Environmental policy and exports: Evidence from China

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October 9, 2012

Work in Progress

Abstract

This paper assesses the effectiveness of environmental regulations in China. Our identification uses the environmental policy of the Two Control Zones (TCZ), which has been implemented by the Chinese government in 1998. The aim of this policy was to reduce the sulfur dioxide (SO2) emissions in targeted cities with particularly high air pollution. We use export data for 1997 to 2003 of 243 Chinese cities among which 150 are targeted by this policy, and exploit variations across time, sectors and firm types to extract the causal effect of the policy on exports. We show that tougher environmental regulations induce a reallocation of export activity away from energy intensive sectors. In line with suspicions of policy enforcement differences related to political pecking order of firms, we find that the TCZ policy has a larger impact the lower the political status of the firm. Also, a greater impact of the regulations is observed in locations with higher governance efficiency.

Keywords: environmental policy, export performance, China
JEL codes: F10, F18, Q53, Q56.

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Introduction

Since 2006, China has overtaken the United States as the world's biggest producer of carbon dioxide, the chief greenhouse gas (IEA, 2009). CO2 emissions in China account for roughly a quarter of the world total and their increase is such that they offset falls in the United States and Europe and contribute to the fact that global emissions beat a record year after year. These statistics do not serve China, criticized by the international community for its chilly commitments to environmental protection. A growing number of countries, led by small island states, argue that China's refusal to cap its emissions is one of the main obstacle to progress against global warming.[1]

Despite its image as a bad student, the People's Republic has adopted a series of regulatory policies. Concerns that the severity of China's environmental problems[2] could soon hamper its economic growth have led the Chinese government to built up an ambitious array of environmental protection laws to induce firms to reduce their emissions. There is however surprisingly little consensus on the impact of these environmental policies on economic activity or even on environmental quality. Many observers question the effective implementation and enforcement of the Chinese environmental laws and regulations that exist largely on paper (OECD, 2006). There is also recurrent doubts over the accuracy and honesty of the pollution data released by the authorities (The Economist, 2012). It hence remains an open question whether Chinese environmental regulations are not just green-washing on an epic scale.

In this paper, we investigate the effectiveness of the so-called Two Control Zones (TCZ) policy in reallocating activity away from polluting sectors. The TCZ policy has been implemented in 1998 by the Chinese central government, to reduce the sulfur dioxide (SO2) emissions in locations with particularly high air pollution. Based on the records in preceding years, a total of 175 cities across 27 provinces were identified as TCZ. Together these cities were responsible for around 60% of the total SO2 emissions in 1995 and 62% of China's GDP, but cover only 11.4% of the territory and about 41% of the national population (Hao et al., 2001). We focus on exports to measure the economic effectiveness of the TCZ policy and ask whether we observe a change in export performance in targeted cities compared to non TCZs.

Our paper contributes to the literature in two ways. First, our analysis will shed light on the claim that the implementation of new environmental standards could be at odds with China's export-oriented growth strategy and hence jeopardize its growth-prospects. Proponents of the Porter hypothesis - that regulation brings cost-reducing

[1] China signed the Kyoto Protocol (contrary to the US) but under an agreement that developing nations (to which China belongs) would not be required to reduce their emissions.

[2] Estimates put the cost of air and water pollution damages in China between 3.5 and 8% of China's GDP every year (World Bank 1997).

innovation - have challenged the traditional activity-deterring view and argue that there could be a positive link between regulatory stringency and exports (Porter, 1991; Porter and Van Der Linde, 1995). Second, it complements the abundant literature on what Taylor (2004) calls a "pollution haven effect," i.e. that tighter environmental rules at the margin have an effect on plant location decisions and activities (Levinson, 1996; Becker and Henderson, 2002; Copeland and Taylor, 2004). Some of these studies look at Chinese environmental regulations (Dean et al., 2009; Lu et al., 2012) but they focus on foreign direct investment.

Our work proposes a careful evaluation of the effectiveness of the TCZ policy. We measure the reallocation of economic activity looking at export data, which proposes the required breakdown into sectors for various years at the level of cities in China.[3] Our work builds on recent efforts to address the problem of omitted variables that traditionally hinders the evaluation of environmental policies' impact on trade (Levinson and Taylor, 2008; Millimet and Roy, 2011).[4] It is indeed likely that environmental policy choice and enforcement are correlated with various broader economic variables, such as GDP per capita or foreign direct investment that are also identified in the literature to drive export performance. Using regional variations within a single country (China), instead of cross-country data makes these problems less severe, and represents a promising alternative route for examining the repercussions of environmental regulations. Nevertheless, in our specific case of the TCZ policy, stricter rules were deliberately applied to more polluted cities which are likely to be different from non-TCZs along many other dimensions that could in turn explain export performance.

Our main strategy to control for endogeneity exploits variation in the expected impact of the TCZ policy across sectors to isolate its direct regulation-related causal effect. The policy was specifically targeting emissions in plants that burn coal, the main source of the country's energy needs and pollution. In TCZs, coal users were encouraged to use low-sulfur coals or required to adapt their coal-burning processes. As industries vary in terms of their intrinsic dependence on coal, we expect the TCZ regulations to have a greater effect on coal-intensive activities and to induce a reallocation of resources across sectors, away from highly energy-intensive to less energy-intensive ones. We exploit this specific feature in our empirical design to extract the causal effect of environmental regulations on export, even if the choice of cities in the TCZ is not exogenous to the economic activity. Our impact evaluation hence consists in filtering the impact of environmental stringency by a sector-level index of energy consumption. Conceptually, our empirical strategy is similar to a triple differences estimate (DDD). We compare i) cities before and after the introduction of the TCZ policy (e.g. first

[3] Production data exist at the city level but are not disaggregated at the sector level.
[4] For a survey of the literature, see Levinson (2008).

difference), ii) cities where the policy was applied to those that were not targeted (e.g., second difference), and iii) sectors that have high coal use to sectors with low coal intensity (e.g., third difference). We exploit sector-level export data to measure the differential impact of the policy across sectors, depending on their degree of energy consumption, so that to drive our results an omitted variable would need to exhibit not only a significant impact on exports, but a differential impact across sectors ordered by energy consumption. We also verify that our results are robust to using an instrument variable strategy proposed by Broner et al. (2012) that exploits information on exogenous meteorological determinants of the speed of dispersion of air pollutants.

Our work tackles the concerns about inadequate enforcement and unsanctioned non-compliance of Chinese environmental regulations (Liu and Diamond, 2005). One typical issue is that as some governmental officials have interests in companies that damage the environment, it is hard for them to enforce environmental policies.[5] Relatedly, some firms may be in a better position to avoid compliance and escape the associated sanctions. China's institutionally-grounded political pecking order of firms is likely to imply a heterogeneous responsiveness to policies across firms depending on their ownership. Dollar and Wei (2007) find that state-owned firms are systematically favored in terms of access to external funding, property rights protection, taxation, and market opportunities by the local authorities. State-owned firms are therefore expected to be impacted less severely by a given policy because of greater bargaining power with the regulator and higher capacity to absorb the additional cost induced by the policy (Huang, 2003b). In our data set we can differeniate between exports of state-owned and private firms. This allows us to explore the potential heteregenous response to the TCZ policy across types of firm ownership. The contribution of this is two-fold: First, it refines our identification strategy to ensure that our results are not driven by endogeneity problems. It proposes a quadruple differences estimate that filters further the impact of the environmental rules by the firm ownership information. Second, it brings to light a possible obstacle to policy effectiveness. This has important implications for China if it is serious about the improvement of air quality.

Our empirical analysis relies on sectoral export data of 243 cities for the years 1997 to 2003. Out of these 243 cities, 150 have been designated as TCZ. We investigate the TCZ policy effect through the study of how TCZs and non-TCZs' exports vary by sectoral coal intensity and depends on the exporter's sector and its political status. We measure a significant relative decline in exports in TCZs after the policy implementation that is more pronounced in sectors with greater requirements for coal, confirming a differential impact of environmental regulations across sectors ordered by

[5] Other reasons for the lack of enforcement are the lack of funding and insufficient manpower and political authority of the supervising authority, the State Environmental Protection Administration (Naughton, 2009).

coal intensity. The heterogeneity in sector-level dependence on coal hence provides a robust methodology to detect the effectiveness of the regulations. Our results suggest that environmental policies affect the sectoral composition of firms' activity away from pollution-intensive activities. Since this may derive from both scaling down and relocation of activities away from TCZ locations, our result would be consistent with the literature on the pollution haven hypothesis (Javorcik and Wei, 2005; and Dean et al. (2009) and Lu et al. (2012) in the specific context of China). Although our results do not allow to conclude on the global impact in terms of pollution, our findings are coherent with those of Dean and Lovely (2010) that the pollution intensity of Chinese exports has fallen dramatically from 1995 to 2004.

Despite the concerns about the lack of enforcement of Chinese environmental regulations, our results are suggestive of the effectiveness of the TCZ policy. They are in line with results of significant repercussions on foreign direct investment (Lu et al., 2012) and health and mortality (Tanaka, 2010). We nevertheless find that the sensitivity of exports to environmental regulations depends on the political status of firms. In line with suspicions of policy enforcement differences related to political pecking order of firms, we measure the effectiveness of TCZ policy to be mitigated by state-ownership. Also, a greater impact of the regulations is observed in locations with higher governance efficiency. After controlling for city-level and sector-level characteristics, we find that environmental regulations induce an export growth bias against polluting sectors in TCZ cities only for non-state firms. State-ownership appears to isolate from the negative repercussions of more stringent environmental regulations suggesting conflicts of interest for governmental officials. This result calls for actions addressing their dichotomy between state and non-state firms even if more work is required to identify what is behind this effect : corruption, higher bargaining power or greater ability to absorb a given cost shock due to softer financial constraints.

The rest of the paper is organized as follows. Section 2 discusses the issue of air pollution in China and presents the Two Control Zones policy. Section 3 details the role of firm ownership in the Chinese economy. Section 4 presents the data and the empirical approach. Our results are described in Section 5. Section 6 concludes.

1 Air pollution and environmental policies in China

1.1 Coal consumption and air pollution

Air pollution is becoming China's biggest health threat. China is home to 16 of the world's 20 most-polluted cities (Pandey et al., 2006). The World Bank (2007) estimates that high levels of air pollution in China's cities leads to 350,000-400,000 premature deaths. In Chinese cities, SO2 emissions have long been a major source of ambient air pollution.[6] They are also the primary cause of acid rain, defined as precipitation with a pH value lower than 5.6, falling on most of China's most fertile land and hurting ecologically sensitive areas.[7] The main source of SO2 emissions is the combustion of coal, which is generally more pollutant than other fossil fuels. China gets 80 percent of electricity and 70 percent its total energy from coal, much of it polluting high-sulphur coal. China has the third biggest coal reserves in the world and coal is the largest locally exploitable fossil resource leading to a heavy dependence of the country on this resource.

The growing concern over the economic costs of SO2 and acid rain has led the Chinese authorities to take more stringent measures to reduce the pollution linked to the use of coal. Two strategies were followed. The first one aims at improving the efficiency of the energy-conversion process. The second one, which is a long-term approach, targets a rise in the efficiency of energy consumption. With these objectives in mind, Chinese authorities have introduced various pollution-control systems, among which the ambitious Two Control Zones policy that is at the center of our study.

1.2 Two Control Zones policy

The Two Control Zones policy has been implemented by the central government in 1998 with the objective of limiting ambient SO2 pollution and reducing the growing problem of acid rain in Southern China. More precisely, this policy aims at reducing SO2 emissions in cities and areas with particularly high air pollution. Cities exceeding certain standards were designated as either acid rain control zone or SO2 pollution control zone based on their records in previous years. Cities are designated as a SO2 pollution control zone if (1) average annual ambient SO2 concentrations exceed the Class II standard, (2) daily average concentrations exceed the Class III standard, and (3) high SO2 emissions are recorded. Cities are designated as Acid Rain control zone if (1) the average annual pH value for precipitation is less than 4.5, (2) sulphate depositions are greater than the critical load, and (3) high SO2 emissions are recorded.[8] In total, 175 cities across 27 provinces were designated as TCZ. Together, these cities account for 11.4% of the Chinese territory, hosted 40.6% of national population, produced

[6] The WHO guideline sets the maximum value at 50 micrograms per cubic meter ($\mu g/m^3$). Out of the 90 Chinese cities that reported data, the median annual SO2 concentration level was $60\mu g/m^3$, with the highest concentration at $418\mu g/m^3$.

[7] Acid rain has expanded from a few pockets in southwestern China in the mid-1980s, to about 30% of the country's land area, touching mainly the South of China.

[8] Class I standard corresponds to an annual average concentration level below $20\mu g/m^3$, Class II is defined as SO2 concentration levels between $20\mu g = m^3$ and $60\mu g = m^3$ and is set as the standard for cities and urban residential areas. Class III is defined as SO2 concentration levels between $60\mu g = m^3$ and $100\mu g = m^3$ (Tanaka, 2010).

62.4% of China's GDP, and were responsible for around 60% of total SO2 emissions in 1995 (Hao et al., 2001).

The National 10th Five-Year (2001-2005) Plan for Environmental Protection required that by 2005 annual sulfur emissions in the Two Control Zones were to be reduced by 20%, compared with their 2000 levels and that annual ambient SO2 concentration levels of 31 non compliant cities must attain the national standard for residential areas. Taking into account that SO2 emissions were previously unregulated in China, these were ambitious targets to meet. In the designated cities, different protection measures have been implemented to promote clean energy use and reduce emissions. The three main policy measures embodied in the TCZs plan consisted mainly in closing the biggest polluters, reducing the sulfur-content of coal and cleaning the coal burning process.

First of all, the sulfur content of coals supplied was regulated. In order to achieve lower sulfur emission for a given amount of coal, construction of new collieries based on coal with a sulfur content of 3% and above is prohibited. Further, existing collieries mining similar coals face production restrictions or are gradually phased out. The use of low-sulfur coals would result in an increase in total operating costs of firms. The World Bank (2003) estimates that industrial boiler operators would have to pay an additional 100 to 150 Yuan per ton for low-sulfur coal, compared with local high-sulfur coal[9]

Second, overall emissions from coal-fired power plants and other polluting industries are set to be reduced. Thus, the construction of coal-fired power plants in downtown and nearby suburbs of medium-size and large cities became prohibited, except for cogeneration plants whose primary purpose is supplying heat. Beijing and Shanghai were the first to establish non-coal districts. Moreover, newly constructed or renovated coal-fired power plants using coals with sulfur content greater than 1% must install sulfur-scrubbing facilities. Existing coal-fired power plants using coals with sulfur content greater than 1% are required to adopt SO2 emission reduction measures. Concretely, all green-field coal-fired power plants with capacities of more than 300 megawatt electrical (MWe) are compelled to install flue-gas desulfurization (FGD) facilities before 1999.[10] Next to regulating the activity of power plants, other industrial facilities with serious sulfur pollution impact were targeted by the policy. Industrial polluters have to install control equipment or adopt other mitigation measures. In order to reduce SO2 pollution sources, emitters are thus required to switch to burn low sulfur coal, modify boilers

[9] This increase in price originiates in higher transportation costs as well as a better quality (higher heating value). Given the reported prices of high-sulfur coal of about 190 250 Yuan per ton, the low-sulfur coal will be 40% to 50% more expensive. World Bank estimates suggest that this increase in prices translates into a cost of about 800 Yuan per ton of SO2 abated.

[10] For a typical coal-fired power station, FGD removes 95% or more of the SO2 in the flue gases.

and kilns, and treat effluent gas.

Finally, one of the main measures is the implementation of SO2 emission fees which is to be collected from the major sulfur emitters. The fees should then be used for specific SO2 pollution control investments at these polluting sources.

As a consequence of these measures, many small factories with inefficient technologies that caused serious pollution were shut down. Already by the end of 1999, collieries producing more than 50 million tons of high sulfur coal had been closed (Hao et al. 2001). By May 2001, 4492 high sulfur coal mines ceased production. Further, 338 small power units, 784 product lines in small cement and glass plants, 404 lines in iron and steel plants, and 1422 additional pollution sources had closed (He et al., 2002).

Several studies document the effectiveness of these comprehensive measures, which have in fact led to a decrease in acid rain and air pollution in the Two Control Zones. According to the official numbers reported by the SEPA, national SO2 emissions fell from 23.7 million tons in 1995 to 19.9 million tons in 2000. SO2 emissions in the TCZ cities decreased steadily until 2000, falling from 1,408,000 tons per year in 1997 to 1,254,000 tons per year in 1998 and to 1,114,000 tons in 1999 (He et al., 2002). Significant improvements have been achieved in reducing acid rain as many cities have limited or banned coal use in downtown areas and made residential and commercial use of gaseous fuels a top priority for urban energy supply.

Among the 175 TCZ cities, the number meeting the national ambient air SO2 concentration standards increased from 1997, where only 81 complied with the Class II standard, to 93 in 1998 and 98 in 1999. SO2 emissions in the TCZ cities fell by about 3 million tons, and about 71% of all factories with initially over 100 tons of emissions per year reduced their SO2 emissions to the standard until 2000 (Tanaka, 2010). By the end of 2000, the total power capacity with FGD equipment exceeded 10,000MW, and small thermal generating units below 50MW, which were characterized by low efficiency and high emissions, have been shut down, reaching 10,000MW in total, which corresponds to a 10,000 kt reductions of raw coal consumption and 40 kt reductions of SO2 emission (Yang et al., 2002).

2 Enforcement of environmental policies and the role of firm ownership

Reflecting the high degree of administrative decentralization in China, local governments are effectively given discretion as to how to interpret and carry out policies. Hence, like in other economic domains, local authorities are legally responsible for enforcing environmental regulations but have limited resources and power to fully enforce them. The unavoidable consequence is generalized bargaining through which many polluters can effectively avoid paying charges, fines or other penalties as argued by Wang et al. (2003). Firms are consequently impacted very differently by policies in general and pollution policies in particular depending on their bargaining power with the regulator and on their capacity to absorb the additional cost induced by the policy. In China, these two dimensions directly relate to the specific ownership structure of the firm. As explained by Huang (2003a), China's institutional landscape is best described as manifesting a political pecking order of firms that systematically advantages state-owned firms both financially and legally.

This ownership bias has very concrete repercussions in terms of discriminatory and incomplete enforcement of policies in China. The dual track approach and the progressivity of China's transition process have delayed the development of a level playing field. Local authorities whose income and promotion prospects are directly tied to the performance of state-owned firms have vested interest that oppose the dismantling of the inefficient public sector. They hence have long resisted the rationalization of the state-owned firms under their supervision through local protectionism. An entire World Bank report has been published in 2005 to detail the various discriminatory measures put in place by local authorities to curb competition and favor politically-connected firms. These measures include direct control over the quantity of sales, price limit and local subsidy, discriminatory regulation enforcement and intervention in the input, labor or financing markets (World Bank, 2005). In line with SOEs' greater political power, regional protection is found to be more widespread in industries dominated by SOEs (Poncet, 2005).

Dean et al. (2009) study the determinants of the enforcement of water pollution charges in China and show that firms from the private sector have less bargaining power than state-owned enterprises. State-owned firms are hence found to be in a better position to escape sanctions.[11]

These findings suggest that negative repercussions (in terms of reduced activity and export performance) of the TCZ policy on firms should be mitigated for state-owned firms. This first source of variation across firm types in terms of policy enforcement differences is amplified by a second one which relates to heterogeneous cost absorption capacities. A large literature identifies that private firms suffer from great credit constraints. A very well acknowledged consequence of the political pecking order of firms in China against the private sector is the systematic misallocation of China's financial resources (Dollar and Wei, 2007). The literature is unanimous on the discrimination that private firms suffer from the formal loan market. Despite the very large and deep

[11] Similar findings are found in terms of taxation. Private firms suffer from the worst tax and legislative treatment (Huang, 2003b).

pool of financial capital in the Chinese state-dominated banking sector, the majority of lending goes to less efficient SOEs leaving healthy private enterprises without access to external funding. SOEs can also count on huge government subsidies such that they are often considered as acting as bottomless pits in sucking government-channeled investment funds (Boyreau-Debray and Wei, 2004). We argue that thanks to reduced obligations to comply to regulations and softer budget constraints, public enterprises may continue their business as usual despite the new environmental regulations while private enterprises are forced to rapidly adjust by cutting their productive and export activities.

3 Data and stylized facts

3.1 Data

3.1.1 Trade data

The main data source is a database collected by the Chinese Customs. It contains Chinese export flows aggregated by locations, year, product and destination country over the period 1997-2003. In our empirical analysis, export flows are aggregated up to the 25 2-digit sectors in manufacturing for which indicators of pollution intensity are available.[12] After combination with macro-level data at the city level (such as GDP and population) we obtain a sample of 243 prefecture level cities that totals 42,525 observations (243 cities, 25 sectors and 7 years) out of which 29.8% do not have any positive export flows.

The Chinese customs data base also provides information on the ownership structure of the exporting firms, which makes it possible to distinguish between exports of state-owned enterprises (SOEs) and privately owned firms.[13] We differentiate between state-owned firms (which include also the collectively-owned firms) and privately owned firms (private firms, fully foreign-owned firms and joint ventures). We will exploit this information of firm ownership in section 4.2.2. The final dataset distinguishing between SOEs and non-SOEs contains twice as much observations as the aggregated sample, since we observe every export flow for a specific city, year and sector now twice, once for each firm ownership type. Out of the 85050 observations, about 41% have zero export flows (32% zeros for SOEs and 49% for private firms).

[12] We use the Chinese 2002 industrial classification.

[13] The categories of firm ownership in the original data set are: State-owned firms, collectively-owned firms, private firms including, fully foreign-owned firms, joint ventures (with foreign ownership less than 100%) and others. The relatively small number of trade flows which is in the category "others" is excluded from our analysis.

3.1.2 Industry-level variables: energy intensity and controls

Our main measure for defining the degree of exposure to stricter environmental regulations of the 25 two-digit sectors is the sector's ratio of coal consumption over value-added. This variable of coal intensity is computed for the year 1997, the year before the TCZ policy was implemented, as it is meant to capture technological characteristics of each sector which are exogenous to firms' regulatory environment, and which determines the degree of reliance of each sector's firms on polluting energy.

We also conduct robustness checks using total energy use over value-added and electricity use over value-added. In addition, we use SO2 emissions over value added instead of the coal intensity variable, however, data for SO2 emissions by sector is available only from 2003, which casts doubt on its exogeneity with respect to the environmental policy. In further robustness checks, we verify that our measures of energy intensity do not simply reflect the sectors' factor intensity. Industry specific variables comes from the China Statistical yearbooks, except the information on the SO2 emissions by sector, which are from Chinese Environmental Yearbooks. Table A-2 displays the correlation between the different industry specific indicators.

In Table A-1 in the Appendix, sectors are ranked in increasing order of their coal intensity. Manufacture of coke and mining of coal stand out with the highest reliance on energy followed by manufacturing of non-metallic mineral products and of basic metals. The sector with the lowest coal and energy intensity is manufacture of tobacco products.

3.1.3 City-level variables: TCZ and controls

Macro-level data at the city level, including GDP and population are taken from China Data Online, provided by the University of Michigan. Combining the customs and macro-level data, we end up with a sample of 243 cities for which we have consistent data on GDP per capita and export structure between 1997 and 2003. Out of the 243 cities in our data set, we identify 150 as designated as TCZ. The list of cities targeted by the policy comes from Tanaka (2010). The geographical distribution of the TCZs is displayed in Figure B-1 in the Appendix.[14] In the empirical analysis, we verify that the TCZ dummy is not simply picking up a heterogeneity in terms of outward orientation of cities. For this we use several control variables. The list of cities hosting any special economic zone is taken from Wang and Wei (2008).[15] The provincial indicator for state efficiency, used in section 4.2.3, is taken from Cole et al. (2009).

[14] Table B-1 provides the full list of the cities in our sample.

[15] Such zones were created by the government starting in 1979 in Guangdong, to promote industrial activity, innovation and export activities. They offer low-tax regimes and faster administrative procedures to favor industrial clustering.

Table A-3 in the Appendix gives some summary statistics separately for TCZ and non-TCZ cities while Table A-4 reports correlation between the main city-level indicators. TCZ significantly differs from Non-TCZ cities in several dimensions. Notably, the TCZ cities display higher GDP per capita and generate larger exports.

3.1.4 Instrumental variable

Our empirical analysis relies on a triple differences estimate to extract the TCZ impact so as to take into account that the selection into the TCZ list is not exogenous. In the present case, the designation of cities as TCZs reflects high pollution level. Since we can not exclude that pollution differences between targeted and non-targeted cities are correlated to other differences that in turn influence the evolution of exports, our empirical specification may suffer from endogeneity problems. In Section 3.1.4 we complement our triple differences estimate by an instrumental variable approach. We follow the methodology proposed by Broner et al. (2012) who study the impact of environmental policy in a cross-country setting. These authors instrument environmental policy with the so-called ventilation coefficient, which reflects the meteorological conditions that influence the speed of dispersion of pollutants in the air. We borrow their hypothesis that meteorological conditions that slow the dispersion of pollutants in the air are likely to lead to the adoption of stricter environmental regulation.[16] In our case this would mean that cities where pollution is dispersed slower are more likely to be targeted by the Two Control Zone policy because for a given amount of local SO2 emissions, the SO2 concentration in the air stays higher for a longer time period.

The ventilation coefficient has been identified by the standard model of atmospheric pollution, the Box model, as the variable that determines the speed of dispersion of air pollution (Jacobsen, 2002). It is defined as the product of wind speed, which determines horizontal dispersion of pollution, and mixing height, which determines the height within which pollutants disperse in the atmosphere. Comparing two locations with the same level of emissions, the location with the higher ventilation coefficient will have lower pollution concentration. As ventilation coefficients are determined by large scale weather systems, they can plausibly be considered to be exogenous to the economic activity in the location. We use this exogenous source of air pollution differences between cities as our instrument for the TCZ designation.

Our construction of the city-level ventilation coefficient as the product of wind speed and mixing height follows Broner et al. (2012). Data on wind speed at 10 meters height and boundary layer height[17] are downloaded from the European Centre

[16] Refer to Broner et al. (2012) for more details on the determinants of atmospheric pollution and discussion on the ventilation coefficient and its suitability as an instrument for environmental policies.

[17] In the data set, mixing height is reported as boundary layer height.

for Medium-Term Weather Forecasting (ECMWF) ERA-Interim data set.[18] These data are available for a global grid of 75 × 75 cells (about 83 squared kilometers). The ventilation coefficient for every grid cell is then constructed by multiplying the average wind speed with the respective boundary layer hight. For every cell, we then average this indicator over the years 1991 to 1996 (two years prior to the implementation of the policy). The data points from the ERA-Interim database can be allocated to the Chinese cities in our dataset via longitudes and latitudes. Longitudes and latitudes for the Chinese cities are obtained from world-gazetteer.com. Every city is associated with the ventilation coefficient from the closest cell from the ERA-Interim grid.[19]

Table A-4 shows the correlation between the ventilation coefficient, the wind speed and the boundary layer height with the TCZ variable as well as with the other city variables. As reported in Table A-3, the ventilation coefficient is on average lower for TCZ cities than for non TCZ cities. The same is true for the two components, wind speed an boundary layer height. This is in line with our expectations: a higher ventilation coefficient indicates that air pollution is dispersed faster. This is likely to reduce the measured concentration of SO2 and hence the need for stringent environmental regulations.

3.2 Stylized facts on export patterns and coal intensity

There is important systematic variations in export patterns across sectors at different levels of coal intensity and across TCZ and non-TCZ cities. Also differences evolved over time in a direction which bode well for the empirical analysis to follow.

Figure B-2 ranks sectors by their coal intensity, and plots the export value of TCZs (left panel) and non-TCZs (right panel) as well as the difference of export value between the two city types for the two extreme years of our trade data (1997 and 2003). Between 1997 and 2003, total exports increased substantially for TCZ and non-TCZ cities.[20] Interestingly, in TCZ cities slower growth of exports occurred in coal intensive sectors over the period. No such pattern appears for non-TCZs. Lower export growth differential between TCZs and non-TCZs for highly polluting sectors is consistent with an export-deterring effect of environmental regulations targeting mainly coal intensive sectors. Overall, our data suggest a relative decline in exports for more polluting sectors, but which is due mostly to the change in the sectoral export composition of TCZ cities. This can be considered a first indication that the policy might indeed have led to a reduction of polluting activities in the targeted cities.

[18] We use the monthly average data at 12 p.m .

[19] We will also check that our results remain when calculating the ventilation coefficient as the mean of the four nearest cells and six nearest cells respectively.

[20] Overall in the 150 TCZ cities, total exports increased every year by 16% on average. In the 93 non-TCZ cities the rate of growth was 13%.

Finally, Figure B-3 compares the relative importance of every sector in total exports for TCZ and non-TCZ cities. While it shows that exports in TCZs were relatively biased in favor of less polluting sectors already in 1997, it indicates that this pattern was slightly reinforced over the years. Interestingly no such bias existed for non-TCZs and especially no similar reallocation occurred in non-TCZ cities over the period. Table A-1 conveys consistent evidence. It can be seen that the average share of exports for the four sectors with the lowest energy intensity for TCZ cities increased from 7.8% in 1997 to 9.7% in 2003, while that for the four sectors with the highest energy intensity declined from 3% to 2.1%. In contrast, the share of highly polluting industries in non-TCZ cities remained relatively stable over the years, declining only from 4.1% to 3.8%. Again, this conforms with the expectation of a reallocation of exports in TCZ cities from high to low energy-intensive sectors.

In Section 4.2, we will investigate the heteregenous effect of the TCZ policy on state-owned and privately owned firms, expecting a more pronounced impact of the policy on exports of private firms in polluting industries. Figure B-4 compares the exports of the two firm types in TCZ cities, illustrating that the sectoral composition of private exports has changed substantially over the years, moving more and more away from polluting industries to cleaner sectors, while the export structure of SOEs in these cities stayed relatively constant. Figure B-5 shows the same graphs for non-TCZ cities, highlighting the increase of exports especially for private firms during the sample period. Nevertheless, the sectoral composition in non-TCZ cities stayed quite similar both for SOEs and private firms.

4 Empirical methodology and results

In this section we present our empirical strategy and the results. Our empirical strategy follows two steps. First, we look at systematic variation in export patterns across sectors of different levels of energy intensity after the TCZ policy implementation. Second, we investigate whether differences emerge depending on state ownership. Also, this second section analyzes the mitigating role of good governance.

4.1 Aggregate export flows

4.1.1 Empirical methodology

We identify the effectiveness of stricter environmental policies from the differential effect of the TCZ policy across sectors ordered by reliance on coal.

We estimate the following equation on our panel of sectoral export data for 243 cities for the years 1997 to 2003.

$$Exports_{ikt} = \alpha TCZ_i \times coal\ int_k \times Post + \nu_{it} + \lambda_{kt} + \theta_{ik} + \varepsilon_{ikt} \qquad (1)$$

where $Exports_{ikt}$ are the free-on-board export sales in industry k in year t for city i. We keep the exports in levels to retain the zero trade flows observations.[21]

TCZ indicates whether a city is targeted by the policy and takes the value one if yes, and zero otherwise. $Post$ denotes a dummy that is 1 for years after 1998, the year the TCZ policy is put in place, and zero otherwise. The indicator $coal\ int_k$ measures coal intensity and varies across sectors. ν_{it}, λ_{kt} and θ_{ik} present city-year, sector-year and city-sector fixed effects.

The potential limiting effect on exports of stricter regulations constraints is identified from the variation across sectors. The main coefficients of interest are hence those on the triple interaction term α. If environmental regulations indeed limit firm exports, we expect relatively lower worldwide sales in targeted cities. However, the export-reducing impact should be weaker in sectors with low coal intensity for which the induced rise in production costs would be limited. We account for the time-varying specificities at the level of cities and sectors respectively through city-year and sector-year fixed effects. City-sector fixed effects control for export performance determinants that are time invariant for a given sector in a given city. Moulton (1990) shows that regressions with more aggregate indicators on the right hand side could induce a downward bias in the estimation of standard-errors. Also Bertrand et al. (2004) argue that difference in difference estimations as we do here often give inconsistent standard errors due to serial correlation of the error term within treated units, which are the cities in our case. For these reasons, standard errors in all regression are clustered at the city level.

4.1.2 Main results for aggregate export flows

In columns 1 and 2 of Table 1 we report the results of estimating Equation (1) without the dyadic fixed effects. The impact of the implementation of the TCZ policy on exports could theoretically be captured by a dummy that is one for TCZ cities in the years after 1998 i.e. the double interaction $TCZ_i \times Post$. In column 1 we look at the coefficient on this interaction term in presence of year, city and sector dummies. It is positive and significant, suggesting a relative increase in sectoral exports in the TCZ cities. This counter-intuitive sign is likely to emerge because the interaction captures the effect on TCZ cities' exports of many other changes that occurred at that

[21] Out of the 6075 city-sector pairs in the panel, 15% never export and 56% export in all years. Over the whole sample period, we have 2057 entries and 1639 exits of sector-city specific export flows.

time in addition to the introduction of environmental regulations. For example, this variable may proxy for more general progress in privatization and trade opening up in preparation of China's WTO entry in 2001. In column 2, we interact the TCZ dummy and the post dummy with the pollution intensity of the sector. The triple interactive term, $TCZ_i \times coal\ int_k \times post$, captures whether firms that are engaged in energy intensive sectors are more sensitive to the new policy and experience a change in their activity relative to firms in less polluting sectors which do not have to undertake a costly adaptation of their production process. To be sure that out triple interaction term does not reflect any general trend in an industry or any particular characteristics of more polluting sectors in TCZ cities, we also add the double interactions between the sector's coal dependence and the post dummy and coal intensity and the TCZ dummy. Our results are thus identified purely from the variation in trade outcomes across sectors in targeted cities, and reflect the way in which firms respond to stricter regulations by reallocating their reduced resources across production and exports in different industries.

Column 3 in Table 1 finally displays our benchmark specification which contains the estimates for Equation (1). Since we include fixed effects at the city-year, sector-year and city-sectoral level, the double interaction terms drop out. The size and significant level of the coefficient of our variable of interest, the triple interaction term, is however not affected by this. In both columns, the triple interaction term is negative and highly significant as expected. This suggests that the applied stricter environmental regulations induced a relative decline of energy-intensive sectors' exports: the higher the share of coal in value-added of the sectors, the larger their relative fall.

The coefficients of the interaction variable in Column 2 and 3 tells us that when comparing two sectors that differ in terms of coal intensity by 10% in a TCZ city, yearly exports of this city in the more coal intensive sector will be lower by 1.2 million US Dollar compared to the other. The mean of exports lying at around 35 million Dollar, this corresponds to a decrease of the TCZ city's export flows of about 3.4% at the mean.

The decrease of exports for polluting sectors in TCZ cities can be due either to a decline in the export volume of existing exporters of energy-intensive sectors (intensive margin), or to their closing down and eventual relocation in a less stringent environment (extensive margin). However, we are not able to disentangle the two channels.[22] Ederington et al. (2005) argue that the relocation process is likely to be limited as those industries with the largest pollution abatement costs also happen to be the least mobile, or footloose, geographically. In any case, given that our dataset is an exhaus-

[22] Note that firm-level regressions would only focus on the intensive margin and hence results would not incorporate information about the self-selection of firms into sectors or cities.

Table 1: TCZ policy and export values

Explained variable:	Exported value (city/sector/year)								
Pollution intensity:	Coal				Energy	Electricity	SO2	Coal	
				w/o extreme sectors					
	1	2	3	4	5	6	7	8	9
$TCZ_i \times$ post	0.218^a	-0.285^b							
	(0.065)	(0.112)							
Pollution $Intensity_k \times$ post		-0.002^a							
		(0.002)							
$TCZ_i \times$Pollution $Intensity_k$		-0.111^a							
		(0.041)							
$TCZ_i \times$Pollution $Intensity_k \times$post		-0.120^a	-0.120^a	-0.225^a	-0.107^a	-0.082^b	-0.125^a	-0.123^a	-0.109^a
		(0.042)	(0.043)	(0.071)	(0.041)	(0.034)	(0.044)	(0.043)	(0.040)
$TCZ_i \times K/L_k \times$post								0.026	
								(0.031)	
$TCZ_i \times K/prod_k \times$post									-0.077^b
									(0.034)
Fixed effects	City, year, sector		City-year, sector-year & sector-city						
Observations	42525	42525	42525	28917	42525	42525	42525	42525	42525
R^2	0.028	0.031	0.200	0.260	0.199	0.199	0.200	0.200	0.200
Nb of cities	243	243	243	243	243	243	243	243	243
Nb of city-sectors	6075	6075	6075	4131	6075	6075	6075	6075	6075
Nb of TCZ cities	150	150	150	150	150	150	150	150	150

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level.

tive record of trade export flows, findings of a negative α suggests that the policy has been effective, reducing the polluting activity in the targeted cities relative to the non-targeted locations. In targeted cities, exports have become relatively cleaner as the more polluting firms have scaled back their activities compared to polluting firms elsewhere.

Columns 4 to 9 of Table 1 propose some robustness tests. Column 4 shows results excluding the top four and bottom four sectors in terms of coal intensity as identified in Table A-1 in the Appendix. The effect is found to be even stronger in comparison to the benchmark, indicating that the previous findings are not exclusively driven by these extreme sectors.[23] In columns 5 and 6 we check that results are robust to alternative measures of energy intensity. Instead of coal over value added we use successively the ratio of total energy over value added and the ratio of electricity over value-added.[24] Our previous results are confirmed: more energy intensive industries suffer from a relative contraction of their exports following the implementation of the TCZ policy compared to less energy intensive and thus less polluting sectors.[25] However, in comparison to our main indicator, which directly reflects the policy's target of reducing coal consumption, the coefficients are slightly lower and less significant. In Column 7 we show an additional robustness check using the SO2 emissions over value-added data for 2003, which confirms the previous results.

In column 8 and 9 we address the concern that polluting industries are in general also very capital intensive (as indicated by the high correlation between capital and pollution intensity in Table A-2). Therefore, to ensure that our indicator of energy intensity does not solely act as a proxy for capital intensity, we further control for this dimension. In Column 8 we interact the $TCZ \times Post$ term with the sector's capital over labor ratio, in column 9 the interaction is with capital over total production. Our main finding of a negative and significant relative decline in coal intensive sectors remains confirming the environment-related channel of impact of the TCZ policy.

4.1.3 Additional controls, IVs and robustness checks

In this section, we conduct a series of sensitivity analyses to verify that our results are not influenced by the endogenous selection of TCZs. We first look at the evolution

[23] The coefficient on the triple interaction term in Column 4 suggests a decrease of about 6.7% of exports (calculated at the mean for the sample used in this column) associated to a 10% increase in coal intensity.

[24] Since more than 75% of China's energy is generated from coal, industries that are intensive in overall energy or electricity are also likely to be affected by the TCZ policy since it heavily regulates power plants and thus energy and electricity supply. Thus firms in TCZ cities are more likely to face power shortages or higher prices for energy and electricity.

[25] Also all other results in Table 1 hold when intensity is compute based on production instead of value added.

of the TCZ policy effect. Second, we control for other city characteristics that could have a heterogenous impact on sectoral exports. Third, we conduct an instrumental variable estimation. Our findings remain robust to all of these validity checks.

As highlighted in Section 3.2, cities that are targeted by the TCZ policy are selected based on their highly polluted air. The high level of pollution could have led to a decrease in the activity of polluting industries in these cities even before the policy was put into place. As shown in Table A-3, these cities are on average bigger, richer and greater exporters than non-TCZ cities. The lack of data prior to 1997 prevents us to check for differential pre-treatment time trends. Instead, in Table 2, we take a closer look at the impact of the policy by testing how it varies over years. We decompose the *post* dummy into the various year dummies, keeping 1997 as the benchmark. Column 1 reports a negative coefficient on the interaction term $TCZ \times coal\ int$ for all years with the effect becoming stronger over the years in absolute terms. These results indicate that compared to 1997, export patterns in TCZs become more and more biased against pollution intensive sectors compared to non-TCZs. The coefficient for the year 1998 is close to be significant suggesting that patterns were close to be similar the year the TCZ was launched. We do not find evidence of sharp rapid repercussions of the policy, instead the export-deterring effect seems to grow as time goes by. In Columns 2 and 3 we verify that this does not solely reflect a common trend of relative decline of coal intensive industries across China. We split the data set between TCZ and non-TCZ cities. Column 2 reports results for exports of non-TCZ cities while Column 3 reports results for exports of TCZ cities. Since all observations in every subsample belong to the same type of cities, our variables of interest here are the interaction between coal intensity and the year dummies. As a consequence, we cannot include sector-year fixed effects, but we keep controlling for city-sector specific characteristics and city-year varying factors. For the non-TCZ cities, we cannot identify any significant decrease in exports in more polluting sectors. By contrast, in the sub-sample of TCZ cities, the negative coefficients indicate a relative decline in exports of more polluting industries over time. These differentiated results reject that the reallocation away from polluting sectors that we identify as that of the TCZ policy emanates from a general shift of exports of Chinese cities towards cleaner industries.

Table 3 provides additional robustness checks to rule out that the observed export-deterring effect of the TCZ policy is driven by omitted variables. While city-year fixed effects account for the time-varying export advantage of cities, we may be concerned that differences between TCZ and non-TCZs drive our results on the triple interaction term.

One of the reasons why we might observe a relative export decline in TCZs location is due to the convergence process at work in China. Over the years, more firms have

Table 2: Yearly effects

Explained variable:	Exported value (city/sector/year)		
	1	2	3
	$TCZ_i \times$coal $int_k \times$Year	coal $int_k \times$Year Non-TCZ cities	coal $int_k \times$Year TCZ cities
1998	-0.013[c]	-0.001	-0.014[c]
	(0.008)	(0.001)	(0.008)
1999	-0.030[b]	-0.001	-0.031[b]
	(0.013)	(0.001)	(0.013)
2000	-0.070[a]	-0.001	-0.071[a]
	(0.027)	(0.001)	(0.027)
2001	-0.107[b]	-0.002	-0.109[b]
	(0.042)	(0.002)	(0.042)
2002	-0.155[a]	-0.002	-0.157[a]
	(0.054)	(0.003)	(0.054)
2003	-0.270[a]	-0.003	-0.273[a]
	(0.096)	(0.004)	(0.096)
City-year FE	yes	yes	yes
City-sector FE	yes	yes	yes
Sector-year FE	yes	no	no
Observations	42525	16275	26250
R^2	0.201	0.117	0.184
Nb of cities	243	93	150
Nb of city-sectors	6075	2325	3750

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. [a], [b] and [c] indicate significance at the 1%, 5% and 10% confidence level.

been relocated or created in the relatively poorer inland provinces. Labor and land is cheaper there. The "Go West" strategy launched in 2000 to develop China's western hinterlands as well as to improve infrastructure in these regions has increased the attractiveness of the inland. In particular polluting firms might find it more attractive to go to regions that are less developed and thus might worry less about the damage to the environment. In Column 1 of Table 3 we try to rule out the possibility that this global trend of relocation and growth of firms in Western China drives our results. We add the interaction of the coal intensity and the post-treatment dummy with *Coast*, a dummy for being located in a coastal province.[26] We can see, that our negative and significant impact of the TCZ policy resists the introduction of this control.

TCZs and non-TCZs may also differ in terms of outward orientation. Over the last decades, the Chinese government has created several special economic zones, High-technology Industry Development Areas, Economic and Technological Development Areas and Export Processing Zones in which a high share of exporting and foreign-owned firms can be found until today. Looking at the list of special policy zones (SPZ)[27], among the 61 cities with a special policy zones in our sample, 50 are also

[26] The coastal provinces are Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan and Guangxi.

[27] It is taken from Wang and Wei (2008) as indicated in Section 3.1.3.

Table 3: TCZ policy and export values: Additional controls

Explained variable:	Exported value (city/sector/year)				
	1	2	3	4	5
				IV	IV
$\text{TCZ}_i \times \text{coal int}_k \times$ post	-0.096^a	-0.057^b	-0.051^c	-0.122^a	-0.250^b
	(0.034)	(0.026)	(0.030)	(0.042)	(0.114)
$\text{Coast}_i \times \text{Coal}_k \times$ post	-0.149^a	-0.116^a	-0.010		0.003
	(0.054)	(0.044)	(0.039)		(0.046)
$\text{SPZ}_i \times \text{Coal}_k \times$ post		-0.217^a	0.012		0.040
		(0.082)	(0.071)		(0.081)
$\ln(\text{GDP pc}_i) \times \text{Coal}_k \times$ post			-0.529^a		-0.509^a
			(0.146)		(0.128)
$\ln(\text{GDP pc}_i)^2 \times \text{Coal}_k \times$ post			-0.315^a		-0.328^a
			(0.097)		(0.094)
Fixed effects	City-year, sector-year & sector-city				
Observations	42525	42525	42525	42525	42525
R^2	0.201	0.203	0.220	0.003	0.025
Nb of cities	243	243	243	243	243
Partial R^2				0.613	0.255
p-value (C-statistics)				0.409	0.115
Underidentification				149.935	37.288
Weak identification				369.070	76.005

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level. Results of the first step for Column 5 and 6 are displayed in Table A-5 in the Appendix. The underidentification test is the Kleinberg-Paap LM statistics. The weak identification test is the Kleinberg-Paap Wald F-statistics.

targeted by the TCZ policy. As can be seen in Table A-4, the correlation between the TCZ and SPZ cities is around 0.23. Column 2 of Table 3 includes an interaction variable between a SPZ dummy, the coal intensity of the sector, and the post-treatment dummy. We see that the coefficient on our variable of interest ($TCZ_i \times coal\ int_k \times post$) remains negative and significant suggesting that the correlation between TCZ and SPZ cities was thus not the driving force behind our results in Table 1.

Next, we want to test whether the decrease in exports in the polluting industries is not simply linked to the fact that over time as cities become wealthier, the demand for good air quality in these locations increases and thus pushing for the closing down of polluting factories. Since cities targeted by the TCZ policy are on average richer, the TCZ variable could capture the higher awareness of the negative impact on health of the polluting industries. Following the environmental Kuznets Curve (Grossman and Krueger, 1991), we could expect an inverse U-shaped relationship between the income level and the pollution intensity of a location. While relatively poorer cities might be willing to encourage local growth by attracting polluting industries, rich locations might care more about clean air and therefore might start shutting down or relocating polluting firms. Also, independent from the demand for cleaner air of the citizens, the city's industry mix may also evolve with income. If firms in polluting sectors require more land or other specific inputs, one would expect relocation of polluting industries from wealthier cities to locations where these inputs are cheaper.

We account for these differential trends in the sector composition related to economic development through the introduction of two additional interaction variables. $coal\ int._k \times post$ is interacted with the natural logarithm of GDP per capita in 1996 and with the squared logarithm of GDP per capita respectively. In Column 3 of Table 3, these interactions are found to attract a negative coefficient that suggests a move away from polluting activities as income rises. Following this check, we observe a fall in the magnitude of the coefficient on our variable $TCZ_i \times coal\ int_k \times post$, but it stays negative and significant at the 10% level.

As a last step, we address the issue of endogeneity with an instrumental variable approach. Column 4 reproduces our benchmark specification of Column 3 in Table 1, instrumenting $TCZ_i \times coal\ int_k \times post$ by the interaction term of the city's ventilation coefficient, coal intensity and the post dummy. Estimates in Column 5 correspond to Column 3 of the same table. The F-tests on the excluded instrument in the first step regression (which equal the Weak identification test in our case) take very high values, indicating that the instrument is correlated significantly with the instrumented variable. Results of the first step estimations are reported in Table A-5 in the Appendix. They show the expected positive and significant correlation between the instrument and the instrumented variable. The IV estimates in Column 4 are highly similar to that in our benchmark regression in OLS from Table 1. When controlling for other city controls, the coefficient is significant at the 5% level and much higher than in the corresponding regression in OLS reported in Column 3 in Table 3. A similar upward effect was obtained in Broner et al. (2012). A possible reason is that the measure of our environmental policy is not perfect and thus OLS estimates might be downward biased due to measurement error. Turning to the test of exogeneity, we cannot reject the null hypothesis that the endogeneity does not affect the OLS estimators as evidenced by the high p-value of the c-statistics (displayed at the bottom of the Table). We therefore continue to rely on OLS estimates.

4.2 The role of firm ownership and good governance

The previous section focuses on the differential impact of the TCZ across sectors. We now refine our investigation of the effect of stricter environmental regulations by exploiting the repercussions of China's institutionally-grounded political pecking order of firms in terms of an heterogeneous responsiveness to policies across firms depending on their political status. Further, we test how responses depend on the local government efficiency.

4.2.1 Empirical approach for the analysis of the role firm ownership

In this section we further investigate the heterogeneous responsiveness to the policy across firm types to isolate the causal effect of stricter environmental regulations on export growth. As argued above and in line with the political pecking order of firms in China favoring state-owned firms, we expect the impact of the TCZ policy to be especially felt by private firms.

To test whether the impact of the policy varies across firm ownership, we differentiate exports coming from state and non-state firms and estimate the following specification:

$$\begin{aligned} &Export^F_{ikt} = \alpha TCZ_i \times coal\ int_k \times Post + \beta TCZ_i \times coal\ int_k \times Post \times SOE \\ &+\gamma_1 TCZ_i \times Post \times SOE + \gamma_2 coal\ int_k \times Post \times SOE \\ &+\theta^F_{ik} + \mu^F_t + \nu_{it} + \lambda_{kt} + \varepsilon^F_{ikt} \end{aligned} \tag{2}$$

where $Exports^F_{ikt}$ are the free-on-board export sales, including zeros, of firm type F in industry k in year t for city i.[28] The binary indicator variable SOE, takes the value of 1 for exports of state-owned firms and 0 otherwise.

[28] Zero export flows account for 41% of observations.

The main coefficients of interest here are those on the two interaction terms α and β. If environmental regulations have indeed a distortional effect on exports against more energy intensive sectors, this should be especially true for non-state firms. Thus compared to the private and foreign firms, the sensitivity of state-owned firms exports to energy intensity after the stricter regulations are in place should be lower because of their higher bargaining power with the regulator and greater capacity to absorb the additional cost induced by the policy. We thus expect α to be negative and β to be positive.

Since we are interested in the quadruple interaction term, we need to add all triple interactions between the four components TCZ_i, *post*, *coal* int_k and SOE. We therefore include $TCZ_i \times post \times SOE$ as well as $coal\ int_k \times post \times SOE$. The remaining triple interaction, $TCZ_i \times coal\ int_k \times SOE$, is captured by the city-industry-firm type fixed effects, θ^F_{ik}. These fixed effects allow us to isolate the impact of the policy from other factors that are common to exports of a given firm type in a specific sector in a given city. As in Equation (1), we control for unobservables by adding city-year (ν_{it}), and sector-year (λ_{kt}) fixed effects. Finally, we include μ^F_t to account for time-varying systematic differences in average export performance between firms of different ownership types.

4.2.2 Empirical results by firm ownership

Table 4 presents empirical results for Equation 2. Column 1 contains the benchmark specification and Columns 2 to 5 report robustness checks. Column 2 verifies that our results hold when excluding the top four and bottom four sectors in terms of coal intensity. Columns 3 and 4 adds interactive terms with capital intensity, measured respectively as the capital over labor (Column 3) and capital over production (Column 4). Column 5 includes interactive terms accounting for non-linear impact of income, the presence of Special Policy zones and the coastal location in the same spirit as in Table 3.

In all five columns, the coefficients α and β have the expected respective positive and negative signs. The bottom line of the table contains the p-value from the test of whether the total impact for the state-owned firms is null, i.e. that the sum of α and β is zero. We can see that in most cases, this hypothesis cannot be rejected, suggesting that the state-ownership shelter firms from the export-deterring effect of the TCZ policy. Export activity reallocation away from pollution intensive activities is limited to non-state owned firms. The overall effect that we have found in the aggregate data set is likely to correspond to changes in exports pattern limited to the case of private firms.

These results suggest a pattern in which the new environmental policy induces

Table 4: TCZ policy and exports by firm ownership

Explained variable:	Exported value (city/sector/year/owner)				
	1	2	3	4	5
	benchmark	w/o extremes	K/L	$K/prod$	
$\text{TCZ}_i \times$coal $\text{int}_k \times$ post	-0.099^a	-0.179^a	-0.104^a	-0.089^a	-0.045^b
	(0.032)	(0.057)	(0.034)	(0.029)	(0.022)
$\text{TCZ}_i \times$coal $\text{int}_k \times$ post$\times$SOE	0.078^a	0.134^a	0.085^a	0.068^a	0.038^b
	(0.026)	(0.048)	(0.028)	(0.023)	(0.017)
$\text{TCZ}_i \times$cap $\text{int}_k \times$ post			0.039^c	-0.075^a	
			(0.021)	(0.027)	
$\text{TCZ}_i \times$cap $\text{int}_k \times$ post$\times$SOE			-0.052	0.073^b	
			(0.032)	(0.029)	
$\text{Coast}_i \times$coal $\text{int}_k \times$ post					-0.016
					(0.029)
$\text{Coast}_i \times$coal $\text{int}_k \times$ $\text{post}_t \times$SOE					0.021
					(0.024)
$\text{SPZ}_i \times$coal $\text{int}_k \times$ post					-0.002
					(0.048)
$\text{SPZ}_i \times$coal $\text{int}_k \times$ post$\times$SOE					0.016
					(0.037)
ln(GDP pc_i)$\times$coal $\text{int}_k \times$ post					-0.399^a
					(0.108)
ln(GDP pc_i)$\times$coal $\text{int}_k \times$ post$\times$SOE					0.270^a
					(0.075)
ln(GDP pc_i)$^2\times$coal $\text{int}_k \times$ post					-0.241^a
					(0.073)
ln(GDP pc_i)$^2\times$coal $\text{int}_k \times$ post$\times$SOE					0.167^a
					(0.051)
Controls	$\text{TCZ}_i\times$SOE$\times$post, $\text{Coal}_k\times$SOE$\times$post				
Fixed effects	city-sector-owner, city-year, sector-year, owner-year				
Observations	85050	57834	85050	85050	85050
R^2	0.123	0.173	0.123	0.123	0.143
Nb of cities	243	243	243	243	243
p-value ($\alpha+\beta=0$)	0.108	0.013	0.091	0.131	0.505

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level. Additional controls: Columns 3 and 4 do not report coefficients on capital $\text{int}_k\times$SOE$\times$ post. In column 5, unreported interactions are those of $Coast_i$; SPZ_i, $ln(GDP\ pc_i)$ and $ln(GDP\ pc_i)^2$ with SOE $\times$ post.

firms with different ownership types to self-select into sectors characterized by different levels of energy intensity constraints: namely, private firms become significantly less specialized in energy-intensive industries. By contrast, no such evolution is observed for state-owned firms.

4.2.3 The role of good governance

In this last section, we address the issue highlighted in section 2, that local governments enjoy a relative discretion concerning the interpretation and control of nation-wide policies. We borrow the indicator of provincial governance efficiency constructed by Cole et al. (2009) to investigate whether better governance leads to a stricter implementation of environmental policies.[29] In Table 5 we thusinteract our variable of interest with this provincial measure of governance efficiency. A closer look at this provincial index shows that eastern provinces are doing on average better than the other provinces, however there have been important changes in the ranking over the years both for Eastern provinces (for example Guangdong and Hainan) and Western provinces (for example Shaanxi and Ningxia).

We expect that firms located in provinces with high governance efficiency are more constrained by the new environmental policy since they are more likely to be faced with local authorities that insist on respecting the new rules. Also, underlying this argument is the idea that in these locations, it is probably more difficult to employ successfully corruptive methods to establish a polluting plant or to escape expensive adaptations of the production process. Column 1 in Table 5 uses the mean of the yearly measure of governance efficiency. $Gov.\ efficiency_p$ is a constant throughout the sample period. Column 2 interacts our variable of interest, $TCZ_i \times coal\ int_k \times post$, with the yearly indicator of governance efficiency, $Gov.\ efficiency_{pt}$. In both cases, we see that the higher the governance efficiency index, the stronger the decrease of exports in polluting industries in TCZ cities. Column 3 and 4 report results when controlling for the other city controls from the previous section.

In the last two columns, we combine the firm ownership dimension with the regional differences in governance efficiency. Here we see that private exports in polluting sectors in TCZ cities decrease the more the higher the governance efficiency index of their province. Again, SOEs seem to be much less affected by regional differences in this indicator.

From these results, we can conclude that it is indeed the case that the effect of the policy is stronger in better governed provinces. This result confirms the argument that

[29] The indicator combines 40 indices including measures of public services, public goods, government size and national welfare. It is available only for 1998 to 2003. We use for 1997 the same value as for 1998.

due to inefficient local authorities, policies in China are likely not to have the effect the national government had originally hoped for.

Table 5: State efficiency at the provincial level

Explained variable:		Exports_{ikt}			Exports_{ikts}	
	1	2	3	4		
	Gov. eff_p	Gov. eff_{pt}	Gov. eff_p	Gov. eff_{pt}	Gov. eff_p	Gov. eff_p
$\text{TCZ}_i \times$coal $\text{int}_k \times$ post	-0.146^a	-0.142^a	-0.081^b	-0.078^b	-0.121^a	-0.072^b
	(0.048)	(0.047)	(0.039)	(0.039)	(0.037)	(0.030)
$\text{TCZ}_i \times$coal $\text{int}_k \times$ post$\times$SOE					0.096^a	0.062^b
					(0.030)	(0.024)
$\text{TCZ}_i \times$coal $\text{int}_k \times$post$\times$Gov. eff.	-0.692^b	-0.673^b	-0.502^c	-0.429^c	-0.589^b	-0.446^b
	(0.288)	(0.284)	(0.263)	(0.249)	(0.240)	(0.217)
$\text{TCZ}_i \times$coal $\text{int}_k \times$ post$\times$Gov. eff.$\times$SOE					0.486^b	0.389^b
					(0.199)	(0.181)
$\text{Coast}_i \times$coal $\text{int}_k \times$ post			0.022	0.019		0.013
			(0.040)	(0.042)		(0.029)
$\text{Coast}_i \times$coal $\text{int}_k \times$ $\text{post}_t \times$SOE						-0.005
						(0.025)
$\text{SPZ}_i \times$coal $\text{int}_k \times$ post			0.016	0.016		0.002
			(0.069)	(0.069)		(0.046)
$\text{SPZ}_i \times$coal $\text{int}_k \times$ post$\times$SOE						0.013
						(0.036)
ln(GDP pc_i)$\times$coal $\text{int}_k \times$ post			-0.507^a	-0.506^a		-0.379^a
			(0.147)	(0.148)		(0.108)
ln(GDP pc_i)$\times$coal $\text{int}_k \times$ post$\times$SOE						0.252^a
						(0.074)
ln(GDP pc_i)$^2\times$coal $\text{int}_k \times$ post			-0.317^a	-0.317^a		-0.243^a
			(0.099)	(0.100)		(0.075)
ln(GDP pc_i)$^2\times$coal $\text{int}_k \times$ post$\times$SOE						0.168^a
						(0.053)
Observations	42525	42525	42525	42525	85050	85050
R^2	0.203	0.203	0.221	0.221	0.127	0.144
Nb of cities	243	243	243	243	243	243

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level. All columns contain: $\text{TCZ}_i\times$ Gov. efficiency $\times$post, coal $\text{int}_k\times$Gov. efficiency$\times$post. Column 2 and 4 contain in addition $\text{TCZ}_i\times$Coal $\text{int}_k\times$ Gov. efficiency. Column 5 and 6: Gov. $\text{efficiency}_p\times$coal $\text{int}_k\times$SOE$\times$post, Gov. $\text{efficiency}_p\times$SOE$\times$post, Gov. $\text{efficiency}_p\times$coal $\text{int}_k\times$SOE, $\text{TCZ}_i\times$ Gov. efficiency_p $\times$SOE$\times$post. Columns 1 to 4 include city-year, sector-year and sector-city fixed effects. Columns 5 and 6 include city-year, sector-year, owner-year and sector-city-owner fixed effects.

5 Conclusion

This paper investigates the impact of stricter environmental regulations from the so-called Two Control Zones (TCZ) policy of 1998 on the export activity of firms in China. We use a data set of 243 Chinese cities (of which 150 are targeted by the policy) for the years 1997 to 2003, and exploit variations across time, sectors and firm types to extract the causal effect of the policy on firms' export performance. We find evidence that the TCZ policy has larger negative repercussions on exports the heavier the pollution content of the activity suggesting that the TCZ policy has been effective. Targeted cities experienced a relative reallocation of export activities away from pollution intensive ones. Results looking at heterogeneity across firm-types are in line with the political pecking order of firms that exists in China. The impact of the environmental policy seems to be mitigated by state ownership.

Overall, the structure of exports in China has hence been distorted by the environmental policy. The Two Control Zones policy disproportionately hindered the export activity of private domestic and foreign firms relative to SOEs. This suggests that thanks to reduced obligations to comply to regulations and softer budget constraints, state ownership shields from the consequences of pollution regulations. Public enterprises may continue their business as usual despite the new environmental regulations while private enterprises are forced to adjust by cutting their productive and export activities as a consequence of the induced increased costs.

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Appendix A

Table A-1: List of sectors

Code	Sector name	Energy intensity			Export Share			
		Coal	Energy	Elec.	1997		2003	
		over value added			TCZ	no TCZ	TCZ	no TCZ
16	Manufacture of tobacco products	.002	.003	.001	.002	.001	.001	.001
18	Manufacture of wearing apparel	.003	.006	.001	.165	.125	.101	.122
19	Tanning and dressing of leather	.003	.005	.001	.069	.097	.045	.064
30	Manufacture of office machinery	.003	.008	.001	.062	.023	.167	.016
31	Manufacture of electrical machinery	.004	.016	.002	.093	.037	.169	.053
32	Manufacture of radio, TV and com.	.004	.016	.002	.053	.024	.058	.028
29	Manuf. of machinery & equipment n.e.c.	.007	.014	.001	.038	.025	.055	.039
28	Manufacture of fabricated metal products	.008	.020	.003	.036	.053	.034	.052
34	Manufacture of motor vehicles, trailers	.008	.015	.002	.020	.008	.020	.017
35	Manufacture of other transport equipment	.008	.015	.002	.009	.006	.016	.010
33	Manuf. of medical, precision & optical	.009	.015	.001	.027	.011	.028	.012
13	Mining of metal ores	.011	.043	.007	.001	.003	.001	.001
25	Manufacture of rubber and plastics products	.012	.023	.003	.034	.023	.028	.032
36	Manuf. of furniture; manufacturing n.e.c.	.015	.033	.004	.086	.066	.068	.092
20	Manuf. of wood; products of wood & cork	.018	.020	.002	.010	.035	.009	.042
17	Manufacture of textiles	.018	.028	.003	.100	.119	.069	.105
15	Manufacture of food & beverages	.021	.021	.002	.037	.118	.021	.111
14	Other mining and quarrying	.026	.032	.003	.004	.019	.002	.012
22	Publishing and printing	.038	.040	.004	.002	.001	.002	.001
21	Manufacture of paper & paper products	.051	.061	.005	.004	.002	.003	.002
24	Manuf. of chemicals & chemical products	.060	.097	.007	.062	.080	.046	.080
27	Manufacture of basic metals	.105	.159	.011	.044	.054	.024	.048
26	Manuf. of other non-metallic mineral prod.	.116	.111	.005	.023	.027	.016	.031
10	Mining of coal & lignite; extr. of peat	.135	.081	.005	.007	.015	.006	.009
23	Manuf. of coke, refined petr. & nuclear fuel	.141	.106	.003	.014	.030	.014	.024

Coal is expressed in 10,000 tons, total energy consumption is expressed in 10,000 tons of SCE, electricity is expressed in 1,000 million kWh. The industry's value added is measured in 100 million yuan. Source: China Statistical Yearbook (1997).

Table A-2: Correlation of industry indicators

	coal int.	energy int.	electricity int.	SO2	K/L	K/pr
coal/value added	1					
energy/value added	0.938^{a}	1				
electricity/value added	0.769^{a}	0.924^{a}	1			
SO2 emisisons/value added	0.862^{a}	0.792^{a}	0.655^{a}	1		
capital/labor	0.303	0.285	0.0697	0.273	1	
capital/total production	0.388^{c}	0.315	0.354^{c}	0.252	-0.516^{a}	1
Observations	25					

^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level.

Table A-3: Summary statistics by city

	TCZ =0		TCZ =1		
	Mean	S.D.	Mean	S.D.	Diff
SPZ	0.129	0.337	0.333	0.473	0.000
Coastal province	0.344	0.478	0.500	0.502	0.017
ln(GDP) , 1996	4.546	0.976	5.26617	1.049	0.000
ln(Pop) , 1996	5.290	0.104	5.688	0.864	0.001
ln(GDP pc) , 1996	-0.744	0.537	-0.422	0.587	0.000
State efficiency index	-0.023	0.188	-0.037	0.203	0.587
ln(Ventilation coefficient) (IV)	7.956	0.188	7.898	0.165	0.012
Boundary layer height (IV), (meter)	536.013	81.374	515.091	70.738	0.035
Wind speed at 10m (IV), (meter/second)	5.471	0.445	5.335	0.338	0.007
Volume of SO2 exhausts/population (in 2003)	4.158	1.115	4.905	1.059	0.000
Total Exports by city (in 10 million USD), 1997	9.440	15.85	91.116	246.714	0.001
Observations	93		150		

Table A-4: Correlation of city indicators

	TCZ	ln(GDP pc)	ln(GDP pc)^2	SPZ	Coast	Index	VC (IV)	height (IV)	wind (IV)
TCZ	1.000								
ln(GDP pc)	0.266^a	1.000							
ln(GDP pc)^2	-0.206^a	-0.514^a	1.000						
SPZ	0.228^a	0.551^a	-0.251^a	1.000					
Coastal province	0.153^b	0.371^a	-0.175^a	0.203^a	1.000				
State efficiency Index	-0.035	0.322^a	-0.147^b	0.196^a	0.400^a	1.000			
ln(Ventilation coefficient) (IV)	-0.160^b	0.153^b	-0.134^b	0.031	0.101	0.452^a	1.000		
Boundary layer height (IV)	-0.135^b	0.131^b	-0.128^b	-0.019	0.065	0.355^a	0.923^a	1.000	
wind speed (IV)	-0.171^a	0.096	-0.046	0.047	-0.035	0.387^a	0.735^a	0.456^a	1.000
Observations	243								

^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level.

Table A-5: Various instruments, first step

Explained variable:	$TCZ_i \times Coal_k \times post_t$	
	1	2
	$ln(VC)$	$ln(VC)$
ln(uv)× coal int_k × post	0.078^a	0.080^a
	(0.004)	(0.009)
$Coast_i$×coal int_k× post		0.069
		(0.067)
SPZ_i×coal int_k× post		0.146^c
		(0.081)
ln(GDP pc_i)× coal int_k× post		0.092
		(0.071)
ln(GDP $pc_i)^2$×coal int_k× post		-0.062^c
		(0.036)
Fixed effects	City-year, sector-year & sector-city	
Observations	42525	42525
R^2	0.613	0.647

Heteroskedasticity-robust standard errors clustered at the city level are reported in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level. Results of the second step are displayed in Column 4 and 5 in Table 3.

7 Appendix B

Figure B-1: Location of Two Control Zones cities

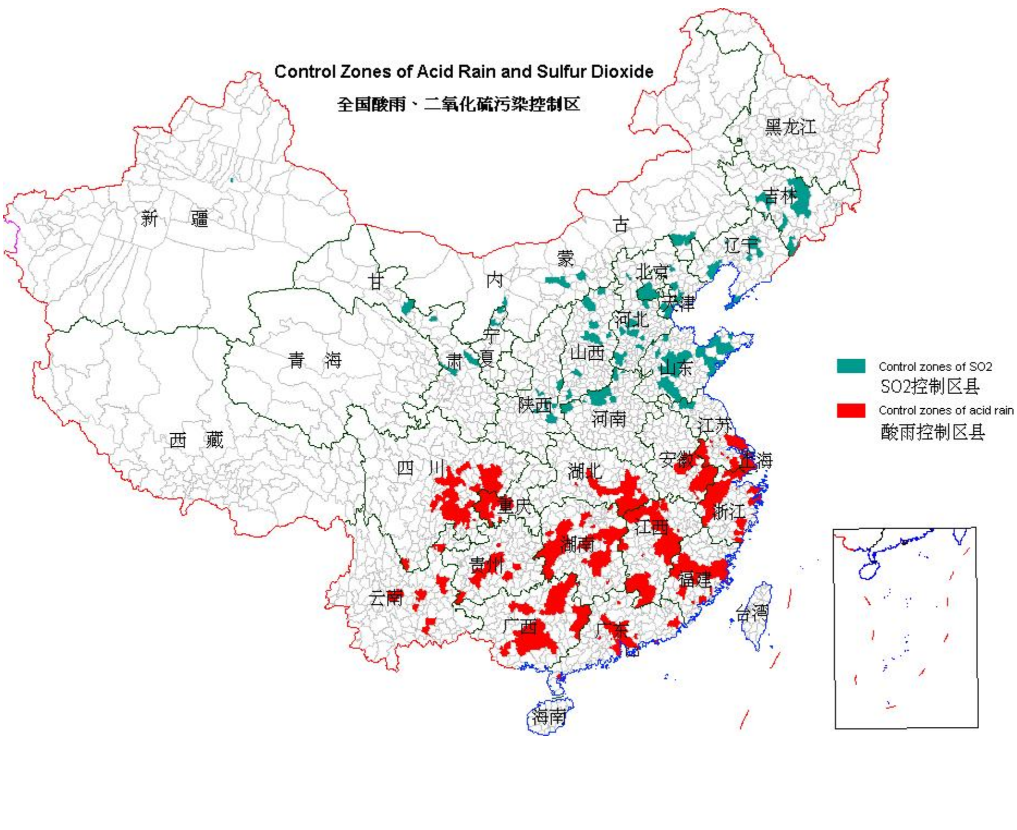

Figure B-2: Export values by city type

Figure B-3: Sectoral composition by city type

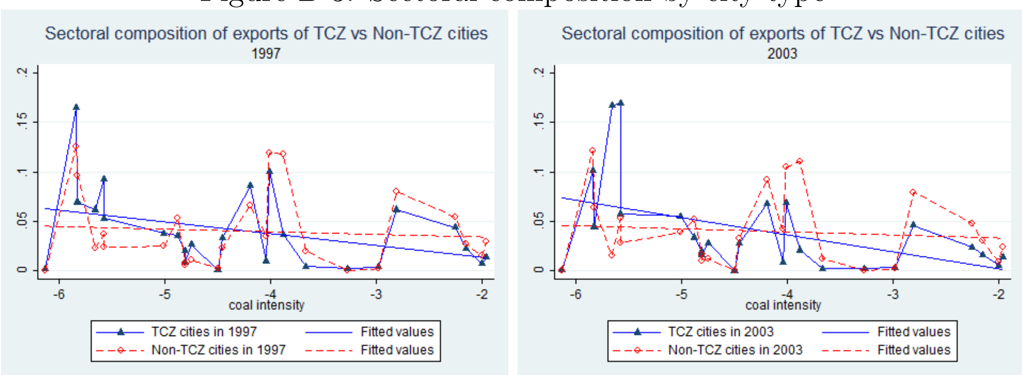

Figure B-4: Exports of TCZ cities, private versus state-owned firms

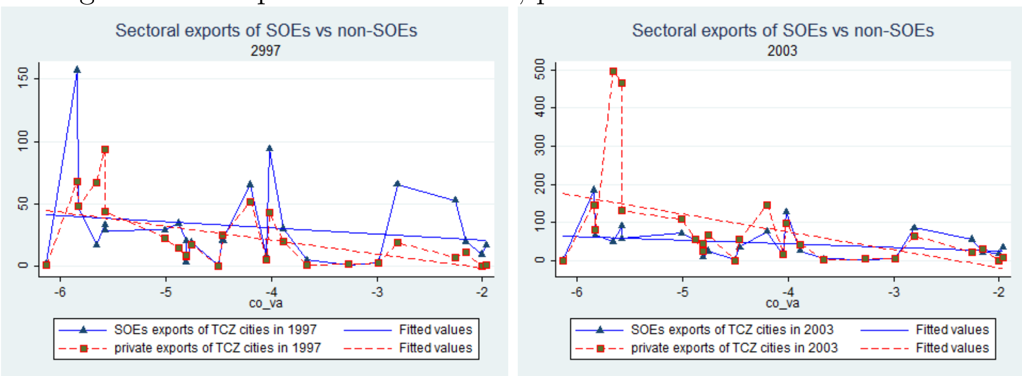

Figure B-5: Exports of non-TCZ cities, private versus state-owned firms

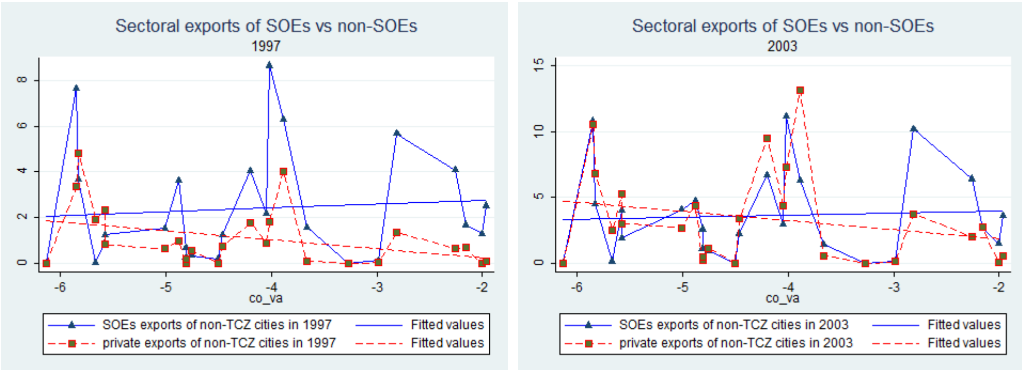

Table B-1: List of cities

province	city	code	TCZ	SPZ	province	city	code	TCZ	SPZ
Beijing	Beijing	1101	1	1	Shandong	Weihai	3710	0	1
Tianjin	Tianjin	1201	1	1	Shandong	Rizhao	3711	0	0
Hebei	Shijiazhuang	1301	1	1	Shandong	Dezhou	3713	1	0
Hebei	Tangshan	1302	1	0	Shandong	Liaocheng	3714	0	0
Hebei	Qinhuangdao	1303	0	1	Shandong	Linyi	3715	0	0
Hebei	Handan	1304	1	0	Shandong	Heze	3716	0	0
Hebei	Xingtai	1305	1	0	Shandong	Laiwu	3720	1	0
Hebei	Baoding	1306	1	1	Henan	Zhengzhou	4101	1	1
Hebei	Zhangjiakou	1307	1	0	Henan	Kaifeng	4102	0	0
Hebei	Chengde	1308	1	0	Henan	Luoyang	4103	1	1
Hebei	Cangzhou	1309	0	0	Henan	Pingdingshan	4104	0	0
Hebei	Langfang	1310	0	0	Henan	Anyang	4105	1	0
Hebei	Hengshui	1311	1	0	Henan	Hebi	4106	0	0
Shanxi	Taiyuan	1401	1	1	Henan	Xinxiang	4107	0	0
Shanxi	Datong	1402	1	0	Henan	Jiaozuo	4108	1	0
Shanxi	Yangquan	1403	1	0	Henan	Puyang	4109	0	0

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TableB-1 – continued from previous page

province	city	code	TCZ	SPZ	province	city	code	TCZ	SPZ
Shanxi	Changzhi	1404	0	0	Henan	Xuchang	4110	0	0
Shanxi	Jincheng	1405	0	0	Henan	Luohe	4111	0	0
Shanxi	Shuozhou	1406	1	0	Henan	Sanmenxia	4112	1	0
Shanxi	Xinzhou	1408	1	0	Henan	Shangqiu	4113	0	0
Shanxi	Linfen	1411	1	0	Henan	Zhoukou	4114	0	0
Shanxi	Yuncheng	1412	1	0	Henan	Zhumadian	4115	0	0
Inner Mongolia	Hohhot	1501	1	0	Henan	Nanyang	4116	0	0
Inner Mongolia	Baotou	1502	1	1	Hubei	Wuhan	4201	1	1
Inner Mongolia	Wuhai	1503	1	0	Hubei	Huangshi	4202	1	0
Inner Mongolia	Chifeng	1504	1	0	Hubei	Shiyan	4203	0	0
Liaoning	Shenyang	2101	1	1	Hubei	Yichang	4205	1	0
Liaoning	Dalian	2102	1	1	Hubei	Xiangfan	4206	0	1
Liaoning	Anshan	2103	1	1	Hubei	Ezhou	4207	1	0
Liaoning	Fushun	2104	1	0	Hubei	Jingmen	4208	1	0
Liaoning	Benxi	2105	1	0	Hubei	Huanggang	4209	0	0
Liaoning	Dandong	2106	0	0	Hubei	Xiaogan	4210	0	0
Liaoning	Jinzhou	2107	1	0	Hubei	Xianning	4211	1	0
Liaoning	Yingkou	2108	0	0	Hubei	Jingzhou	4212	1	0
Liaoning	Fuxin	2109	1	0	Hubei	Suizhou	4215	0	0
Liaoning	Liaoyang	2110	1	0	Hunan	Changsha	4301	1	1
Liaoning	Panjin	2111	0	0	Hunan	Zhuzhou	4302	1	0
Liaoning	Tieling	2112	0	0	Hunan	Xiangtan	4303	1	0
Liaoning	Chaoyang	2113	0	0	Hunan	Hengyang	4304	1	0
Jilin	Changchun	2201	0	1	Hunan	Shaoyang	4305	0	0
Jilin	Jilin	2202	1	1	Hunan	Yueyang	4306	1	0
Jilin	Siping	2203	1	0	Hunan	Changde	4307	1	0
Jilin	Liaoyuan	2204	0	0	Hunan	Yiyang	4309	1	0
Jilin	Tonghua	2205	1	0	Hunan	Chenzhou	4311	1	0
Jilin	Baicheng	2209	0	0	Hunan	Huaihua	4313	1	0
Heilongjiang	Harbin	2301	0	1	Guangdong	Guangzhou	4401	1	1
Heilongjiang	Qiqihar	2302	0	0	Guangdong	Shaoguan	4402	1	0
Heilongjiang	Jixi	2303	0	0	Guangdong	Shenzhen	4403	1	1
Heilongjiang	Hegang	2304	0	0	Guangdong	Zhuhai	4404	1	1
Heilongjiang	Shuangyashan	2305	0	0	Guangdong	Shantou	4405	1	1
Heilongjiang	Daqing	2306	0	1	Guangdong	Foshan	4406	1	1
Heilongjiang	Yichun	2307	0	0	Guangdong	Jiangmen	4407	1	0
Heilongjiang	Jiamusi	2308	0	0	Guangdong	Zhanjiang	4408	1	1
Heilongjiang	Qitaihe	2309	0	0	Guangdong	Maoming	4409	0	0
Heilongjiang	Mudanjiang	2310	0	0	Guangdong	Zhaoqing	4412	1	0
Heilongjiang	Heihe	2311	0	0	Guangdong	Huizhou	4413	1	1
Heilongjiang	Suihua	2314	0	0	Guangdong	Meizhou	4414	0	0
Shanghai	Shanghai	3101	1	1	Guangdong	Shanwei	4415	1	0
Jiangsu	Nanjing	3201	1	1	Guangdong	Heyuan	4416	0	0

Continued on next page

TableB-1 – continued from previous page

province	city	code	TCZ	SPZ	province	city	code	TCZ	SPZ
Jiangsu	Wuxi	3202	1	1	Guangdong	Yangjiang	4417	0	0
Jiangsu	Xuzhou	3203	1	0	Guangdong	Qingyuan	4418	1	0
Jiangsu	Changzhou	3204	1	1	Guangdong	Dongguan	4419	1	0
Jiangsu	Suzhou	3205	1	1	Guangdong	Zhongshan	4420	1	1
Jiangsu	Nantong	3206	1	1	Guangdong	Chaozhou	4421	1	0
Jiangsu	Lianyungang	3207	0	1	Guangdong	Jieyang	4424	1	0
Jiangsu	Yancheng	3209	0	0	Guangxi	Nanning	4501	1	1
Jiangsu	Yangzhou	3210	1	0	Guangxi	Liuzhou	4502	1	0
Jiangsu	Zhenjiang	3211	1	1	Guangxi	Guilin	4503	1	1
Jiangsu	Taizhou	3212	1	0	Guangxi	Wuzhou	4504	1	0
Jiangsu	Suqian	3217	0	0	Guangxi	Beihai	4505	0	1
Jiangsu	Huaian	3221	0	0	Guangxi	Yulin	4506	1	0
Zhejiang	Hangzhou	3301	1	1	Guangxi	Baise	4507	0	0
Zhejiang	Ningbo	3302	1	1	Guangxi	Hechi	4508	1	0
Zhejiang	Wenzhou	3303	1	1	Guangxi	Qinzhou	4509	0	0
Zhejiang	Jiaxing	3304	1	0	Guangxi	Fangchenggang	4512	0	0
Zhejiang	Huzhou	3305	1	0	Guangxi	Guigang	4513	1	0
Zhejiang	Shaoxing	3306	1	0	Hainan	Haikou	4601	0	1
Zhejiang	Jinhua	3307	1	0	Chongqing	Chongqing	5001	1	0
Zhejiang	Quzhou	3308	1	0	Sichuan	Chengdu	5101	1	1
Zhejiang	Zhoushan	3309	0	0	Sichuan	Zigong	5103	1	0
Zhejiang	Lishui	3310	0	0	Sichuan	Panzhihua	5104	1	0
Zhejiang	Taizhou	3311	1	0	Sichuan	Luzhou	5105	1	0
Anhui	Hefei	3401	0	1	Sichuan	Deyang	5106	1	0
Anhui	Wuhu	3402	1	1	Sichuan	Mianyang	5107	1	1
Anhui	Bengbu	3403	0	0	Sichuan	Guangyuan	5108	0	0
Anhui	Huainan	3404	0	0	Sichuan	Suining	5109	1	0
Anhui	Maanshan	3405	1	0	Sichuan	Neijiang	5110	1	0
Anhui	Huaibei	3406	0	0	Sichuan	Leshan	5111	1	0
Anhui	Tongling	3407	1	0	Sichuan	Yibin	5114	1	0
Anhui	Anqing	3408	0	0	Sichuan	Nanchong	5115	1	0
Anhui	Huangshan	3409	1	0	Sichuan	Yaan	5117	0	0
Anhui	Fuyang	3410	0	0	Guizhou	Guiyang	5201	1	1
Anhui	Liuan	3413	0	0	Guizhou	Liupanshui	5202	0	0
Anhui	Chaohu	3415	1	0	Guizhou	Zunyi	5203	1	0
Fujian	Fuzhou	3501	1	1	Guizhou	Anshun	5207	1	0
Fujian	Xiamen	3502	1	1	Yunnan	Kunming	5301	1	1
Fujian	Putian	3503	0	0	Yunnan	Zhaotong	5303	1	0
Fujian	Sanming	3504	1	0	Yunnan	Qujing	5304	1	0
Fujian	Quanzhou	3505	1	0	Yunnan	Baoshan	5312	0	0
Fujian	Zhangzhou	3506	1	0	Shaanxi	Xian	6101	1	1
Fujian	Nanping	3507	0	0	Shaanxi	Tongchuan	6102	1	0
Fujian	Ningde	3508	0	0	Shaanxi	Baoji	6103	0	1

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TableB-1 – continued from previous page

province	city	code	TCZ	SPZ	province	city	code	TCZ	SPZ
Fujian	Longyan	3509	1	0	Shaanxi	Xianyang	6104	0	1
Jiangxi	Nanchang	3601	1	1	Shaanxi	Weinan	6105	1	0
Jiangxi	Jingdezhen	3602	0	0	Shaanxi	Hanzhong	6106	0	0
Jiangxi	Pingxiang	3603	1	0	Shaanxi	Ankang	6107	0	0
Jiangxi	Jiujiang	3604	1	0	Shaanxi	Yanan	6109	0	0
Jiangxi	Xinyu	3605	0	0	Gansu	Lanzhou	6201	1	1
Jiangxi	Yingtan	3606	1	0	Gansu	Jiayuguan	6202	0	0
Jiangxi	Yichun	3608	0	0	Gansu	Jinchang	6203	1	0
Jiangxi	Shangrao	3609	0	0	Gansu	Baiyin	6204	1	0
Jiangxi	Jian	3610	1	0	Gansu	Tianshui	6205	0	0
Jiangxi	Fuzhou	3611	1	0	Gansu	Jiuquan	6206	0	0
Shandong	Jinan	3701	1	1	Gansu	Zhangye	6207	1	0
Shandong	Qingdao	3702	1	1	Gansu	Wuwei	6208	0	0
Shandong	Zibo	3703	1	1	Gansu	Pingliang	6211	0	0
Shandong	Zaozhuang	3704	1	0	Qinghai	Xining	6301	0	0
Shandong	Dongying	3705	0	0	Ningxia	Yinchuan	6401	1	0
Shandong	Yantai	3706	1	1	Ningxia	Shizuishan	6402	1	0
Shandong	Weifang	3707	1	1	Xinjiang	Urumqi	6501	1	1
Shandong	Jining	3708	1	0	Xinjiang	Karamay	6502	0	0
Shandong	Taian	3709	1	0					