Environmental policy and trade performance: Evidence from China

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Abstract

This paper aims at assessing the impact of environmental regulations on the export activity of firms in China. The environmental policy we study is the so-called Two Control Zones (TCZ) policy, which has been implemented in 1998 in China. The aim of this policy was to reduce the sulfur dioxide (SO2) emissions in targeted cities with particularly high air pollution. We use a data set of 265 Chinese cities 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' performance. We indeed expect the TCZ policy to have a larger impact the heavier the pollution content of the activity and the lower the political status of the firm. In line with the political pecking order of firms that exists in China, we expect the impact of the environmental policy to be mitigated by state ownership. We find that State-owned firms are less intensively affected and thus able to export relatively more, especially in energy intensive sectors. By contrast, we see a relative decline in foreign and private firms' exports; the more the energy-use of the sector the larger the decline.

Keywords: environmental policy, export performance, China
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1 Introduction

All around the world, governments have been considering measures to improve the environmental standards and reduce the environmental footprint of the manufacturing sector. In the last decade, in the context of rapid economic growth, China experienced a significant increase in air and water pollution, deforestation and other environmental damage. The World Bank (1997) estimates that in 1995 China's air pollution resulted in 178,000 premature deaths, 346,000 registered hospital admissions, more than 6 million emergency room visits, and more than 75 million asthma incidences. Further, the World Bank report highlights that air and water pollution together cost every year between 3.5 and 8% of China's GDP. Concerns that the severity of China's environmental problems could soon hamper its economic growth have put environmental protection high on the agenda of the Chinese government.

However, the implementation of new environmental standards could be at odds with China's export-oriented growth strategy. The effect of pollution regulations is likely to affect the firm's activity negatively through a higher cost of production either due to higher prices of inputs, notably energy, or due to the forced adaption of the production process. As industries vary in terms of their intrinsic dependence on energy and energy-intensive activities are specifically targeted by most of the regulations, these policies are likely to induce a reallocation of resources across sectors, away from highly energy-intensive to less energy-intensive ones.

A city's export performance may be negatively impacted through two channels. First, firms required to invest in the reduction of their environmental footprint might have less financial scope to invest in other assets that would increase their production or improve productivity and hence support their outward-oriented activities. Second, footloose firms could be tempted to leave to other locations, where standards are less stringent. This scenario lies at the core of the literature on pollution havens and fuels fears of an emerging dichotomy between regions with low environmental protection but performing economy on the one side, and economically struggling regions with stringent regulations on the other side.

In this paper, we study how the export activity of Chinese firms is affected by the implementation of stricter environmental standards. We use a data set of 265 Chinese cities for the years 1997 to 2003, allowing us to compare the firms' performance before and after the implementation of the policy.

So far the evaluation of the impact of environmental policies on economic outcome has been difficult. In the context of China, empirical studies have shown little evidence to support the pollution haven hypothesis (Javorcik and Wei 2005, Dean et al. 2009). It is however likely that policies are not exogenous to the economic performance of a location, hence preventing studies lacking a proper identification strategy from isolating the effect of the policy on the variable of interest. Both environmental policy and export performance could be driven by a common omitted factor. Environmental policy choice and enforcement can be expected to be 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. The endogeneity issue is all the more acute in the context of cross-country regressions. As we rely on regional variations within a single country (China), we test the repercussions of environmental regulations, with the advantage that, by comparing China's cities, we can mitigate the problems of omitted variables related to different specialization patterns, endowments and institutional systems that arise in a cross-country analysis.

Moreover, our strategy in face of this endogeneity issue is 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 exploit a specificity of China's institutional landscape to further ensure that our results are not driven by endogeneity problems. China's institutionally-grounded political pecking order of firms is likely to imply a heterogeneous responsiveness to policies across firms in China depending on their ownership. State-owned firms in comparison to private firms are shown to be systematically favored in terms of access to external funding, property rights protection, taxation, and market opportunities by the local authorities (Dollar and Wei, 2007). Compared to state-owned firms, domestic private firms (and to a lesser extent foreign-owned firms) are therefore expected to be impacted more severely by a given policy because of weaker bargaining power with the regulator and reduced capacity to absorb the additional cost induced by the policy (Huang, 2003a). Our identification strategy hence is a difference in difference approach exploiting changes over time across sectors and across firm ownership types.

The environmental policy we study in this paper is the so-called Two Control Zones (TCZ) policy, which has been implemented in 1998 by the Chinese central government. The aim of this policy is to reduce the sulfur dioxide (SO2) emissions in cities and areas with particularly high air pollution. Based on the records in preceding years, cities are designated as a SO2 pollution control zone or Acid rain zone. In total, 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). Under this regulatory regime, coal users are encouraged to use low-sulfur coals or required to adapt their coal-burning processes.

In this study, we investigate the impact of environmental regulations on the economic activity of firms based on very detailed export data. Ideally, we would have liked to use data on production. However, contrary to the export data, output information broken down by firm ownership and sector is not available at the city-level.

The main advantage of our dataset is that it allows us to extract the effect of environmental regulations on export, even if the choice of cities in the TCZ are not exogenous to the economic activity. Our empirical strategy does not only compare the export performance change following the policy implementation for firms in and out TCZs but also exploits variations in the TCZ policy effect across firms of a given location depending on the firm's sector and political status. We expect that environmental regulations have a more pronounced impact in industries intrinsically more dependent on polluting inputs. The heterogeneity in sector-level dependence on coal provides a robust methodology to detect the effectiveness of the regulations. We should then observe a greater reduction in export value (due to scaling down and relocation of export activities by local firms) in more polluting sectors in cities where the policy is in place compared to locations that are not targeted.

Further, we identify the impact of the policy through its heterogeneous effect depending on firm political status. In line with the political pecking order of firms that exists in China, we expect the impact of environmental policy to be mitigated by state ownership. After controlling for city-level and sector-level characteristics, we test whether environmental regulations induce an export growth bias against polluting sectors in TCZ cities especially for firms with low political status. State-owned firms thanks to their greater bargaining power with the environmental regulator and greater ability to absorb a given cost shock are expected to be in a better position to escape sanctions than private firms (and to a lesser extent foreign firms). We hence anticipate that state-owned firms are less intensively impacted by the environmental policy and thus able to relatively export more, especially in energy intensive sectors. By contrast, we expect a relative decline in private firms exports, due to larger scaling down of activities and more numerous relocations; the higher the energy-use of the sector the larger the decline.

Our findings confirm a differential impact of environmental regulations across sectors ordered by pollution intensity. We measure a relative decline in export revenues in TCZs after the policy implementation that is more pronounced in sectors with greater requirements for pollutant inputs. Our results suggest that environmental policies affect the sectoral composition of firms' activity away from pollution-intensive activities. Moreover, we find that the sensitivity of exports to environmental regulations depends on the political status of firms. We measure a greater relative export decline for private firms while state-owned firms are globally unaffected. Hence, the environmental policy has induced firms with different ownership types to self-select into sectors characterized by different levels of energy use: namely, state firms are significantly more specialized in energy intensive industries, in comparison with foreign and private firms.

The rest of the paper is organized as follows. Section 2 describes some main facts about air pollution in China and presents the Two Control Zones policy. Section 3 discusses 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.

2 Air pollution and environmental policies in China

2.1 Coal consumption and air pollution

The reduction of air pollution has been one of the major objectives of the environmental policy in China. Most of China's air pollution is due to SO2 emissions. In Chinese cities, SO2 emissions have long been a major source to ambient air pollution. 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.

The main source of SO2 emissions is the combustion of coal, which is generally more pollutant than other fossil fuels. 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 main use of coal in China is for generating energy and for producing manufacturing goods. In 2000, these two end uses accounted for about 42% and 26% of China's total coal consumption (Aden et al., 2009).[1]

Even though in the last years, the use of coal in most industries has declined, representing in 2006 only 20% of total coal consumption, the ongoing rapid economic growth has accentuated China's reliance on coal due to the increasing demand for energy and electricity, of which abound 75% is generated by coal. Energy supply represents now more than 50% of China's total coal consumption. Since 1980 total SO2 emissions in China increased rapidly, peaking in 1995 with 23.7 million tons (Yang and Schreifels, 2003), before decreasing slightly. By then, ambient SO2 pollution was severe and common in major cities. 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 $418\mu g/m^3$. In the same time, acid rain had expanded from a few pockets in southwestern China in the mid-1980s, to about 30% of the country's land area, touching mainly

[1] Other main uses include heating and residential cooking.

the South of China.

But given the big coal reserves and the increasing demand for energy, China's reliance on coal is not expected to change in the near future. Indeed, in 2006 China became the world's leading source of sulfur dioxide emissions, attaining 25.5 million tons, which was 27% more than in 2000. The government thus follows two strategies for environmental control in order to reduce the pollution linked to the use of coal. 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.

2.2 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.[2] 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 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. As a consequence of this policy, in the designated

[2] 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).

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.

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 co-generation 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.[3] 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 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

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

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).

3 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).

The empirical evaluation we perform in this paper takes advantage of the way this negotiation process and hence the incompleteness of the pollution regulation enforcement are shaped by the institutional distortions of the Chinese economy. Our identification strategy exploits not only the variation in energy consumption across sectors but also the variation in political status across firms. Our main hypothesis is that of a heterogeneous responsiveness to policies across firms in China depending on their ownership type.

Firms are expected to be impacted more or less severely 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 (2003b), China's institutional landscape is best described as manifesting a political pecking order of firms that systematically disadvantages indigenous private firms both financially and legally. In this hierarchy, foreign firms benefit from an intermediate position. The comparative timing of the legal recognition of each category of firms is telling in this respect. While the Chinese constitution protected the legal rights of foreign enterprises as early as 1982, only by 1999 did it acknowledge that the Chinese private sector was an integral part of the economy, putting it on an equal footing with state-owned enterprises (SOEs). The constitutional commitment to protect the legal status of private enterprises (i.e. not to nationalize or expropriate the assets of private investors) came even later in 2007.

These ownership biases have very concrete repercussions apparent in various subjective and objective comparisons across firm types. Huang (2008) computes differences in business environment perceptions based on data from the World Business Environment Survey implemented by the World Bank in 2000. Despite all the caveats in this type of survey research, domestic private firms appear to feel more constrained than other firms in the area of regulations and access to financing. They also express more concerns about corruption practices and express less confidence in China's judicial system. Interestingly, this latter result is in line with empirical findings on 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. They 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. In line with SOEs' greater political power, regional protection is found to be more widespread in industries dominated by the 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 followed by foreign firms. Private domestic firms were identified as the least likely to evade payment of the full amount of the calculated pollution levy.[4]

[4]Similar findings are found in terms of taxation. Private firms suffer from the worst tax and legislative treatment. The differences in tax treatments between foreign and domestic firms do not only result from the well-known difference in corporate profit (Foreign owned firms are taxed at 15%,

These findings suggest that negative repercussions (in terms of reduced activity and export performance) of the TCZ policy on firms should be magnified for private firms compared to foreign firms and even more so compared to 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 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). Foreign affiliates would again hold an intermediate position in terms of credit constraints because they can access additional funding from their parent company (Manova et al., 2011).

Because of higher financial constraints on their activity, we expect domestic private firms to be more intensively impacted by a given increase in their operating costs (whether or not related to environmental regulations) than foreign-owned and state-owned firms. They are hence more likely to be forced to scale down their export activities.

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.

4 Data and empirical Methodology

4.1 Data

4.1.1 Trade data

Our main data source is a database collected by the Chinese Customs. It contains export flows by product and destination country at the city level over the period 1997-

a rate half that of domestic firms) but also relate to differences in tax and surcharges burden. Huang (2003a) computes that as a percentage ratio of sales, foreign firms had the lowest ratios of this levy as compared with SOEs and private firms at 0.67, 0.86 and 1.03%, respectively.

2003.[5] In our empirical analysis, trade flows are aggregated up to 25 2-digit sectors in manufacturing for which our indicators of energy intensity are available. The Chinese trade data were aggregated to HS (6-digit) and then converted to the sector categories using the official Chinese concordance. Our final sample covers 265 cities.

The dataset also provides information on the ownership structure of firms, which makes it possible to distinguish between state-owned enterprises (SOEs), private domestic firms[6] and foreign firms.[7]

4.1.2 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 is computed for the year 1997 as it is meant to capture technological characteristics of each sector which are exogenous to firms' regulatory environment, and which determine the degree of reliance of each sector's firms on polluting energy. We also conduct robustness checks using coal consumption over gross industrial output value, total energy use over value-added and electricity use over value-added. In further robustness checks, we verify that our measures of energy intensity do not simply reflect the sectors' factor intensity. 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. Interestingly, the average share of exports for the 4 sectors with the lowest energy intensity for TCZ cities remained rather stable at 0.6% between 1997 and 2003 while that for the 4 sectors with the highest energy intensity declined from 10 to 8%, which conforms with the expectation of a reallocation of exports in TCZs from high to low energy-intensive sectors.

4.1.3 City-level variables: TCZ and controls

Our list of TCZ cities is taken from Tanaka (2010). As shown in Tables A-2 and A-3, out of the 265 covered in the trade data, 156 are designated as TCZs. The geographical distribution of the TCZs is displayed in Figure A-1 in the Appendix. Our regressions verify that the TCZ dummy is not simply picking up an heterogeneity in terms of

[5]The original data are identified by a 8-digit code. As there were major reclassifications in the international HS 6-digit classifications in 1996 and 2002, we convert them to the same HS 6-digit classifications used in 1992, to avoid problems related to codes reclassification. Moreover, in order to avoid classifying a product as a new variety just because there has been a new product code or because previous codes were split, we drop product lines that changed classification at the 6-digit level over the period due to nomenclature changes.

[6]We define private firms including collectively-owned firms.

[7]They include fully foreign-owned firms, and joint ventures (with foreign ownership less than 100%).

outward orientation of cities. We use the list of cities hosting a special policy zones built by Wang and Wei (2008).[8] Other control variables measured at the city level such as GDP come from the Urban Statistical Yearbooks published by China's State Statistical Bureau.

4.2 Empirical approach

Our empirical approach identifies the potential export reducing impact of environmental regulations based on the systematic variation in export patterns across sectors at different levels of energy intensity. We investigate the differential effect of the TCZ policy across sectors ordered by reliance on coal. Our hypothesis is that the implementation of stricter environmental policies lead to a lower growth rate of exports that is amplified the greater the industry's share of coal in the value added.

We estimate the following equation relying on panel export data for 265 cities for the years 1997 to 2003.

$$\ln \text{Exports}_{ikt} = \alpha \text{TCZ}_i \times \text{Energy Intensity}_k \times \text{Post} + \gamma_{it} + \lambda_{kt} + \theta_{ik} + \varepsilon_{ikt} \tag{1}$$

where Exports_{ikt} are the free-on-board export sales in industry k in year t for city i. Post denotes a dummy that is 1 for years after 1998, the year the TCZ policy is put in place. The impact on exports of the implementation of the TCZ policy could theoretically be captured by a dummy that is one for TCZ cities in the years after 1998 i.e. the double interaction $\text{TCZ}_i\times$ Post. However, this interaction is likely to capture the effect on TCZ cities' exports of many other changes that occurred at that 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. To circumvent this endogeneity problem we concentrate on the differential impact across sectors ordered by coal intensity after accounting for the time-varying specificities at the level of cities and sectors respectively through city-year and sector-year fixed effects. 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. In presence of sector-year fixed effects (λ_{kt}) that control for systematic time-varying differences in exports across sectors and city-year dummies (γ_{it}) that account for time-varying export advantages of cities, the main effect of stricter environmental regulations on exports (lower exports growth in TCZs after the implementation) can not be observed. Hence, we focus on

[8]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.

the variation in export sales across industries according to their use of pollutant inputs within a given city targeted by the policy after its implementation. The main coefficient of interest in Equation 1 is α, the coefficient of the triple interaction term.

Our regressions also include city-industry fixed effects to control for differences in average export performance that are invariant across time 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. All regressions are thus clustered at the sector-year level.

In a second step, our investigation of the effect of stricter environmental regulations further exploits 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. We anticipate the export-reducing effect of stricter environmental regulations to be mitigated by political status. Lower worldwide sales in more coal dependent sectors should be especially visible for firms of low political status such as private firms. We differentiate exports between state, private and foreign trading firms and estimate the following specification:

$$\begin{aligned}
&\text{Ln Export}^F_{ikt} = \alpha^F D^F \times \text{TCZ}_i \times \text{Energy intensity}_k \times \text{Post} \\
&+\beta^F_1 D^F \times \text{TCZ}_i \times \text{Energy intensity}_k + \beta^F_2 D^F \times \text{Energy intensity}_k \times \text{Post} \\
&+\delta^F_1 D^F \times \eta_i + \delta^F_2 D^F \times \mu_k + \delta^F_3 D^F \times \nu_t + \gamma_{it} + \lambda_{kt} + \theta_{ik} + \varepsilon^F_{ikt}
\end{aligned} \tag{2}$$

Where Exports^F_{ikt} are the free-on-board export sales of firm type F in industry k in year t for city i. Firm types F include Private, State-owned and Foreign firms. Binary indicator variables, D^F, take the value of 1 for firm type F and 0 otherwise.

The main coefficients of interest here are those on the three interaction terms, α_F. If environmental regulations indeed have a distortionary effect on exports against more energy intensive sectors, this should be especially true for private firms and foreign firms and less so for state-owned firms. Thus compared to the state-owned firms, the sensitivity of their exports to energy intensity after the stricter regulations are in place should be higher as they are expected to be impacted more severely by a given policy because of weaker bargaining power with the regulator and reduced capacity to absorb the additional cost induced by the policy.

As in Equation 1, we control for unobservables by adding city-year (γ_{it}), sector-year (λ_{kt}) and city-industry (θ_{ik}) fixed effects. To control for differences between firm types, we add firm type fixed effects which are interacted respectively with city, industry and year dummies. Through the latter fixed effects ($D_F \times \nu_t$), we account for (time-varying) systematic differences in average export performance between firms of different ownership types. Fixed effects $D_F \times \eta_i$ and $D_F \times \mu_k$ respectively control for export performance heterogeneity between firms of different ownership types that are specific to a given city and to a given industry. In addition, we add triple interactions between our TCZ dummy, energy intensity and firm type as well as between energy intensity, the Post dummy and the firm type. The corresponding coefficients (β_1^F and β_2^F) are measured with respect to a reference group, which we choose to be state-owned firms.

The potential limiting effect on exports of environmental regulations is now identified from the variation across firm types. Since we rely on export data summed up by sector and firm type and look at the distribution of total exports of each firm type across sectors, we measure the result of two effects, the selection of firms into exporting, and the export value of selected firms. Theoretically, both margins should be affected by environmental regulations. A negative coefficient α_F would be consistent with both a reduced relative presence of private firms in energy-intensive sectors (selection effect) and a lower value of their exports when they are present.

The use of export data instead of production data implies that we study a very particular subsample of Chinese firms. The recent literature in international trade has shown that exporters are bigger and more productive than non-exporters (Bernard and Jensen 1999; Melitz 2003). Nevertheless, we do not expect this sample selection to harm our identification strategy. On the contrary: the political pecking order of firms is likely to be reduced when considering exporting firms only. Hence we expect the mitigating effect of state-ownership on the regulations' impact to be reduced in this sample of exporting firms. Since exporters are in general more homogeneous than non exporters and are bigger and more productive firms, the government is less likely to discriminate strongly between private and foreign exporters (compared to state firms) under their jurisdiction. Thus, if we still observe a heterogeneous effect of the environmental policy between firm types, we can expect it to be even bigger when considering all producers, including non exporters. Thus, our estimates can be held as a lower bound.

5 Results

In this section, we are interested in how the export performance of firms in a specific sector in a given city is affected by the implementation of the TCZ policy.

5.1 Aggregate exports

Table 1 displays the regression results for Equation (1). Our benchmark regression is displayed in Column 1, before the following columns provide robustness checks.

The triple interactive term between energy intensity, TCZ and Post captures whether firms that are engaged in energy intensive sectors are more sensitive to the new po-

Table 1: TCZ policy and export values

Explained variable:	Log exported value (city/product/year)				
Energy intensity:	Coal	Coal w/o extreme sectors	Energy	Electricity	
	1	2	3	4	5
$TCZ_i \times$ Energy Intensity$_k \times$ Post	-0.081[a]	-0.078[b]	-0.091[a]	-0.089[a]	
	(0.021)	(0.037)	(0.027)	(0.034)	
$TCZ_i \times K/L_k \times$post					-0.016
					(0.069)
City-year fixed effects	yes	yes	yes	yes	yes
Sector-year fixed effects	yes	yes	yes	yes	yes
Sector-city fixed effects	yes	yes	yes	yes	yes
Observations	31381	24283	31381	31381	31381
R^2	0.185	0.211	0.185	0.185	0.185

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

licy 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. 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. Our interaction term attracts a negative and significant coefficient. 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.

This decrease 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). We are not able to disentangle the two channels.[9] 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 geographically mobile, or footloose. In any case, given that our dataset is an exhaustive record of trade export flows, findings of a negative α suggests that the policy has been effective. In targeted cities, exports have

[9]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.

become relatively cleaner as the more polluting firms have scaled back their activities.

Columns 2 to 5 of Table 1 propose some robustness tests. In Column 2 shows results excluding the top 4 and bottom 4 sectors in terms of coal intensity.[10] Results are slightly weaker in comparison to the benchmark, but our coefficient of interest is still negative and significant, indicating that the previous findings are not driven by these extreme sectors.

Further, we want to know whether results are robust to our definition of the sector's energy intensity. We have chosen coal over value added as our main indicator since the policy aims specifically at the main SO2 emitters and thus industries intensive in coal are the most concerned. However, 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.[11] Thus firms in TCZ cities are more likely to face power shortages or higher prices for energy or electricity. In Column 3 and Table 4 of Table 1, we display results from our benchmark regression, replacing coal over value added by total energy over value added (Column 3) and electricity over value added (Column 4). 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.[12]

In Column 5 we address the concern that our indicator of energy intensity acts as a proxy for capital intensity. We therefore replace energy intensity with the industry's capital over labor ratio to be sure that it is well the energy intensity that drives our results. Indeed, we see that the triple interaction term is not significant.

Table 2 provides additional robustness checks to rule out that the observed negative effect is driven by omitted variables. This is an important concern since the TCZ designation is clearly not exogenous to the city-level economic activity. Cities were identified as being a TCZ when they were exhibiting a high pollution level. Consequently, most TCZs were highly industrialized and outward-oriented cities. While city-year fixed effects account for the time-varying export advantage of cities, we may be concerned that these specific features drive our results on the triple interaction term.

Our first strategy to control for outward orientation of a city is to take into account whether the city has been designated as one of the different economic development

[10] As Table A-1 in the Appendix shows, the four most coal intensive industries are manufacturing of coke, refined petroleum and nuclear fuel, mining of coal and lignite and extraction of peat, manufacturing of other non-metallic mineral products and manufacturing of basic metals. The four least coal intensive industries are manufacturing of tobacco products, manufacturing of wearing apparel, tanning and dressing of leather and manufacturing of office machinery.

[11] Indeed, the industry's energy intensity and electricity intensity are highly correlated with coal intensity (0.938 and 0.769 respectively).

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

Table 2: TCZ policy and export values: Additional controls			
Explained variable:	Log exported value (city/product/year)		
	1	2	3
$\text{TCZ}_i \times \text{coal intensity}_k \times \text{Post}$	-0.055^b	-0.072^a	-0.056^b
	(0.022)	(0.021)	(0.027)
$\text{SEZ}_i \times \text{coal intensity}_k \times \text{Post}$	-0.106^a		
	(0.026)		
$\text{Coast}_i \times \text{coal intensity}_k \times \text{Post}$		-0.060^b	
		(0.029)	
$\text{GDP pc}_i \times \text{coal intensity}_k \times \text{Post}$			-0.047^b
			(0.020)
City-year fixed effects	yes	yes	yes
Sector-year fixed effects	yes	yes	yes
Sector-city fixed effects	yes	yes	yes
Observations	31381	31381	28135
R^2	0.186	0.185	0.182

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

zones. 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 until today. We thus create a dummy variable SEZ which takes the value one if the city is in any of these economic development zones.[13]

Among the 156 TCZ cities in our sample, 50 are also in a particular economic development zone. The correlation between the TCZ and SEZ cities is 0.2. Column 1 of Table 2 includes an interaction variable between a SEZ dummy, the coal intensity of the sector, and the post-treatment dummy. We see that the coefficient of our variable of interest (TCZ× Energy Intensity× Post) remains negative and significant. The correlation between TCZ and SEZ cities is thus not the driving force behind our results in Table 1.

A further concern is that we might observe a negative impact of the policy on exports in the TCZ cities, because these cities are located mostly in the industrialized coastal provinces. Over the years, more firms have been relocated or created in the inland provinces. Labor and land is still cheaper there but the overall increase in per capita income in the country, as well as improved 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. This global trend of relocation and growth of firms in Western China could therefore also be driving our results. In Column 2 of Table 2, we thus add the interaction of the coal intensity and the post-treatment dummy with a dummy for Coast.[14] We can see, that our negative and significant impact of the TCZ policy resists the introduction of this control.

Lastly, 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 richer, they are putting more weight on good air quality and thus polluting industries in these cities are relocated. Since TCZ cities are mainly wealthy cities, the TCZ variable could capture the role of an increasing income per capita and thus higher awareness of the negative impact on health of the polluting industries. We expect that richer cities drive out polluting industries and thus anticipate a negative effect on exports from this interaction variable. In Column 3, we thus add the interaction of GDP per capita with the intensity of coal use per sector and the post-treatment period dummy. As expected, this interaction attracts a negative coefficient that suggests a relative decline in the most polluting activities in richer cities over time. This additional control nevertheless leaves our finding of a significant impact of the TCZ policy unaffected.

[13]We use information about the city classification from Wang and Wei (2008), see Section 4.1.3.

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

Table 3: TCZ policy and exports by firm ownership

Explained variable:	Log export value (firm type/city/sector/year)				
Energy intensity:	Coal		Energy	Electricity	K/L
	1	2	3	4	5
TCZ_i × Energy $Intensity_k$× Post	-0.013	-0.033	-0.002	-0.003	0.054
	(0.021)	(0.033)	(0.025)	(0.031)	(0.063)
TCZ_i × Energy $Intensity_k$× Post × Foreign	-0.034^c	-0.038^b	-0.039^b	-0.025^b	0.022^c
	(0.017)	(0.018)	(0.019)	(0.012)	(0.013)
TCZ_i × Energy $Intensity_k$× Post × Private	-0.090^a	-0.114^a	-0.101^a	-0.069^a	0.074^a
	(0.034)	(0.029)	(0.037)	(0.021)	(0.017)
TCZ_i× Energy $Intensity_k$ × Foreign	0.030	0.083	0.026	0.016	-0.200^b
	(0.039)	(0.052)	(0.047)	(0.056)	(0.093)
TCZ_i× Energy $Intensity_k$ × Private	0.099^c	0.191^a	0.089	0.052	-0.284^a
	(0.059)	(0.072)	(0.069)	(0.072)	(0.100)
Energy $Intensity_k$× Post × Foreign	-0.009	0.181^a	-0.028	-0.042	-0.104
	(0.040)	(0.058)	(0.047)	(0.058)	(0.100)
Energy $Intensity_k$× Post × Private	0.097^c	0.046	0.105^c	0.128^b	-0.323^b
	(0.058)	(0.059)	(0.063)	(0.061)	(0.138)
City-year fixed effects	yes	yes	yes	yes	yes
Sector-year fixed effects	yes	yes	yes	yes	yes
Sector-city fixed effects	yes	yes	yes	yes	yes
Ownership-year fixed effects	yes	yes	yes	yes	yes
Ownership-city fixed effects	yes	yes	yes	yes	yes
Ownership-sector fixed effects	yes	yes	yes	yes	yes
Observations	66042	51840	66042	66042	66042
R^2	0.411	0.425	0.411	0.411	0.411

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

5.2 Exploiting firm type heterogeneity

The previous section focuses on the differential impact of the TCZ across sectors. 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 (and to a lesser extent by foreign firms). This expectation derives from the empirical evidence that private Chinese firms have lower negotiation power and reduced capacity to absorb new regulation costs and consequently are forced to rapidly adjust to new policies by cutting their productive and export activities.

Table 3 presents empirical results for Equation 2. They suggest a pattern in which the new environmental policy induces firms with different ownership types to self-select into sectors characterized by different levels of energy intensity constraints: namely, private and foreign firms become significantly less specialized in energy-intensive industries. By contrast, no such evolution is observed for state-owned firms suggesting that they are in a better position to escape the negative consequences of TCZ enforcement. Column 2 verifies that our results hold when excluding the top 4 and bottom 4 sectors in terms of energy intensity. Despite the smaller number of observations, it is striking that the export-reducing effect of TCZ implementation remains significant and of the same size as before. As in Table 1, we verify that our results are robust to the use of alternative proxies for energy intensity. Total energy use over value added and Electricity use over value-added are used successively in Columns 3 and 4. As before, the choice of the variable capturing pollution intensity does not affect the results. In the last column, we see that rather capital intensive sectors increase their exports in the TCZ cities.

Finally, Table 4 shows that findings on a relative private and foreign firms exports decline following the implementation of TCZ is robust to the inclusion of interactive terms between firm ownership dummies, energy intensity and a dummy for Special Economic zones (Column 1), a dummy for coastal province (Column 2) and the cities' GDP per capita in 1997 (Column 3). Overall, our main message stays the same.

We can then conclude from the results presented in this section that environmental regulations seem to leave the export activity of SOEs unchanged, but leads to a relative export decline for private firms, and to a lesser extent for foreign firms. Hence, state ownership can be associated with a significant specialization in "pollution-intensive" industries.

Table 4: TCZ policy and exports by firm ownership: additional controls

Explained variable:	Log export value (firm type/city/sector/year)		
	1	2	3
TCZ_i × coal intensity_k× Post	-0.005	-0.012	-0.009
	(0.021)	(0.021)	(0.027)
TCZ_i × coal intensity_k× Post × Foreign	-0.036^b	-0.026	-0.045^b
	(0.018)	(0.016)	(0.019)
TCZ_i × coal intensity_k× Post × Private	-0.064^b	-0.080^b	-0.069^b
	(0.032)	(0.034)	(0.033)
SEZ_i × coal intensity_k× Post	-0.028		
	(0.021)		
SEZ_i × coal intensity_k× Post × Foreign	0.008		
	(0.020)		
SEZ_i × coal intensity_k× Post × Private	-0.064^b		
	(0.025)		
Coast_i × coal intensity_k× Post		-0.014	
		(0.029)	
Coast_i × coal intensity_k× Post × Foreign		-0.047^b	
		(0.022)	
Coast_i × coal intensity_k× Post × Private		-0.065^b	
		(0.028)	
GDP pc_i × coal intensity_k× Post			-0.004
			(0.017)
GDP pc_i × coal intensity_k× Post × Foreign			-0.006
			(0.013)
GDP pc_i × coal intensity_k× Post × Private			-0.070^a
			(0.015)
coal intensity_k× post×D_F	yes	yes	yes
TCZ_i× coal intensity_k × D_F	yes	yes	yes
SEZ_i× coal intensity_k × D_F	yes	no	no
Coast_i× coal intensity_k × D_F	no	yes	no
GDP pc_i× coal intensity_k × D_F	no	no	yes
City-year fixed effects	yes	yes	yes
Sector-year fixed effects	yes	yes	yes
Sector-city fixed effects	yes	yes	yes
Ownership-year fixed effects	yes	yes	yes
Ownership-city fixed effects	yes	yes	yes
Ownership-sector fixed effects	yes	yes	yes
Observations	66042	66042	60776
R^2	0.411	0.411	0.424

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

6 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 265 Chinese cities (of which 165 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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7 Appendix

Figure A-1: Location of Two Control Zones cities

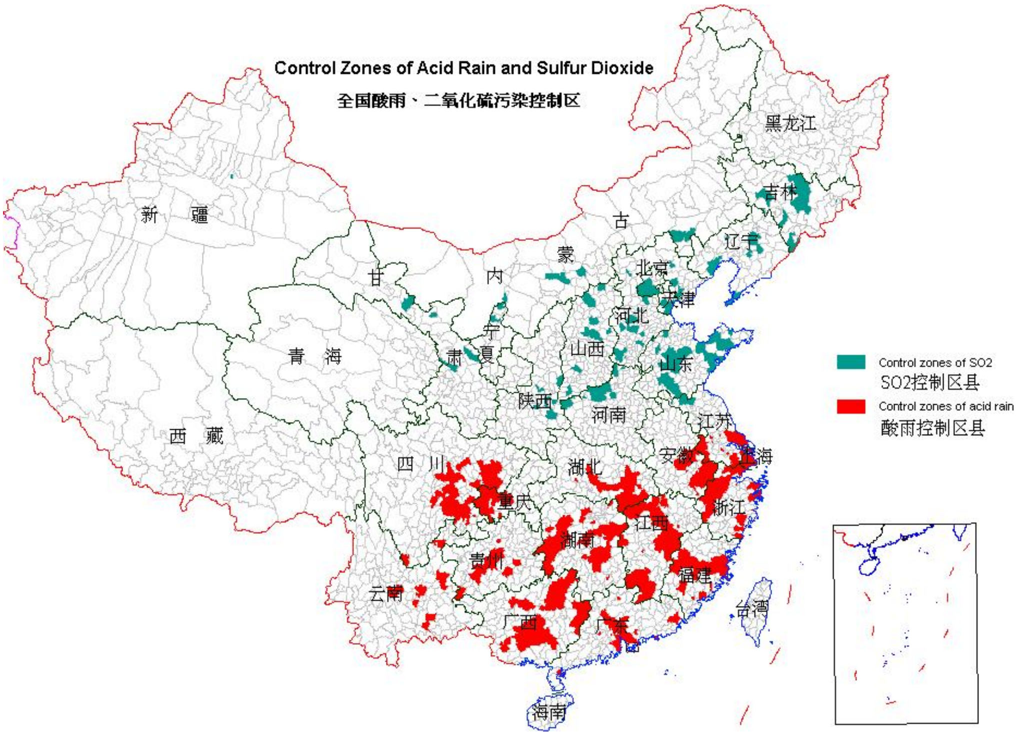

Table A-1: List of sectors

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	.000	.04	0.01	.03	.02
18	Manufacture of wearing apparel	.003	.006	.001	.13	.11	.11	.09
19	Tanning and dressing of leather	.003	.005	.001	.04	.05	.03	.03
30	Manufacture of office machinery	.003	.008	.001	.02	.02	.05	.01
31	Manufacture of electrical machinery	.004	.016	.002	.03	.02	.03	.03
32	Manufacture of radio, TV and com.	.004	.016	.002	.04	.04	.06	.03
29	Manuf. of machinery & equipment n.e.c.	.007	.014	.001	.04	.03	.05	.06
28	Manufacture of fabricated metal products	.008	.020	.003	.04	.03	.03	.03
34	Manufacture of motor vehicles, trailers	.008	.015	.002	.01	.02	.01	.02
35	Manufacture of other transport equipment	.008	.015	.002	.01	.02	.02	.03
33	Manuf. of medical, precision & optical	.009	.015	.001	.01	.01	.01	.02
13	Mining of metal ores	.011	.043	.007	.01	.05	.01	.01
25	Manufacture of rubber and plastics products	.012	.023	.003	.02	.03	.02	.03
36	Manuf. of furniture; manufacturing n.e.c.	.015	.033	.004	.05	.05	.04	.06
20	Manuf. of wood; products of wood & cork	.018	.020	.002	.02	.07	.02	.05
17	Manufacture of textiles	.018	.028	.003	.13	.18	.11	.12
15	Manufacture of food & beverages	.021	.021	.002	.07	.15	.05	.15
14	Other mining and quarrying	.026	.032	.003	.02	.02	.01	.03
22	Publishing and printing	.038	.040	.004	.00	.00	.00	.00
21	Manufacture of paper & paper products	.051	.061	.005	.00	.01	.00	.00
24	Manuf. of chemicals & chemical products	.060	.097	.007	.13	.12	.15	.15
27	Manufacture of basic metals	.105	.159	.011	.19	.14	.17	.14
26	Manuf. of other non-metallic mineral prod.	.116	.111	.005	.04	.04	.03	.04
10	Mining of coal & lignite; extr. of peat	.135	.081	.005	.13	.26	.09	.21
23	Manuf. of coke, refined petr. & nuclear fuel	.141	.106	.003	.04	.13	.04	.09

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: List of cities 1/2

Province	City	Code	TCZ	SEZ	Province	City	Code	TCZ	SEZ
Beijing	Beijing	1101	1	1	Jiangsu	Changzhou	3204	1	1
Tianjin	Tianjin	1201	1	1	Jiangsu	Suzhou	3205	1	1
Hebei	Shijiazhuang	1301	1	1	Jiangsu	Nantong	3206	1	1
Hebei	Tangshan	1302	1	0	Jiangsu	Lianyungang	3207	0	1
Hebei	Qinhuangdao	1303	0	1	Jiangsu	Yancheng	3209	0	0
Hebei	Handan	1304	1	0	Jiangsu	Yangzhou	3210	1	0
Hebei	Xingtai	1305	1	0	Jiangsu	Zhenjiang	3211	1	1
Hebei	Baoding	1306	1	1	Jiangsu	Taizhou	3212	1	0
Hebei	Zhangjiakou	1307	1	0	Jiangsu	Suqian	3217	0	0
Hebei	Chengde	1308	1	0	Jiangsu	Huaian	3221	0	0
Hebei	Cangzhou	1309	0	0	Zhejiang	Hangzhou	3301	1	1
Hebei	Langfang	1310	0	0	Zhejiang	Ningbo	3302	1	1
Hebei	Hengshui	1311	1	0	Zhejiang	Wenzhou	3303	1	1
Shanxi	Taiyuan	1401	1	1	Zhejiang	Jiaxing	3304	1	0
Shanxi	Datong	1402	1	0	Zhejiang	Huzhou	3305	1	0
Shanxi	Yangquan	1403	1	0	Zhejiang	Shaoxing	3306	1	0
Shanxi	Changzhi	1404	0	0	Zhejiang	Jinhua	3307	1	0
Shanxi	Jincheng	1405	0	0	Zhejiang	Quzhou	3308	1	0
Shanxi	Shuozhou	1406	1	0	Zhejiang	Zhoushan	3309	0	0
Shanxi	Xinzhou	1408	1	0	Zhejiang	Lishui	3310	0	0
Shanxi	Luliang	1409	0	0	Zhejiang	Taizhou	3311	1	0
Shanxi	Jinzhong	1410	0	0	Anhui	Hefei	3401	0	1
Shanxi	Linfen	1411	1	0	Anhui	Wuhu	3402	1	1
Shanxi	Yuncheng	1412	1	0	Anhui	Bengbu	3403	0	0
Inner Mongolia	Hohhot	1501	1	0	Anhui	Huainan	3404	0	0
Inner Mongolia	Baotou	1502	1	1	Anhui	Maanshan	3405	1	0
Inner Mongolia	Wuhai	1503	1	0	Anhui	Huaibei	3406	0	0
Inner Mongolia	Chifeng	1504	1	0	Anhui	Tongling	3407	1	0
Inner Mongolia	Hulunbeir	1507	0	0	Anhui	Anqing	3408	0	0
Inner Mongolia	Ulanqab	1510	0	0	Anhui	Huangshan	3409	1	0
Inner Mongolia	Bayannaoer	1511	0	0	Anhui	Fuyang	3410	0	0
Liaoning	Shenyang	2101	1	1	Anhui	Liuan	3413	0	0
Liaoning	Dalian	2102	1	1	Anhui	Xuancheng	3414	1	0
Liaoning	Anshan	2103	1	1	Anhui	Chaohu	3415	1	0
Liaoning	Fushun	2104	1	0	Anhui	Chizhou	3416	0	0
Liaoning	Benxi	2105	1	0	Fujian	Fuzhou	3501	1	1
Liaoning	Dandong	2106	0	0	Fujian	Xiamen	3502	1	1
Liaoning	Jinzhou	2107	1	0	Fujian	Putian	3503	0	0
Liaoning	Yingkou	2108	0	0	Fujian	Sanming	3504	1	0
Liaoning	Fuxin	2109	1	0	Fujian	Quanzhou	3505	1	0
Liaoning	Liaoyang	2110	1	0	Fujian	Zhangzhou	3506	1	0
Liaoning	Panjin	2111	0	0	Fujian	Nanping	3507	0	0
Liaoning	Tieling	2112	0	0	Fujian	Ningde	3508	0	0
Liaoning	Chaoyang	2113	0	0	Fujian	Longyan	3509	1	0
Jilin	Changchun	2201	0	1	Jiangxi	Nanchang	3601	1	1
Jilin	Jilin	2202	1	1	Jiangxi	Jingdezhen	3602	0	0
Jilin	Siping	2203	1	0	Jiangxi	Pingxiang	3603	1	0
Jilin	Liaoyuan	2204	0	0	Jiangxi	Jiujiang	3604	1	0
Jilin	Tonghua	2205	1	0	Jiangxi	Xinyu	3605	0	0
Jilin	Baicheng	2209	0	0	Jiangxi	Yingtan	3606	1	0
Heilongjiang	Harbin	2301	0	1	Jiangxi	Ganzhou	3607	1	0
Heilongjiang	Qiqihar	2302	0	0	Jiangxi	Yichun	3608	0	0
Heilongjiang	Jixi	2303	0	0	Jiangxi	Shangrao	3609	0	0
Heilongjiang	Hegang	2304	0	0	Jiangxi	Jian	3610	1	0
Heilongjiang	Shuangyashan	2305	0	0	Jiangxi	Fuzhou	3611	1	0
Heilongjiang	Daqing	2306	0	1	Shandong	Jinan	3701	1	1
Heilongjiang	Yichun	2307	0	0	Shandong	Qingdao	3702	1	1
Heilongjiang	Jiamusi	2308	0	0	Shandong	Zibo	3703	1	1
Heilongjiang	Qitaihe	2309	0	0	Shandong	Zaozhuang	3704	1	0
Heilongjiang	Mudanjiang	2310	0	0	Shandong	Dongying	3705	0	0
Heilongjiang	Heihe	2311	0	0	Shandong	Yantai	3706	1	1
Heilongjiang	Suihua	2314	0	0	Shandong	Weifang	3707	1	1
Shanghai	Shanghai	3101	1	1	Shandong	Jining	3708	1	0
Jiangsu	Nanjing	3201	1	1	Shandong	Taian	3709	1	0
Jiangsu	Wuxi	3202	1	1	Shandong	Weihai	3710	0	1
Jiangsu	Xuzhou	3203	1	0	Shandong	Rizhao	3711	0	0

Table A-3: List of cities 2/2

Province	City	Code	TCZ	SEZ	Province	City	Code	TCZ	SEZ
Shandong	Dezhou	3713	1	0	Guangxi	Liuzhou	4502	1	0
Shandong	Liaocheng	3714	0	0	Guangxi	Guilin	4503	1	1
Shandong	Linyi	3715	0	0	Guangxi	Wuzhou	4504	1	0
Shandong	Heze	3716	0	0	Guangxi	Beihai	4505	0	1
Shandong	Laiwu	3720	1	0	Guangxi	Yulin	4506	1	0
Henan	Zhengzhou	4101	1	1	Guangxi	Baise	4507	0	0
Henan	Kaifeng	4102	0	0	Guangxi	Hechi	4508	1	0
Henan	Luoyang	4103	1	1	Guangxi	Qinzhou	4509	0	0
Henan	Pingdingshan	4104	0	0	Guangxi	Fangchenggang	4512	0	0
Henan	Anyang	4105	1	0	Guangxi	Guigang	4513	1	0
Henan	Hebi	4106	0	0	Guangxi	Hezhou	4516	1	0
Henan	Xinxiang	4107	0	0	Hainan	Haikou	4601	0	1
Henan	Jiaozuo	4108	1	0	Chongqing	Chongqing	5001	1	0
Henan	Puyang	4109	0	0	Sichuan	Chengdu	5101	1	1
Henan	Xuchang	4110	0	0	Sichuan	Zigong	5103	1	0
Henan	Luohe	4111	0	0	Sichuan	Panzhihua	5104	1	0
Henan	Sanmenxia	4112	1	0	Sichuan	Luzhou	5105	1	0
Henan	Shangqiu	4113	0	0	Sichuan	Deyang	5106	1	0
Henan	Zhoukou	4114	0	0	Sichuan	Mianyang	5107	1	1
Henan	Zhumadian	4115	0	0	Sichuan	Guangyuan	5108	0	0
Henan	Nanyang	4116	0	0	Sichuan	Suining	5109	1	0
Henan	Xinyang	4117	0	0	Sichuan	Neijiang	5110	1	0
Hubei	Wuhan	4201	1	1	Sichuan	Leshan	5111	1	0
Hubei	Huangshi	4202	1	0	Sichuan	Yibin	5114	1	0
Hubei	Shiyan	4203	0	0	Sichuan	Nanchong	5115	1	0
Hubei	Yichang	4205	1	0	Sichuan	Yaan	5117	0	0
Hubei	Xiangfan	4206	0	1	Sichuan	Guangan	5122	1	0
Hubei	Ezhou	4207	1	0	Guizhou	Guiyang	5201	1	1
Hubei	Jingmen	4208	1	0	Guizhou	Liupanshui	5202	0	0
Hubei	Huanggang	4209	0	0	Guizhou	Zunyi	5203	1	0
Hubei	Xiaogan	4210	0	0	Guizhou	Anshun	5207	1	0
Hubei	Xianning	4211	1	0	Yunnan	Kunming	5301	1	1
Hubei	Jingzhou	4212	1	0	Yunnan	Zhaotong	5303	1	0
Hubei	Suizhou	4215	0	0	Yunnan	Qujing	5304	1	0
Hunan	Changsha	4301	1	1	Yunnan	Yuxi	5306	1	0
Hunan	Zhuzhou	4302	1	0	Yunnan	Simao	5309	0	0
Hunan	Xiangtan	4303	1	0	Yunnan	Baoshan	5312	0	0
Hunan	Hengyang	4304	1	0	Yunnan	Lijiang	5314	0	0
Hunan	Shaoyang	4305	0	0	Yunnan	Lincang	5317	0	0
Hunan	Yueyang	4306	1	0	Shaanxi	Xian	6101	1	1
Hunan	Changde	4307	1	0	Shaanxi	Tongchuan	6102	1	0
Hunan	Yiyang	4309	1	0	Shaanxi	Baoji	6103	0	1
Hunan	Loudi	4310	1	0	Shaanxi	Xianyang	6104	0	1
Hunan	Chenzhou	4311	1	0	Shaanxi	Weinan	6105	1	0
Hunan	Huaihua	4313	1	0	Shaanxi	Hanzhong	6106	0	0
Guangdong	Guangzhou	4401	1	1	Shaanxi	Ankang	6107	0	0
Guangdong	Shaoguan	4402	1	0	Shaanxi	Shangluo	6108	0	0
Guangdong	Shenzhen	4403	1	1	Shaanxi	Yanan	6109	0	0
Guangdong	Zhuhai	4404	1	1	Shaanxi	Yulin	6110	0	0
Guangdong	Shantou	4405	1	1	Gansu	Lanzhou	6201	1	1
Guangdong	Foshan	4406	1	1	Gansu	Jiayuguan	6202	0	0
Guangdong	Jiangmen	4407	1	0	Gansu	Jinchang	6203	1	0
Guangdong	Zhanjiang	4408	1	1	Gansu	Baiyin	6204	1	0
Guangdong	Maoming	4409	0	0	Gansu	Tianshui	6205	0	0
Guangdong	Zhaoqing	4412	1	0	Gansu	Jiuquan	6206	0	0
Guangdong	Huizhou	4413	1	1	Gansu	Zhangye	6207	1	0
Guangdong	Meizhou	4414	0	0	Gansu	Wuwei	6208	0	0
Guangdong	Shanwei	4415	1	0	Gansu	Dingxi	6209	0	0
Guangdong	Heyuan	4416	0	0	Gansu	Longnan	6210	0	0
Guangdong	Yangjiang	4417	0	0	Gansu	Pingliang	6211	0	0
Guangdong	Qingyuan	4418	1	0	Gansu	Qingyang	6212	0	0
Guangdong	Dongguan	4419	1	0	Qinghai	Xining	6301	0	0
Guangdong	Zhongshan	4420	1	1	Ningxia	Yinchuan	6401	1	0
Guangdong	Chaozhou	4421	1	0	Ningxia	Shizuishan	6402	1	0
Guangdong	Jieyang	4424	1	0	Ningxia	Guyuan	6404	0	0
Guangxi	Nanning	4501	1	1	Xinjiang	Urumqi	6501	1	1
					Xinjiang	Karamay	6502	0	0