004). Environmental performance rating and disclosure: China's GreenWatch program. *Journal of Environmental Management*, *71*(2), 123–133. https://doi.org/10.1016/j.jenvman.2004.01.007

Weiss, J., & Anisimova, T. (2019). The innovation and performance effects of well-designed environmental regulation: Evidence from Sweden. *Industry and Innovation*, *26*(5), 534–567. https://doi.org/10.1080/13662716.2018.1468240

World Bank. (2005). China-integration of national product and factor markets economic benefits and policy recommendations. Report No. 31973-CHA. The World Bank.

Xu, X. (2000). International trade and environment regulation: Time series evidence and cross section test. *Environmental and Resource Economics*, *17*(3), 233–257. https://doi.org/10.1023/A:1026428806818

Appendix A

Table A1. Robustness check 4, Sample attrition and city/sector sorting (Without extreme sectors).

Dependent var.	If export		Log(export value)		If export		Log(export value)		If export		Log(export value)		If exit
W/o extreme sectors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
$PITI_{ct} \times$ Pollution $intensity_s$	**−0.099*****	**−0.118*****	**0.154*****	**0.113*****	**−0.091*****	**−0.108*****	**0.167*****	**0.132*****	**−0.096*****	**−0.1*****	**0.133*****	**0.101*****	**0.023*****
	(0.033)	**(0.033)**	**(0.041)**	**(0.041)**	**(0.033)**	**(0.033)**	**(0.041)**	**(0.042)**	**(0.027)**	**(0.028)**	**(0.036)**	**(0.036)**	**(0.003)**
$Punish_{ct} \times$ Pollution $intensity_s$		−0.391		−1.986***		−0.403		−1.656**		−0.679		−2.198***	
		(0.51)		(0.733)		(0.51)		(0.752)		(0.42)		(0.739)	
$Log(gdp\_p)_{ct} \times$ Pollution $intensity_s$		10.1***		13.523***		9.05***		11.629***		3.85		16.37***	
		(2.66)		(3.014)		(2.66)		(3.114)		(2.39)		(2.926)	
If export													**−0.0096*****
													(0.0025)
Sample used	Excluding firms exiting before 2010				Including only firms surviving 2008–2010				Excluding firms changing city/sector				All
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Obs.	277,693	277,693	69,621	69,621	225,227	225,227	44,942	44,942	417,919	417,919	85,628	85,628	376,175

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity, $PITI_{ct}$, $Punish_{ct}$, and $Log(gdp\_p)_{ct}$. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively. In Model (13), we first track the last year when each firm is observed in the sample and only keep the last two years' observations. Then we assign 1 to the variable 'If exit' for the last-year × firm combination if the firm exits the sample before 2010. We assign 0 to 'If exit' for all other year × firm combination.

Table A2. Does PITI reflect other city characteristics? (Without extreme sectors).

Dependent var.	If export					Log(export value)				
W/o extreme sectors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$PITI_{ct}$ × Pollution $intensity_s$	−0.094***	−0.083***	−0.084***	−0.064**	−0.068**	0.089**	0.12***	0.115***	0.168***	0.15***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)	(0.035)	(0.036)	(0.035)	(0.036)	(0.038)
$Log(gdp\_p)_{ct}$ × Pollution $intensity_s$	5.43**				3.53	15.35***				22***
	(2.34)				(2.8)	(2.86)				(3.86)
$Punish_{ct}$ × Pollution $intensity_s$	−0.775*				−1.06**	−1.637**				−2.09***
	(0.42)				(0.42)	(0.668)				(0.704)
$Log(SO_2)_{ct}$ × Pollution $intensity_s$		1.03			1.02		−1.7			6.92***
		(1.17)			(1.37)		(13.8)			(1.81)
$Log(distance)_{ct}$ × Pollution $intensity_s$		−11.06*			−12.72**		−97.01			−104.9
		(6.04)			(6.07)		(97.44)			(91.3)
$Internet_{ct}$ × Pollution $intensity_s$			−4.21***		−3.86***			−1.627***		4.78
			(0.58)		(0.62)			(0.556)		(6.14)
$Log(firm\ size)_{ct}$ × Pollution $intensity_s$			3.67*		2.89			−6.282**		−9.012***
			(1.9)		(1.98)			(2.61)		(2.99)
$Tenure_{ct}$ × Pollution $intensity_s$				−0.861***	−0.75***				−2.4***	−2.44***
				(0.21)	(0.22)				(0.339)	(0.339)
$Native_{ct}$ × Pollution $intensity_s$				−0.626	−0.52				−5.38**	−4.458*
				(1.2)	(1.28)				(2.61)	(2.62)
PhD_{ct} × Pollution $intensity_s$				0.16	−0.046				18.09***	17.22***
				(1.16)	(1.17)				(2.03)	(2.01)
Estimation method	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE	Firm FE
Observations	381,838	381,838	381,838	381,838	381,838	55,417	55,417	55,417	55,417	55,417

Notes: Firm, city, sector and year fixed effects have been controlled for. We also control for firm age, labour productivity, capital-labour ratio, employment (all in logs), firms' new-product intensity. $PITI_{ct}$ and other city characteristics are also controlled for. Robust standard errors clustered at the city level are in parentheses. ***, ** and * represent 1%, 5% and 10% significance levels, respectively.