Pollution Control and Foreign Firms' Exit Behavior in China

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Abstract

China faces a common dilemma of how to maintain rapid economic growth while also reducing the pollution that has accompanied growth. Will stricter pollution controls drive away the foreign firms that have helped spur growth in China? This paper studies the effects of the Two-Control-Zone (TCZ) pollution control policy on foreign firms' exit behavior in China. Based on firm-level data from 1998 to 2009, we find that foreign firms' responses are not significantly different from domestic firms on average once environmental regulations impose an added cost of business. However, foreign firms' responses to stricter pollution controls tend to differ based on various firm characteristics. Our estimation indicates that larger size, higher productivity and exporting all make foreign firms less likely to exit than similar domestic firms in regions with stricter pollution control.

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1. Introduction

The potential relationship between foreign direct investment (FDI) and environmental deterioration has garnered a lot of research attention due to conflicting hypotheses and their conflicting policy implications. Much of the debate centers on the "pollution haven" hypothesis which argues that weak environmental regulations in developing countries attract foreign investors from industrial countries with more restrictive regulations. Theoretical studies have developed this hypothesis and some empirical studies have found support for it by showing that capital tends to move from higher to lower regulation countries.[1] However, other studies have found that foreign companies tend to use better management practices and more advanced technologies than host developing country firms, thereby contributing to cleaner environmental outcomes. These results fit the "pollution halo" hypothesis.[2]

As the largest developing country and the most attractive FDI destination, China presents a unique case for testing the FDI—pollution relationship. Government officials and the general public in China recognize that FDI firms have made important contributions to China's economic development, but they also criticize China's serious pollution problems due to years of rapid, unregulated growth. Due to pollution haven effects, foreign firms may have been attracted by the previously weak pollution controls within China, and therefore they face criticism for damaging the local environment.[3] In addition to aggregate environmental impacts, FDI firms may have exacerbated regional disparities in environmental quality since the geographic distribution of FDI in China is highly uneven.[4] Regional environmental inequality in terms of residents' access to clean air and/or clean water has been evaluated somewhat by public health economists but is

[1] See, for example, Markusen et. al. (1993), Dean, Lovely, and Wang (2009), and Kellenberg (2009).

[2] Examples of these findings include Blackman and Wu (1999), Eskeland and Harrison (2003), Cole et. al. (2008), and D'Agostino (2015).

[3] See, for example, People's Daily online: http://en.people.cn/200611/01/eng20061101_317249.html

[4] Regional disparities in the impacts of FDI on China's economy are documented in Tseng and Zebregs (2002).

still an underexplored aspect of inequality.[5] We contribute to this broad topic area by examining the firm-level impacts of China's recent regional environmental protection laws.

The Chinese government has recently announced a series of laws to better regulate and reduce pollution. Observers now worry that the Chinese government's efforts to improve pollution control may drive away FDI firms and impede the development of local economies. For the government's policies to have their desired effects, they must induce movements towards cleaner technologies within industries and/or the exit of the most polluting firms or industries if production technologies cannot be improved. Our data allows us to analyze the latter issue; that is: how have the government's regional pollution controls affected existing firms, both foreign and domestic, in different regions? Are foreign firms more mobile than domestic firms, and therefore more likely to exit a region in China due to a change in the environmental regulations? Alternatively, are foreign firms less likely to exit a region in China once environmental regulations impose an added cost of business on domestic rivals that use more pollution-intensive technologies?

To address these research questions, we conduct a cross-firm study on firms' relocation or exit behavior, comparing domestic and foreign-owned firms in Two Control Zones (TCZs) or non-TCZs. The TCZ policy was initially adopted in 1998 by the State Council of China. The major target of TCZ policy is to control the output of sulfur dioxide (SO_2). The majority of the sulfur dioxide output can be measured accurately and inexpensively through acid rain analysis in southern China, while in northern China it is measured directly by SO_2 emissions data collection due to climate differences. Therefore, controlling the SO_2 air pollution in northern China and controlling acid rain in southern China are the so-called "Two Controls." According to the State

[5] For example, the Journal of Economic Perspectives' Spring 2016 edition features a symposium entitled "Inequality Beyond Income" which covers inequalities in consumption, mortality, health insurance, marriage and childbearing, and crime and criminal justice, but no coverage of environmental quality inequality.

Council documents (1998, 2002), there are five major aspects in the TCZ policy[6]: 1) Based on the records before 1998, cities with particularly high output of SO_2 are designated as SO_2 emission control zones or acid rain zones, the so-called TCZs. The list of TCZs has not been changed since 1998. In total, the TCZs include 11.4% of China's land area (175 prefecture cities), and they produce 67% of its GDP and 66% of its SO_2 emissions in 2000. 2) The policy sets targets on total SO_2 output and geographic density of SO_2 output for each TCZ. 3) The policy requires specific higher SO_2-related standards on fuel quality for all firms in TCZs and higher standards of SO_2 emission control for firms in pollution-intensive industries in TCZs. Some high-pollution coal-related producers are required to shut down or upgrade. 4) TCZs must change their industry structure to become more environmentally friendly; and 5) the management of emission fees in TCZs must be stricter and more efficient. Therefore, for firms following low standards of SO_2 emission control previously and/or with SO_2-related fuel-intensive production, the implementation of TCZ policies increases their production cost and may even drive these firms to exit the market. This effect can be especially strong for FDI firms if the pollution haven hypothesis holds. Otherwise, if the pollution halo hypothesis dominates, the relocation effect of TCZ policies should be weaker for FDI firms than domestic firms. In this paper, we investigate the effects of TCZ policies on the exit behavior of manufacturing firms in China based on 1998-2009 firm-level data.

This paper contributes to the existing literature in two respects. First, we investigate the impact of pollution control policies on the exit behavior of foreign firms in the manufacturing sector of China, the largest FDI recipient among developing countries. Second, based on abundant firm-level data, we find supporting evidence for both the pollution halo and pollution haven hypotheses. The exit behavior of foreign firms is found to depend on their size,

[6] For more details, please see Hering and Poncet (2011).

productivity, exporter status and SO_2-related industrial and regional characteristics. Our results indicate that larger size, higher productivity and exporting all make foreign firms less likely to exit than similar domestic firms in regions with stricter pollution control.

The rest of this paper is organized as follows. Section 2 reviews related literature and introduces the empirical strategies. Section 3 describes the data. Section 4 reports the estimation results and conducts various robustness tests. Concluding remarks are presented in Section 5.

2. Literature Review and Methodology

There is a large body of theoretical and empirical literature devoted to the effect of pollution controls on FDI firms. However, empirical studies fail to provide a consensus conclusion on this relationship. Some researchers document significant evidence supporting the pollution haven hypothesis (e.g., Henderson, 1996; Becker and Henderson, 2000; Keller and Levinson, 2002; Chung, 2014), but other studies find no significant supporting evidence (e.g., Friedman, et. al. 1992; Levinson, 1996; Eskeland and Harrison, 2003; Javorcik and Wei, 2004). As Levinson and Taylor (2008) suggested, unobserved heterogeneity between firms might be an important cause of the conflicting results among these empirical studies.

Recent theoretical contributions have tried to incorporate heterogeneity at different levels into the models. Using a standard game theoretic approach with endogenous market structure (i.e., industry heterogeneity), Elliott and Zhou (2013) demonstrate that greater stringency in environmental standards can lead to a strategic increase in capital inflows under some market structures. Tang et. al. (2014) set up a partial equilibrium model with heterogeneous firms to study the effect of environmental policies on firms' decisions regarding output, pollution emission and relocation. They find that with appropriate policy design, the least productive firms will exit the market, while the total output may be unaffected. In the field of industrial

organization, many studies have included firm, industry and regional features in the framework of firms' exit decisions (e.g., Ericson and Pakes, 1995; Weintraub, 2008).

Some empirical studies have confirmed the importance of allowing for industrial and firm-level heterogeneity. Based on a sample of over 3,800 FDI observations between 1993 and 1996, Dean, Lovely and Wang (2009) find significant evidence of pollution haven behavior of FDI firms funded by investors from Hong Kong, Macao, and Taiwan operating in highly-polluting industries in China. But FDI firms funded by non-ethnically Chinese sources are not significantly attracted by weak pollution standards, regardless of the pollution intensity of the industry. They thus ask for further investigation into differences in technology between industrial and developing country investors.

Using city-level panel data covering all the major metropolitan areas, Liang (2008) treats China's geographic features and regional differences in trade policies as exogenous sources of variation in access to FDI. He finds that for some regions, FDI may have beneficial effects on China's environment as multinationals crowd out inefficient local firms and improve local productivity and energy efficiency. This finding indicates that FDI can affect the local environment through different channels under different regional features. Lu, et. al. (2013) use the implementation of the Two Control Zone (TCZ) policy as a quasi-natural experiment and analyze the effect of environmental regulation differences on FDI flows with city-level data. They find that cities with tougher environmental regulation attract less FDI and this negative effect is stronger for polluting industries than for non-polluting industries.

Following Lu, et. al. (2013), we also use the implementation of the TCZ policy as a quasi-natural experiment, but instead of analyzing FDI inflows as a macroeconomic indicator of entry by foreign firms, we use firm-level data to analyze the exit decisions of incumbent foreign

and domestic firms following the TCZ policy implementation. Lu, et. al. focus on the effects of TCZ policy on FDI inflows at the city level. Our study investigates if firms' exit behavior are affected by the implementation of the TCZ policy. To accomplish this task, we follow the framework provided by Ericson and Pakes (1995) and developed by Weintraub et. al. (2008). The model aims to explain the great variability empirically observed between firms in terms of their exit processes given that some critical industrial and regional features are controlled. We assume each existing firm in the market makes decisions based only on its own state and knowledge of the long-run average industry and regional state, but it ignores current information about competitors' states. At any given time *t*, the firm must decide to continue or exit the market. The exit rule is based on the comparison between the sell-off value ϕ and the optimal expected net present value of all future profits. At any time *t*, it thus solves:

$$W_t(\omega_t, s_t) \equiv max_{\chi_t}\{E_t[\sum_{\tau=t}^{\infty}\beta^{\tau-t}R(\omega_\tau, x_\tau, s_\tau)\chi_\tau + \beta^{\tau-t}(\chi_{\tau-1} - \chi_\tau)\phi], \phi\}, \qquad (1)$$

where χ_τ is the continuation decision dummy variable. If the firm exits, $\chi_\tau = 0$, otherwise, $\chi_\tau = 1$. β is the discount factor, $R(\cdot)$ is the one period profit function, and ω_τ denotes firm's productivity. The firm's investment at period τ is $x_\tau \geq 0$. s_τ is a status vector that describes the market structure of the industry. If the first term in the bracket is greater than the second, the firm stays in the industry; otherwise, it leaves. The firm's maximized net present value at time *t*, W_t, therefore depends on both its productivity, ω_τ, and the industry market structure, s_τ.

Our study is based on this model, but introduces three additional types of control variables: 1) firm features other than productivity; 2) locational features to capture the sub-regional economic environment; and 3) industry features to capture the possible fixed industrial differences in response to TCZ policies. One of the important firm features that may affect a firm's exit decision is the capital intensity. Higher capital intensity indicates greater sunk cost.

Sunk costs can be barriers to exit because they induce irrecoverable losses for firms when they decide to leave the market (Sutton, 1991). In addition, higher capital intensity increases the entry cost of potential competitors, which may also lower incumbent's exit probability (O'Brien and Folta, 2009). There are also several other firm-level variables which are often included in firm exiting literature, such as firm size, financial leverage and firm age. Firms with higher short-run or long-run debt ratios tend to face higher financial risk and are more likely to exit the market (Harris and Raviv, 1991; Zwiebel, 1996).

Since 1978, China has adopted different regional development policies for coastal and inner land areas (Fung, et.al., 2004). As a result, China's coastal and inner regions are now in different development phases which may cause regional differences in firm behavior. Therefore, we add a regional dummy $coast_j$ into the regression which is equal to 1 when city *j* belongs to a coastal province or a municipality, and 0 otherwise. To control for possible industry heterogeneity, we also add industry dummies for each 2-digit level industry[7].

Based on the above arguments, we assume that the probability of firm exit depends on the firm's time-varying features, such as productivity, capital intensity, firm size, financial leverage and age (denoted by vector X_{ijkt}), and on control variables such as industry variables (ind_k), a regional dummy variable ($coast_j$), and year dummies ($year_t$). Therefore, a reduced form of the exit equation can be written as follows:

$$\Pr\left(Exit_{ijkt}\right) = p(X_{ijkt}, ind_{2k}, ind_{4k}, coast_j, year_t) \qquad (2),$$

where subscript *i* denotes firm, *j* denotes city, *2k* or *4k* denote 2-digit or 4-digit industry, and *t* denotes time.

[7] Based on the classification provided by National Statistical Bureau of China, there are 30 2-digit industries in the manufacturing sector. However, data for the nuclear industry is not available in our data source, so we have 29 industries in total.

Equation (2) is our benchmark equation. To study the effect of TCZ policy on firms' exit behavior, we add the dummy variable TCZ_j which is equal to 1 when city *j* is a two control zone and 0 otherwise. As mentioned above, firm heterogeneity may cause different impacts of pollution control policies. Therefore we add interaction terms between TCZ_j and firm size, productivity and exporter status, respectively.

According to Hering and Poncet (2011), differences in TCZ policy effects may be due to pre-TCZ industry heterogeneity that can be measured by three SO_2 emission-related industry variables: coal consumption over value-added for industry *k* ($coal_k$), its total energy use over value-added ($energy_k$) and its electricity use over value-added ($electricity_k$)[8]. To investigate the effects of industry heterogeneity, we add these three variables and the interactions between them and *TCZ* into our exit equation. On the other hand, since the TCZ policy has set specific targets for total SO_2 emissions and the emissions density, the differences in TCZ policy impacts may also be due to the differences in local SO_2 emissions control levels. TCZ city *j* with higher total SO_2 emission ($SO_2\_emission_{jt}$) or emission density (SO_2 emission over area ratio, denoted as $SO_2\_emission\_density_{jt}$) at time *t* may reflect loose implementation of pollution control policies, which can further weaken the impacts of TCZ policies. At the same time, TCZ city *j* with high efficiency of SO_2 emission at time *t* (SO_2 emission over output ratio, denoted as $SO_2\_emission\_efficiency_{jt}$) may indicate strong pollution control ability. Therefore, we incorporate these three regional pollution variables and the interactions between them and TCZ_j into our exit equation to study the effects of regional heterogeneity.

Since our focus is FDI firms' responses to TCZ policies, we first compare the exit behavior of FDI firms in TCZs and those in non-TCZs in the following statistical and

[8] We follow Hering and Poncet (2011) in using year 1997 data at the 2-digit industry level for these three variables to capture pre-TCZ industry heterogeneity. Therefore, these variables do not change over time.

econometric analyses. The differences can be reflected by the estimated coefficients of TCZ_j as well as the interactions between TCZ_j and other variables. Then, we compare the policy response differences between FDI firms and domestic firms. The differences can be reflected by the interactions between TCZ_j and firm ownership ($TCZ_j \bullet FDI$), as well as the interactions between $TCZ_j \bullet FDI$ and other variables.

3. Data and Summary Statistics

We use both city-level and firm-level data analysis in this paper. Most of our city-level data are 1997-2013 yearly data from the Chinese City Statistical Yearbook, which covers 291 prefectural level cities[9]. The Chinese City Statistical Yearbooks provide us the data on regional output, land area, total SO_2 emission, per km^2 SO_2 emission, number of firms, etc. The Consumer Price Index (CPI) for 27 provinces and 4 municipality cities is also reported by the Chinese City Statistical Yearbook for each year. Therefore, all value-related variables are deflated with provincial CPI in the following analysis. Another source of city-level data is the State Council's official document, "The Official Reply of the State Council Concerning Acid Rain Control Areas and SO2 Pollution Control Areas". It lists the names of all cities that belong to the Two Control Zones.

Figure 1 shows the total SO_2 emission in TCZs and non-TCZs from 1997 to 2013, as well as the percentage differences of SO_2 emission and Gross Regional Product (GRP) between TCZs and non-TCZs. The left vertical axis is for total SO_2 emission while the right vertical axis is for the percentage difference. We can see that the total SO_2 emission for both TCZs and non-TCZs increased a lot from 1997 to 2013, due to China's rapid economic growth. We also notice that the percentage difference of SO_2 emission between TCZs and non-TCZs decreased steadily during the same period. However, the percentage difference of GRP between TCZs and non-TCZs did

[9] A prefectural level city ranks below a province and above a county in China's administrative structure.

not change much. This indicates that the implementation of TCZ policies may have had some effects on the total SO_2 emission.

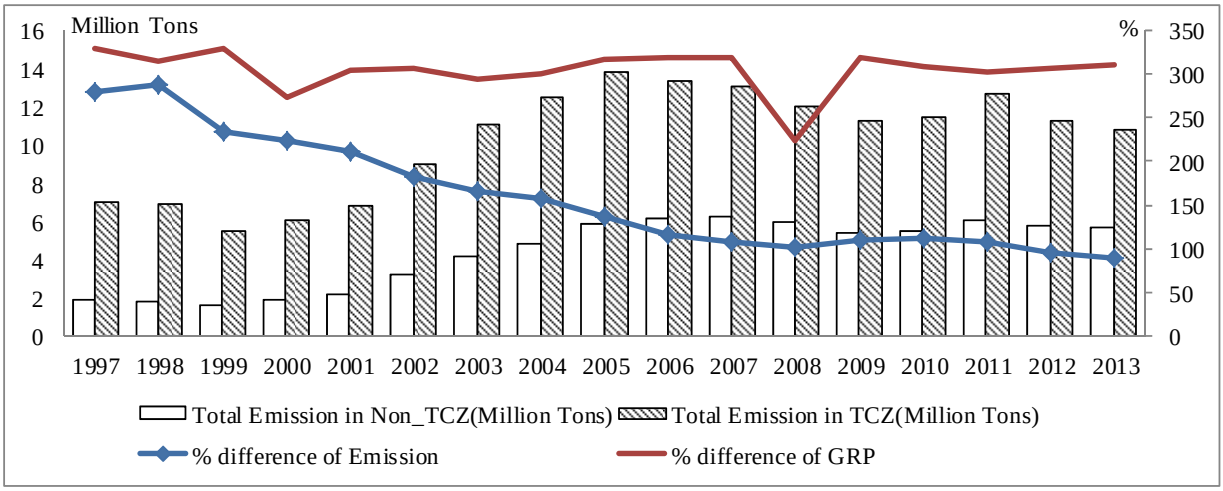

Figure 1. Total SO_2 Emission in TCZs and Non-TCZs

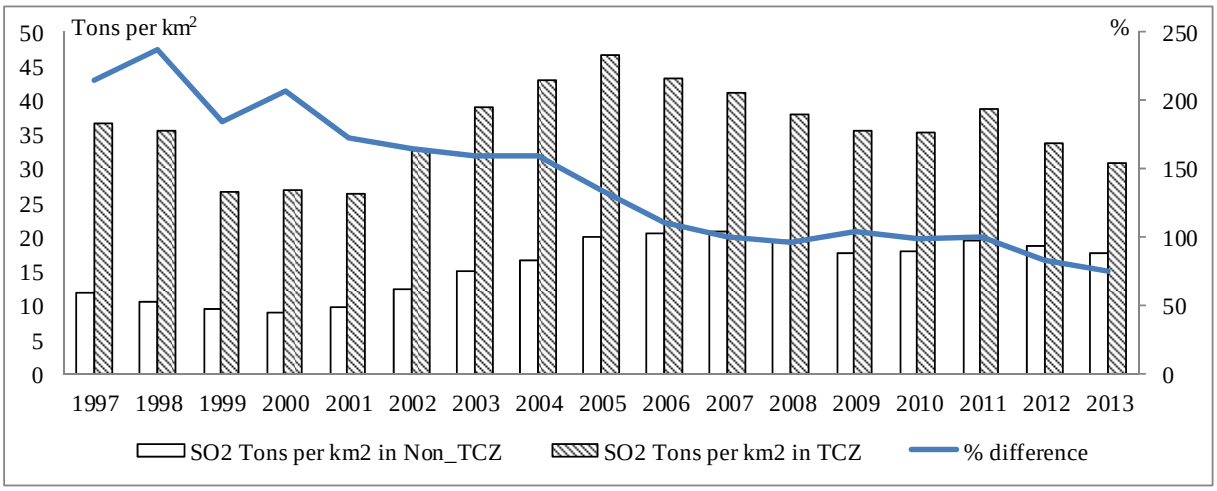

Figure 2. SO_2 Emission per km^2 in TCZs and Non-TCZs

Figure 2 presents the SO_2 emission per km^2, a measurement of the SO_2 emission density, in TCZs and non-TCZs and the % difference. Figure 3 reports the SO_2 emission per 10 yuan of GRP, a measurement of the SO_2 emission efficiency, in TCZs and non-TCZs and the % difference. We find that TCZs have higher SO_2 emission density but better SO_2 emission efficiency when compared with non-TCZs. The percentage difference of SO_2 emission density

between TCZs and non-TCZs decreased over the study period, which again suggests the effectiveness of TCZ policies. On the other hand, although the SO_2 emissions efficiency has decreased for both TCZs and non-TCZs from 1997 to 2013, the % difference has grown during the same period, as seen in Fig. 3 by negative values that increase in absolute value. This means that the SO_2 emission efficiency has improved more in TCZs than in non-TCZs, which again suggests the effectiveness of TCZ policies.

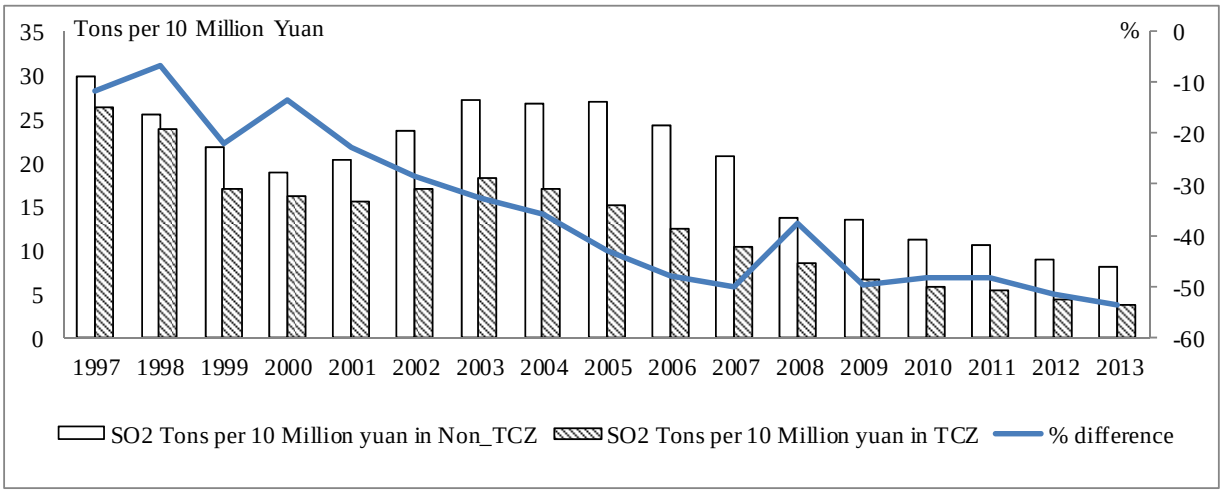

Figure 3. SO_2 Emission per 10 Million yuan GRP in TCZs and Non-TCZs

Since the city-level data seem to indicate real effects of TCZ policies, we continue investigating the TCZ policy effects by looking for evidence at the firm-level. Our firm-level data are annual observations for 1998-2009 from the Financial Information Database for Chinese industrial enterprises provided by the National Bureau of Statistics of China (NBSC). The firm-level database covers all non-state owned industrial firms with annual sales of 5 million yuan or more and all state-owned industrial firms in China. These firms can be divided into 37 industries at the 2-digit level, including 29 manufacturing industries, 5 mining industries and 3 utilities and recycling industries. We focus on the 29 manufacturing industries. As described in detail in Greaney and Li (2013), the firms are classified by ownership into five types: state-owned

enterprises (SOEs), other domestic enterprises (ODEs),[10] foreign-direct-invested enterprises (FDIEs) and Hong-Kong-Macao-Taiwan-invested-enterprises (HMTEs). The firm-level data is cleaned by excluding firms that report values that include apparent errors (i.e., negative values for assets, exports exceeding sales, employment subgroups that do not add up to totals reported, total fixed assets exceeding total assets, etc.) or non-exiting firms that report less than 10 employees or less than 1000 yuan in average annual income per worker or total assets. We lose about 7% of firms in our chosen industries through data cleaning.

Many studies have shown that environment policies may affect firms' entry decisions and cause so-called "selection effects". Firms born in TCZ cities after the implementation of the TCZ policies may already have cleaner production techniques and be more likely to survive under strict environment controls. To exclude this selection effect, our analysis only focuses on firms established before 1998, the year that TCZ policies went into effect. [11]

Our firm-level dataset provides basic information for each firm such as firm name and ID number, establishment year and month, zip code, sector and ownership information. It also provides data on each firm's output, employment, capital and other operations-related data. The strength of our data is the detailed information we have at the firm level to use in explaining the exit decisions of firms. By government registration procedures, each firm name and ID number are unique identifiers for a single firm. We use the ID number to identify each firm since the firm names in Chinese are more likely to have typos. In our data, whenever a firm exits the market, its data record stops. Unfortunately for our inquiry, there is another reason why a firm's data record may stop—a change of ownership. Even if a firm remains in the same location and industry, its ID number changes with a change of ownership (e.g., a foreign takeover or privatization). This

[10] ODEs include collectives and private domestic enterprises.
[11] There are more than 150 thousand firms established before 1998 in our dataset.

type of ownership change does not move the production location of the firm, so the firm continues to be subject to the same pollution control policies. To exclude these types of ownership changes from the firm exits that we wish to study, we reassign unique firm ID numbers to observations with the same firm name, zip code and sector ID, thereby including these ownership-changing firms as continuing (i.e., non-exiting) firms.[12]

An additional weakness of our data is that it does not include the parent company of firms that newly enter the market. The starting year indicated in our data can be the year in which the firm changed its ownership. Due to these data limitations, we do not study firms' entry behavior.

Our variables are constructed as follows:

Exit: According to the definition of exit in Weintraub et. al. (2008), an incumbent at period *t* is a firm that is present both during the current year *t* and the next year, whereas a firm that exits at period *t* is in the market during year *t* but not during period *t+1* and all following years. $Exit_{it}$ is a dummy variable equal to 1 if firm *i* exits in year *t*, and 0 otherwise. Therefore, the firm-level data for 2009 are dropped in our regression since we cannot observe if the firms are still in market in 2010. As firms may disappear in period *t+1* and appear in period *t+2* again, we also dropped 2008 firm-level data to avoid these cases.[13]

Firm-specific variables (X_{it}): Firm *i*'s size at time *t* is measured by its number of employees (L_{it}). To measure productivity of firm *i* at time *t* (ω_{it}), we estimate firm *i*'s total factor productivity at time *t* (tfp_{it}) using the Olley-Pakes (1996) production function. Capital intensity is

[12] There are 29,713 firms that change their firm ID without changing location or industry, which covers 123,094 observations, about 10% of our total observations. In unreported estimations, we dropped these ownership-changing firms from our data and found that the signs and significance of estimated coefficients are not different from those reported in Tables 4 and 5. A firm's record also may be stopped because its annual sales fall below 5 million yuan. In this case, we treat the firm as exiting the market. For firms with records that disappear for some years and then appear again, we only count its last disappearance as an exit.

[13] We have 50,262 firms that disappear from the data in year t+1 and appear again in year t+2. But only 4,768 firms disappear for more than 2 years and appear again.

measured by the ratio of fixed capital over L_{it}. The average annual wage level of each firm ($Wage_{it}$) is measured by the total wage bill divided by L_{it}. An exiting firm may become smaller and pay lower wages, so an endogeneity problem may exist between $Exit_{it}$ and L_{it} or $Exit_{it}$ and $Wage_{it}$. Therefore we take one period lags for L_{it} and $Wage_{it}$ to solve the endogeneity problem. We thus dropped firm-level data for 1998 in our regression. Two ratios are used to measure a firm's financial leverage: current liability over total assets and long-term liability over total assets. For firm ownership types, we focus on two dummy variables, *HMTE* and *FDIE*, which equal 1 when the firm is a HMTE or FDIE and 0 otherwise.

Finally, two dummy variables are used to measure a firm's exporter status: *PEX* and *EX*. If a firm is a pure exporter that exports more than 90% of its sales, *PEX* equals 1, and 0 otherwise. If a firm exports but is not a pure exporter, *EX* equals 1, and otherwise 0. Since pure exporters export almost all of their output, China's various sources of comparative advantage, possibly including its lax environmental policies, may be more important for them than for non-exporting or regular exporting firms. Therefore, pure exporters may be more sensitive to changes in pollution control than other firms. Alternatively, Defever and Riaño (2012) and Lu, Lu and Tao (2014) find that special subsidies given to pure exporters allow them to operate even when they are less productive than regular exporters, but more productive than non-exporters, on average. This evidence supports our inclusion of separate *PEX* and *EX* dummies, and suggests that ranking regular, pure and non-exporters based on their sensitivity to pollution control policies is complicated by the existence of productivity and subsidy differentials.

Industry-specific variables (Ind_{kt}): Following Blanchard (2012), the industry structure is measured using the Herfindahl-Hirschman concentration index calculated from the firm-level data for each 4-digit industry *k* observed at year *t*:

$$Concen_{4kt} = \sum_{i=1}^{i=N_{4kt}} \left(\frac{VA_{it}}{\sum_{i=1}^{i=N_{4kt}} VA_{it}} \right)^2$$

where N_{4kt} is the number of firms belonging to industry *k* in year *t*. VA_{it} is the output of firm *i* in year *t*. For the three SO_2 emission-related industry variables ($coal_{2k}$, $energy_{2k}$ and $electricity_{2k}$) we borrow from Hering and Poncet (2011) and match with each firm based on its sector information.

Region-specific variables (Reg_{jt}): Based on a firm's zip code information, we set $TCZ_{ij} = 1$, if the firm is located in a TCZ. Otherwise, $TCZ_{ij} = 0$. Among the 280 cities covered by our firm level data, 155 are listed as TCZ cities. According to Hering and Poncet (2011), although most of the TCZs are located in the middle and coastal regions of China, the TCZ dummy variable is not "simply picking up heterogeneity in terms of outward orientation of cities". All TCZs have FDI and HMT firms. There are also FDI and HMT firms in Non-TCZs. Three other regional variables are *total* SO_2 *emission*$_{jt}$ (Million Tons), SO_2 *emission density*$_{jt}$ (Tons per 1000 km^2) and SO_2 *efficiency*$_{jt}$ (Tons per 10,000 yuan)[14] mentioned earlier. These city-level data are matched with firm-level data based on firm zip code.

Table 1 shows the shares of firms with specific features by firm ownership in TCZs or Non-TCZs. Small firms refer to firms with employment less than median employment over all firms in the same year. Small firms tend to be more sensitive to cost changes (Monk, 2000) and the tightening of pollution control can cause costs to increase. Therefore, small firms may be more sensitive to changes in pollution policies. Firms with high TFP refer to firms with TFP greater than the median TFP over all firms in the same year. Coal- (or energy-) intensive firms refer to firms with coal (or energy) consumption greater than the median level over all firms in

[14] In Figure 3, we use tons per 10 million yuan for the units of SO_2 *efficiency*$_{jt}$ for convenience in displaying the figure's scale. Here, we use tons per 10,000 yuan so that the estimated coefficients in later regressions are not too large in scale.

the same year. We can see that the majority of the firms are domestic firms (0.416 for ODE and 0.14 for SOE). Across all regions domestic firms have greater shares of small, coal-intensive, energy-intensive and exiting firms. FDIEs or HMTEs have greater shares of high TFP firms and exporters. On the other hand, TCZs have greater shares of small firms and exporters, but smaller shares of high TFP, coal-intensive, energy-intensive and exiting firms. However, there are

Table 1.Share of Firms with Specific Features by Region and Firm Type
(Based on 1999-2007data)

Regions	Firm Types	Small Firms	Firms with High TFP	Regular Exporter	Pure Exporter	Coal-Intensive Firms	Energy-Intensive Firms	Firms Exit	Share in the Region
Non-TCZs	FDIE	0.348	0.639	0.343	0.224	0.540	0.084	0.112	0.052
	HMTE	0.384	0.565	0.274	0.199	0.566	0.087	0.130	0.045
	ODE	0.430	0.543	0.138	0.040	0.640	0.134	0.148	0.456
	SOE	0.370	0.403	0.106	0.012	0.655	0.111	0.210	0.185
	All	0.425	0.516	0.140	0.051	0.641	0.131	0.168	
TCZs	FDIE	0.377	0.626	0.382	0.286	0.464	0.093	0.094	0.108
	HMTE	0.359	0.513	0.284	0.371	0.483	0.091	0.114	0.140
	ODE	0.466	0.509	0.174	0.074	0.541	0.119	0.125	0.406
	SOE	0.381	0.392	0.151	0.015	0.555	0.109	0.187	0.129
	All	0.438	0.502	0.196	0.129	0.533	0.117	0.140	
All Regions	FDIE	0.374	0.628	0.378	0.279	0.472	0.092	0.096	0.097
	HMTE	0.361	0.518	0.283	0.358	0.490	0.090	0.116	0.122
	ODE	0.458	0.520	0.166	0.066	0.564	0.122	0.131	0.416
	SOE	0.379	0.422	0.135	0.014	0.589	0.110	0.192	0.140
	All	0.435	0.512	0.183	0.113	0.557	0.120	0.146	

different patterns for domestic and foreign firms in some aspects. For example, FDIEs and HMTEs have greater shares of energy-intensive firms in TCZs, but SOEs and ODEs have greater shares of energy-intensive firms in Non-TCZs. There are greater shares of FDIEs and HMTEs in TCZs than in Non-TCZs, and correspondingly greater shares of SOEs and ODEs in Non-TCZs than in TCZs. We can also see some differences between HMTEs and FDIEs. FDIEs have greater shares of small firms in TCZs while HMTEs have greater shares of small firms in Non-TCZs. The share of HMTE pure exporters in TCZs is almost twice the corresponding share in Non-

TCZs, but the difference for FDIEs is small. Therefore, if these firm characteristics impact firms' exiting behavior, they may cause different responses to TCZ policies.

Table 1 also shows that FDIEs and HMTEs have lower shares of exiting firms in TCZs than in Non-TCZs. This observation that foreign firms are less likely to exit from regions with stricter pollution control goes against a basic prediction of the pollution haven hypothesis. However, since TCZs have lower shares of exiting firms overall than Non-TCZs, there may be other regional characteristics that dominate the pollution haven effect and attract foreign firms.

Table 2 shows the annual exit rate of firms with specific features in TCZs and Non-TCZs. We can see from the "All" firms column that in most years, firms in TCZs have lower exit rates than those in Non-TCZs on average. FDIEs have the lowest exit rates among all ownership types in both regions and in most years while SOEs have the highest exit rates. For both regions, exporters or firms with higher TFP have lower than average exit rates in most years, while firms with smaller size or higher coal consumption intensity have higher than average exit rates. The exit rate differences (in percentage terms) between high TFP firms and average level firms are greater in Non-TCZs than in TCZs. The exit rate differences between small firms and average firms are greater in Non-TCZs for years before 2002 and greater in TCZs from 2002 onward. At the same time, energy-intensive firms in Non-TCZs have lower than average exit rates in 7 of 9 years, but those in TCZs have greater than average exit rates in 6 of 9 years. Therefore, firms with different ownership, size, TFP or exporter status have different exiting tendencies. Firms in industries with different coal-intensity or energy-intensity may also have different exiting tendencies. The impact of firm features and industry features can also differ by regions with different pollution control policies.

Table 2. Exit Rates of Firms with Specific Features in TCZs and Non-TCZs

Regions	year	All	FDIE	HMTE	ODE	SOE	Small	Regular Exporters	Pure Exporters	High TFP	Coal-Intensive	Energy-Intensive
Non TCZs	1999	0.134	0.093	0.094	0.122	0.148	0.155	0.088	0.094	0.107	0.138	0.133
	2000	0.198	0.108	0.138	0.198	0.211	0.223	0.149	0.173	0.175	0.206	0.182
	2001	0.159	0.093	0.113	0.133	0.191	0.194	0.109	0.112	0.134	0.164	0.165
	2002	0.183	0.109	0.148	0.151	0.226	0.213	0.110	0.136	0.158	0.193	0.192
	2003	0.295	0.163	0.185	0.282	0.319	0.352	0.175	0.200	0.250	0.314	0.272
	2004	0.134	0.098	0.121	0.085	0.318	0.112	0.077	0.089	0.099	0.127	0.117
	2005	0.090	0.065	0.089	0.074	0.158	0.101	0.080	0.072	0.070	0.097	0.089
	2006	0.100	0.072	0.081	0.070	0.338	0.125	0.061	0.071	0.067	0.109	0.093
	2007	0.282	0.226	0.221	0.273	0.320	0.303	0.237	0.239	0.275	0.291	0.270
TCZs	1999	0.144	0.074	0.104	0.139	0.150	0.163	0.102	0.108	0.114	0.147	0.146
	2000	0.189	0.091	0.123	0.193	0.210	0.210	0.127	0.133	0.161	0.197	0.200
	2001	0.113	0.062	0.078	0.101	0.150	0.138	0.070	0.080	0.086	0.118	0.124
	2002	0.127	0.067	0.086	0.113	0.190	0.150	0.078	0.086	0.102	0.133	0.137
	2003	0.199	0.110	0.150	0.188	0.254	0.240	0.132	0.141	0.163	0.204	0.186
	2004	0.116	0.082	0.100	0.094	0.252	0.105	0.070	0.088	0.083	0.117	0.111
	2005	0.086	0.072	0.083	0.072	0.147	0.104	0.065	0.075	0.056	0.089	0.089
	2006	0.090	0.065	0.082	0.066	0.314	0.116	0.052	0.077	0.053	0.095	0.087
	2007	0.228	0.193	0.219	0.218	0.325	0.248	0.200	0.195	0.220	0.237	0.230

4. Estimation Results

As Figures 1-3 have shown, TCZ and Non-TCZ regions differ in their SO_2 emission, density and efficiency every year, as well as in the time trends of these variables. These disparities may reflect both the differences in pollution control levels between the two regions and the differences in how heterogeneous firms respond to pollution controls. To further study the effects of TCZ policies on foreign firms' exit behavior, our next step is to estimate equation (2) based on FDIEs and HMTEs established before 1998 with a random effect panel logit regression. Table 3 shows the results. The equation estimated in column (1) includes only firm-specific variables.

We add region- and industry-specific variables step by step in columns (2)-(7). We can see that all control variables are significant with expected signs. Foreign firms with higher productivity (TFP), larger size, greater capital intensity and better workers (measured by higher average wage) are less likely to exit the market, as one would expect. Firms that are older or facing higher financial risk (i.e., higher current or long-run liability ratio) are more likely to exit. As we mentioned earlier, coastal regions of China have better economic development, so we expect that firms in coastal regions are more competitive and less likely to exit than those in other regions. Our estimation results in column (2) are consistent with this expectation. The estimated coefficient for *coast* is negative and significant. The estimated coefficient for *Industry Concentration* is significant and positive, as expected. Column (3) shows that the estimated coefficient for *TCZ* is negative and significant. The estimated coefficient for *coast* is still significant and negative, but the absolute value is smaller than in column (2). These results indicate that after controlling for coastal locations, industry concentration and firm features such as TFP and firm size, foreign firms in TCZs are still less likely to exit than those in Non-TCZs on average. This evidence runs counter to the prediction of the pollution haven hypothesis. In

column (4), the estimated coefficients for *FDIE* and *FDIE*TCZ* are insignificant, which indicates that the exit behavior of FDIEs is not significantly different from that of HMTEs in both TCZs and Non-TCZs.

In columns (5) and (6), we add the interactions *TFP*TCZ* or *Firm Size*TCZ* into the regression. The estimated coefficients for the two interaction terms are both negative and significant. This indicates that TFP and firm size are even stronger exit deterrents in TCZs than in non-TCZs. However, the estimated coefficients for *TCZ* become positive and significant in columns (5) and (6). This means that, if foreign firms are very small or have very low productivity, the total effect of *TCZ + TFP*TCZ* or *TCZ + Firm Size*TCZ* can be positive; that is they are more likely to exit the market in TCZs than in Non-TCZs. On the other hand, if foreign firms are large or have high productivity, they are less likely to exit the market in TCZs than in Non-TCZs. These results imply that firm characteristics matter in looking for evidence of the pollution haven hypothesis.

In column (7), we add exporter status dummies and interactions between them and *TCZ* into the estimation. We can see that the estimated coefficients for *EX* and *PEX* are both significant and negative. It indicates that both types of exporters are less likely to exit. This is consistent with the Melitz (2003) model prediction. The estimated coefficient for *EX*TCZ* is also significant and negative. This means that exporter status is a stronger exit deterrent for regular exporters in TCZs than those in Non-TCZs. However, the estimated coefficient for *PEX*TCZ* is significant and positive, indicating that exporter status is a weaker exit deterrent for pure exporters in TCZs than those in Non-TCZs. These results imply that foreign regular exporters and foreign pure exporters respond differently to TCZ policies, on average.

As we have mentioned earlier, there may be reasons other than TCZ policies that make all

firms in TCZs less likely to exit than those in Non-TCZs on average. Therefore our next step is to examine the exit behavior of both foreign and domestic firms. Table 4 reports our estimation results for foreign firms only, domestic firms only, and all firms combined. In unreported results, all control variables are still significant with expected signs in regressions reported in Table 4. The estimated coefficients in the first block "Foreign Firms" are the same as those in Table 3. For

Table 3. Panel Logit Regression Results For FDI and HMT Firms Established Before 1998

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm Age	0.471 ***	0.223 ***	0.220 ***	0.202 ***	0.219 ***	0.216 ***	0.196 ***
Firm Size$_{i,t-1}$	-0.304 ***	-0.341 ***	-0.340 ***	-0.340 ***	-0.340 ***	-0.234 ***	-0.286 ***
TFP	-0.287 ***	-0.432 ***	-0.433 ***	-0.428 ***	-0.362 ***	-0.433 ***	-0.434 ***
K/L	-0.051 ***	-0.021 ***	-0.022 ***	-0.019 ***	-0.021 ***	-0.022 ***	-0.033 ***
Wage$_{i,t_1}$	-0.157 ***	-0.224 ***	-0.217 ***	-0.208 ***	-0.216 ***	-0.218 ***	-0.201 ***
Current Liability/K	0.349 ***	0.442 ***	0.442 ***	0.439 ***	0.444 ***	0.441 ***	0.413 ***
Long-term Liability/K	0.591 ***	0.712 ***	0.706 ***	0.708 ***	0.707 ***	0.704 ***	0.658 ***
Coast		-0.116 ***	-0.087 ***	-0.100 ***	-0.090 ***	-0.088 ***	0.002
Industry Concentration		2.080 ***	2.075 ***	2.069 ***	2.065 ***	2.065 ***	2.060 ***
TCZ			-0.130 ***	-0.099 **	0.496 **	0.457 ***	-0.105 **
FDIE				-0.068			
FDIE*TCZ				-0.089			
TFP*TCZ					-0.081 ***		
Firm Size$_{i,t-1}$*TCZ						-0.117 ***	
EX							-0.294 ***
EX*TCZ							-0.688 ***
PEX							-0.141 *
PEX*TCZ							0.191 **
Num. of Obs.	188,664	188,664	188,664	188,664	188,664	188,664	188,664
Industry Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***=significant at the 1% level; **=significant at the 5% level;
*=significant at the 10% level;

the "Domestic Firm" results, we can see that the estimated coefficients for *TCZ* are still significant and negative in most cases. Therefore, on average, domestic firms in TCZs are less likely to exit than those in Non-TCZs, similar to the result found for foreign firms. The estimated coefficients for *SOE* and *TCZ*SOE* are both significant and positive. This indicates that SOEs are more likely to exit than other domestic firms and this effect is stronger in TCZs than in Non-TCZs. This result differs from Hering and Poncet's (2011) finding that the implementation of TCZ policies is weaker on SOEs than on other types of firms. This may be because Hering and Poncet (2011) focus on firms' exporting behavior instead of exiting behavior, so they include only SOE exporters while we include all SOEs.[15]

The estimated coefficients for *TFP*, *EX*, *PEX* and *Firm Size* are all significant and negative for domestic firms, similar to the results found for foreign firms. However, the estimated coefficients for interactions *TCZ*TFP*, *TCZ*EX* and *TCZ*PEX* are not significant for domestic firms. Therefore, the effect of productivity and exporter status on domestic firms' exit behavior does not differ based on whether a firm is subject to TCZ policies or not. On the other hand, the estimated coefficient for the interaction *TCZ*Firm Size* is still significant and negative. Therefore, the TCZ policies enhance the effects of firm size in deterring firm exit.

For the "All Firms" block of results, we can see that the estimated coefficients for *TCZ*, *FDIE* and *HMTE* are all significant and negative. This means that firms in TCZs are significantly different from those in Non-TCZs in that they are less likely to exit, on average. At the same time, foreign firms are less likely to exit than private domestic firms. The estimated coefficients for *SOE* and *SOE*TCZ* in the benchmark column are significant and positive. This indicates that SOEs are more likely to exit than private domestic firms and the TCZ policies strengthen this

[15] Since we find no evidence that the implementation of TCZ policies is weaker for SOEs than for other domestic firms, we compare foreign firms with all domestic firms combined (i.e., SOEs and other domestic firms) in most of the later analysis in the paper.

effect. However, the estimated coefficients for *FDIE*TCZ* and *HMTE*TCZ* in the benchmark column are not significant. We can interpret the results from the estimated coefficients on *FDIE*, *HMTE*, *FDIE*TCZ* and *HMTE*TCZ* to mean that foreign firms, on average, are less likely to exit than private domestic firms and TCZ policies do not change this difference significantly. On

Table 4. The Effects of Firm Features on Firms' Responses to TCZ Policies

Firm Types	Variables	Firm Features					
		FDIE	SOE	TFP	EX	PEX	Firm Size
Foreign Firms	TCZ	-0.099 **		0.496 **	-0.105 **	-0.105 **	0.457 ***
	Firm Feature	-0.068		-0.362 ***	-0.294 ***	-0.141 *	-0.234 ***
	TCZ*Firm Feature	-0.089		-0.081 ***	-0.688 ***	0.191 **	-0.117 ***
	Num. of Obs.	188,664		188,061	188,664	188,664	188,664
Domestic Firms	TCZ		-0.136 ***	-0.100 **	-0.118 ***	-0.118 ***	0.006
	Firm Feature		0.095 ***	-0.221 ***	-0.195 ***	-0.325 ***	-0.168 ***
	TCZ*Firm Feature		0.061 ***	-0.003	0.002	0.042	-0.026 ***
	Num. of Obs.		621,252	621,253	621,254	621,255	621,256
		Firm Features					
		Benchmark		TFP	EX	PEX	Firm Size
All Firms	TCZ	-0.137 ***		-0.139 ***	-0.131 ***	-0.131 ***	-0.135 ***
	FDIE	-0.336 ***		-0.328 ***	-0.268 ***	-0.268 ***	-0.348 ***
	HMTE	-0.249 ***		-0.250 ***	-0.200 ***	-0.200 ***	-0.256 ***
	SOE	0.077 ***		0.021	0.074 ***	0.074 ***	0.077 ***
	FDIE*TCZ	-0.036		0.278 **	0.101 **	0.101 **	0.481 ***
	HMTE*TCZ	0.022		0.636 ***	0.149 ***	0.149 ***	0.726 ***
	SOE*TCZ	0.063 ***		-1.062 ***	0.049 **	0.049 **	0.058 ***
	Firm Feature			-0.291 ***	-0.183 ***	-0.298 ***	-0.185 ***
	FDIE*TCZ *Firm Feature			-0.040 ***	-0.248 ***	-0.170 ***	-0.104 ***
	HMT*TCZ *Firm Feature			-0.081 ***	-0.210 ***	-0.130 ***	-0.141 ***
	SOE*TCZ *Firm Feature			0.167 ***			
	Num. of Obs.	809,916		809,916	809,916	809,916	809,916

Notes: ***=significant at the 1% level; **=significant at the 5% level;
*=significant at the 10% level;

the other hand, if we combine the results from the *TCZ*, *FDIE*TCZ* and *HMTE*TCZ* coefficients, they show that the higher tendency for firms to exit in TCZs than in non-TCZ does not vary significantly with firm ownership. These results can be interpreted as supporting neither the pollution halo hypothesis nor the pollution haven hypothesis since we found that foreign firms were neither less likely nor more likely to exit from TCZs than domestic private firms.

However, in the last four columns of the "All Firms" results in Table 4, when we add interactions between firm features and *FDIE*TCZ*, *HMTE*TCZ* into the regressions, the estimated coefficients for *FDIE*TCZ* and *HMTE*TCZ* all become significant and positive. The estimated coefficients for firm features, such as *TFP*, *EX*, *PEX* and *Firm Size*, are still all significant and negative. The 3-variable interactions between these firm features and *FDIE*TCZ* or *HMTE*TCZ* are also significant and negative. These results indicate that among firms that export, are large or have high TFP in TCZs, foreign firms are less likely to exit than domestic firms. This is consistent with the pollution halo hypothesis. On the other hand, among TCZ firms that are non-exporters, small, or have low TFP, foreign ownership is associated with a higher probability of exit than domestic ownership. This result is consistent with the pollution haven hypothesis.

However, the above analysis does not control for other features of TCZ regions, aside from pollution control policies, that may contribute to the different responses of foreign firms and domestic firms in TCZs versus non-TCZs. To solve this problem, we add SO_2-related industry features or regional features into the regressions. Table 5 reports the estimated coefficients of industry or regional variables and the interactions between them and TCZ for regressions based on data of different types of firms. We can see that the estimated coefficients of all industry variables are significant and positive while all those for regional variables are

insignificant for regressions based on foreign firm data. Only one interaction, *TCZ*Electricity*, has a significant coefficient and it is negative. These results mean that foreign firms in industries with more intensive coal, energy or electricity consumption are more likely to exit, and TCZ policies weaken the effect of electricity consumption on firm exit. On the other hand, the selected regional features have no significant effects on foreign firms' exit behavior.

Table 5. The Effects of Regional or Industry Features on Firms' Responses to TCZ Policies

Firm Types	Variables	Industry Feature			Regional Feature		
		Coal	Energy	Electricity	SO2 Emission Density	Total SO2 Emission	SO2 Efficiency
Foreign Firms	*TCZ*	-0.12***	-0.12***	-0.06	-0.11**	-0.13**	-0.09*
	RegF or *IndF*	261.06***	32.78***	284.94***	0.16	0.13	-0.21
	*TCZ*RegF* or *TCZ*IndF*	-0.43	-0.45	-27.16*	0.11	0.33	-0.28
	Num. of Obs.	188,061	176,994	188,061	165,938	165,941	166,285
All Firms	*TCZ*	-0.138***	-0.098***	-0.082***	-0.14***	-0.13***	-0.13***
	FDIE	-0.342***	-0.263***	-0.280***	-0.33***	-0.33***	-0.33***
	HMTE	-0.251***	-0.188***	-0.166***	-0.28***	-0.28***	-0.27***
	SOE	0.078***	0.107***	0.154***	0.09***	0.08***	0.08***
	FDIE*TCZ	-0.041	-0.117***	-0.062*	-0.03	-0.07*	-0.03
	HMTE*TCZ	0.022	-0.023	-0.020	0.034	-0.02	0.06
	SOE*TCZ	0.060***	0.022	0.004	0.054**	0.05**	0.06***
	RegF or IndF	357.139***	1.576	154.470	0.127***	-0.24***	-0.28**
	FDIE*TCZ*RegF or FDIE*TCZ*IndF	0.212	0.084	-11.898*	0.166	0.73***	0.45
	HMT*TCZ*RegF or HMT*TCZ*IndF	-0.016	-0.086	-11.699**	0.502***	1.30***	-0.36
	Num. of Obs.	807,346	741,304	807,346	705,675	705,797	714,528

Notes: 1. ***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level;
2. *RegF* denotes regional feature variables: *Coal*, *Energy*, or *Electricity*; *IndF* denotes industry feature varibles: SO_2 *Emission Density*, *Total* SO_2 *Emission* or SO_2 *Efficiency*

For Table 5 regressions based on data for all firms, we can see that the estimated coefficients for *FDIE*TCZ* are negative in all cases but significant in only three of the six

specifications when *Energy*, *Electricity* or *Total SO_2 Emission* is added into the regression. In these three cases, FDIEs are less likely to exit than domestic firms in TCZs, which is consistent with the pollution halo hypothesis. The *HMTE*TCZ* term does not produce any significant coefficients, so HMTEs do not appear less likely to exit than domestic firms from TCZs on average. However, the estimated coefficients for *FDIE*TCZ*Electricity* and *HMTE*TCZ*Electricity* are significant and negative. This indicates that in industries with high electricity consumption, both types of foreign firms are less likely to exit than domestic firms from TCZs. On the other hand, we also find that the estimated coefficients for *HMTE*TCZ*SO_2 Emission Density*, *HMTE*TCZ*Total SO_2 Emission* and *FDIE*TCZ*Total SO_2 Emission* are significant and positive. These results indicate that among TCZ cities with higher total SO_2 emission, both types of foreign firms are more likely to exit than domestic firms. Among TCZ cities with higher SO_2 emission density, HMTEs are more likely to exit than domestic firms. This may be because TCZ cities with higher SO_2 emission density and total SO_2 emission may have weaker implementation of pollution control. This can further weaken foreign firms' comparative advantage in environmentally friendly operations and the pollution halo effect.

5. Conclusions

In this paper, we study the effect of China's pollution control policies, the Two Control Zones policies, on the exiting behavior of different types of firms in China. We find that on average, foreign firms' response to TCZ policies are not significantly different from domestic firms. However, if firms are disaggregated based on their size, productivity and exporter status, we find evidence supporting both the pollution halo and pollution haven hypotheses. Foreign firms with smaller size, lower productivity or non-exporter status are more likely to exit TCZs than Non-TCZs and this differential tendency is stronger than that of domestic firms. This is

consistent with the pollution haven hypothesis. On the other hand, foreign firms with larger size, higher productivity or exporter status are less likely to exit TCZs than Non-TCZs and this differential is stronger than that for domestic firms. This is consistent with the pollution halo hypothesis.

We also find that for industries with higher electricity consumption, the pollution halo effects are even stronger. For foreign firms in industries with higher electricity consumption, the tendency to stay in regions with stronger pollution control is even stronger. At the same time, for TCZs with weak implementation of pollution control, as indicated by higher total SO_2 emissions or higher SO_2 density, the pollution halo effects are weakened. The probability of exiting for foreign firms is thus higher in TCZs with weaker implementation of pollution control. Weak enforcement of pollution control also may correspond with weak enforcement of government policies in general, which may make a city less attractive for foreign firms.

Overall, we find that the effects of pollution control policies on foreign firms' exiting behavior can be different due to the differences in firms' size, productivity and exporter status. SO_2-related industrial and regional characteristics also can affect foreign firms' responses to pollution control policies. Further research on these issues can help to inform policy makers so that China can take advantage of pollution halo effects and avoid pollution haven problems.

References

Becker, Randy and Vernon Henderson. 2000. "Effects of Air Quality Regulations on Polluting Industries," *Journal of Political Economy*, 108, 379-421.

Blackman, Allen & Wu, Xun, 1999. "Foreign direct investment in china's power sector: trends, benefits and barriers," *Energy Policy*. 27(12), 695-711.

Blanchard, Pierre and Huiban, Jean-Pierre and Mathieu, Claude, 2012. "The determinants of firm exit in the French food industries," *Review of Agricultural and Environmental Studies*, 93(2), 193-212.

Cole, Matthew A. & Elliott, Robert J.R. & Strobl, Eric, 2008. "The environmental performance of firms: The role of foreign ownership, training, and experience," *Ecological Economics*, 65(3), 538-546.

Chung, Sunghoon, 2014. "Environmental regulation and foreign direct investment: Evidence from South Korea, " *Journal of Development Economics*, Elsevier, 108(C), 222-236

D'Agostino, Lorena, 2015. "How MNEs respond to environmental regulation: integrating the Porter hypothesis and the pollution haven hypothesis," *Economia Politica*, 32(2), 245-269.

Dean, Judith M., Mary E. Lovely, and Hua Wang. 2009. "Are Foreign Investors Attracted to Weak Environmental Regulations? Evaluating the Evidence from China," *Journal of Development Economics*, 90, 1-13.

Defever, Fabrice and Riaño, Alejandro, 2012. "China's Pure Exporter Subsidies", CESifo Working Paper No. 4054.

Elliott, Robert and Zhou, Ying, 2013. "Environmental Regulation Induced Foreign Direct Investment," *Environmental & Resource Economics*, 55(1), 141-158.

Ericson Richard, Pakes Ariel. 1995. "Markov-perfect industry dynamics: A framework for empirical work," *Review of Economic Studies*, 62 (1), 53-82.

Eskeland, Gunnar S. and Ann E. Harrison. 2003. "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis," *Journal of Development Economics*, 70, 1-23

Friedman, Joseph, Daniel A. Gerlowski, and Johnathan Silberman. 1992. "What Attracts Foreign Multinational Corporations? Evidence from Branch Plant Location in the United States," *Journal of Regional Science*, 32, 403-418.

Fung, Kwok-Chiu, Iizaka, Hitomi and Tong, Sarah, 2004. "Foreign Direct Investment in China: Policy, Recent Trend and Impact," *Global Economic Review*, 33, 99-130.

Harris Milton, and Artur Raviv. 1991. "The Theory of Capital Structure," *Journal of Finance*, 46(1), 297-355

Henderson, Vernon. 1996. "Effects of Air Quality Regulation", *American Economic Review*, 86, 789-813.

Hering, Laura and Poncet, Sandra, 2011. "Environmental policy and trade performance: Evidence from China," Working Papers 2011-30, CEPII research center

Javorcik, Beata S. and Shang-jin Wei. 2004. "Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth? ," *Contributions to Economic Analysis & Policy* 3, Article 8.

Kellenberg, Derek K. 2009. "An Empirical Investigation of the Pollution Haven Effect with Strategic Environment and Trade Policy", *Journal of International Economics*, 78, 242-255.

Keller, Wolfgang and Arik Levinson. 2002. "Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States", *Review of Economics and Statistics*, 84, 691-703.

Levinson, Arik. 1996. "Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures", *Journal of Public Economics*, 62, 5-29.

Levinson, Arik and Taylor, M. Scott. 2008, "Unmasking the pollution haven effect", *International Economic Review*, 49, 223-254.

Liang, Feng Helen. 2008. "Does Foreign Direct Investment Harm the Host Country's Environment? Evidence from China", Available at SSRN: http://ssrn.com/abstract=1479864 or http://dx.doi.org/10.2139/ssrn.1479864

Lu, Jiangyong, Yi Lu, and Zhigang Tao, 2014. "Pure Exporter: Theory and Evidence from China", The World Economy 37(9), 1219-1236.

Lu, Yi, Mingqin Wu, and Linhui Yu. 2013. "Does Environmental Regulation Drive away Inbound Foreign Direct Investment? Evidence from a Quasi-Natural Experiment in China", working paper.

Markusen, James, Edward Morey and Olewiler Nancy D., 1993, "Environmental Policy when Market Structure and Plant Locations Are Endogenous", *Journal of Environmental Economics and Management*, 24, 69-86.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," Econometrica 71: 1695-1725.

Monk, Richard, 2000, "Why Small Business Fail? ", CMA Management 74(6), 12-13.

O'Brien Jonathan, Folta Timothy , 2009. "Sunk Costs, Uncertainty and Market Exit: A Real Options Perspective," *Industrial and Corporate Change*, 18 (5), 807-833.

People's Daily online, 2006. "Multinational corporations in China blacklisted for pollution." Available at http://en.people.cn/200611/01/eng20061101_317249.html .

Sutton, John, 1991. Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration, Cambridge, MIT Press.

Tang, Erzi and Liu, Fengchao and Zhang, Jingjing and Yu, Jiao, 2014. "A model to analyze the environmental policy of resource reallocation and pollution control based on firms' heterogeneity," *Resources Policy*, 39(C), 88-91

The State Council of China, 1998. "Comment by State Council on Questions Related to Acid Rain Controlled-Area and Sulfur Dioxide Pollution Controlled-Area," Document [1998]5

The State Council of China, 2002. "Comment by State Council on the 10th Plan of Acid Rain and Sulfur Dioxide Pollution Controlled," Document [2002]84

Tseng, Wanda and Zebregs, Harm, 2002. "Foreign Direct Investment in China: Some Lessons for Other Countries," IMF Policy Discussion Papers 02/3, International Monetary Fund

Weintraub, Gabriel, Lanier Benkard and Ben Van Roy.. 2008. "Markov Perfect Industry Dynamics With Many Firms," *Econometrica*, 76 (6), 1375–1411

Zwiebel, Jeffrey. 1996. “Dynamic Capital Structure under Managerial Entrechment,” *American Economic Review*, 86 (5), 1197-1215