Article

The Impact of Environmental Regulation on Firm Export: Evidence from China’s Ecological Protection Red Line Policy?

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Abstract: China conducted a comprehensive overhaul of its environmental regulation as of April 2014. The regulation, which calls for a holistic approach to protect the environment, is also called the “Ecological Protection Red Line” (Red Line). It sets comprehensive standards for pollutants and mandates provinces to implement the regulations. The Porter and pollution haven hypotheses were tested for the impact of the Red Line on firm exports using a sample of Chinese A-share firms from 2011 to 2017. Our findings are consistent with the Porter hypothesis. The implementation of the Red Line has a positive impact on a firm’s exports. The findings are robust to alternative metrics of exports and different sub-samples. A firm’s innovation activities (in terms of research and development investments) and production efficiency were found to be the transmission channels, corroborating the underlying logic of the Porter hypothesis. Policy implications are discussed.

Keywords: environmental regulation; Porter hypothesis; pollution haven hypothesis

1. Introduction

China has had spectacular economic growth for the last 40 years. According to the World Bank, the average real GDP growth rate of China was 9.6% from 1978 to 2017, despite recent slower GDP growth rates of 6.7% and 6.9% in 2016 and 2017, respectively (the details are provided in https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2017&locations=CN&start=1961&view=chart (accessed 15 April 2019)). Despite the economic success, pollution is widespread, and the ineffectiveness of environmental protection is of great concern in China (Du et al. [1]; Ji et al. [2]).

One common explanation for the tradeoff between pollution and economic growth is the pollution haven hypothesis. That is, tough environmental protections have an adverse effect on a country’s economy because these protections hurt firm exports, especially when a less-developed country (LDC) has an export-oriented economic growth policy that attracts polluting firms to relocate from developed countries to LDCs. Once environmental protections are tightened in LDCs, firms from developed countries then move away, and the exports of the host country (an LDC) stall (Kearsley and Riddel [3]; Kolcava et al. [4]). The pollution haven hypothesis is supported in empirical studies in China (Xu et al. [5], India (Rana and Sharma [6]), and East European countries (Martinez-Zarzoso et al. [7]). In contrast to the pollution haven hypothesis, Porter [8] hypothesizes that if environmental protection policies are designed properly, they stimulate firms to innovate and compete. The increased innovation makes firms more efficient and propels them to generate more than sufficient profits to offset the increased costs of complying with environmental regulations. Thus, export is increased in these LDCs. Several studies provide evidence to support the Porter hypothesis (Ramzy and Zaki [9]; Tsurumi et al. [10]).
However, it is not clear if the Porter hypothesis is valid in China, with its most recent and comprehensive overhaul of its environmental regulation as of April 2014. The newest regulation in 2014 is also called the “Ecological Protection Red Line” (hereafter, Red Line), where explicitly stated environmental indicators are called for to manage pollution and hold provincial political leaders accountable to the enforcement of the regulations. The Chinese government essentially uses the Red Line to implicitly set up “tournaments” among provincial political leaders in the context of environment protection because the government will continuously announce the progress of all provinces towards the goals in the Red Line to the public. It is not clear if firm exports are helped or hurt by the Red Line.

The purpose of this paper is to test the Porter vis-à-vis the pollution haven hypothesis regarding the impact of tightening of environmental regulation on firm exports, using the Red Line as an exogenous shock in China. Our paper is interesting for two reasons. First, China is an LDC and the second largest economy in the world (as of 2017), and Chinese exports are viewed as the engine of its economic growth. Thus, the findings on the impact of a holistic environmental regulation approach using the Red Line on exports in China offer guidance for the country’s economic and environmental policies. Second, despite the Chinese government’s numerous piecewise environmental regulations, the effectiveness of its environmental protection is considered unsatisfactory (Zhu et al. [11]). The new Red Line regulation represents the Chinese government’s determination, and, most importantly, it holds provincial leaders accountable for the effectiveness of environmental protection. Hence, the success (or failure) of the new Red Line carries important environmental policy implications. Leveraging from the fact that there are differences in the timing of reaching specific Red Line policy goals among provinces, we used a difference-in-difference (DID) and propensity score matching (PSM) research design to examine the impact of the policy on firm exports.

Using the Chinese A-share firms from 2011 to 2017 and the Red Line policy, our findings from the DID-PSM method suggest that, consistent with the Porter hypothesis, firm exports are positively affected by the implementation of the Red Line (not just setting the environmental standards). The findings were found to be robust to an alternative metric of exports. Hence, there is no tradeoff between exports and environmental protection, contrary to what the pollution haven hypothesis predicts. Additional analysis suggests that a firm’s innovation activities (in terms of research and development investments) and production efficiency are the channels of the impact of Red Line policy on firm exports, corroborating the underlying logic of the Porter hypothesis. Our findings are in contrast to the literature that uses piecewise environmental regulation on firm exports (Hering and Poncet [12]). Thus, the impact of environmental protection on firm exports depends, in part, on both the types and the effective execution of environmental regulations.

We make two contributions to the literature. First, the impact of a holistic environmental regulation approach (the Red Line) on firm exports was found to be consistent with the Porter hypothesis. Hence, we cast doubt on the pollution haven hypothesis to explain the recent Chinese Red Line approach to environmental regulation. If policies are properly designed and executed, they can promote firm exports. Second, the Red Line in China shows that a holistic approach with local political leader accountability is effective in curbing pollution, and, most importantly, can promote firm exports. Overall, the findings in China offer positive lessons for other LDCs in terms of setting up and executing environmental regulations.

2. Background and Literature Review

2.1. Background

Despite several rounds of environmental regulations by China, the results were not viewed as satisfactory. Then, a new approach (the Environmental Protection Law) was adopted by the Chinese government on 24 April 2014, and it was passed in the 7th meeting of the Standing Committee of the General Assembly. The objective of the Law is to set up the “ecological protection red line” (the Red Line) to “protect and improve the environment, prevent pollution and other public hazards, safeguard public...
health, promote the construction of the ecological civilization, and promote sustainable economic and social development” (the details are provided in [http://www.law-lib.com/law/law_view.asp?id=6229 (accessed 13 April 2019)]). The Law was implemented on different dates in different provinces, beginning in 2014. The major provision of the Law is to explicitly define ecological protection standards (red lines) in each province. Different from the previous silo approach of having separate legislation for land, forest, air, solid waste, and water pollution, the Environmental Protection Law represents a holistic approach to environment protection.

With mandates from central government, each province is asked to set environmental protection standards (red lines) on ecological, environmental, and resource sustainability considerations, and considers all aspects of protecting the environment. In July 2015, each province finalized the new standards, and the CPC Central Committee and State Council of China approved the standards in late 2017. In terms of execution of the Red Line, there are four phases: (1) setting the specific pollution standards (red lines), (2) completing the legislation and the implementation of the Red Line, (3) surveying the results and continuous improvement of the red lines, and (4) evaluating the effectiveness of the Red Line. Table 1 presents the progress of each province as of 1 January 2018. Three provinces (Guangdong, Hubei, and Hainan) reached Phase 3 of the Red Line, 10 other provinces reached Phase 2, and the remaining provinces remain in Phase 1.

Table 1. The progress of Red Line regulation among 31 provinces as of 1 January 2018.

| Provinces and Autonomous Cities | Phase in the Red Line (as of 1 January 2018) |
|---------------------------------|---------------------------------------------|
| Anhui                           | 2                                           |
| Beijing                         | 1                                           |
| Chongqing                       | 1                                           |
| Fujian                          | 1                                           |
| Gansu                           | 2                                           |
| Guangdong                       | 3                                           |
| Guangxi                         | 2                                           |
| Guizhou                         | 2                                           |
| Hainan                          | 3                                           |
| Hebei                           | 2                                           |
| Heilongjiang                    | 2                                           |
| Henan                           | 1                                           |
| Hubei                           | 3                                           |
| Hunan                           | 1                                           |
| Jiangsu                         | 2                                           |
| Jiangxi                         | 1                                           |
| Jilin                           | 2                                           |
| Liaoning                        | 1                                           |
| Neimenggu                       | 1                                           |
| Ningxia                         | 1                                           |
| Qinghai                         | 1                                           |
| Shandong                        | 1                                           |
| Shanghai                        | 1                                           |
| Shanxi                          | 1                                           |
| Shanxi                          | 2                                           |
| Sichuan                         | 1                                           |
| Tianjin                         | 1                                           |
| Xinjiang                        | 1                                           |
| Xizang                          | 2                                           |
| Yunnan                          | 1                                           |
| Zhejiang                        | 2                                           |

Table 1 presents the four phases of the Red Line as of 1 January 2018. The four phases are: (1) setting the specific pollution standards (red lines), (2) completing the legislation and the implementation of the Red Line, (3) surveying the results and continuous improvement of the red lines, and (4) evaluating the effectiveness of the Red Line.
The Red Line policy has two major features which are different from other environmental regulations. First, different from the previous silo approach of previous environmental regulations in which having separate land, forest, air, solid waste, or water pollution legislations, the Red Line is considered as a holistic approach to environment protection. Therefore, all major pollution standards were set. Government officials are required to follow the standards. Hence, government officials do not look at one pollutant at a time. Instead, government officials are charged with a system-wide effort in tackling all types of pollution under their jurisdictions. Second, the Chinese government publicly announces the progress of each province toward specific phases of the Red Line, which de facto sets up a pseudo tournament for all provinces to show their results in the execution of the Red Line. Provincial leaders are implicitly asked to compete with their peers in the environmental performance under the standards in the Red Line. When one or several provinces advance in the specific phase of the Red Line, other provincial leaders are then pressed to catch up in the pollution performance along the Red Line standards.

2.2. Literature Review

Two strands of related literature are discussed below. Given the voluminous amount of studies, we only highlight some of them here. The first strand concerns the pollution haven hypothesis. This hypothesis puts forth that firms in developed countries move to LDCs in order to take advantage of their lower pollution standards. The finished products are then exported to the rest of the world. As LDCs continue to grow, they raise their environmental protection standards. Then, the costs of production in LDCs are raised. Subsequently, the firms from the developed countries are forced to move out of the LDCs due to high environmental standards. Accordingly, firm exports decrease in LDCs. Essentially, LDCs are pollution havens for firms from developed countries. Kearsley and Riddel [3], Kolcava et al. [4], Xu et al. [5], Rana and Sharma [6], and Martinez-Zarzoso et al. [7] offer cross-country or single-country evidence to support the hypothesis.

In addition, heavily polluting firms in a country typically increase their foreign direct investments and production to circumvent the environmental regulations in their home countries, as reported in Hanna [13]. Chinese target and non-target cities are compared in Hering and Poncet [12] in terms of strict regulations on sulfur dioxide emissions (two control zone policy). The authors report that firm exports in target cities (with stricter pollution standards) decreased relative to non-target cities. Similarly, a decrease in foreign direct investments in the target cities in China was shown in Cai et al. [14]. Using firms in heavily polluting industries, Shi and Wu [15] found that stricter environmental regulations reduce both the probability that a firm will export and the volume of exports in China. Using counties in New York State in the USA and the passage of the Clean Air Act, List and McHone [16] report that pollution-intensive manufacturing plants relocated from counties with stringent environmental regulations to less-stringent counties. After applying a PSM method to properly match polluted firms with non-polluted firms, List et al. [17] and Milliment and List [18] find that polluted firms respond to environmental regulations by moving to less-stringent locations. Thus, while they do not directly relate to LDC exports, these within-country studies offer support to the pollution haven hypothesis.

Some studies report opposing evidence regarding the pollution haven hypothesis. For instance, Birdsall and Wheeler [19] document that foreign direct investments in Latin American countries do not concentrate on heavily polluting firms, and thus cast doubt on the pollution haven hypothesis. Liang [20] examines air pollution in China and finds that foreign firms move into LDCs and crowd out inefficient local firms. Consequently, local air pollution is alleviated.

The second strand of the literature is related to the Porter hypothesis. The hypothesis was proposed by Porter [8] to show that a properly designed environmental regulation can stimulate firm innovation and enhance the firm competitiveness. The increased cost of responding to the high standards of environmental regulation can be more than offset by an increase in production efficiency and profit. Consequently, firm exports increase. Specifically, Ramzy and Zaki [9] study
the impact of stringent environmental protection regulation on agricultural trade between countries in the European Union, Middle East, and North Africa, and report evidence to support the Porter hypothesis. Tsurumi et al. [10] examine bilateral trade flow data and find support for the Porter hypothesis. Porter and van der Linde [21] further suggest that the scope in previous studies of the pollution haven hypothesis was limited to the direct effect of pollution on production. The externality of firm innovation brought by environmental regulations is seldom incorporated. The authors argue that environmental regulations can promote firm exports. Several studies offer evidence to support the Porter hypothesis. For instance, environmental regulations are found by Berman and Bui to accelerate the technological improvement of the oil refining industry [22]. Bi et al. find that the carbon tax in China promoted long-run economic growth [23]. Similarly, the Porter hypothesis is found to be valid in Sweden by Weiss and Anisimova [24]. They show that a flexible and dynamic command-and-control environmental regulation is particularly useful in promoting innovation—a key underlying element of the Porter hypothesis. Jin et al. [25] report that in foreign direct investment settings, environmental regulations stimulate the environmental innovation of a local firm due to its parent’s superior cross-border environmental management capabilities. In contrast, Dou and Han [26] examine Chinese firms during 2000–2015 and report that some firms simply moved to a province with lower environmental standards after their previous host provinces raised their environmental standards, suggesting that the Porter hypothesis may not be valid in China.

In sum, two conclusions can be drawn from the literature. First, the pollution haven hypothesis literature provides mixed findings. Second, there is plenty of evidence supporting the Porter hypothesis. However, some studies document that the Porter hypothesis may not be applicable in China. Overall, the evidence is mixed for the impact of environmental regulations on firm exports.

We argue that these studies examine one specific pollution indicator, such as air pollution (List and McHone [15]). Hence, the investigation in the literature is silo. In addition, data prior to 2015 are used in studies reporting evidence supporting the pollution haven hypothesis (e.g., List and McHone [15]) or do not support the Porter hypothesis (e.g., Dou and Han [26]). The mixed evidence about the pollution haven and the Porter hypotheses suggest that it is worthwhile to re-examine the two competing hypotheses. In addition, the Chinese environmental regulations have been found to be ineffective (Zhu et al. [11]). Thus, it is also interesting to study the impact of a holistic environmental regulation positioning the approach as pseudo-tournaments for government officials (i.e., the Red Line regulation) on firm exports using more recent data. It remains a research question if the Red Line is able to help in protecting the environment while promoting firm exports. The findings carry significant policy directive to other LDCs in adopting a holistic approach to tackle environmental issues. We propose the testable hypothesis as follows:

**Hypothesis 1. The Red Line policy promotes firm exports.**

### 3. Methods and Data

#### 3.1. Regression Model

We follow Hoynes et al. [27] and Rashid and Waqar [28] to use their DID firm fixed effect model. We examined the impact of the Red Line on firm exports. Essentially, the Red Line is considered as an exogenous event to examine H1. The model is:

\[
p[D_{\text{EXP},i,t} = 1] = \alpha_0 + \alpha_1 ERI_{1,i,t} \text{(or } ERI_{2,i,t}\text{)} + \gamma Z_{i,t} + FIRM + YEAR + \epsilon_{i,t},
\]

\[
LNEX_{i,t} = \beta_0 + \beta_1 ERI_{1,i,t} \text{(or } ERI_{2,i,t}\text{)} + \theta Z_{i,t} + FIRM + YEAR + \pi_{i,t},
\]

where \(ERI_{1,i,t}\) (\(ERI_{2,i,t}\)) is an environmental policy dummy variable with a value of 1 if firm \(i\) is located in a province that completed Phase 1 (Phase 2) of the Red Line at \(t\), and is zero otherwise; \(D_{\text{EXP},i,t}\) is a dummy variable with a value of 1 if a firm has exports, and is zero otherwise; \(LNEX_{i,t}\) is the logarithm
value of a firm’s exports; \( Z_{i,t} \) is a set of control variables. \( \varepsilon_{i,t} \) and \( \pi_{i,t} \) are standard errors. We control for year and firm fixed effects in Equations (1) and (2).

Both \( D_{EXP,i,t} \) and \( LNEXP_{i,t} \) are used as the dependent variables to account for the fact that some firms do not have exports. Hence, Equation (1) concerns the extensive impact of the Red Line on firm exports, whereas Equation (2) focuses on the intensive impact. The impact of unobserved firm-level characteristics on firm exports are accounted for using the firm fixed effect model.

A number of control variables are included, such as borrowing capacity (\( BAR \)), financial leverage (\( LEV \)), labor cost (\( LINTSTY \)), labor wage expenditure (\( LNWAGE \)), capital intensiveness (\( CK \)), financial constraint (\( FINANCE \)), provincial per capital GDP (\( LNGDPPC \)), provincial foreign direct investment level (\( LNFDI \)), and the industry structure to which the firm belongs (\( IND3 \)). The control variables account for the impact of firm characteristics, foreign ownership, provincial characteristics, and production cost. The detailed definitions of all variables are presented in Table 2. If H1 is valid, then \( \alpha_1 \) and \( \beta_1 \) are positive and significant. We estimate Equation (1) by logistic regression and Equation (2) by ordinary least squares.

### Table 2. Variable definitions.

| Variables | Definitions |
|-----------|-------------|
| \( D_{EXP} \) | If a firm has exports in a given year, the value is 1, and it is zero otherwise |
| \( LNEXP \) | The natural logarithm of a firm’s export |
| \( ER1 \) | If a firm is located in a province that meets Phase 1 of the Red Line policy, the value is 1, and it is zero otherwise |
| \( ER2 \) | If a firm is located in a province that meets Phase 2 of the Red Line policy, the value is 1, and it is zero otherwise |
| \( BAR \) | Net fixed assets to total assets ratio |
| \( LEV \) | Total liabilities to total assets ratio |
| \( LINTSTY \) | Total wages paid to sales ratio |
| \( LNWAGE \) | Logarithm value of average wage of employee |
| \( CK \) | Total assets to sales ratio |
| \( FINANCE \) | Accounts receivable to sales ratio |
| \( LNGDPPC \) | Provincial per capita GDP in natural logarithm |
| \( LNFDI \) | Natural logarithm of foreign direct investment in a province |
| \( IND3 \) | Provincial tertiary sector to GDP ratio |

#### 3.2. Data

Chinese A-share public firms from 2011–2017 were used to examine H1. The 2011–2017 period includes three years before and after the Red Line in 2014. Provincial data were retrieved from the China Economic and Social Development Statistics Database, and the Red Line data were hand-collected from the 31 official provincial websites. After excluding observations with missing information and special treatment firms (firms with financial distress), the final sample contained 16,033 firm-years. The period of 2011–2017 was used to allow us to include pre- and post-Red Line policy implementation to execute the DID analysis.

#### 4. Results and Discussions

##### 4.1. Summary Statistics

The summary statistics of the sample are presented in Table 3. The mean of \( D_{EXP} \) is 0.5140, suggesting that 51.4% of the sample had exports in the sample period. The mean of \( LNEXP \) is 9.418, which is RMB12,307 before natural logarithm. The low mean value of exports is due to the fact that some firms do not have any exports. For \( ER1 \) and \( ER2 \), the means are 0.4133 and 0.1560, suggesting that 41.33% and 15.6% of the firm-years belonged to firms in provinces meeting Phases 1 and 2, respectively.
Table 3. Summary statistics of the sample. Definitions of all variables follow Table 2.

| Variables | N  | Mean  | Std. Dev. | Min | Max |
|-----------|----|-------|-----------|-----|-----|
| D_EXP     | 16033 | 0.5140 | 0.5000 | 0 | 1 |
| LNEXP     | 16033 | 9.4180 | 9.2630 | 0 | 21 |
| ER1       | 16033 | 0.4133 | 0.4924 | 0 | 1 |
| ER2       | 16033 | 0.1560 | 0.3630 | 0 | 1 |
| BAR       | 16033 | 0.2160 | 0.1660 | 0 | 0.9480 |
| LEV       | 16033 | 0.4120 | 0.2170 | 0.0071 | 4.0250 |
| LINTSTY   | 16033 | 0.1330 | 0.1670 | 0.0015 | 16.0500 |
| LNWAGE    | 16033 | 18.8400 | 1.2190 | 13.3700 | 25.5100 |
| CK        | 16033 | 3.5910 | 30.6200 | 0.0071 | 3.2690 |
| FINANCE   | 16033 | 0.0003 | 0.0097 | 0 | 0.7400 |
| LNGDPPC   | 16033 | 11.0200 | 0.4210 | 9.7060 | 11.7700 |
| LNFDI     | 16033 | 7.5450 | 1.2690 | 1.9820 | 9.7770 |
| IND3      | 16033 | 0.4995 | 0.1247 | 0.2967 | 0.8056 |

4.2. Base Findings

The results for Equations (1) and (2) are presented in Table 4. For robustness, the analysis was conducted in the following ways:

(a) A reduced sample of the 17 provinces meeting only Phase 1 of the Red Line was used to compare firms located in only Phase 1 provinces vs. firms in pre-Red Line. The results are presented in columns (1) and (2);

(b) The full samples were used to compare firms located in provinces meeting at least Phase 2 vs. firms in pre-Red Line and located in Phase 1 provinces. The results are presented in columns (3) and (4);

(c) A reduced sample was used to compare firms located only in Phase 2 provinces vs. firms in pre-Red Line and located in Phase 1 provinces. The results are presented in columns (5) and (6).

For Phase 1 of the Red Line policy, the coefficients of $ER1$ in columns (1) to (2) are not significant, suggesting that for firms located in provinces, simply setting Red Line standards did not have any impact on firm exports; presumably, these provinces had not engaged in any real activities to manage pollution. In contrast, for firms located in provinces meeting Phase 2, the coefficients of $ER2$ are positive and significant at the 5% and 10% level in columns (3) to (6), indicating that when a province completes the legislation of the Red Line standards, firms located in the province experience an increase in firm exports. These findings are economically significant. Using column (3), the coefficient of $ER2$ is 0.4364. That is, a firm located in a Phase 2 province had 0.4364 more exports than a firm located in a Phase 1 province. Given that the mean of $LNEXP$ is 9.4180, 0.4364 more exports represent approximately 4.6% higher exports for a typical firm. That is, when a province has engaged in some real activities (e.g., legislation of pollution standards in all pollutants) to manage pollution, firms located in the province make changes so that firm exports increase. These findings support H1.

Thus, the Porter hypothesis is supported by our findings when a province adopts the holistic environmental protection policies (the Red Line). Control variables, if significant, carry the expected signs. For instance, the coefficients of $LNWAGE$ are positive and significant at the 1% level. When a firm has a high average wage, we expect that its employees, on average, are more productive and, thus, the firm is able to export more goods.
Table 4. The impact of Red Line policy on firm exports.

| Phase 1 | Phase 2 |
|---------|---------|
| Reduced Sample: Compare Firms Located in Only Phase 1 Provinces vs. Firms in Pre-Red Line. | Full Sample: Compare Firms Located in Provinces That Meet at Least Phase 2 vs. Firms in Pre-Red Line and Located in Phase 1 Provinces. |
| Reduced Sample: Compare Firms Located Only in Phase 2 Provinces vs. Firms in Pre-Red Line and Located in Phase 1 Provinces. |

| Variable | (1) D_EXP | LNEXP | (2) D_EXP | LNEXP | (3) D_EXP | LNEXP | (4) D_EXP | LNEXP | (5) D_EXP | LNEXP | (6) D_EXP | LNEXP |
|----------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
| ER1      | -0.0072   | -0.1080 | 0.0220 *  | 0.4364 ** | 0.0217 *  | 0.4410 ** |
|          | (-0.51)   | (-0.44) | (1.84)    | (2.01)  | (1.75)    | (1.97) |
| ER2      | -0.0018   | -0.1100 | -0.0125   | -0.3350  | -0.0098   | -0.2590 |
|          | (-0.02)   | (-0.08) | (-0.69)   | (-0.90) | (-0.51)   | (-0.68) |
| BAR      | 0.1921 *** | 3.7866 *** | 0.0648 *** | 1.4494 *** | 0.0725 *** | 1.6984 *** |
|          | (3.80)    | (3.75)  | (4.28)    | (5.06)  | (4.86)    | (5.78) |
| LINTSTY  | -0.0269   | -0.6650 | 0.0001    | 0.0027  | 0.0002    | 0.0032 |
|          | (-1.04)   | (-1.32) | (0.79)    | (0.92)  | (0.85)    | (0.90) |
| LEV      | 0.0817 *** | 1.7480 *** | -1.9045 ** | -36.0362 ** | -2.1039 ** | -39.5026 ** |
|          | (3.53)    | (5.20)  | (-2.51)   | (-2.49) | (-2.41)   | (-2.26) |
| CK       | 0.0040    | 0.0082  | 0.0338    | 0.0300  | 0.0173    | 0.0516 |
|          | (1.41)    | (1.57)  | (0.67)    | (0.92)  | (0.31)    | (0.51) |
| FINANCE  | -3.2495 *** | -65.2287 *** | 0.0177    | 0.0300  | 0.0316    | 0.0576 |
|          | (-2.75)   | (-2.85) | (1.13)    | (1.05)  | (1.62)    | (1.63) |
| LNGDPPC  | -0.0039   | 0.0260  | -0.1270   | -3.4250  | -0.1620   | -3.9480 |
|          | (0.06)    | (0.24)  | (-0.79)   | (-1.16) | (-0.90)   | (-1.20) |
| LNFDI    | 0.0471 *  | 0.8350 * | -1.2209 ** | -28.9616 ** | -1.2796 ** | -30.3800 ** |
|          | (1.74)    | (1.69)  | (-2.10)   | (-2.71) | (-2.13)   | (-2.77) |
| IND3     | -0.0858   | -2.2210 | 0.0220 *  | 0.4364 ** | 0.0217 *  | 0.4410 ** |
|          | (-0.40)   | (-0.56) | (1.84)    | (2.01)  | (1.75)    | (1.97) |
| Constant | -1.5298 * | -34.7420 ** | 0.0058    | 0.1610  | -0.0073   | -0.1500 |
|          | (-1.88)   | (-2.36) | (0.12)    | (0.18)  | (-0.13)   | (-0.15) |
| Year fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Pseudo R² | 0.7680 | 0.7800 | 0.7730 | 0.7910 | 0.7910 | 0.7910 |
| N       | 7911      | 7911    | 16,033    | 16,033  | 12,981    | 12,981 |

Table 4 presents the results for the impact of the Red Line policy on firm exports. Phase 1 refers to setting the environmental standards, and Phase 2 means that the province has completed legislation for the proposed standards. Definitions of all variables follow Table 2. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.3. Robustness Checks

4.3.1. Propensity Score Matching (PSM)

Though it is unlikely, we may have a sample selection issue, because some firms that choose to export their goods may be more sensitive to environmental protection. To mitigate this potential issue, we conduct a PSM to match firms that experience the Red Line policy (treatment firms) with control firms, using firm size, average wage, intangible assets, account receivable turnover, provincial ammonia emission, and provincial environmental investment share of GDP. The PSM is a 1:1 match with replacement (Shipman et al. 2016). However, PSM does not address endogeneity concerns if selection is due to unobserved characteristics. For instance, if unobserved managerial quality influences both foreign ownership and exports, foreign ownership becomes endogenous. Essentially, the PSM avoids the parametric assumptions of a linear model.

The results in Table 5 show the before and after PSM differences in the means of the matching variables. Before PSM, five out of the six matching variables showed significant differences. After PSM, all of the variables are not significantly different. We had 6627 samples from each of treatment and control firm sub-samples after PSM.

The results of Equations (1) and (2) using the PSM samples are presented in Table 6. We used only ER2 in Equations (1) and (2) and applied it to sample (b) in Section 4.2, because ER1 was not significant in Table 4. The coefficients of ER2 in columns (1) and (2) are positive and significant at the 5% level. Thus, the findings are qualitatively similar to those in Table 3. Hence, our support of H1 is robust to
the potential sample selection issue. Despite raising environmental standards in all types of pollutions, the Red Line policy is effective in promoting exports.

Table 5. Propensity score matching (PSM) balance check.

| Variables              | Mean | t-Test | p > |t| |
|------------------------|------|--------|-----|---|---|
|                        | Sample | Treated | Control | %bias | [bias] | t | p > |t| |
| Firm size              | Before PSM | 7.5003 | 7.4727 | 2.3  | 39.60 | 1.43 | 0.1540 |
|                        | After PSM | 7.5003 | 7.5169 | −1.4 | −0.80 | 0.4250 |
| Average wage           | Before PSM | 18.9090 | 18.7940 | 9.5  | 83.50 | 5.90 | 0.0000 |
|                        | After PSM | 18.9090 | 18.9280 | −1.6 | −0.91 | 0.3640 |
| Intangible assets      | Before PSM | 4.6000 | 5.6000 | −2.7 | 30.00 | −1.66 | 0.0980 |
|                        | After PSM | 4.6000 | 5.3000 | −1.9 | 82.70 | −1.15 | 0.2520 |
| Account receivable     | Before PSM | 74.8680 | 80.3900 | −2.0 | 92.50 | −1.15 | 0.2510 |
| turnover               | After PSM | 74.8680 | 75.2900 | −0.1 | 10.62 | 0.42 | 0.6740 |
| Ammonia emission       | Before PSM | 2.3813 | 2.2798 | 10.8 | 5.40 | 0.0060 |
| Environmental investment share of GDP | After PSM | 2.3813 | 2.3638 | 1.9 | 82.70 | 0.107 | 0.2030 |

Table 6. The impact of the Red Line policy on firm exports using PSM samples.

| Variable | Phase 2 of Red Line | D_EXP | LNEXP |
|----------|---------------------|-------|-------|
| ER2      | 0.0317 **           | 0.5841 ** |
|          | (2.29)              | (2.32) |
| BAR      | −0.0082             | −0.2560 |
|          | (−0.47)             | (−0.73) |
| LEV      | 0.0671 ***          | 1.4999 *** |
|          | (3.85)              | (4.54) |
| LINTSTY  | 0.0001              | 0.0024 |
|          | (0.61)              | (0.82) |
| LNWAGE   | −1.5621 **          | −30.9186 ** |
|          | (−2.17)             | (−2.23) |
| CK       | 0.0636              | 1.3980 |
|          | (1.14)              | (1.38) |
| FINANCE  | 0.0088              | 0.1330 |
|          | (0.52)              | (0.43) |
| LNGDPPC  | −0.2200             | −5.4020 |
|          | (−1.20)             | (−1.62) |
| LNFDI    | −1.4844 **          | −34.0973 *** |
|          | (−2.20)             | (−2.72) |
| IND3     | 0.0317 **           | 0.5841 ** |
|          | (2.29)              | (2.32) |
| Constant | 0.0154              | 0.4620 |
|          | (0.27)              | (0.44) |
| Year fixed effect | Yes | Yes |
| Firm fixed effect  | Yes | Yes |
| Adj.R²   | 0.7840              | 0.8000 |
| N        | 13254               | 13,254 |

Table 6 presents the results for the impact of the Red Line policy on firm exports using PSM samples. Phase 2 means that the province has completed legislations and implementation of the Red Line. The definitions of all variables follow Table 2. *** and ** indicate significance at the 1% and 5% levels.

4.3.2. Using Alternative Measure of Firm Exports

Firm exports do not factor in the relative importance of exports to a firm. As an alternative measure, we use the exports to sales ratio (EXPORTSALES) of a firm as the dependent variable in Equation (2). We present the results in Table 7. Similar to the base results in Table 4, the coefficient of ER2 is positive and significant at the 5% level. Again, the support of H1 is robust to alternative measure of firm exports.
Table 7. Using an alternative measure of firm exports.

| Variables | Phase 2 of Red Line EXPORTS/SALES |
|-----------|-----------------------------------|
| ER2       | 0.0157 **                        |
|           | (2.35)                            |
| BAR       | 0.0001 **                        |
|           | (1.98)                            |
| LEV       | 0.0256 ***                       |
|           | (3.60)                            |
| LINTSTY   | 0.0000                            |
|           | (0.30)                            |
| LNAGE     | −0.2082 *                        |
|           | (−1.72)                           |
| CK        | −0.0076                           |
|           | (−0.32)                           |
| FINANCE   | 0.0140 *                         |
|           | (1.89)                            |
| LNGDPPC   | −0.0658                           |
|           | (−0.84)                           |
| LNFDI     | −0.3540                           |
|           | (−3.16)                           |
| IND3      | 0.0157 **                        |
|           | (2.35)                            |
| Constant  | 0.0347                            |
|           | (1.37)                            |
| Year fixed effect | Yes                        |
| Firm fixed effect | Yes                        |
| Adj.R²    | 0.7650                            |
| N         | 16,004                            |

Table 7 presents the results for the impact of the Red Line policy on firm exports using the ratio of a firm’s exports to sales (EXPORTS/SALES). Phase 2 means that the province has completed legislations and implementation of the Red Line. The definitions of all variables follow Table 2. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.4. Transmission Mechanism

The micro-foundation of the Porter hypothesis is the increase in innovation after the increase in environmental regulation. If this is the case, firms are expected to increase their innovation and their production efficiency after the Red Line. The following models are used to conduct the examination:

\[
RD_{it} = \theta_0 + \theta_1 ER_{it} + aM_{it} + FIRM + YEAR \ e_{it}, \quad (3)
\]

\[
TFP_{it} = \rho_0 + \rho_1 ER_{it} + \tau X_{it} + FIRM + YEAR + \iota_{it}. \quad (4)
\]

For Equation (3), \(RD_{it}\) is the research and development expense of a firm, and \(M_{it}\) is a set of control variables, including firm age (LNAGE), firm size (SIZE), sales growth (GROW), profitability (ROA), financial leverage (LEV), top shareholder ownership (TOPI), and capital concentration (CK). For Equation (4), \(TFP_{it}\) is the total factor of production, which was derived using data envelopment analysis of employees and fixed assets’ input and product output. \(X_{it}\) is a set of control variables using state-ownership of the firm (SOE), firm size (SIZE), firm age (LNAGE), employee wages (LNWAGE), capital concentration (CK), financial constrains (FINANCE), provincial per capita GDP (LNGDPPC), and foreign direct investment (LNFDI). If the underlying logic of H1 is correct, \(\theta_1\) and \(\rho_1\) are expected to be positive and significant.

Our findings are presented in Panels A and B of Table 8. In both panels, the coefficients of \(ER2\) are positive and significant at the 1% or 10% level, suggesting that a firm’s \(RD\) and \(TFP\) increase when it is located in a Phase 2 Red Line province. Thus, the findings in Table 8 confirm the validity of the underlying logic in the Porter hypothesis. That is, a firm in a Phase 2 Red Line province increases its research and development and total factor production. Collectively, the findings in Table 8 confirm the micro foundations of H1. After the Red Line policy, firms engage in more innovations and gain...
operational efficiency improvement. Accordingly, firms are able to increase their exports, supporting the Porter hypothesis.

Table 8. The impact of the Red Line on innovation and efficiency.

| Panel (A): Research and development. | \(RD\) |
|-------------------------------------|--------|
| \(ER2\)                             | 0.5040 *** |
| (3.35)                              |        |
| \(LNAGE\)                           | −6.4981 *** |
| (−9.95)                             |        |
| \(SIZE\)                            | 0.7456 *** |
| (7.01)                              |        |
| \(GROW\)                            | 0.0000 |
| (0.57)                              |        |
| \(ROA\)                             | −1.5000 * |
| (−1.78)                             |        |
| \(LEV\)                             | −2.2650 *** |
| (−5.63)                             |        |
| \(TOP1\)                            | 0.0017 |
| (0.25)                              |        |
| \(CK\)                              | −0.0035 *** |
| (−2.99)                             |        |
| Constant                            | 7.5567 *** |
| (2.73)                              |        |
| Year fixed effect                   | Yes    |
| Firm fixed effect                   | Yes    |
| Adj.R\(^2\)                         | 0.7380 |
| N                                  | 15,043 |

| Panel (B): Production efficiency. | \(TFP\) |
|-----------------------------------|--------|
| \(ER2\)                           | 0.0017 * |
| (1.87)                             |        |
| \(SOE\)                            | −0.0047 |
| (−1.50)                            |        |
| \(SIZE\)                           | 0.0038 *** |
| (2.60)                             |        |
| \(LNAGE\)                          | −0.0078 * |
| (−1.72)                            |        |
| \(LNWAGE\)                         | −0.0066 *** |
| (−4.04)                            |        |
| \(CK\)                             | −0.0001 ** |
| (−2.32)                            |        |
| \(FINANCE\)                        | 0.1478 * |
| (1.69)                             |        |
| \(LNGDPPC\)                        | −0.0041 |
| (−1.01)                            |        |
| \(LNFDI\)                          | 0.0040 *** |
| (3.00)                             |        |
| Constant                           | 0.7174 *** |
| (17.02)                            |        |
| Year fixed effect                  | Yes    |
| Firm fixed effect                  | Yes    |
| Adj.R\(^2\)                        | 0.9050 |
| N                                  | 14,537 |

Table 8 presents the results for the impact of Red Line policy on firm research and development (RD) and total factor of production (TFP). Phase 2 means the province has completed the legislations and implementation of the Red Line. The definitions of all variables follow Table 2. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
When compared to studies related to Porter and pollution haven hypotheses, we provide several new findings. First, relative to studies not supporting the pollution haven hypothesis (e.g., List and MaHone [15], Dou and Han [26]), we find evidence to support the Porter hypothesis. The different findings can be attributed to our inclusion of all pollution standards, not just air pollution standards. Second, Zhu et al. [11] did not find that environmental protection policies were effective in China, while our studies indicate there are some positive aspects of the Red Line policy. The differences could be due to using more recent data and the new and novel approach of the Chinese government in executing environmental policy.

5. Summary

We use the quasi-natural experiment of the Red Line policy to examine the impact of environmental regulation on firm-level exports. Our findings suggest that just proposing the Red Line policy does not change firm exports. Instead, the setting-up of the environmental standards under the Red Line policy enhances firm exports. The findings are robust to different export metrics. Additional analysis suggests that the Red Line standard stimulates firms to spend more on research and development and increase their production efficiency. Overall, the Porter hypothesis is supported by the evidence.

Our findings offer an important policy implication. The pollution haven hypothesis does not always apply in LDCs, that is, the enactment of environmental regulation does not necessarily mean hurting firm exports. Instead, the Chinese findings are shown to be consistent with the Porter hypothesis. If a government has the necessary determination, such as using a holistic approach to environmental regulation, firms increase their innovation and production efficiency to promote exports. Based on our findings, we suggest that a government—especially an LDC—can consider a holistic approach to environmental regulations and perhaps setting up “tournaments” to pressure governmental officials to perform well in executing environmental regulations.

Two limitations are noted. First, the Red Line policy is a trial. Our findings, while promising, only represent an early outcome. It may take more time to examine the long-term impact of the Red Line policy. Second, the Red Line policy works well in China. This does not indicate if similar approaches may work in other LDCs, due to different socio-economic backgrounds. Collectively, it would be interesting to extend the research to a longer time period and other LDCs to document the effectiveness of holistic approaches to environmental regulation.

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