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Does environmental regulation affect firm exports? Evidence from wastewater discharge standard in China

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ABSTRACT

This paper examines the effect of water pollution regulation on polluters' exporting decisions and exporting structure. Using a detailed firm-by-product level dataset, we employ a difference-in-differenceds model to identify the causal relationship between environmental regulation and firms' exporting performance. We find that stringent environmental regulation decreases both export likelihood and export values. Moreover, we examine the channels that the environmental regulation could affect firms' exporting performance through entry-exit of the export market, price transmission, adjustments of exporting destinations, and product switch. The tightening wastewater discharge standard appears to deter the new polluters rather than incumbents to enter the export market. Productive polluters could gain the relative larger export market by lowering down exporting prices and selling more products overseas. In response to this water pollution regulation, polluters would make substantial adjustments in their exporting destinations, exporting products, and exports value via different trade modes.

1. Introduction

Deteriorating environmental pollution calls for an urgent need for government intervention, leading to rising concern about the relationship between environmental regulation and firm-level decisions. Despite some benefits from the cleanup of the environment, however, worriers argue that environmental regulation may mirror the loss of comparative advantage, affecting firms' participation in the global market. The growing empirical literature has set out to estimate the aggregate-level (industrial or regional) variations in response to tightened environmental policies. Little has been revealed about the firm-level adjustments of exporting decisions and its channels.

This paper examines the exporting decisions and channels in response to tightened environmental control, using the firm-level data during the 2001–2006 period. The implementation of wastewater discharge standards in Jiangsu Province in the Lake Tai area in China, which is the policy of interest in this paper, acts as a quasi-natural experiment. Using a difference-in-differences (DID) model, we seek to estimate the causal impact of the tightened wastewater standard on firms' decision of exports and values of exports by comparing those in the textile, printing and dyeing (TPD) industry and residing in the treated areas (Jiangsu Province in the Lake Tai area) with those within the same TPD industry and located in the control areas (other provinces in the Lake Tai area). Furthermore, we are interested in exploring the mechanism of how firms' exporting performance responds to the stringent regulation. We take a closer look at the heterogeneous regulatory impacts by firm productivity and ownership. More importantly, exporting channels are further explored to reveal the heterogeneous adjustments between incumbents and new entrants of the export market, price

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transmission, exporting destination adjustments, and product switch. Specifically, we are interested in examining whether the tightened standard affects the entry-exit of the exporting market, delivers a pass-through effect on exporting price and exporting volume, and induces water pollutant emitting firms to switch products from more pollution-intensive products to less intensive ones.

We obtain several novel findings about the regulatory impacts on firm-level exporting performance. An increase in wastewater discharge standards has significantly reduced the export propensity of firms located in the treatment areas relative to those residing in the control areas. So do their values of total exports. The negative impact of environmental policies on firms' exporting decisions are more pronounced on the least productive firms, but have a modest impact on productive firms. The declining exporting propensity in response to tightened policy is attributed to prevent new entries into the exporting market, while the shrinking exporting values arise from the declining number of exporting destinations, mainly through non-OECD exporting destinations. In response to the stringent emission discharge standard, polluters tend to adjust their product lines by substituting away from water pollution-intensive textile dyeing and finishing products. Finally, we conduct a series of robustness checks and placebo tests, including the anticipation and dynamic effects, confounding factors, pseudo treated areas and pseudo covered sectors and the alternative model specification using a triple DID. Moreover, we also address the concern about the potential relocation of polluters in response to the tightened environmental control. The main conclusions are robust against these alternative checks.

This paper contributes to the growing literature about trade and the environment centering around the theoretical and empirical relationship among trade liberalization, environmental regulation, and environmental pollution (Antweiler, Copeland, & Taylor, 2001; Cherniwchan, Copeland, & Taylor, 2017; Cole & Elliott, 2003; Copeland & Taylor, 1994, 1995; Cui, 2017; Cui, Lapan, & Moschini, 2016; Frankel & Rose, 2005; Keller & Levinson, 2002; Levinson & Taylor, 2008; Managi, Hibiki, & Tsurumi, 2009; McAusland & Millimet, 2012). Copeland and Taylor (2004) distinguish the impact of trade liberalization on the environment from the impact of environmental regulation on trade. The former is related to the Pollution Haven Hypothesis, which states that tariff cuts could lead to the relocation of dirty industries from countries with stringent environmental control to countries with lax environmental regulations. The latter refers to the Pollution Haven Effect, suggesting that a stringent environmental regulation would affect site choices of dirty industries and henceforth the direction of trade flows.

This paper is closely related to the literature on the Pollution Haven Effect, in particular, those related to China. Based upon the country or industry-level data, earlier studies adopt pollution abatement costs and expenditures or emission intensity as measures for the stringency of environmental regulation (Keller & Levinson, 2002; Levinson & Taylor, 2008; Manderson & Kneller, 2011). Recent work focuses on specific environmental regulation implemented at the nation-wide scale or regional levels, and seek to tease out the causal impact of environmental control on region-level or firm-level foreign direct investment (FDI) inflow, site choices of FDI, and selection to trade. Hering and Poncet (2014) look at the two control zone (TCZ) policy (i.e., SO_2 and acid rain control zones) implemented by the Chinese central government in 1998. They examine the impacts of the regional TCZ policy on city-level industrial exports. Along with this line, another paper by Cai, Lu, Wu, and Yu (2016) explores whether the TCZ policy leads to a decline in FDI inflow at the firm level. Another two existing work study the total amount control policy of chemical oxygen demand (COD) and SO_2 in China's "Total Pollution Control Plan for Major Pollutants during the Eleventh Five-Year Plan" (Lin & Sun, 2016; Shi & Xu, 2018). Lin and Sun (2016) focus on whether this provincial-level emission control policy affects site choices of FDI firms, while Shi and Xu (2018) study whether this policy is associated with a decline in exporting likelihood and export sales.

This paper also adds to a strand of literature that seeks to understand the water pollution issue and water quality regulations in China. Rapid industrialization has been accompanied by environmental degradation, including a severe deterioration of water quality in China. Ebenstein (2012)'s findings on the positive relationship between water pollution and the digestive cancer death rate raise widespread concerns regarding the water quality in China. Severe deterioration in water quality in the country's lakes and rivers calls for urgent government intervention. Liu, Shadbegian, and Zhang (2017) study the wastewater discharge standard in Jiangsu Province in the Lake Tai area, which is also the policy interest of our paper, while Wang, Wu, and Zhang (2018) examine the three rivers and three lakes basins as key regions for water pollution control implemented by the central government of China. The former examines the impact of local wastewater discharge standards on COD pollution and labor employment in the pollution-intensive sectors, the latter evaluates the effects of the water quality regulations on firms' emissions of COD and productivity. Using COD emission reduction target set by the central government of China during the 11th Five-year Plan, Chen, Kahn, Yu, and Wang (2018) study the effectiveness of this policy in water pollution reduction and examine the regulatory effect on the relocation of water-polluting industries.

We make substantial contributions to the existing literature. Firstly, this paper seeks to tease out the causal relationship between environmental regulation and firms' exporting performance. Wastewater discharge standard used in this paper acts as a quasi-natural experiment, providing an opportunity of making a causal inference. This policy was put into effective by the local government of Jiangsu Province in 2004, offering us a comparison of firms' export activities between polluting firms residing in Jiangsu Province in the Lake Tai area (treatment groups) with those located in other provinces in the Lake Tai area (control groups) and between the pre- and post-policy periods. The reasons that our baseline model setting studies polluters in the single TPD sector and residing in the Lake Tai area lie in concerns about regional and industrial confounding factors affecting firms' decisions to export. Firms residing in the Lake Tai area share similar regional economic and social characteristics including local agglomeration, input market, infrastructure, and the distance to the coastal cities. By focusing only on the Lake Tai area, the baseline DID model specification helps better mitigate regional confounding factors. More importantly, during the study period of 2001–2006, China was experiencing trade liberalization due to the accession to WTO. By comparing firms' activities within the single TPD industry, which was set as the targeted emission-intensive industries by the policy, we could better remove the confounding factors of trade liberalization and help identify the causal impact of environmental regulation on firms' export decisions.

Another contribution that this paper adds to the existing literature centers on the identification of the detailed mechanism regarding exporting decisions at the firm-level. Existing work focuses on understanding how the selection to trade and export values respond to environmental regulations in China, for example, city-level variations in trade decisions by Hering and Poncet (2014) and firms' exporting decisions by Shi and Xu (2018). In line with them, we first adopt the firm-level matched dataset to examine the firm-level exporting decision in response to the environmental policy. Moreover, an important departure from this strand of literature is to unveil the mechanism in which polluting exporters adjust their exporting performance, using the firm–product- destination-year data. This dataset provides detailed information regarding exporting firms' product at 8-digit HS code, exporting destinations, exporting prices and quantities, and trade mode (general trade vs. processing trade), allowing us to unveil the adjustments of exporting market structure, product switch, and trade mode in response to the environmental policy shock.

The remaining of the paper is structured as follows. The next section introduces the policy background, while Section 3 presents data sources and model specifications. Section 4 discusses the empirical results. The last section concludes the paper.

2. Policy background

With the rapid economic development, water pollution in the Lake Tai Area has deteriorated. Early in the 1980s, the sound lyrics "Lake Tai is beautiful for the sake of its beautiful water" once made countless people imagine the beautiful scene of Lake Tai. At that time, the water quality of Lake Tai reaches the second class level, meeting the quality requirement for drinking water. Since then, water pollution in the Lake Tai area becomes severe. In the latest 20 years, water quality has degraded down by two grades, from the former type II water to the present type IV water level. Since the 1990s, both the central and local governments have made substantial efforts to prevent and control water pollution in Lake Tai but with little improvement in water quality.[1] The water crisis has aroused nationwide attention and once again sounded the alarming bells for water pollution control, in particular, polluting activities in the TPD sector, the most water-pollution-intensive sector.

On July 1 of 1992, the Ministry of Environment Protection of China starts launching the first discharge standard of water pollutant policy targeting at the TPD industry. The discharge standards are graded into three levels by different water usage. Class 1 standard is set for centralized drinking water sources, swimming, and other scenic areas, while Class 2 standard is for general industrial water, farmland water, and landscape areas. Class 3 standard is adopted for wastewater discharged into city and town sewage systems, which have the secondary wastewater treatment plants. For firms operating after January 1 of 1989, the maximum COD concentration levels are classified into 100 mg/L (Class 1), 180 mg/L (Class 2), and 500 mg/L (Class 3). For the grandfather enterprises existing before January 1 of 1989, they are subject to less stringent requirements with the corresponding standards for COD concentrations levels ranging from 180 mg/L (Class 1), 240 mg/L (Class 2), and 500 mg/L (Class 3). The wastewater of the TPD firms belongs to the industrial pollutants, thereby subject to the Class 2 standard (i.e., 180 mg/L for new entries and 240 mg/L for grandfather).

On June 1 of 2004, the Department of Environmental Protection and Bureau of Quality and Technical Supervision in Jiangsu province implements a strict water pollutant discharge standard for TPD firms in the jurisdiction. This is the first local water pollution discharge standard for the TPD industry in Jiangsu province around the Lake Tai Area. The new local standard is more stringent than the national one. In the government's official documents, the maximum COD discharge concentration in TPD enterprises directly discharged into groundwater is adjusted down from 180 mg/L to 100 mg/L. This policy is implemented in two phases. In the first phase starting on January 1 of 2005, the policy only targets at the TPD enterprises in the Lake Tai area of Jiangsu Province, including Suzhou, Wuxi, Changzhou, and Zhenjiang cities, while the rest of the Lake Tai area, including Huzhou, Jiaxing, and Hangzhou in Zhejiang province and Shanghai municipality are not covered. In the second phase starting on January 1 of 2007, the policy target is expanded to all TPD enterprises in Lake Tai area.

Taking advantage of the wastewater discharge standard targeting the TPD industry in the Lake Tai area, this paper aims to investigate how the stringent wastewater discharge standard affects the firms' exporting performance. Firstly, this paper focuses on the Lake Tai area, covering 36,895 km^2. Its administrative area is divided into three provinces (i.e., Jiangsu, Zhejiang, and Anhui) and one municipality city (i.e., Shanghai). In 2015, the regional GDP reaches 6688.4 billion RMB, accounting for 9.9% of China's total GDP, while the per capita GDP is about 112,000 RMB, twice larger than China's average level. In terms of industrial activities, the TPD industry, a heavy emitter of water pollution, is the primary sector in the Lake Tai area. In the meanwhile, nearly half of TPD enterprises are exporters. The stringent water pollution control would directly increase the production cost, affecting the export behavior of TPD enterprises.

Secondly, the wastewater discharge standard implemented in Jiangsu province around the Lake Tai area provides the variations across years and regions. The policy is put into effect in the year 2004, allowing us to compare the export decisions of enterprises between the pre- and post-policy of wastewater discharge standards. As illustrated in Fig. 1, Jiangsu province around the Lake Tai area implements the stringent wastewater discharge standards, while other areas of the Lake Tai Area, including Zhejiang Province and Shanghai Municipality, are free from the regulation. The former denotes to the treatment region, while the latter refers to the

[1] In 1991, a major flood occurred in the Lake Tai Area, and the water level in Lake Tai rose to a maximum of 4.79 m. The State Council convened the first working conference on harnessing the Huang River and decided to build ten key projects for the comprehensive management of the Lake Tai Area. Wangyu River project and Tai Pu River project started construction. Then the second, third, fourth working meetings were held in 1992, 1994 and 1997 respectively. In 1998, the State Council approved the "95" plan for the prevention and control of water pollution in Lake Tai. In 2001, the State Council approved the "fifteen" plan for the prevention and control of water pollution in Lake Tai and held the third working conference on the prevention and control of water pollution in Lake Tai.

Fig. 1. Geographic location of Lake Tai and surrounding provinces and municipality in China. (Map source: Baidu map.)
Note: Jiangsu province in green is the treatment area receiving wastewater discharge standard, while Zhejiang province and Shanghai municipality are the group areas without the regulatory control. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

control region. We could estimate the impact of the strict environmental policy on exporting behavior of water pollution-intensive enterprises by comparing them within the same TPD industry but across regions (the treatment and control regions).

3. Data and empirical strategy

3.1. Data sources

The firm-level production data pertain to China's Industrial Enterprises Database (CIED) from the National Bureau of Statistics during the 2001–2006 period.[2] The CIED covers all the state-owned enterprises (SOE) and the large and medium-sized manufacturing enterprises with values of sales exceeding a threshold level of 5 million RMB (about US$827,000). It provides detailed firm-level economic characteristics including value-added, output, values of sales, employees, total wages, and many others. Since the focus of this paper is on the exporting decisions of TPD enterprises in the Lake Tai Area, we pick up firms from the textile industry with the 2-digit China industry code of 17.[3] Based upon firms' location in the Lake Tai Area, we then separate these observations into the treatment group (i.e., firms located in Suzhou, Wuxi, Changzhou, and Zhenjiang in Jiangsu province)and the control group (firms residing in Huzhou, Jiaxing, and Hangzhou in Zhejiang province, and Shanghai municipality). Table 1 presents descriptive statistics of key variables. There is no significant difference in sales, export, assets, employment, wages, and productivity between the treatment and the control groups.

To understand detailed exporting behavior in response to stringent environmental regulation, we further merge the firm-level production dataset with transaction-level trade data. The firm-level transaction data are obtained from China's General Administration of Customs, including detailed information about firms' export behavior, including export value, export price, product type (HS 8-digitcode), exporting destination, and trade mode (e.g., processing trade and general trade). The data is merged by the firms' information (such as firms' names, year, zip code, and phone number). From 2001 to 2006, we have successfully matched 6237

[2] Since 2007, CIED Enterprise Statistics range from 5 million yuan to 20 million yuan, so the match between the year after 2007 and the year before 2007 is very different, so this paper only applies the industrial enterprise database during the 2001–2006 period.

[3] Industry code of 17 includes 171 Cotton textile and printing and dyeing finishing;172 Wool textile and dyeing and finishing;173 Linen textile and dyeing and finishing;174 Silk spinning and printing and dyeing finishing;175 Chemical fiber weaving and printing and dyeing finishing;176 Knitted or crochet knitted fabric and its products;177 Manufacture of household textile products;178 Manufacture of non-household textile products.

Table 1
Summary statistics.

Variable	Observations	Mean	Std	Min	Max	Mean for treatment group	Mean for control group
Size(ln)	26,459	10.14	1.02	8.52	16.32	10.31	10.03
Export(ln)	12,034	9.56	1.46	0.00	14.76	9.71	9.46
Capital(ln)	26,459	7.98	1.54	0.00	14.48	8.05	7.93
Wage(ln)	26,454	7.29	1.08	2.56	13.82	7.45	7.18
Labor(ln)	26,459	4.84	1.03	2.08	10.48	5.01	4.72
Age(ln)	26,459	1.66	0.84	0	4.59	1.69	1.62
TFP(ln)	25,279	1.45	0.17	−0.13	2.02	1.43	1.48

Notes: Treatment groups are firms located in areas subject to wastewater discharge standard, while control groups are those free from this regulatory control.

observations.[4]

3.2. Empirical model

This paper seeks to estimate the causal impact of strict environmental regulation on firms' exporting performances, including selection to export and exporting value. Based on the quasi-natural experiment of the wastewater discharge standard enforced by Jiangsu Province around the Lake Tai area, we employ the DID model by comparing firms' exporting performance between those located in the treated areas and those in the control areas and between the pre- and post-regulatory periods. The model is proposed as follows:

$$Export_{irt} = \alpha + \beta Treat_r \times Post_t + X_{it} + \delta_i + \varphi_{jt} + \theta_t + \varepsilon_{it} \tag{1}$$

where $Export_{irt}$ is the firms' export performance, including firms' exporting likelihood, exporting value, and exporting structure. The key variable of interest is denoted by $Treat_r$, equaling one if the firm is located in Jiangsu Province and the Lake Tai area (treatment groups) and zero otherwise (control groups). $Post_t$ denotes a post-policy period, equaling one if the year is in 2004 and afterward and zero otherwise. We also control firm-level covariates captured by X_{it}, including firm size (measured by employment), productivity (measured by TFP),[5] and firm age. δ_i and θ_t indicate the firm fixed effect and year fixed effect, respectively, while φ_{jt} denotes the 4-digit industry-year fixed effects, capturing unobservable industry-by-year confounding factors. ε_{it} is the idiosyncratic error term.

The identification strategy of the DID model calls for the parallel trend during the pre- policy periods. Fig. 2 depicts the variations of exporting likelihood and exporting values between the treatment and control groups across years during the 2001–2006 period, respectively. Prior to the policy implementation of 2004, we notice a parallel upward trend in exporting values between the treatment and control groups. During the post-period, the total export of the treatment group drops sharply and then bounces back in a short period, while the treatment group still keeps up the upward trend. Panel b of Fig. 2 depicts the trend in the proportions of exporting firms, measured by the number of exporters to total firms. The proportion of exporting firms in the treatment group experiences a sharp decline than that for the control group around 2001. Both groups then start to share a similar downward trend from 2002 to 2004. From 2005 onward, the proportion of exporters drops substantially for the treated group compared with the control group during the post-policy, and it then bounces back for both groups in a short period. Fig. 2 suggests the contemporaneous shock of the wastewater discharge standard on firms' decisions of exporting and their exporting values.

4. Empirical results

In this section, we begin with a discussion on the baseline results for the impacts of wastewater discharge standards on firms' exports. To test the stability of the baseline results, we conduct a series of robustness checks. Finally, we focus on unveiling the mechanism that how the wastewater discharging standard affects firms' export.

4.1. Baseline results

We first examine the effects of a tightened wastewater discharge standard on firms' decisions to export and export values using the baseline DID model. The first three columns in Table 2 report the corresponding results on exporting decisions, while the remaining columns present the results on export values. Except column (3) reporting the estimated exporting likelihood from the logit model, all columns include a set of fixed effects at the firm, year, and industry-year levels. The standard errors presented in the parenthesis are clustered at the firm level.

[4] Following the existing work (Yu, 2015; Yu & Tian, 2012; Cai and Liu, 2019), we match the transaction-level trade data with the firm-level CEID production data by firm name, year, zip code and the last seven digits of a firm's phone number.

[5] We calculate TFP for each firm-year using a semi-parametric algorithm methodology developed by Olley & Pakes (henceforthOlley & Pakes, 1996). This approach takes into account the simultaneity of productivity shocks and input choice, as well as the endogenous exit of firms (Dai, Maitra, & Yu, 2016).

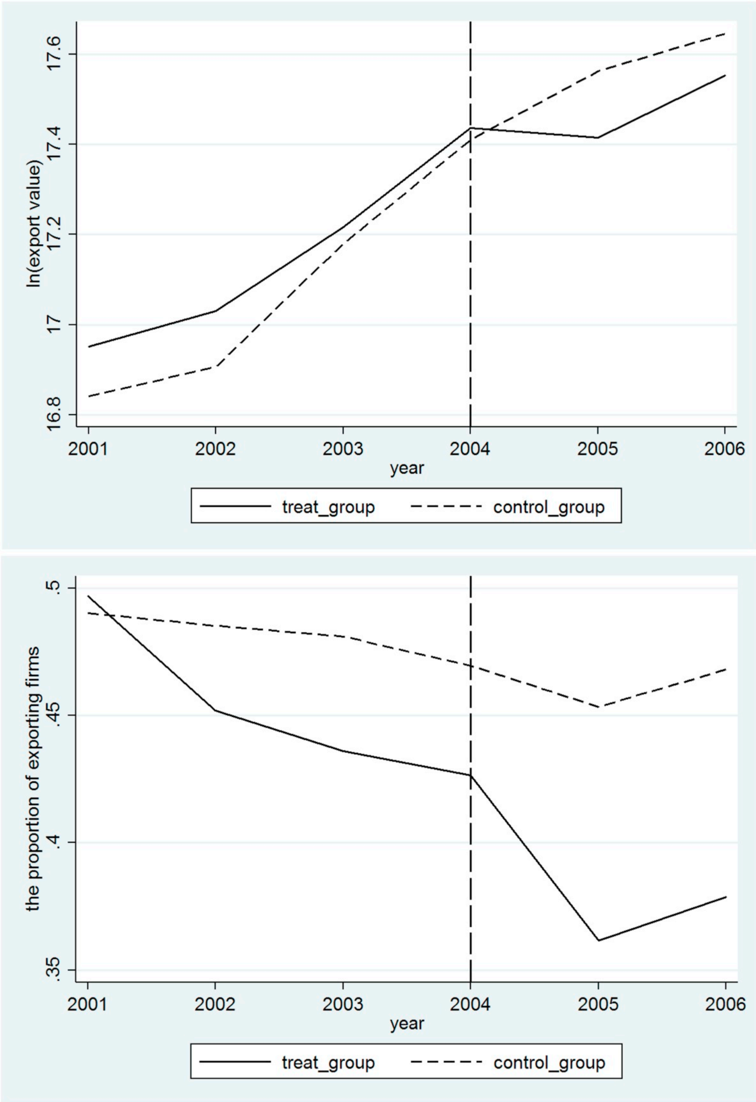


Fig. 2. Parallel trends on export value and decision of exporting firms between treat and control groups.

In columns (1) and (2) of Table 2, we document the negative coefficients on the interaction term between the wastewater discharge regulation indicator (*Treat*) and the post-year dummy (*Post*). These coefficients are economically and statistically significant at the 10% level, indicating the tightened environmental control leads to a decline in firms' selection to export. Controlling for firms' attributes as shown in column (2), the stringent environmental regulation is associated with a 3% decrease in exporting probability for firms in textile and dyeing industries and located in the treated areas compared with those within the same industry but residing in the control areas. There are some disadvantages of the linear probability model in certain cases, such as its fitted values are not constrained to lie in the unit interval. To mitigate this concern, we adopt the logit model by regressing the regulatory effects on firms' likelihood of participating in the export market. The corresponding result is provided in column (3). In line with the OLS results, we obtain the statistically significant and negative effects of the stringent environmental policy on exporting decisions at the firm-level.

When it comes to the regulatory impacts on firms exporting values, columns (4)–(6) of Table 2 report the negative coefficients with statistical significance reaching conventional levels. These negative coefficients capture that the environmental control is associated with a loss in export values when comparing firms within the same textile and dyeing industries but differing across the areas that receive the treatment. The magnitude of this negative regulatory impact is around 11% with the inclusion of additional firm-level controls as shown in column (5) of Table 2. In column (6), we include the observations of non-exporters by taking care of zeros in exporting values. The coefficient of the interaction term remains negative and statistically significant at the 1% level, lending further support on the baseline results regarding the negative regulatory impact on firms' exporting values.

Table 2
Main results based upon DID model.

Variables	Export dummy			Export values		
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	−0.034**	−0.033*	−0.492***	−0.134**	−0.118*	−0.405***
	(0.016)	(0.017)	(0.056)	(0.068)	(0.061)	(0.155)
Size		0.103***	0.745***		1.073***	1.425***
		(0.010)	(0.031)		(0.036)	(0.092)
TFP		−0.014	−0.185		−0.130	−0.170
		(0.028)	(0.136)		(0.099)	(0.258)
Age		−0.002	0.164***		−0.004	−0.044
		(0.009)	(0.031)		(0.032)	(0.084)
Constant	0.450***	−0.473***	−7.710***	9.812***	−1.238***	−8.764***
	(0.010)	(0.090)	(0.301)	(0.085)	(0.358)	(0.862)
Observations	26,459	26,459	25,250	12,034	12,034	25,261
R-squared	0.803	0.806		0.831	0.873	0.838
Pseudo-R-squared			0.152			
Firm FE	Y	Y		Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Region FE			Y			
Industry-year FE	Y	Y	Y	Y	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. In column (3), we report the estimated results from the logit model for firms' selection to trade, while in column (6), all zero values of export are included in the OLS regression. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

4.2. Robustness checks

To test the stability of the baseline results, we conduct a series of robustness checks, including the anticipation and dynamic effects, placebo tests regarding the pseudo-assignments of treated areas and covered sectors, and the concern of firms' relocation in response to the regulatory control.

4.2.1. Anticipation and dynamic effects

The exogenous assumption of the policy implementation centers on the issue of whether firms had expected the tightened environmental standard to occur in Jiangsu Province around the Lake Tai area. If so, they would then adjust their production plans accordingly prior to the policy implementation period of 2004. In the robustness check, we define a pre-policy indicator denoted by*Post2003*, equaling one if the year is in 2003 and zero otherwise. In an attempt to test whether firms adjust their exporting behavior prior to the policy period, we then add an additional interaction term between the treatment area indicator (*Treat*) and the pre-policy indicator (*Post2003*) into the baseline specification. The corresponding results are presented in columns (1) and (2) of Table 3. In column (1), the estimated coefficient on the interaction between the treatment area and the post year dummy is negative and statistically significant at the 1% level, while the coefficient on the interaction between the treatment area and the pre-policy indicator is negative but not statistically significant at any conventional levels. This finding suggests that firms did not expect the tightening standard on wastewater discharge to come into place prior to 2004. The adjustment of their exporting decisions is more likely due to the implementation of the 2004 standard. In column (2) of Table 3, we present the results on exporting values. There is a negative and statistically significant coefficient for the post-policy interaction term, but a positive and statistically insignificant coefficient for the pre-policy interaction term. These findings suggest little evidence on the anticipation effect in which firms would adjust exporting performance in anticipation of the stringent environmental control on discharging wastewater in the Lake Tai area.

In our main DID regression, we use a year dummy *Post* to separate the pre-policy and post-policy period. The estimation from the interaction term yields the average treatment effects by comparing mean differences in firm-level outcome variables between the treatment and control groups and between the pre- and post-policy of wastewater discharge standard. To illustrate the treatment effect over time, we come up with a series of year dummies during the 2001–2006 period, and then interact these dummies with the treatment area indicator based upon the baseline model specification Eq. (1). We further incorporate the covariates of size, age, TFP, and a set of fixed effects at the firm, year, and industry (4-digit)-year levels. By setting up the year 2004 as the benchmark, we regress these interaction terms on exporting likelihood and exporting values. The estimation specification of the dynamic model is as follows:

$$Export_{irt} = \alpha + \sum_{m=1}^{3} \beta_m Treat_r \times Post_{t-m} + \sum_{n=1}^{2} \beta_n Treat_r \times Post_{t+n} + X_{it} + \delta_i + \varphi_{jt} + \theta_t + \varepsilon_{it} \tag{2}$$

where β_m and β_n denote the mth lag and nth lead of the policy indicators, respectively. In the appendix, Table A1 provides the estimated coefficents of β_m and β_n. Fig. 3 plots a series of the estimated coefficients for the interaction terms ($Treat_r$ × $year_t$), illustrating the variations in the firm-level exporting behavior between the treatment and control groups over time. We find that the

Table 3
Robustness checks for confounding factors and policies.

Variables	Export dummy	Export value	Export dummy		Export value		Export dummy	Export value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treat × Post	−0.041***	−0.132***	−0.045***	−0.047***	−0.172***	−0.158***	−0.045***	−0.130***
	(0.011)	(0.05)	(0.010)	(0.010)	(0.042)	(0.043)	(0.011)	(0.045)
Treat × Post2003	−0.005	0.055						
	(0.013)	(0.054)						
Post × $Pollute_{water}$			0.006***		0.013**			
			(0.001)		(0.005)			
Post × Abatement			−0.075**	0.043*	0.092	−0.144		
			(0.032)	(0.024)	(0.120)	(0.154)		
Post × COD				0.001***		0.0003		
				(0.0004)		(0.002)		
SOE_reform							−0.084	0.644
							(0.137)	(0.581)
FDI_reform							−0.012	0.007
							(0.009)	(0.037)
Observations	26,459	12,034	23,569	23,569	10,615	10,615	24,351	11,068
R-squared	0.805	0.843	0.801	0.801	0.836	0.836	0.807	0.845
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	N	N	N	N	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004, while Post2003 is an indicator for year 2003 only. All columns include firm. All columns include a set of fixed effects at the firm, year, and 4-digit industry-year levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

treatment and control groups were not statistically significant in both the exporting value and exporting dummy prior to the year 2004, indicating good comparability between these two groups conditional on a set of controls and co-variates. During the post-2004 period, the treatment groups start to experience a decline in both the exporting probability and value.

4.2.2. Controls for confounding factors

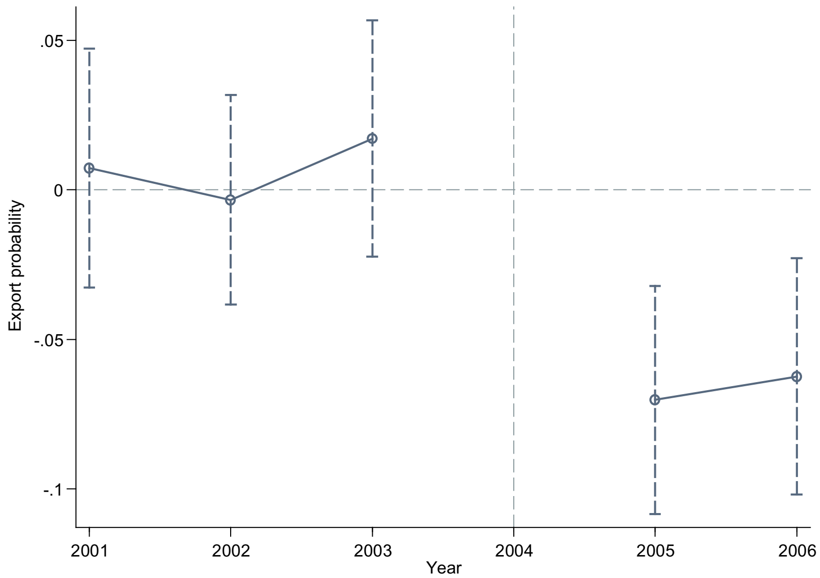
The policy of wastewater discharge standards aims to cleanup water pollution and improve water pollutants abatement equipment and technologies. There is a worry that the treated and control areas may exist some systematical differences in environmental performance prior to 2004, leading to an endogenous decision of wastewater discharge standard in the treated areas. To mitigate this concern, we further control for regional pollution abatement efforts, regional wastewater emissions, and regional COD emissions based upon the baseline DID model. The pollution abatement effort is measured by wastewater abatement per value of sales. These regional variables are constructed and aggregated from the firm-level observations of wastewater abatement, wastewater emissions, and COD emissions in year 2003. Columns (3)–(6) of Table 3 report the estimated results with the inclusion of additional interaction terms between the treatment dummy and the regional pollution abatement or regional wastewater an COD emissions, as $Post \times Pollute_{water,} Post \times Abatement$ and $Post \times COD$. While controlling for the regional confounding factors, we still document the consistently negative coefficients on the policy variable of interests. Our main results hold against this alternative check, indicating the tightened wastewater discharge standard lowers down firms' exporting likelihood and leads to a loss in export values.

Policies such as the reform of SOE and foreign direct investment (FDI) deregulation may act as ongoing factors affecting firms' exporting performance. To further mitigate this concern, we add two controls of SOE_reform_{rt} (regional SOE capital ratio) and FDI_reform_{rt} (regional FDI values) into the baseline DID model. The last two columns of Table 3 present the corresponding results. In line with the baseline conclusion, we document the negative impacts of environmental standards on export decisions and export values.

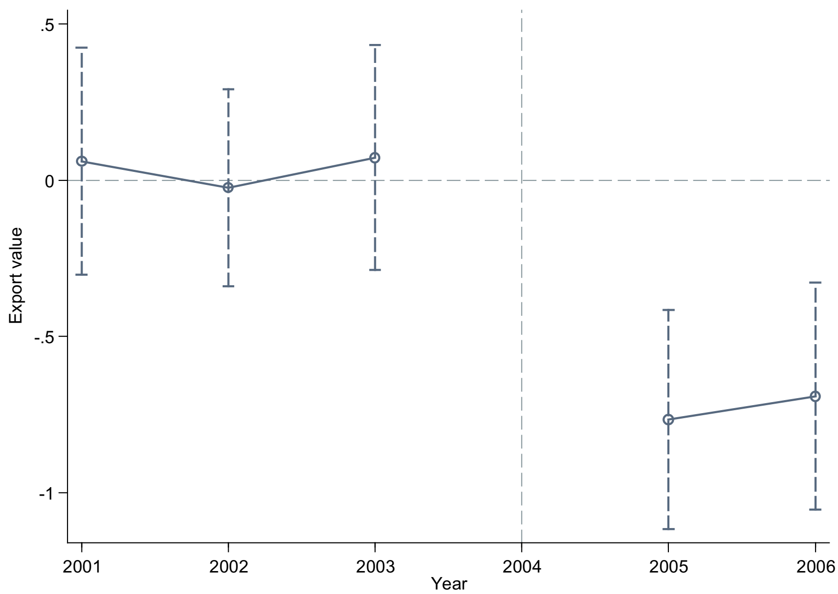
4.2.3. Placebo tests

To provide corroborating evidence, we conduct a series of tests with alternative control groups and placebo tests using pseudo treatment areas or pseudo covered sectors. Table 4 provides the corresponding results. First, in the baseline, we set Jiangsu Province in the Lake Tai area as the treatment areas and define other Lake Tai areas as the control groups. Firms in the textile and dyeing industry may relocate from Jiangsu Province to other regions outside Lake Tai. To mitigate this concern, we redefine the control group as the textile and dyeing firms in Yangtze-rive-delta area, and further expand the control group into those firms in the nationwide areas. The corresponding results are presented in columns (1) and (2) of Table 4. Our main results are robust against the alternative definition of control areas.

Secondly, the policy focuses on the textile and dyeing industry. We consider iron and paper printing industries as pseudo covered sectors and choose another province (i.e., Zhejiang Province) as pseudo areas receiving the policy standard. Using the pseudo covered sectors and pseudo treatment areas, the baseline DID model is re-estimated. As reported in columns (3)–(5) of Table 4, the estimated



a. Export Dummy



b. Export Value

Fig. 3. Dynamic effects of environmental regulation on export decision and export value.
Notes: The solid line captures the estimated regulatory impacts on firms' export likelihood and export value across years. The dashed lines represent the 95% confidence interval of the estimated effects.

coefficients for these pseudo areas are not statistically significant at any conventional level, providing further corroborating evidence in support for our main conclusions that a stringent environmental control puts pressures on dirty exporters.

4.2.4. Concerns for firms' relocation

In theory, firms may relocate from areas with environmental pressures to areas without environmental compliances. By observing

Table 4
Placebo tests using pseudo covered sectors or pseudo covered area.

Variables	Use Yangtze-river-delta areas as control groups	Use all firms in textile and dyeing industry in the nationwide areas as control groups	Use Iron industry as pseudo covered sectors	Use paper printing industry as pseudo covered sectors	Use another province (Zhejiang) as pseudo area receiving the policy standard
	(1)	(2)	(3)	(4)	(5)
Treat × Post	−0.036***	−0.042***	0.007	−0.021	0.020
	(0.008)	(0.007)	(0.017)	(0.019)	(0.011)
Size	0.076***	0.056***	0.043***	0.052***	0.082***
	(0.004)	(0.002)	(0.008)	(0.009)	(0.005)
Constant	−0.252***	−0.134***	−0.334***	−0.232	−0.317***
	(0.037)	(0.022)	(0.088)	(0.266)	(0.051)
Observations	49,129	97,275	3946	5440	28,650
R-squared	0.833	0.834	0.824	0.811	0.824
Firm FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. All columns include a set of fixed effects at the firm, year, and 4-digit industry-year levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

the parallel trend of exporting values in the treated and control groups, we do notice a contemporaneous shock in exports after the implementation of the stringent standard in 2004. Assuming the contemporaneous environmental costs would not exceed the fixed costs of relocation, it is less likely that firms would consider relocating. If the relocation does occur for some polluters,[6] it would influence the treatment effect of the wastewater discharge standard on firms' exporting behavior due to changes in the composition of polluting firms in the treated and control groups.

Due to a lack of detailed information tracing out the historical site choices of polluting firms during the study period, however, we are not able to identify the potential firms' relocation decisions in response to the strict wastewater discharge standard. To circumvent this data limitation, we have to restrict the data sample to continuously operating firms during the sample period. Along this line, we further employ the propensity score matching (PSM) method to match the most comparable control group with the treated group using the nearest neighbor matching estimator. The corresponding results are shown in Table 5. Columns (1) and (2) report the results for the balanced subsample of the continuously operating firms, while columns (3) and (4) report the results for the balanced subsample using the PSM-DID method.[7] In all columns of Table 5, we document the consistently negative and statistically significant estimates for the interaction terms, lending further support to our baseline conclusions that the stringent environmental regulation leads to a decline in exporting likelihood and a loss in exporting value.

4.2.5. Alternative model specification

Lastly, but not least, we employ a triple DID method by including firms in all manufacturing sectors and comparing firm-level outcome variables between firms in the TPD industry and firms in other industries. The triple DID estimation specification is proposed as follows,

$$Export_{irt} = \alpha_2 + \beta_2 Treat_r \times Industry_j \times Post_t + X_{it} + \delta_i + \phi_{jt} + \varphi_{rt} + \chi_{jr} + \theta_t + \varepsilon_{it} \quad (3)$$

where $Treat_r$ is a dummy for Jiangsu Province that receives the treatment of the strict wastewater discharge standards, $Industry_j$ is an indicator for the TPD industry which are heavy polluters of wastewater, and $Post_t$ refers to the post-policy indicator for the year 2004. We also control for the firm-level attribute and a set of fixed effects at the firm (δ_i), year (θ_t), region-year (φ_{rt}), industry-year (ϕ_{jt}), and region-industry (χ_{jr}) levels. The parameter of interest, denoted byβ_2, captures the differences in exporting decisions between the pre- and post-policy period, between firms in the TPD industry and those in non-TPD industries, and between firms located in Jiangsu province and those residing in other provinces. Table 6 presents the corresponding results. In all columns, the estimated coefficients for the triple interaction terms are consistently negative and statistically significant at conventional levels, providing further corroborating evidence in support for the main conclusion that the strict wastewater discharge standard lowers down firms' selection to export and their exporting values.

[6] The potential site choices for relocation could be either within or outside of the Lake Tai area. If polluting firms left Jiangsu province (the treated area) and were relocated in the control regions in the Lake Tai area, it gives rise to the overestimation for the treatment effect due to the change of the composition in both treated and control groups. If polluters relocated to other regions outside of the Lake Tai area, it could have less influence for the treatment effect.

[7] The balancing test is satisfied for the PSM method. The corresponding result is presented in Table A2 in the Appendix.

Table 5
Results for incumbent firms using the PSM-DID method.

Variables	Export dummy	Export value	Export dummy	Export value
	(1)	(2)	(3)	(4)
Treat × Post	−0.044**	−0.170***	−0.054***	−0.142*
	(0.018)	(0.053)	(0.019)	(0.082)
Size	0.123***	1.031***	0.115***	1.332***
	(0.014)	(0.041)	(0.014)	(0.185)
Constant	−0.692***	−1.074**	−0.591***	8.160***
	(0.150)	(0.452)	(0.156)	(0.299)
Observations	4179	2592	4116	2440
R-squared	0.733	0.848	0.750	0.811
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. All columns include a set of fixed effects at the firm, year, and industry-year levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

Table 6
Robust checks with the triple DID.

Variables	Export dummy			Export value		
	(1)	(2)	(3)	(4)	(5)	(6)
$Treat_r$ × Post × $Industry_j$	−0.024**	−0.020*	−0.025**	−0.168***	−0.109***	−0.140***
	(0.011)	(0.011)	(0.011)	(0.048)	(0.041)	(0.044)
Size		0.054***	0.054***		1.013***	1.012***
		(0.002)	(0.002)		(0.009)	(0.009)
Constant	−0.186	−0.219***	−0.263***	8.541***	−1.935***	−2.205***
	(0.285)	(0.032)	(0.034)	(0.441)	(0.393)	(0.433)
Observations	223,312	222,616	222,616	79,768	79,768	79,768
R-squared	0.820	0.823	0.823	0.864	0.902	0.902
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y
Region-year FE	Y	Y	Y	Y	Y	Y
Industry-region FE	N	N	Y	N	N	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. $Industry_j$ is an indicator for textile and dyeing industry. Post is a dummy variable for the policy implementation year 2004. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

4.3. Heterogeneity discussion

We further explore the heterogeneous effect of wastewater discharge standards by firm productivity and ownership.

4.3.1. Heterogeneity on firm productivity

As predicted in the Melitz-type trade model, firms preserve heterogeneous productivity, thereby responding differently to the stringent environmental standard. We add an interaction term between environmental regulation and one-year lagged firm TFP, capturing the heterogeneous response to the rising standard. In columns (1) and (2) of Table 7, the corresponding results are reported. The coefficients on the interaction term between the treatment area indicator and the post-policy indicator are consistently negative and statistically significant at the 1% level, confirming the negative regulatory impacts on both exporting likelihood and exporting values. Moreover, the estimated coefficients for the triple interaction term among Treat, Post, and TFP are, however, positive and statistically significant at the 1% level for both the selection to export and export values. These findings suggest that the more productive firms, the smaller the decline in exporting likelihood and values the firm would experience in response to the tightened regulation.

4.3.2. Heterogeneity on firm ownership

We examine the heterogeneous impacts of environmental standards on firms' exporting performance by firm ownership.

Table 7
Mechanism on firm productivity and ownership.

Variables	Export dummy	Export value	Export dummy	Export value
	(1)	(2)	(3)	(4)
Treat × Post	−0.124***	−1.313***	−0.030***	−0.161***
	(0.033)	(0.160)	(0.011)	(0.054)
Treat × Post × TFP	0.019***	0.256***		
	(0.007)	(0.033)		
FDI × Treat × Post			0.027*	0.210***
			(0.016)	(0.067)
SOE × Treat × Post			−0.043**	0.112
			(0.018)	(0.086)
Size	0.084***	0.557***	0.984***	0.985***
	(0.006)	(0.026)	(0.001)	(0.001)
Constant	0.125***	6.857***	−1.417***	−1.426***
	(0.036)	(0.156)	(0.124)	(0.124)
Observations	25,277	11,542	26,456	12,033
R-squared	0.807	0.846	0.808	0.875
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. All columns include a set of fixed effects at the firm, year, and 4-digit industry-year levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.

Specifically, we construct two indicators of ownership: one is the SOE indicator equaling one if SOE firm and zero otherwise, and the other is FDI dummy equaling 1 if firms receive FDI and zero otherwise. In columns (3) and (4) of Table 7, the main conclusions regarding the negative impacts of the environmental standard on firms exporting behavior are consistent with the baseline results. Moreover, as shown in column (3) for exporting likelihood, there is a positive and statistically significant coefficient of the FDI interaction term, but a negative and statistically significant coefficient of the SOE interaction term. This finding indicates that firms receiving FDI and SOE firms respond substantially differently to the tightened environmental standard. The former experiences an increase in the exporting decision, while the latter suffers a decline in exporting likelihood, capturing the potential resource reallocation of market size among FDI firms, SOE, and the remaining groups. This reshuffling market size is more favorable to FDI firms rather than SOE ones. A possible reason lies in that FDI firms, in general, have equipped with relatively advanced pollution abatement technologies than their domestic counterparts, hence suffering less environmental shocks (Albornoz, Cole, Elliott, & Ercolani, 2014; Cole, Elliott, & Strobl, 2008; Zarsky, 2008). When it comes to values of export, the last column of Table 7 reports a positive and statistically significant coefficient for the TFP interaction term, but not a statistically significant coefficient for the SOE interaction term. Resources reallocation in the exporting market leads to further gains in exporting values for FDI firms.

4.4. Mechanism discussion

Our central interest is to test the mechanism through which exporters' behavior is affected by the rising environmental standard implemented in Jiangsu province in the Lake Tai area.

4.4.1. Mechanism on entry-exit of the export market

Whether the tightened wastewater discharge standard affects the exporting likelihood of new entry or incumbents? We further decompose the exporting decisions of firms into new entry and incumbents. In line with Shi and Xu (2018), we define incumbents as firms with exports during the 2000–2004 period, while defining new entry as those consistently non-exporters prior to the implementation of the environmental standard in 2004. We then aggregate the number of firms, the number of incumbents, and the number of new entry by the industry-region-year level. Dependent variables of interests are the ratio of incumbents relative to the total number of firms, the ratio of new entries relative to the total number of firms. A variant of the baseline DID model is proposed as follows,

$$Y_{jrt} = \alpha_3 + \beta_3 Treat_r \times Post_t + \lambda_r + \theta_t + \gamma_j + \varepsilon_{jrt} \tag{4}$$

where j is for the industry at 4-digit China industry classification level, r is for the 4-digit region, and t represents year. A series of fixed effects are included to control for year trend (θ_t), industrial (γ_j) and regional unobservable (λ_r). The parameter $\beta_3$captures the effect of the wastewater discharge standard on the entry-exit of the exporting market, which is measured by the ratio of incumbent exporting firms and the ratio of new exporters relative to the total number of firms at the industry-region-year level.

Table 8 reports the results on the regulatory impacts on new entry and incumbents of the export market. Column (1) presents the

Table 8
Mechanism on entry-exit of the export market.

Variables	Ratio of new entry	Ratio of incumbents
	(1)	(2)
Treat × Post	−0.088*	−0.247
	(0.053)	(0.216)
Constant	0.739***	0.794***
	(0.027)	(0.089)
Observations	893	3291
R-squared	0.877	0.800
Industry-province FE	Y	Y
Province-year FE	Y	Y
Industry-year FE	Y	Y

Notes: The firm-level data is aggregated to calculate the number of firms, the number of incumbents and the number of new entry by industry-region-year. Dependent variables, Ratio of New Entry denotes the number of new entries relative to the total number of firms by the industry-region-year level, while Ratio of Incumbents denotes the number of incumbents relative to the total number of firms by the industry-region-year level. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. All columns include a set of fixed effects at the province-year, 4-digit industry-province, and 4-digit industry-year levels. Standard errors in parentheses are clustered at the region level. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.

ratio of new entry firms in the export market, while column (2) shows the ratio of incumbents firms in the export market. In both columns, we document negative coefficients for the regulatory impacts. The negative regulatory impact on the new-entry of the export market is economically and statistically significant at the 10% level, while the effect on the incumbent of the export market is not statistically significant at any conventional level. Thus, the tightening wastewater discharge standard tends to deter new firms rather than incumbents to enter the export market.

4.4.2. Mechanism on export Price and quantity

The baseline findings suggest that stringent environmental regulations lead to a decline in firms' selection to export and export values. Along this line, we take a closer look at how exporting price and exporting volume varies with the environmental pressures. To this end, we use the merged firm-level data between CIED and China Customs Dataset. The latter provides detailed product-level exporting prices and quantities for all exporters during the study period.

Table 9 presents the regulatory impacts on export prices and quantities, both in logarithm fashion. In all columns we control for a set of fixed effects at the firm, year, exporting mode, and exporting destinations. In the first two columns, the estimated coefficients for the regulatory impacts on exporting prices are negative and statistically significant at the 5% level. The regulatory impact varies

Table 9
Mechanism on export price and quantity.

Variables	Export price		Export quantity	
	(1)	(2)	(3)	(4)
Treat × Post	−0.013**	−0.072**	−0.004	0.094***
	(0.006)	(0.028)	(0.007)	(0.033)
Treat × Post × TFP		0.039**		−0.066***
		(0.017)		(0.020)
Size	0.020***	0.020***	0.984***	0.985***
	(0.004)	(0.004)	(0.001)	(0.001)
Constant	−0.856	−0.921	−1.417***	−1.426***
	(0.637)	(0.634)	(0.124)	(0.124)
Observations	379,896	364,723	379,896	364,723
R-squared	0.722	0.724	0.894	0.895
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Mode FE	Y	Y	Y	Y
Product FE	Y	Y	Y	Y
Destination FE	Y	Y	Y	Y

Notes: Dependent variables: Export Price and Export Quantity are measured in the logarithm fashion. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. Post is a dummy variable for the policy implementation year 2004. All columns include a set of fixed effects at the firm, year, trading mode, product, and exporting destination levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

Table 10
Mechanism on exporting structure.

Variables	Number of exporting destinations		Product number	TPD product ratio	Export value via general trade	Export value via processing trade
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	−0.815**	−0.585*	−0.439	−0.212*	−0.268***	−0.020
	(0.362)	(0.327)	(1.314)	(0.127)	(0.083)	(0.127)
Treat × Post × OECD		0.439*				
		(0.265)				
Size	2.928***	2.924***	2.558***	1.152***	0.957***	0.565***
	(0.226)	(0.167)	(0.774)	(0.120)	(0.046)	(0.080)
Constant	−26.255***	−26.205***	−18.055**	11.79***	2.840***	7.483***
	(2.553)	(1.857)	(8.323)	(0.186)	(0.517)	(0.882)
Observations	6237	6237	6237	5972	6026	2131
R-squared	0.867	0.867	0.718	0.818	0.827	0.860
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y

Notes: Dependent variables are the number of exporting destinations, the number of product, the ratio of TPD products, export values via general grade mode, and export values via processing trade mode. OECD is an indicator, equaling one if firm exports to OECD countries and zero otherwise. All columns include a set of fixed effects at the firm, year, and 4-digit industry-year levels. Standard errors in parentheses are clustered at the firm level. ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

with firms' productivity as suggested by the positive and statistically significant coefficient of the triple interaction term between the regulatory control and TFP. Productive firms experience less negative shocks of environmental compliances on export prices.

In the remaining columns of Table 9, the estimated coefficients for the regulatory effects on the exporting quantity are positive and statistically significant. These findings suggest that in response to the tightening standard, exporters could not pass through the environmental burdens to the customer in the overseas market, but they have to lower down exporting prices and sell more to the export market. One of the reasons lies in the potential market size reallocation from less productive exporters to more productive ones. In response to the environmental policy shock, the more productive firms are likely to gain a relatively larger market and sell products with higher quality.

4.4.3. Mechanism on export structure

How does the stringent wastewater discharge standard affect firms exporting structure? We further explore the variations of exporting destinations, exporting product adjustments, and exporting mode in response to this tightened regulatory control in Jiangsu province at the Lake Tai area. Using the merged dataset between CIED and China Customs Dataset, we could retrieve the detailed information about exporting destinations, exporting mode (processing trade vs. general trade), and exporting products (textile and dyeing product vs. non-textile and dyeing product).

Firstly, we compute the number of export destinations and the number of export destinations to developed countries at the firm-level. We are interested in examining how the wastewater discharge standard affects the adjustment of exporting destinations for firms in the TPD industry. Column (1) of Table 10 reports the results on the number of export destinations, while column (2) shows the corresponding results on the number of export destinations to developed countries. In both columns, there are consistently negative and statistically significant coefficients on the regulatory impacts, indicating that the tough environmental standard is associated with a substantial decline in the number of export destinations. When adding an interaction term between the regulation dummy and an indicator of OECD exporting destinations (equaling one if the destination is OECD country and zero otherwise), we document a positive and statistically significant coefficient for this interaction term. The stringent regulatory control leads to a relative increase in the number of export destinations to OECD countries, which in general have higher environmental protection standards than other countries.

Secondly, we test whether the stringent water pollution control brings with the adjustment in products from the TPD products to non-TPD ones. Provided that there is no unique concordance between HS product and industry codes, within the single TPD industry we distinguish products between the textile and dyeing ones and the apparel products. The former is considered to be more water-pollutant intensive than the latter. Using the product-level (8-digit HS code) information from China Customs Data, we define the TDP products as the textile and dyeing products, while defining the non-TPD as the apparel products.[8] We then calculate the ratio of the TPD products relative to all products for firms in the TPD sector. Column (3) and (4) of Table 10 reports the corresponding results about the regulatory impacts on the product adjustment. The stringent water standard has a muted impact on the number of products, but a negative and statistically significant effect on the ratio of the relative more polluted TPD products. The results suggest that water-pollution intensive firms would tend to adjust their product line by reducing emission-intensive products embodied the TPD products.

[8] In the appendix, Table A3 provides a list of 8-digit HS code for the TPD products.

Lastly, we distinguish the exporting mode by general trade and processing trade. Export values by trade mode are further calculated. The last two columns of Table 10 report the results for the tightened environmental standard on export values by trade mode. It appears that the negative regulatory impact is more pronounced in the general trade compared with the processing trade.

5. Conclusion

Taking advantage of a quasi-natural experiment of wastewater discharge standard implemented in Jiangsu Province around Lake Tai area in 2004, this paper adopts the DID model to make the causal inference of the stringent environmental regulation on firm-level exporting performance. This estimation compares exporting behavior between firms in the TPD industry and located in the treated areas with those in the same industry and residing in the control regions around the Lake Tai area.

We find that the tightened wastewater discharging standard lowers down exporters' selection to trade and exporting values. This main conclusion is robust against a series of alternative checks and placebo tests regarding the confounding factors, assignment of treated areas and covered sectors. Moreover, we adopt the merged firm-by-product panel dataset to take a closer look at the adjustments of exporting structure in response to the tightened standard. Some novel results about the regulatory impacts are obtained. First, more productive firms and foreign-owned enterprises are less sensitive to environmental regulation. Second, the tightening wastewater discharge standard tends to deter new firms rather than incumbents to enter the export market. Third, in response to the environmental policy shock, productive firms could gain the relative larger export market by lowering down exporting prices and selling more products overseas. Moreover, the environmental pressure induces water pollutant emitting firms to switch products from more pollution-intensive products to less intensive ones.

The findings presented in this paper make substantial contributions to the growing literature on the economic impacts of water pollution regulation in China. This strand of literature has documented the effectiveness of water pollution regulation on reducing the firm-level COD emissions (Wang et al., 2018), potential health benefits from COD emissions reductions (Ebenstein, 2012), a loss in labor employment in water-pollution intensive sectors (Liu et al., 2017), and relocation of water-polluting activities (Chen et al., 2018). We also add a piece of novel evidence showing the causal impacts of stringent water pollution standards on the adjustment of exporting structure at the firm level. Moreover, our estimates could contribute to the policy debate regarding the benefits and costs of water pollution regulation in China.

Finally, our results shed light on profound policy implications. Worriers argue that stringent environmental regulations mirror the loss in firms' competitiveness in the global market. At first glance, a tightened regulatory control lowers down the likelihood of exporting decisions. This negative regulatory impact on exports mainly comes from deterring the less productive polluters from entering the exporting market. For polluting firms in a developing country like China, participating in the global market requiring them not only to follow the general trade rule, but also to update pollution abatement technologies to adapt with more stringent environmental standards in developed countries.

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Appendix

Table A1
Dynamic effects.

Variables	Export dummy	Export value
	(1)	(2)
$Treat_r \times Post_{2001}$	0.014	0.142
	(0.014)	(0.123)
$Treat_r \times Post_{2002}$	−0.000	0.020
	(0.013)	(0.117)
$Treat_r \times Post_{2003}$	0.017	0.068
	(0.012)	(0.112)
$Treat_r \times Post_{2005}$	−0.062***	−0.699***
	(0.013)	(0.117)
$Treat_r \times Post_{2006}$	−0.052***	−0.610***
	(0.013)	(0.119)
Size	0.110***	1.483***
	(0.006)	(0.055)
Age	−0.003	−0.051
	(0.006)	(0.057)

(continued on next page)

Table A1 (*continued*)

Variables	Export dummy	Export value
	(1)	(2)
TFP	−0.023	−0.247
	(0.019)	(0.172)
Constant	−0.603***	−10.023***
	(0.054)	(0.485)
Observations	25,261	25,261
R-squared	0.805	0.835
Firm FE	Y	Y
Year FE	Y	Y
Industry (4-digit) -year FE	Y	Y

Notes: Dependent variables: Export Dummy is an indicator for firms' selection to export, equaling one if export and zero otherwise, while Export Values is the logarithm values of exports. Treat is a dummy variable, which takes the value of one if the area is subject to wastewater discharge standard and zero otherwise. $Post_t$ is a year-specific dummy variable for the year t. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table A2
Balancing tests for the matched samples.

Variable	Mean		*t*-test
	Treated	Control	
Matching results for exporters			
Sale	11.091	11.103	−0.11
Capital	9.1693	9.1604	0.05
Wage	8.3597	8.4071	−0.39
Labor	5.8934	5.9181	−0.21
TFP	1.5197	1.5156	0.36
Matching results for exporting decisions			
Sale	10.898	10.914	−0.16
Capital	8.7439	8.7842	−0.29
Wage	8.1172	8.1509	−0.34
Labor	5.7091	5.7216	−0.14
TFP	1.5029	1.5036	−0.08

Note: We select matched controls groups based upon firm-level characteristics (i.e., sales, capital, labor registration status, and TPF) prior to the implementation of wastewater discharge standard, using the nearest neighbor matching estimator. After the matching, there is no statistically significant difference in the firm-level covariate between the treatment and matched control groups.

Table A3
8-Digit HS code for textile and dyeing products.

China Customs Database provides the following 8-digit HS code for textile and dyeing products
43040010, 50071090, 50072090, 50079090, 51111900, 52081100, 52083000, 52083100, 52085100, 52085200, 52085910, 52085990, 52093200, 52095100, 52095200, 52095900, 52105000, 52105100, 52115200, 52115900, 52122500, 53091900, 53092120, 53092900, 53110000, 53110012, 53110015, 5407-4200, 54074400, 54075200, 54075300, 54075400, 54076100, 54076900, 54077300, 54077400, 54078100, 54078200, 54078400, 54079400, 54082110, 54082290, 54082410, 54082420, 55121900, 55132100, 55122900, 55132900, 55133920, 55134100, 55134910, 55134990, 55144100, 55161400, 5516-2400, 55164100, 55169400, 56039490, 58013100, 58013300, 58041030, 59070090, 59119000, 60012200, 60019200, 55162400, 55164100, 55169400, 56039490, 58013100, 58013300, 58041030, 59070090, 59119000, 60012200, 60019200, 60052400, 60053400, 60062100, 60062200, 60062400, 6006-3100, 60063400, 62046300, 63022190, 63023110, 63071000, 63079000, 64041900, 84514000, 84518000, 61101990, 61102000, 61103000, 61109010, 61109090, 61112000, 61113000, 61119010, 61119090, 61121100, 61121200, 61121900, 61122010, 61122090, 61123100, 61123900, 61124100, 6112-4900, 61130000, 61142000, 61143000, 61149010, 61149090, 61151000, 61152100, 61152200, 61152910, 61152990, 61153000, 61159400, 61159500, 61159600, 61159900, 61161000, 61169100, 61169200, 61169300, 61169900.

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