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Environmental policy and exports: Evidence from China

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Abstract

This paper assesses the effectiveness of environmental regulations in China. Our identication is based on the environmental policy of the Two Control Zones (TCZ), which was implemented by the Chinese government in 1998. The aim of this policy was to reduce sulfur dioxide (SO2) emissions in targeted cities with particularly severe air pollution. We use export data from 265 Chinese cities among which 158 were targeted by this policy, and exploit variations over time, sector and firm type to establish the causal effect of this policy on exports. Our results are robust to using an instrumental variable approach. Tougher environmental regulations lead to the reallocation of export activities away from energy-intensive sectors. In line with a suspicion of differences in policy enforcement according to the political pecking order of firms, the TCZ policy is found to have a greater impact the lower the firm's political status.

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

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1. Introduction

In 2006, China overtook the United States as the world's largest producer of carbon dioxide, the chief greenhouse gas (IEA, 2009). CO2 emissions in China account for roughly one quarter of the world total and their increase has been large enough to offset falls in the United States and Europe, and explain why global emissions reach new record levels every year. These statistics do not help China, which has been 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 obstacles to progress against global warming.[1]

Despite its image as a bad student, the People's Republic has adopted a series of regulatory policies. The worry that the severity of China's environmental problems[2] may soon hamper its economic growth has led the Chinese government to build 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. A number of observers now question the effective implementation and enforcement of Chinese environmental laws and regulations which exist largely only on paper (OECD, 2006). There are also recurrent doubts over the accuracy and honesty of the official pollution data (The Economist, 2012). It hence remains an open question whether Chinese environmental regulations are not just green-washing on an epic scale.

This paper investigates the effectiveness of the so-called Two Control Zones (TCZ) policy in reallocating activity away from polluting sectors. The TCZ policy was implemented in 1998 by the Chinese central government to reduce sulfur dioxide (SO2) emissions in locations with particularly severe air pollution. Based on previous years' records, a total of 175 cities across 27 provinces were identified as TCZ. We focus on city sectoral exports to measure the economic effect of the TCZ policy, and ask whether it led to any bias against polluting sectors in TCZ as compared to non-TCZ cities.[3]

Our paper contributes to the literature in two ways. We first shed light on the claim that new environmental standards may 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 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, we add to the abundant literature on what Taylor (2004) calls the "pollution haven effect," whereby tighter environmental rules at the margin affect plant location decisions and activities (Levinson, 1996; Becker and Henderson, 2002; Copeland and Taylor, 2004).

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[1] China signed the Kyoto Protocol (contrary to the US) but under the agreement that developing countries (of which China is one) would not be required to reduce their emissions.

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

[3] Export data, contrary to production data, are disaggregated by sector and city level.

Some of this work has looked at Chinese environmental regulations (Dean et al., 2009; Lu et al., 2012) but focuses on the attraction of foreign direct investment.

We here propose an evaluation of the TCZ policy. We build on recent efforts to address the problem of omitted variables which traditionally hinders the evaluation of environmental policies' impact on trade (Levinson and Taylor, 2008; Millimet and Roy, 2011).[4] It is indeed likely that the way in which environmental policy is designed and enforced in an area is correlated with various broader economic variables, such as GDP per capita or foreign direct investment, where the latter have also been identified in the literature as drivers of export performance. Using regional variations within a single country (China) instead of cross-country data reduces the severity of the problems, and represents a promising alternative way to examine the repercussions of environmental regulations. Nevertheless, in the specific case of the TCZ policy, stricter rules were deliberately applied to more polluted cities which likely differ from non-TCZs in a number of dimensions that could in turn explain export performance.

Our main strategy to counter endogeneity exploits variations in the expected impact of the TCZ policy by sector to isolate the direct regulation-related causal effect. The policy specifically targeted emissions in plants that burn coal, the main source of the China's energy needs and pollution. In TCZs, coal users were encouraged to use low-sulfur coal or required to adapt their coal-burning processes. As industries vary in terms of their intrinsic dependence on coal, we expect TCZ regulations to have a greater effect on coal-intensive activities and induce a reallocation of resources from higher to lower energy-intensive sectors. This particularity allows us to determine the causal effect of environmental regulations on exports, even if the selection of TCZs was not exogenous to economic activity. We thus filter the impact of environmental stringency using a sector-level index of energy consumption. This strategy is conceptually similar to a triple differences estimate (DDD). We compare i) cities before and after the introduction of the TCZ policy (first difference), ii) targeted vs. non-targeted cities (second difference), and iii) sectors with higher vs. lower coal use (third difference). We appeal to sectoral export data to evaluate the effect of the policy by sector, according to their energy consumption. Any omitted variable behind our results would thus have to exhibit not only a significant export impact, but also an export impact by sector reflecting energy consumption. The validity of our estimation hinges on the condition that the treated cities would have followed the export trend of the control cities if they had not implemented the new environmental policy. To verify the validity of this identification assumption, we conduct a series of sensitivity analyses, including checking any differential pre-treatment time trends, verifying the consistency of the policy impact over time and including proxies for time-varying differences between the two groups. We also check that our results are robust to the instrumental variable strategy proposed by Broner et al. (2012), exploiting the exogenous meteorological determinants of the speed of air pollution dispersion.

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[4] For a survey of the literature, see Levinson (2008).

Our work also addresses concerns about the inadequate enforcement and unsanctioned non-compliance of Chinese environmental regulations (Liu and Diamond, 2005). One common issue is that it is hard for some governmental officials who have interests in companies that damage the environment to enforce environmental policies.[5] Along the same lines, some firms may be in a better position to avoid compliance and escape the associated sanctions. The institutionally-grounded political pecking order of Chinese firms likely implies heterogeneous policy responses by firms according to their ownership. Dollar and Wei (2007) find that state-owned firms are systematically favored by local authorities in terms of access to external funding, property-rights protection, taxation, and market opportunities. State-owned firms will then probably be less affected by policy due to their greater bargaining power with the regulator and capacity to absorb the additional costs from the policy (Huang, 2003b). Our data allow us to differentiate between the exports of state-owned and private firms. There are thus reasons to consider heterogeneity in TCZ policy response by ownership type. First, our identification strategy ensures that the results do not reflect endogeneity: the quadruple difference estimate further filters the impact of environmental rules by firm ownership. Second, it uncovers a potential obstacle to policy effectiveness, which is important for China if it is serious about improving air quality.

Our empirical analysis appeals to sectoral export data from 265 cities for 1997 to 2003, 158 of which were designated as TCZ. The TCZ policy effect is identified by the exports of TCZs and non-TCZs according to sectoral coal intensity and the firm's political status. The fall in exports following the TCZ policy is sharper in sectors with greater coal use. As the move away from pollution-intensive activities may reflect both scaling down and relocation away from TCZ areas, our results are consistent withthe pollution-haven hypothesis (Javorcik and Wei, 2005; and in the specific context of China, Dean et al., 2009; and Lu et al., 2012). Although we do not identify the global pollution impact, our findings are in line with Dean and Lovely's (2010) conclusion that the pollution intensity of Chinese exports fell dramatically from 1995 to 2004.

Despite the concerns about poorly-enforced Chinese environmental regulations, our results suggest that the TCZ policy was effective. They confirm the findings of significant repercussions on foreign direct investment (Lu et al., 2012) and health and mortality (Tanaka, 2010). We nonetheless find that the export effect of environmental regulations depends on firm political status. In particular, the TCZ policy is less effective in state-owned firms, but has a larger effect in areas with more efficient governments. After controlling for city- and sector-level characteristics, environmental regulations are shown to produce an export growth bias against polluting sectors in TCZ cities only for non-state firms. State-ownership thus protects firms from more stringent environmental regulations, suggesting a conflict of interest for governmental officials. It would thus seem important to address the gap between state and non-state firms, even if more work is needed to understand what is behind this effect: corruption, greater bargaining power or a greater

[5] Weak enforcement may also result from a lack of funding, insufficient manpower and the political authority of the supervising authority, the State Environmental Protection Administration (Naughton, 2009).

ability to absorb a given cost shock due to softer financial constraints.

The remainder of the paper is organized as follows. Section 2 discusses air pollution in China and presents the Two Control Zones policy, and Section 3 sets out the role of firm ownership in the Chinese economy. Section 4 then presents the data and the empirical approach, and our results are described in Section 5. Last, Section 6 concludes.

2. Air pollution and environmental policies in China

2.1. Coal consumption and air pollution

Air pollution is becoming China's greatest 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 air pollution in China leads to 350,000-400,000 premature deaths per annum. SO2 emissions have long been a major source of ambient air pollution in Chinese cities.[6] They are also the primary source of acid rain, defined as precipitation with a pH value under 5.6.[7] The main source of SO2 emissions is coal burning, which generally pollutes more than other fossil fuels. China obtains 80 percent of its electricity and 70 percent of its total energy from coal, much of it polluting high-sulphur coal. China has the third largest coal reserves in the world, and coal is the largest locally-exploitable fossil resource leading to considerable dependence on this resource.

The growing concern over the economic costs of SO2 and acid rain led the Chinese authorities to take more stringent measures to reduce coal-related pollution. Two strategies were followed: the first seeks to improve the efficiency of energy-conversion; the second, which is more long-term, aims for more efficient energy consumption. To achieve these objectives, Chinese authorities introduced various pollution-control systems, including the ambitious Two Control Zones policy which we analyze here.

2.2. Two Control Zones policy

The Two Control Zones policy was implemented by the central government in 1998 with the objective of reducing SO2 emissions in cities and areas with particularly high air pollution. Cities exceeding certain standards were designated as either acid rain orSO2 pollution control zones, according to their records in recent years.[8] In total, 175 cities across 27 provinces were designated as TCZ. Together, these cities account for 11.4% of the Chinese territory, 40.6% of national population, 62.4% of China's GDP, and around 60% of total SO2 emissions in 1995 (Hao et al., 2001).

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

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

[8] Cities are designated as SO2 pollution control zones if (1) average annual ambient SO2 concentrations exceed $20\mu g/m^3$ (Class II standard), (2) daily average concentrations exceed 60 $\mu g/m^3$ (Class III standard), and (3) high SO2 emissions are recorded. Cities are designated as Acid Rain control zones 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 (Tanaka, 2010).

The National 10th Five-Year (2001-2005) Plan for Environmental Protection required that annual sulfur emissions in the Two Control Zones be reduced by 20% by 2005, from their 2000 levels. As SO2 emissions were previously unregulated in China, this is an ambitious target. The three main policy measures embodied in the TCZ plan were the closing of the biggest polluters, reducing the sulfur-content of coal, and cleaner coal-burning.

First, the construction of new collieries based on coal with a sulfur content of 3% and above was prohibited, and existing collieries mining similar coal faced production restrictions or were gradually phased out. The World Bank (2003) estimates low-sulfur coal increases firm total operating costs as it is 40% to 50% more expensive than local high-sulfur coal.[9]

Second, overall emissions from coal-fired power plants and other polluting industries were set to be reduced. The construction of coal-fired power plants in the center or close suburbs of medium and large cities was prohibited, except for co-generation plants whose primary purpose is to supply heat. Moreover, newly constructed or renovated coal-fired power plants using coal with a sulfur content of over 1% had to install sulfur-scrubbers. Existing coal-fired power plants using this high-sulfur coal were required to adopt SO2 emission-reduction measures. All green-field coal-fired power plants with capacity over 300 megawatt electrical (MWe) were compelled to put in place flue-gas desulfurization (FGD) facilities.[10] Industrial polluters were required to install control equipment or adopt other mitigation measures in order to reduce emissions (switch to low-sulfur coal, modify their boilers and kilns, and treat effluent gas).

Finally, one of the main measures was the implementation of SO2 emission fees collected from the major sulfur emitters.

These measures led many small factories with inefficient technologies causing serious pollution to shut down. By the end of 1999, collieries producing over 50 million tons of high-sulfur coal had been shut (Hao et al. 2001), and by May 2001, 4492 high-sulfur coal mines had 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).

A number of contributions have documented the effectiveness of these comprehensive measures in reducing acid rain and air pollution in the Two Control Zones (He et al., 2002; Xu et al., 2004). Among the 175 TCZ cities, the number meeting the national ambient air SO2 concentration standards increased from 81 in 1997 to 98 in 1999. SO2 emissions in the TCZ cities fell by about 3 million tons, and about 71% of factories with initial emissions of over 100 tons per year reduced their SO2 emissions to the standard by 2000 (Tanaka, 2010).

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[9] These estimates are based on prices of high-sulfur coal of about 190 - 250 Yuan per ton. Industrial boiler operators are expected to pay an additional 100 to 150 Yuan per ton for low-sulfur coal, compared to local high-sulfur coal. This higher price reflects higher transportation costs as well as better quality (better heating value).

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

3. The enforcement of environmental policies and the role of firm ownership

Reflecting the considerable administrative decentralization in China, local governments are effectively given discretion as to how to interpret and carry out policies. Hence, as in other economic domains, local authorities are legally responsible for enforcing environmental regulations but have only limited resources and power to do so (Wang et al., 2003). The unavoidable consequence is generalized bargaining through which many polluters can effectively avoid paying charges, fines or other penalties. As such, firms are affected very differently by policies in general, and pollution policies in particular, depending on their bargaining power with the regulator and their capacity to absorb the additional costs resulting from the policy. In China, these two dimensions directly relate to firm ownership. Huang (2003a) notes that China's institutional landscape is best described as a political pecking order systematically favoring state-owned entreprises (SOEs), both financially and legally. Local authorities, whose income and promotion prospects are directly tied to the performance of state-owned firms, have vested interests which oppose the dismantling of the inefficient public sector.

This ownership bias has very concrete repercussions in terms of discriminatory and incomplete policy enforcement in China. Local governments tend to resist the rationalization of state-owned firms under their supervision through local protectionism. An entire World Bank report details the various discriminatory measures put in place by local authorities to curb competition and favor politically-connected firms (World Bank, 2005). These measures include direct control over the quantity of sales, price limits and local subsidies, discriminatory regulation enforcement, and intervention in the input, labor and finance markets. In line with public firms' greater political power, regional protection is more widespread in industries dominated by SOEs (Poncet, 2005). Dean et al. (2009) consider the enforcement of water-pollution charges in China and show that private-sector firms have less bargaining power than state-owned enterprises: state-owned firms are in a better position to escape sanctions.[11]

These findings suggest that any repercussions of the TCZ policy on firms may be mitigated for state-owned firms. This first source difference by firm-ownership type is amplified by a second relating to heterogeneous cost-absorption capacities. A large literature has shown that private firms suffer from greater credit constraints. One well-acknowledged consequence of the China's political pecking order of firms is the systematic misallocation of financial resources (Dollar and Wei, 2007). Despite the very large 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, to the extent that they are often seen as bottomless pits for government-channeled investment funds (Boyreau-Debray and Wei, 2004). We argue that, thanks to reduced obligations to comply with regulations and softer budget constraints, public enterprises may continue their business as usual

[11] Similar findings are found in terms of taxation: private firms experience worse tax and legislative treatment (Huang, 2003b).

despite the new environmental regulations, while private enterprises are forced to adjust by cutting their productive and export activities.

4. Data and stylized facts

4.1. Data

4.1.1. Trade data

Our main data source is Chinese Customs, providing information on Chinese export flows by location, year, product and destination country over the 1997-2003 period. Our dependent variable is annual total exports by city and sector. Export flows are aggregated up to the 25 2-digit sectors for which indicators of pollution intensity are available.[12] We are limiting our sample to exports from the 4 municipalities[13] and 261 prefecture-level cities that we can identify in the trade data set.[14] These cities export at least in one sector in every year and keep their prefecture-level status throughout the period under study. Together, these 265 cities are responsible for 90% of China's total export flows for the sectors we analyze. Our final sample consists thus of 46,375 observations (265 cities, 25 sectors, 7 years).

We also have information on the ownership structure of exporting firms, and can distinguish between the exports of state-owned enterprises (SOEs) and privately-owned firms.[15] We exploit this information on firm ownership in Section 2, where we differentiate between SOEs (which also include collectively-owned firms) and privately owned firms (private firms, fully foreign-owned firms and joint ventures). The final dataset distinguishing between SOEs and non-SOEs contains 92,750 observations (46,375 city-sector-year observations for each firm-ownership type).

4.1.2. Industry-level variables: energy intensity and controls

Our main measure of exposure to stricter environmental regulations at the sector level is the sector's ratio of coal consumption to value-added ($coal\ int_k$). Coal intensity is computed for 25 two-digit sectors in 1997, the year before the TCZ policy was implemented. This captures the technological characteristics of each sector which are supposed exogenous to firms' regulatory environment.

We also carry out robustness checks using the total energy use over value-added and electricity use over value-added.[16] We will also use SO2 emissions over value added by sector for 2003, as this is the first year in which they appear in the Chinese Environmental Yearbooks. In further robustness

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[12] We use the 2002 Chinese industrial classification.

[13] They include Beijing, Tianjin, Shanghai and Chongqing.

[14] Our sample hence does not cover county-level cities.

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

[16] In unreported results our findings are robust to measuring energy intensity based on production instead of value added.

checks, we include controls for sectoral labor and capital intensity. All industry variables come from the China Statistical yearbooks. The correlation between the different industry indicators appears in Table A-2. In Appendix Table A-1, sectors are ranked by their coal intensity. The manufacture of coke and coal mining exhibit the greatest reliance on energy, followed by manufacturing of non-metallic mineral products and basic metals. The sector with the lowest coal and energy intensity is the manufacture of tobacco products.

4.1.3. City-level variables: TCZ and controls

Of the 265 cities in our data set, 158 are designated as TCZ. The list of cities targeted by the policy comes from Tanaka (2010). The geographical distribution of the TCZs is displayed in Appendix Figure B-1.[17] In the empirical analysis, we control for the special policy zones listed by Wang and Wei (2008).[18]

Macro-economic 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, our final sample is of 243 cities for which we have consistent data on GDP per capita between 1997 and 2003.[19] Appendix Table A-3 provides some summary statistics separately for TCZ and non-TCZ cities, while Table A-4 shows the correlation between the main city-level indicators. TCZs differ significantly from non-TCZs in a number of dimensions. Notably, TCZ cities have higher GDP per capita and more exports.

4.1.4. Instrumental variable

Our empirical analysis relies on a triple-difference estimate to estimate the impact of TCZ given that selection into TCZ is not exogenous. The designation of cities as TCZs reflects initial high pollution levels. Since pollution may be correlated with other characteristics that in turn affect exports, we may have endogeneity problems. In Section 5 we complement the triple differences estimates by an instrumental variable. We follow Broner et al. (2012), who study the impact of environmental policy in cross-country data. They instrument environmental policy using the ventilation coefficient, reflecting the meteorological conditions that influence the speed of dispersion of pollutants in the air. The hypothesis is that meteorological conditions which slow the dispersion of pollutants in the air likely lead to the adoption of stricter environmental regulation.[20] Here, cities where pollution is dispersed more slowly are more likely to be targeted by the Two Control Zones policy as, for given local SO2 emissions, the SO2 concentration in the air remains

[17] Table B-1 lists all of the cities in our sample.

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

[19] For the time period we study, there are overall 287 prefecture level cities/municipalities. 22 of them do not export (they do not figure in the export database), for another 22 cities data on GDP per capita is inconsistent, leading to a final sample of 243 cities. GDP per capita is calculated using data from the whole prefecture, not only the urban part, since export data is available only at the total prefecture-level.

[20] See Broner et al. (2012) for more details on the determinants of atmospheric pollution, the ventilation coefficient and its suitability as an environmental-policy instrument.

higher for longer.

The ventilation coefficient is identified in the standard Box model of atmospheric pollution as the determinant of the dispersion speed of air pollution (Jacobsen, 2002). This is defined as the product of wind speed, which determines the horizontal dispersion of pollution, and mixing height, which determines the height at which pollutants disperse in the atmosphere. For two locations with the same level of emissions, that with the higher ventilation coefficient has less pollution. As ventilation coefficients are determined by large-scale weather systems, they can plausibly be considered as exogenous to local economic activity. We use this exogenous source of air pollution differences between cities as our instrument for the TCZ label.

We follow Broner et al. (2012) for the data. Wind speed at 10 meters height and mixing height[21] come from the European Centre for Medium-Term Weather Forecasting (ECMWF) ERA-Interim data set.[22] These data are available for a global grid of 75°×75° cells (about 83 square kilometers). The ventilation coefficient for every grid cell is then constructed by multiplying average wind speed and boundary layer height. We then average this indicator by cell for 1991 to 1996 (two years prior to the implementation of the policy). The locations in the ERA-Interim database can be matched to our Chinese cities via latitudes and longitudes (obtained from world-gazetteer.com). Every city is associated with the ventilation coefficient from the closest cell in the ERA-Interim grid.[23]

Appendix Table A-4 shows the correlations between the ventilation coefficient, wind speed and boundary layer height and the TCZ variable, as well as with other city variables. As seen in Table A-3, the ventilation coefficient is on average lower for TCZ than for non-TCZ cities. The same holds for the two components, wind speed and boundary layer height. This is as expected: a higher ventilation coefficient reflects the faster dispersion of air pollution. This likely reduces the measured concentration of SO2 and hence the need for stringent environmental regulations.

4.2. Stylized facts regarding export patterns and coal intensity

There are large systematic variations in sectoral export by coal intensity and TCZ status. These differences changed over time in a way which bodes well for the empirical analysis below.

Figure B-2 ranks sectors by coal intensity, and plots the export value of TCZs (left panel) and non-TCZs (right panel) as well as the difference in export value between the two city types for the two extreme years of the trade data (1997 and 2003). Between 1997 and 2003, total exports increased substantially in both TCZ and non-TCZ cities.[24] In the former, exports increased more slowly in coal-intensive sectors; no such pattern appears for non-TCZ cities. The bottom panel shows a rising export premium for low-pollution sectors in TCZs relative to non-TCZs. This is

[21] Mixing height refers to boundary layer height in the ERA-Interim data set we use.
[22] We use the monthly average of daily means.
[23] We check that our results hold when using the mean ventilation coefficient from the four and six nearest cells.
[24] Overall in the 158 TCZ cities, total exports increased every year by 16% on average. In the 107 non-TCZ cities the average growth rate was 13.5%.

consistent with environmental regulations deterring exports mainly in coal-intensive sectors. Overall, the data suggest the reallocation of exports from high to low energy-intensive sectors, but only for TCZs. This is a first hint that the policy might have reduced pollution in targeted cities.

5. Empirical methodology and results

Our empirical analysis is carried out in two steps. We first look at the sectoral export patterns by energy intensity following the TCZ policy; we then see whether there are any differences according to firm ownership.

5.1. Aggregate export flows

5.1.1. Empirical methodology

We identify the effect of stricter environmental policies from the differential sectoral effect of the TCZ policy according to their exposure.

We estimate the following equation on our panel of sectoral export data for 265 cities over 1997-2003.

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

where $Exports_{ikt}$ are the free-on-board export sales in industry k at year t for city i, TCZ is a dummy for the city having been targeted by the policy, and $Post$ is a dummy for the years post 1998, the year the TCZ policy was implemented. The variable $Exposure_k$ reflects exposure to stricter environmental regulations and varies across sectors. As explained in Section 4.1.2 our main proxy of exposure at the sector level is the sector's ratio of coal consumption to value-added (in logs).

In Equation (1) ν_{it}, λ_{kt} and θ_{ik} correspond to city-year, sector-year and city-sector fixed effects, and ε_{ikt} is an idiosyncratic error term. We run regressions with exports in levels instead of logs, as we can then include the zero export flows, which represent about 32% of our final sample.[25] With the fixed effects, our estimates appeal to within changes that are different between TCZ and non-TCZ cities. The export effect of stricter regulatory constraints is identified by comparing across sectors. Our main coefficient of interest is hence that on the triple interaction term α. If environmental regulations do reduce firm exports, we expect exports to be lower in targeted cities. However, this effect should be smaller in low coal-intensity sectors where the rise in production costs is muted. Moulton (1990) shows that regressions with aggregated right-hand side variables can produce downward bias in the estimated standard errors. Also Bertrand et al. (2004) argue that

[25] A more standard approach to incorporate the zero trade flows would be to use a generalized linear model with a log link (also called PQML estimator). However, we here encounter computation problems when we want to control for time-varying city and sector characteristics at the same time as city-sector fixed effects. Our benchmark estimates are based on exports in levels, but we will show that our results are robust to limiting the sample to positive flows (in levels and in logarithm), and to generalized linear model estimates with a reduced number of fixed effects. Ideally, we would also check for robustness using a Heckman two-stage procedure, but we lack a convincing exclusion restriction.

difference in difference estimations, as we have here, often yield inconsistent standard errors due to the serial correlation of the error term within the treated units (here the cities). As such, the standard errors in our regressions are clustered at the city level.

5.1.2. Main results for aggregate export flows

In columns 1 and 2 of Table 1 we estimate Equation (1) without the dyadic (city-year, sector-year, sector-city) fixed effects, including only year, city and sector dummies. Theoretically, the TCZ export impact is captured by the dummy for TCZ cities post 1998 (i.e. the double interaction $TCZ_i \times Post$). In column 1, the coefficient on this interaction term is positive and significant, suggesting a rise in sectoral exports in TCZ cities. This counter-intuitive result likely reflects other changes in TCZ cities at that time which affected exports. For example, the general privatization and opening of trade that occurred in these cities in preparation for China's WTO entry in 2001. In column 2, we triple interact the TCZ and post dummies with sectoral coal intensity, on top of the double interactions between sectoral coal intensity and both the post and TCZ dummies. This triple interaction term, $TCZ_i \times coal\ int_k \times post$, shows whether there is a differentialeffect by coal intensity in treated cities.

Column 3 shows our benchmark specification in Equation (1). Since we include fixed effects at the city-year, sector-year and city-sectoral levels, the double interaction terms drop out, which however does not affect the size and significance of α. As in column 2, this is negative and very significant, suggesting that stricter environmental regulations did indeed reduce exports as a function of sectoral coal intensity. A 10% difference in coal intensity in a TCZ city is estimated to reduce yearly exports by 2.2%.[26].

Lower exports in polluting sectors in TCZ cities can result from either a fall in the export volume of existing exporters (the intensive margin), or firm closure and eventual relocation to a less stringent environment (the extensive margin). However, we cannot disentangle these two channels. Ederington et al. (2005) argue that relocation will likely only be limited as the industries with the greatest pollution abatement costs are also the least mobile geographically. In any case, given that our dataset is a quasi exhaustive list of export flows, finding a negative α indicates that the policy has been effective, reducing pollution in the targeted relative to the non-targeted cities. This suggests that exports in targeted cities have become cleaner as the more polluting firms scale back their activities compared to polluting firms elsewhere.

[26] This figure reflects the fall of 1.14 million US Dollars compared to mean exports of around 51 million US Dollars in TCZ cities.

Table 1. TCZ policy and export values

Dependent variable:	Exported value (city/sector/year)								
Exposure:	Coal				Energy	Electricity	SO2	Coal	
				W/o extreme sectors					
	1	2	3	4	5	6	7	8	9
TCZ$_i$×post	0.207[a]	-0.275[b]							
	(0.062)	(0.106)							
Exposure×post		-0.000							
		(0.002)							
TCZ$_i$×Exposure		-0.106[a]							
		(0.039)							
TCZ$_i$×Exposure×post		-0.114[a]	-0.114[a]	-0.214[a]	-0.102[a]	-0.078[b]	-0.119[a]	-0.117[a]	-0.104[a]
		(0.040)	(0.040)	(0.068)	(0.039)	(0.032)	(0.041)	(0.041)	(0.038)
TCZ$_i$×K/L×post								0.025	
								(0.029)	
TCZ$_i$×K/prod×post									-0.075[b]
									(0.033)
Fixed effects	City, year, sector		City-year, sector-year & sector-city						
Observations	46375	46375	46375	31535			46375		
R^2	0.025	0.029	0.198	0.258	0.197	0.197	0.199	0.198	0.198
No. of cities	265	265	265	265	265	265	265	265	265
No. of TCZ cities	158	158	158	158	158	158	158	158	158

Heteroskedasticity-robust standard errors clustered at the city level appear in parentheses; [a], [b] and [c] indicate significance at the 1%, 5% and 10% confidence levels. Exposure to stricter regulations at the sector level is computed by the sector's ratio of coal consumption to value-added (in logs) in columns 1 to 4 and in columns 8 and 9, the logarithm of the sector's total energy use over value added in column 5, the logarithm of the sector's electricity use over value added in column 6 and the logarithm of the sector's SO2 emissions over value added in column 7.

Columns 4 to 9 of Table 1 present some robustness tests.[27] Column 4 excludes the top and bottom four sectors in terms of coal intensity, as identified in Appendix Table A-1. The estimated α is higher, so that our benchmark findings were not driven by these extreme sectors.[28] In columns 5 and 6 we check that the results are robust to alternative measures of energy intensity. Instead of coal over value added we consider in turn the ratio of total energy to value added and the ratio of electricity to value-added.[29] More energy intensive industries continue to suffer from a relative fall in exports following the TCZ policy compared to less energy-intensive and thus less polluting sectors. Logically the coefficients here are slightly lower and less significant, reflecting the policy's target of reducing coal consumption. In column 7 the exposure of sectors to the policy is measured by the ratio of SO2 emissions to value-added (constructed with 2003 data), which does not change the overall message. In columns 8 and 9 we address the concern that polluting industries are in general also capital intensive (as indicated by the correlation between capital and pollution intensity in Table A-2). We therefore add in column 8 the interaction of the $TCZ \times Post$ term with the sectoral capital-labor ratio, and in column 9 the interaction with capital to total production. Our main finding of a relative decline in coal-intensive sectors remains, confirming the environmental impact of the TCZ policy.

Before we carry out further robustness tests, we would like to understand the role of zero export flows in our sample. Since we have around 32% of zeros in our data base, we would ideally like to use a Poisson quasi-maximum likelihood estimator (PQMLE). However, including all of the fixed effects as in the OLS regressions is not feasible. In columns 1 and 2 of Table A-5, we present the PQMLE results of our benchmark regression in Table 1, column 3 and the robustness check in column 8, including only city-year and sector-year fixed effects. For comparison, we display in columns 3 and 4 results of OLS regressions with the same fixed effects. The two estimation methods provide rather similar predictions for a 0.1 increase in the triple interaction term. Results in column 1 suggest that yearly exports would reduce by 1-exp(-0.0119)=1.2% while the corresponding value based on column 3 results and using the average value of yearly city-sector exports for the entire sample of 32 million US dollar is 3.6%=0.1×0.114/0.32. Columns 5 to 8 of Table A-5 show the estimates when we limit our analysis to positive trade flows. In columns 5 and 6 we use a log transformation of the dependent variable while the last two columns show the results using the original specification on a sample of positive export flows only. The finding of a reallocation of export activities away from exposed coal-intensive sectors is confirmed throughout the specifications.

In the following section, we conduct a series of sensitivity analyses to see whether our results are affected by the endogenous selection of TCZs. We first check the validity of the parallel trend

[27] In unreported results we check that our findings are robust to the deletion of any given city and any given sector from our sample.

[28] The coefficient on the triple interaction term in column 4 suggests a fall of about 4.5% in exports (calculated at the mean for the sample of TCZ cities used in this column) from a 10% rise in coal intensity.

[29] Since more than 75% of China's energy is generated from coal, industries that are intensive in overall energy or electricity are also likely affected by the TCZ policy as they are more likely to face power shortages or higher energy prices.

assumption in TCZs and non-TCZs. Second, we control for some other city characteristics that are potentially correlated with sectoral exports. Third, we carry out an instrumental variable estimation. Our findings remain robust to all of these checks.

5.1.3. Verifying the parallel trend assumption

This section proposes two complementary approaches to verify that our results of diverging export patterns between TCZs and non-TCZs do not solely reflect different trends.

First we take a closer look at the policy impact by seeing how it evolves over time. Therefore, in Table 2 we decompose the $post$ dummy into various year dummies, keeping 1997 as the benchmark. Column 1 shows negative coefficients on the yearly interaction terms of $TCZ \times coal\ int$, which become larger over time. The coefficient for 1998 is negative but insignificant, suggesting that export patterns between TCZs and non-TCZs were similar the year the TCZ policy was launched. TCZ export patterns became increasingly biased against pollution-intensive sectors over time, compared to non-TCZs. This is consistent with the delays inherent to the production and organizational changes required by the policy.[30]

In columns 2 and 3 we check that our main result does not merely reflect a secular trend of a relative decline in coal-intensive industries across China. We split the data up into TCZ and non-TCZ cities. Column 2 shows the results for exports in non-TCZ cities while column 3 reports those for TCZ cities. Our variables of interest here are the interactions between coal intensity and the year dummies, controlling for city-sector and city-year fixed effects. In non-TCZ cities, we see no significant fall in exports related to coal requirements. By contrast, in the sub-sample of TCZ cities, the negative coefficients indicate a relative decline in the exports of more polluting industries that becomes larger in size over time. In this sub-sample, we find a significant impact in 1998, the year the policy was launched. These contrasting results suggest that the reallocation away from polluting sectors, which we interpret as the effect of the TCZ policy, does not reflect a general shift of the exports of Chinese cities towards cleaner industries.[31]

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[30] We check that our results in Table 2 hold when using the alternative specifications of pollution intensity as in Table 1.

[31] In unreported results we obtain similar results when replacing coal intensity with the various measures of pollution intensity used in Table 1.

Table 2. Yearly effects

Dependent variable:	Exported value (city/sector/year)		
Coefficient for	TCZ_i×Coal int_k ×Year	Coal int_k ×Year non-TCZ cities	Coal int_k ×Year TCZ cities
	1	2	3
1998	-0.013	-0.000	-0.013[c]
	(0.008)	(0.001)	(0.008)
1999	-0.028[b]	-0.001	-0.029[b]
	(0.013)	(0.001)	(0.013)
2000	-0.066[a]	-0.000	-0.066[a]
	(0.025)	(0.001)	(0.025)
2001	-0.103[b]	0.001	-0.103[b]
	(0.040)	(0.002)	(0.040)
2002	-0.148[a]	-0.000	-0.149[a]
	(0.052)	(0.003)	(0.052)
2003	-0.258[a]	-0.001	-0.258[a]
	(0.091)	(0.004)	(0.091)
City-year fixed effects	yes	yes	yes
City-sector fixed effects	yes	yes	yes
Sector-year fixed effects	yes	no	no
Observations	46375	18725	27650
R^2	0.199	0.108	0.184
No. of cities	265	107	158

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

Our second approach is to use pre-treatment data to verify that the relative decline in coal-intensive industries we observe in TCZs did not exist prior to the new environmental policy. As highlighted in Section 2, the cities targeted by the TCZ policy had very polluted air. This high level of pollution may have induced authorities to limit emissive activities even before the policy was implemented. Sectoral export flows at the city-level are unfortunately not available for the years before 1997. The finer level of geographic disaggregation is provincial. Despite this limitation we investigate the parallel trend hypothesis on a panel of sectoral export flows at the provincial level between 1992 and 2003. We test whether we observe a significant reallocation of exports away from coal intensive sectors that reflects the importance of to-be-TCZ cities in the province. While we expect such an evolution after 1998, the common trend assumption would require that no such pattern exists before. We rely on three proxies to capture the weight of to-be TCZ cities at the province-level: the percentage of prefecture-level cities in the province that are designated as TCZs, their share in the province-level GDP (measured in 1996), and their share in the province-level export value (measured in 1997). The results based on these respective proxies are displayed in columns 1 to 3 of Table 3.

They suggest a reduction of polluting exports that is proportional to the importance of TCZs and that started after 1998. In columns 4 to 6, we regress export value at the province-sector-year on yearly interactive terms between the importance of to-be TCZs and coal intensity in a spirit similar to Table 2 and using 1997 as the reference. Whatever the proxy of the province-level importance of TCZs negative and significant coefficients are found only for terms after 1998.

5.1.4. Additional controls and IVs

Table 4 provides additional robustness checks to see whether the export-deterring effect of the TCZ policy is driven by omitted variables which match the time-varying differences between TCZ and non-TCZ cities.

One reason to see a relative export decline in TCZ locations is the convergence observed in China. Over the years, more firms have relocated or created in the relatively poorer inland provinces, where labor and land are cheaper. The "Go West" strategy launched in 2000 to develop China's Western hinterlands and improve their infrastructure has further increased their attractiveness. Moreover polluting firms may find less-developed regions more attractive as there is less concern there about environmental damage. In column 1 of Table 4 we consider whether the relocation and growth of firms away from coastal China drives our results. We add the interaction of coal intensity and the post-treatment dummy with *Coast*, a dummy for being located in a coastal province.[32] The negative and significant effect of the TCZ policy is robust to this control.

TCZ and non-TCZ cities may also differ in terms of their outward orientation.

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

Table 3. Estimations at the provincial level

Explained variable	Exports (province/sector/year)					
Proxy for TCZs weight (TCZ)	Nb cities	GDP	Exports	Nb cities	GDP	Exports
	1	2	3	4	5	6
TCZ_p×coal int_k ×Trend 1992-1998	-0.095	-0.081[c]	-0.062			
	(0.059)	(0.045)	(0.042)			
TCZ_p×coal int_k ×Trend 1999-2003	-0.540[b]	-0.420b	-0.308c			
	(0.254)	(0.197)	(0.168)			
TCZ_p×coal int_k ×1992				0.876	0.726c	0.562
				(0.558)	(0.419)	(0.390)
TCZ_p×coal int_k ×1993				0.755	0.606	0.466
				(0.486)	(0.365)	(0.342)
TCZ_p×coal int_k ×1994				0.457	0.386	0.279
				(0.340)	(0.255)	(0.239)
TCZ_p×coal int_k ×1995				0.521	0.396	0.295
				(0.309)	(0.233)	(0.217)
TCZ_p×coal int_k ×1996				0.374	0.305	0.215
				(0.290)	(0.217)	(0.204)
TCZ_p×coal int_k ×1998				-0.085	-0.060	-0.050
				(0.080)	(0.057)	(0.049)
TCZ_p×coal int_k ×1999				-0.247	-0.144	-0.118
				(0.180)	(0.123)	(0.094)
TCZ_p×coal int_k ×2000				-0.585c	-0.418[c]	-0.305[c]
				(0.306)	(0.225)	(0.165)
TCZ_p×coal int_k ×2001				-0.904[c]	-0.657[c]	-0.443
				(0.482)	(0.356)	(0.262)
TCZ_p×coal int_k ×2002				-1.234[b]	-0.914[b]	-0.656[b]
				(0.555)	(0.426)	(0.324)
TCZ_p×coal int_k ×2003				-1.944[b]	-1.474[b]	-1.069[c]
				(0.893)	(0.697)	(0.557)
Fixed effects	province-sector, province-year, year-sector					
Observations	8700	8700	8700	8700	8700	8700
Nb of provinces	29	29	29	29	29	29
R-squared	0.414	0.412	0.410	0.414	0.412	0.410

Heteroskedasticity-robust standard errors clustered at the province level appear in parentheses; [a], [b] and [c] indicate significance at the 1%, 5% and 10% confidence levels.

Table 4. TCZ policy and export values: Additional controls

Dependent variable:	Exported value (city/sector/year)					
					IV	IV
	1	2	3	4	5	6
$TCZ_i \times$ coal int_k ×post	-0.088[a]	-0.050[b]	-0.120[a]	-0.051[c]	-0.058	-0.229
	(0.031)	(0.023)	(0.043)	(0.030)	(0.092)	(0.155)
$Coast_i \times$coal int_k ×post	-0.148[a]	-0.112[a]		-0.010		0.001
	(0.053)	(0.043)		(0.039)		(0.040)
$SPZ_i \times$coal int_k ×post		-0.217[a]		0.012		0.036
		(0.081)		(0.071)		(0.071)
ln(GDP pc_i)×coal int_k ×post				-0.529[a]		-0.510[a]
				(0.146)		(0.135)
ln(GDP $pc_i)^2$ ×coal int_k ×post				-0.315[a]		-0.327[a]
				(0.097)		(0.093)
Fixed effects	City-year, sector-year & sector-city					
Observations	46375	46375	42525	42525	46375	42525
R-squared	0.199	0.202	0.200	0.220	0.001	0.024
No. of cities	265	265	243	243	265	243
Partial R-squared					0.039	0.047
p-value (C-statistics)					0.495	0.153
Underidentification					9.922	10.250
p-value (Underid.)					0.00	0.00
Weak identification					11.061	11.097
p-value (Weak id.)					0.001	0.001

Heteroskedasticity-robust standard errors clustered at the city level appear in parentheses. a, b and c indicate significance at the 1%, 5% and 10% confidence levels. The results from the first step of columns 5 and 6 appear in Appendix Table A-6. The substantial p-values of the C-statistics for the exogeneity of TCZ×coal int×post indicate that the IV and OLS results are not significantly different from each other. The underidentification test is reflected in the Kleinbergen-Paap LM statistics, and the weak identification test in the Kleinberg-Paap Wald F-statistics. The values obtained from both tests suggest that our instrument is relevant.

In recent decades, the Chinese government has created a number of special economic zones, High-technology Industry Development Areas, Economic and Technological Development Areas and Export Processing Zones, to which preferential fiscal treatment has attracted many exporters and foreign-owned firms (Wang and Wei, 2008). Among the 62 cities with a special policy zone (SPZ) in our sample, 50 were targeted by the TCZ policy. Table A-3 shows that the correlation between the TCZ and SPZ cities is around 0.23. Column 2 of Table 3 includes an interaction between an SPZ dummy, sectoral coal intensity, and the post-treatment dummy: the coefficient on our variable of interest ($TCZ_i \times coal\ int_k \times post$) remains negative and significant, so that the correlation between TCZ and SPZ cities did not drive the results in Table 1.

We next want to test whether the fall in exports by coal intensity reflects that as cities become wealthier they demand better air quality, and thus push for polluting factories to be closed down. This is related to the environmental Kuznets Curve (Grossman and Krueger, 1993) predicting a hump-shaped relationship between income and pollution intensity. Since TCZ cities are on average richer, the TCZ variable could capture a greater demand for health. Also, independently of the demand for cleaner air, the city's industry mix may also change with income. If firms in polluting sectors require more land or other particular inputs, we expect the relocation of polluting industries from wealthier cities to areas where these inputs are cheaper.

We account for any trends in sectoral composition from economic development via two new variables: $TCZ_i \times coal\ int_k$ is interacted with the natural logarithm of GDP per capita and its square.[33] As we do not have reliable information on GDP per capita for all cities in our sample, our number of observation drops to 42525 (243 cities, 7 years, and 25 sectors). Column 3 therefore shows the benchmark specification for this reduced sample, confirming that the TCZ policy reduced exports in more polluting industries. Column 4 introduces the new interactions. These attract a negative coefficient, suggesting a move away from polluting activities as income rises. The coefficient on the variable $TCZ_i \times coal\ int_k \times post$ is smaller but remains negative and significant at the 10% level.

In a final step, we address the issue of the endogenous selection of TCZs with instrumental variables. Column 5 reproduces the benchmark specification of column 3 in Table 1, instrumenting $TCZ_i \times coal\ int_k \times post$ by the interaction of the city's ventilation coefficient, coal intensity and the post dummy. Having only a single instrument, we cannot test model overidentification and check the exogeneity of our instrument. However, the bottom of the table shows the F-test on the excluded instrument in the first-step regression; this is equal to the Weak identification test in our case. The test coefficient indicates that our instrument is relevant. The results of the first-step estimations appear in Appendix Table A-6: these reveal a negative and significant correlation between the instrument and the instrumented variable, as expected. The IV estimates in column 5 of Table 4 are very similar to those in our OLS benchmark regression in Table 1. The p-values of the C-statistics (higher than 0.1) indicate that - under the assumption that our instrument is valid - there is no significant difference between the OLS and IV estimates. We thus cannot reject the null hypothesis that there is no endogeneity problem with the OLS estimators. We therefore continue to consider OLS estimates, which indicate a negative and significant impact of the policy for coal intensive sectors.

5.2. The role of firm ownership and good governance

The previous section focused on the different impact of the TCZ policy across sectors. We now refine our approach by appealing to the political pecking order of Chinese firms.

5.2.1. Firm ownership

As argued above, and in line with the political preference for state-owned firms, the TCZ policy should particularly affect private firms. We thus differentiate between state and non-state firms,

[33] We use values for 1996 so as to mitigate any endogeneity problems. Yearly city-level data on population are often criticized for their inaccurate account of the large number of illegal migrants. We therefore verified that our results (not reported here) remain when using population figures from the 2000 census.

and estimate the following regression:

$$\text{Exports}^{F}_{ikt}=\alpha\ \text{TCZ}_i\times\text{Coal int}_k\times\text{Post}+\ \beta\ \text{TCZ}_i\times\text{Coal int}_k\times\text{Post}\times\text{SOE}$$

$$+\ \gamma_1\ \text{TCZ}_i\times\text{Post}\times\text{SOE}+\gamma_2\ \text{Coal int}_k\times\text{Post}\times\text{SOE}+\mu^{F}_{t}+\lambda_{kt}+\theta^{F}_{ik}+v_{it}+\varepsilon_{ikt}$$

where Exports^{F}_{ikt} are the free-on-board export sales of firm type F in industry k in year t for city i.[34] We consider two firm types, state-owned and private (domestic non state-owned and foreign firms). The SOE dummy is 1 for exports of state-owned firms and 0 otherwise.

The coefficients of interest here are those on the two interaction terms, α and β. If environmental regulations do distort exports according to energy intensity, this should especially hold for non-state firms. Compared to private firms, the exports of state-owned firms should be less sensitive to energy intensity after the introduction of the TCZ policy due to their greater bargaining power with the regulator and capacity to absorb the policy's higher costs.

Our estimates control for all of the triple interactions between the four components TCZ_i, $Coal\ int_k$, *Post 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, $TCZ\times Coal\ int_k\times SOE$, is captured by the city-industry-firm type fixed effects, θ^{F}_{ik}. These latter allow us to separate the policy impact 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 (v_{it}), and sector-year (λ_{kt}) fixed effects. Finally, we include μ^{F}_{t} to account for any systematic time-varying differences in average export performance between firms of different ownership types.

5.2.2. Empirical results by firm ownership

Table 5 presents the empirical results from Equation (2). The benchmark specification is in column 1 and columns 2 to 5 show the robustness checks.

[34] Zero export flows account for about 44% of observations.

Table 5. TCZ policy and exports by firm ownership

Dependent variable:	$Exports^F_{ikt}$ (city/sector/year/firm-type)				
	Benchmark	W/o extremes	K/L	K/prod	
	1	2	3	4	5
TCZ_i×coal int_k× post	-0.094[a]	-0.170[a]	-0.098[a]	-0.084[a]	-0.044[b]
	(0.031)	(0.055)	(0.033)	(0.028)	(0.022)
TCZ_i×coal int_k ×post×SOE	0.073[a]	0.127[a]	0.079a	0.064a	0.038b
	(0.024)	(0.046)	(0.026)	(0.022)	(0.017)
TCZ_i ×cap int_k × post			0.037[c]	-0.072[a]	
			(0.019)	(0.026)	
TCZ_i ×cap int_k ×post×SOE			-0.049	0.068[a]	
			(0.030)	(0.028)	
$Coast_i$×coal int_k × post					-0.015
					(0.029)
$Coast_i$×coal int_k ×post×SOE					0.021
					(0.024)
SPZ_i×coal int_k ×post					-0.001
					(0.048)
SPZ_i×coal int_k ×post×SOE					0.015
					(0.037)
ln(GDP pc_i) coal int_k × post					-0.399[a]
					(0.108)
ln(GDP pc_i)^2 ×coal int_k ×post×SOE					0.270[a]
					(0.076)
ln(GDP pc) ×coal int_k ×post					-0.241[a]
					(0.073)
ln(GDP pc)^2 ×coal int_k ×post×SOE					0.167[a]
					(0.051)
Controls	TCZ_i×SOE×post, $Coal_k$×SOE×post				
Fixed effects: city-sector-firm-type, city-year, sector-year, firm-type-year					
Observations	92750	63070	92750	92750	85050
R-squared	0.122	0.172	0.122	0.122	0.143
No. of cities	265	265	265	265	243
p-value (α+β=0)	0.096	0.013	0.079	0.122	0.505

Heteroskedasticity-robust standard errors clustered at the city level appear in parentheses. [a, b] and [c] indicate significance at the 1%, 5% and 10% confidence levels. Additional controls: columns 3 and 4 do not show the coefficients on capital int×SOE×post. In column 5, the unreported interactions are those of SOE×post with the four variables *$Coast_i$, SPZ_i, ln(GDP pc_i) and ln(GDP pc_i)^2*.

Column 2 excludes the top and bottom four sectors in terms of coal intensity. Columns 3 and 4 add interaction terms with capital intensity, measured respectively as the ratio of capital over labor and capital over production. Column 5 includes interactions for the non-linear impact of income, Special Policy Zones and coastal location, in the same spirit as Table 4.[35]

In all five columns, the coefficients α and β have the expected respective positive and negative signs. The bottom of the table shows the p-value from the test of the impact for state-owned firms being null, i.e. $\alpha+\beta=0$. Once we include the additional controls, this hypothesis cannot be rejected, so that state-ownership shelters firms from the export-effect of the TCZ policy. Export reallocation away from pollution-intensive activities is limited to non-state owned firms. The new environmental policy then induces firms of different ownership types to self-select into sectors with different energy-intensity constraints: namely, private firms will become less specialized in energy-intensive industries. By way of contrast, any change in the sectoral composition of exports of state-owned firms seems to much less pronounced.

6. Conclusion

This paper has considered the impact of stricter environmental regulations from the 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 158 were targeted by the policy) in 1997to 2003, and exploit variations across time, sector and firm type to extract the causal effect of the policy on firms' export performance. We find evidence that the TCZ policy has greater negative repercussions on exports the larger the pollution content of the activity, suggesting that the TCZ policy was effective. Targeted cities experienced a relative reallocation of export activities away from those that were less pollution-intensive. The results by firm-type reflect the political pecking order of Chinese firms. The impact of environmental policy is mitigated by state ownership.

Overall, the structure of Chinese exports has hence been distorted by 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 weaker obligations to comply with regulations and softer budget constraints, state ownership protects from the consequences of pollution regulations. Public enterprises may continue their business more or less as usual despite the new environmental regulations, while private firms are forced to adjust by cutting their productive and export activities as a consequence of the associated higher costs.

[35] As in Table 2, we check that our results are robust to the use of alternative proxies for energy intensity, but for the sake of space we do not show the results here.

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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	.003	.001	.001	.000
18	Manufacture of wearing apparel	.003	.006	.001	.165	.125	.101	.118
19	Tanning and dressing of leather	.003	.005	.001	.069	.096	.045	.062
30	Manufacture of office machinery	.003	.008	.001	.062	.023	.167	.015
31	Manufacture of electrical machinery	.004	.016	.002	.093	.036	.169	.051
32	Manufacture of radio, TV and com.	.004	.016	.002	.053	.024	.058	.027
29	Manuf. of machinery & equipment n.e.c.	.007	.014	.001	.038	.025	.055	.038
28	Manufacture of fabricated metal products	.008	.020	.003	.036	.052	.034	.050
34	Manufacture of motor vehicles, trailers	.008	.015	.002	.020	.008	.020	.016
35	Manufacture of other transport equipment	.008	.015	.002	.009	.005	.016	.009
33	Manuf. of medical, precision & optical	.009	.015	.001	.026	.011	.028	.012
13	Mining of metal ores	.011	.043	.007	.001	.003	.001	.000
25	Manuf. of rubber and plastics products	.012	.023	.003	.033	.023	.028	.031
36	Manuf. of furniture; manufacturing n.e.c.	.015	.033	.004	.086	.066	.068	.089
20	Manuf. of wood; products of wood & cork	.018	.020	.002	.010	.035	.009	.041
17	Manufacture of textiles	.018	.028	.003	.100	.119	.069	.103
15	Manufacture of food & beverages	.021	.021	.002	.037	.118	.021	.108
14	Other mining and quarrying	.026	.032	.003	.004	.019	.002	.013
22	Publishing and printing	.038	.040	.004	.002	.000	.002	.000
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	.078
27	Manufacture of basic metals	.105	.159	.011	.044	.055	.024	.048
26	Manuf. of other non-metallic mineral prod.	.116	.111	.005	.023	.027	.016	.030
10	Mining of coal & lignite; extr. of peat	.135	.081	.005	.007	.018	.006	.032
23	Manuf. of coke, refined petr. & nucl. fuel	.141	.106	.003	.014	.031	.014	.025

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
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]
Observations			25		

a, b and c indicate significance at the 1%, 5% and 10% confidence levels.

Table A-3. Summary statistics by city

	Total	TCZ =0		TCZ =1		Proba
	Obs	Mean	S.D.	Mean	S.D.	Diff
$Exports_{ikt}$ (in 100 million USD), 1997-2003	46375	0.044	0.209	0.510	3.061	0.000
$Exports_{ikt}$ (in 100 million USD), 1997-2003	1855	1.107	2.033	12.756	40.371	0.000
Special Policy Zone dummy (SPZ)	265	0.112	0.317	0.316	0.467	0.000
Coastal province	265	0.299	0.460	0.481	0.501	0.003
ln(GDP), 1996	243	4.546	0.976	5.266	1.049	0.000
ln(Pop), 1996	243	5.290	1.004	5.689	0.864	0.001
ln(GDP pc), 1996	243	-0.744	0.537	-0.422	0.587	0.000
State efficiency index	265	-0.032	0.181	-0.045	0.202	0.589
ln(Ventilation coefficient) (IV)	265	7.962	0.183	7.892	0.164	0.001
Boundary layer height (IV), (meter)	265	537.8	79.12	512.9	70.61	0.007
Wind speed at 10m (IV), (meter/second)	265	5.492	0.440	5.323	0.335	0.000
Volume of SO2 exhaust/population (in 2003)	264	4.084	1.179	4.868	1.061	0.000
Number of cities		107		158		

Table A-4. Correlation of city indicators

	TCZ	ln(GDP pc)	ln(GDP pc)²	SPZ	Coast	Index	VC (IV)	Height (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 [a]	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]
Observations	243							

a, b and c indicate significance at the 1%, 5% and 10% confidence levels.

Table A-5. Alternative specifications: TCZ policy and exports

Dependent variable:	$Exports_{ikt}$ PQML		$Exports_{ikt}$ OLS		Ln ($Exports_{ikt}$)		$Exports_{ikt}$ OLS	
	all export flows				positive export flows			
	1	2	3	4	5	6	7	8
TCZ_i×coal int_k×post	-0.119 [a]	-0.165 [a]	-0.114 [a]	-0.117 [a]	-0.076 [a]	-0.104 [a]	-0.163 [a]	-0.213 [a]
	(0.045)	(0.047)	(0.040)	(0.040)	(0.043)	(0.050)	(0.057)	(0.071)
TCZ_i×coal int_k	-0.262 [a]	-0.332 [a]	-0.106 [a]	-0.084 [a]				
	(0.094)	(0.096)	(0.039)	(0.034)				
TCZ_i ×capital/$labor_k$×post		0.288b		0.025		0.132		0.227b
		(0.126)		(0.029)		(0.126)		(0.094)
TCZ_i ×capital/$labor_k$		0.304c		-0.185 [a]				
		(0.163)		(0.051)				
City-year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Sector-year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
City-sector fixed effects	no	no	no	no	yes	yes	yes	yes
Observations	46375	46375	46375	46375	31391	31391	31391	31391
R^2			0.032	0.033	0.185	0.185	0.226	0.226
Nb of cities	265	265	265	265	265	265	265	265

Heteroskedasticity-robust standard errors clustered at the city level appear in parentheses; a, b and c indicate significance at the 1%, 5% and 10% confidence levels.

Table A-6. IV estimations, first step

Dependent variable:	TCZ× Coal× post	
	1	2
$\ln(VC_i)\times Coal_k\times$ post	-0.556[a]	-0.582 [a]
	(0.167)	(0.175)
$Coast_i\times Coal_k\times$ post		0.074
		(0.065)
$SPZ_i\times Coal_k\times$ post		0.118
		(0.078)
$\ln(GDP\ pc_i)\times Coal_k\times$ post		0.127b
		(0.064)
$\ln(GDP\ pc_i)^2\times Coal_k\times$ post		-0.075[b]
		(0.033)
Observations	46375	42525
R^2	0.039	0.134
Partial R^2	0.039	0.047
No. of cities	265	243
F-test	11.061	11.097
P-value	0.001	0.001

Heteroskedasticity-robust standard errors clustered at the city level appear in parentheses. a, b and c indicate significance at the 1%, 5% and 10% confidence levels. The results of the second step appear in columns 4 and 5 of Table 4.

Appendix B

Figure B-1. Location of Two Control Zones cities

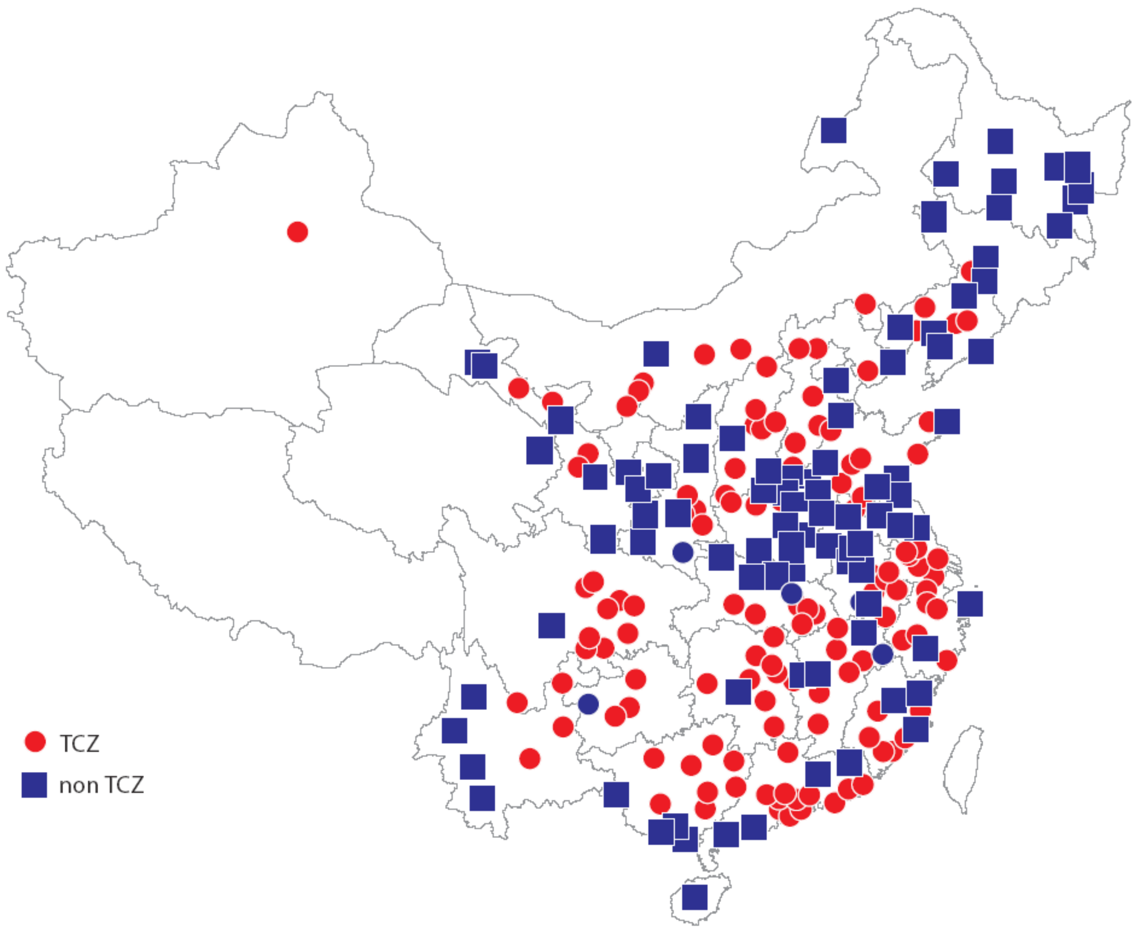
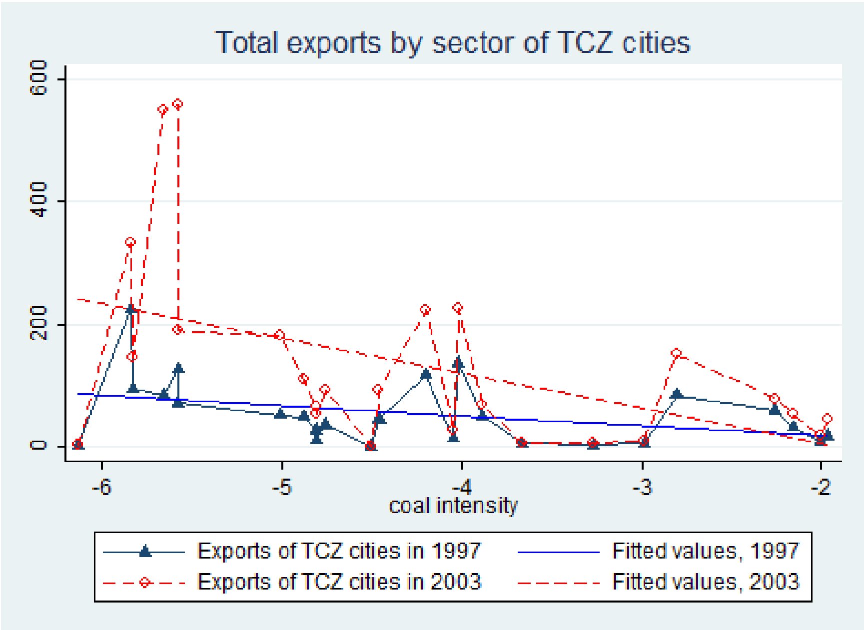
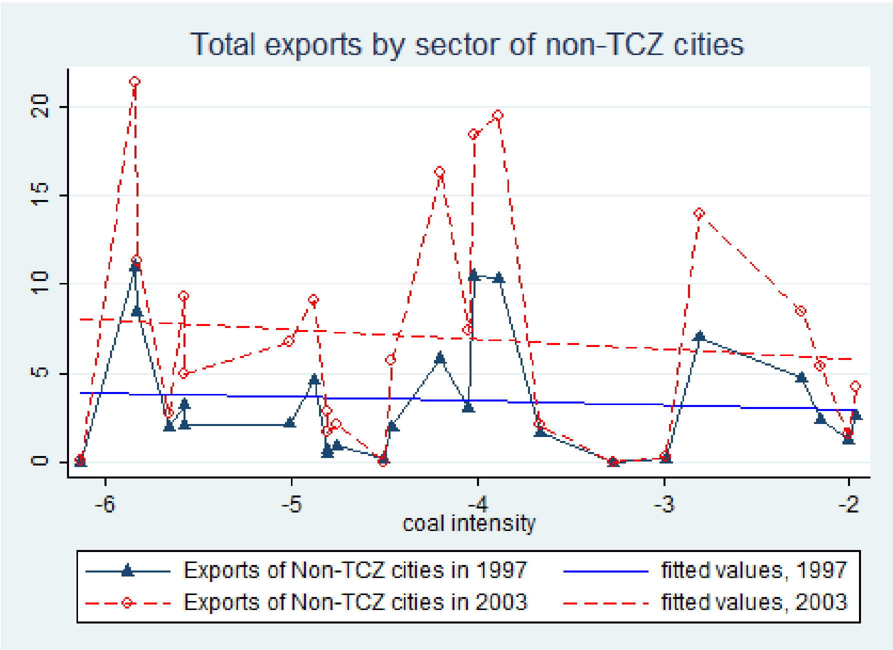


Figure B-2. Export values by city type (100 million US $)





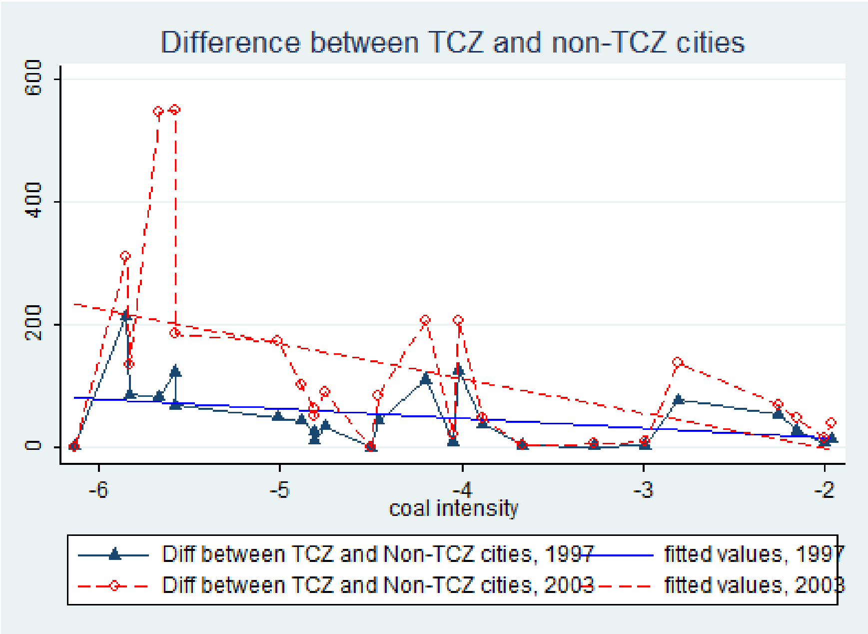

Difference between TCZ and non-TCZ cities
600
400
200
0
-6
-5
-4
-3
-2
coal intensity
Diff between TCZ and Non-TCZ cities, 1997
fitted values, 1997
Diff between TCZ and Non-TCZ cities, 2003
fitted values, 2003

Table B-1. List of cities

Province	City	Code	TCZ	SPZ	Province	City	Code	TCZ	SPZ
Beijing	Beijing	1101	1	1	Shandong	Liaocheng	3714	0	0
Tianjin	Tianjin	1201	1	1	Shandong	Linyi	3715	0	0
Hebei	Shijiazhuang	1301	1	1	Shandong	Heze	3716	0	0
Hebei	Tangshan	1302	1	0	Shandong	Laiwu	3720	1	0
Hebei	Qinhuangdao	1303	0	1	Henan	Zhengzhou	4101	1	1
Hebei	Handan	1304	1	0	Henan	Kaifeng	4102	0	0
Hebei	Xingtai	1305	1	0	Henan	Luoyang	4103	1	1
Hebei	Baoding	1306	1	1	Henan	Pingdingshan	4104	0	0
Hebei	Zhangjiakou	1307	1	0	Henan	Anyang	4105	1	0
Hebei	Chengde	1308	1	0	Henan	Hebi	4106	0	0
Hebei	Cangzhou	1309	0	0	Henan	Xinxiang	4107	0	0
Hebei	Langfang	1310	0	0	Henan	Jiaozuo	4108	1	0
Hebei	Hengshui	1311	1	0	Henan	Puyang	4109	0	0
Shanxi	Taiyuan	1401	1	1	Henan	Xuchang	4110	0	0
Shanxi	Datong	1402	1	0	Henan	Luohe	4111	0	0
Shanxi	Yangquan	1403	1	0	Henan	Sanmenxia	4112	1	0
Shanxi	Changzhi	1404	0	0	Henan	Shangqiu	4113	0	0
Shanxi	Jincheng	1405	0	0	Henan	Zhoukou	4114	0	0
Shanxi	Shuozhou	1406	1	0	Henan	Zhumadian	4115	0	0
Shanxi	Xinzhou	1408	1	0	Henan	Nanyang	4116	0	0
Shanxi	Luliang*	1409	0	0	Henan	Xinyang*	4117	0	0
Shanxi	Jinzhong*	1410	1	0	Hubei	Wuhan	4201	1	1
Shanxi	Linfen	1411	1	0	Hubei	Huangshi	4202	1	0
Shanxi	Yuncheng	1412	1	0	Hubei	Shiyan	4203	0	0
Inner Mongolia	Hohhot	1501	1	0	Hubei	Yichang	4205	1	0
Inner Mongolia	Baotou	1502	1	1	Hubei	Xiangfan	4206	0	1
Inner Mongolia	Wuhai	1503	1	0	Hubei	Ezhou	4207	1	0
Inner Mongolia	Chifeng	1504	1	0	Hubei	Jingmen	4208	1	0
Inner Mongolia	Hulunbeir*	1507	0	0	Hubei	Huanggang	4209	0	0
Inner Mongolia	Ulanqab*	1510	0	0	Hubei	Xiaogan	4210	0	0
Inner Mongolia	Bayannaoer*	1511	0	0	Hubei	Xianning	4211	1	0
Liaoning	Shenyang	2101	1	1	Hubei	Jingzhou	4212	1	0
Liaoning	Dalian	2102	1	1	Hubei	Suizhou	4215	0	0
Liaoning	Anshan	2103	1	1	Hunan	Changsha	4301	1	1
Liaoning	Fushun	2104	1	0	Hunan	Zhuzhou	4302	1	0
Liaoning	Benxi	2105	1	0	Hunan	Xiangtan	4303	1	0
Liaoning	Dandong	2106	0	0	Hunan	Hengyang	4304	1	0
Liaoning	Jinzhou	2107	1	0	Hunan	Shaoyang	4305	0	0
Liaoning	Yingkou	2108	0	0	Hunan	Yueyang	4306	1	0
Liaoning	Fuxin	2109	1	0	Hunan	Changde	4307	1	0
Liaoning	Liaoyang	2110	1	0	Hunan	Yiyang	4309	1	0
Liaoning	Panjin	2111	0	0	Hunan	Loudi*	4310	1	0
Liaoning	Tieling	2112	0	0	Hunan	Chenzhou	4311	1	0
Liaoning	Chaoyang	2113	0	0	Hunan	Huaihua	4313	1	0
Jilin	Changchun	2201	0	1	Guangdong	Guangzhou	4401	1	1
Jilin	Jilin	2202	1	1	Guangdong	Shaoguan	4402	1	0
Jilin	Siping	2203	1	0	Guangdong	Shenzhen	4403	1	1
Jilin	Liaoyuan	2204	0	0	Guangdong	Zhuhai	4404	1	1
Jilin	Tonghua	2205	1	0	Guangdong	Shantou	4405	1	1
Jilin	Baicheng	2209	0	0	Guangdong	Foshan	4406	1	1
Heilongjiang	Harbin	2301	0	1	Guangdong	Jiangmen	4407	1	0
Heilongjiang	Qiqihar	2302	0	0	Guangdong	Zhanjiang	4408	1	1
Heilongjiang	Jixi	2303	0	0	Guangdong	Maoming	4409	0	0
Heilongjiang	Hegang	2304	0	0	Guangdong	Zhaoqing	4412	1	0
Heilongjiang	Shuangyashan	2305	0	0	Guangdong	Huizhou	4413	1	1
Heilongjiang	Daqing	2306	0	1	Guangdong	Meizhou	4414	0	0
Heilongjiang	Yichun	2307	0	0	Guangdong	Shanwei	4415	1	0
Heilongjiang	Jiamusi	2308	0	0	Guangdong	Heyuan	4416	0	0
Heilongjiang	Qitaihe	2309	0	0	Guangdong	Yangjiang	4417	0	0
Heilongjiang	Mudanjiang	2310	0	0	Guangdong	Qingyuan	4418	1	0
Heilongjiang	Heihe	2311	0	0	Guangdong	Dongguan	4419	1	0
Heilongjiang	Suihua	2314	0	0	Guangdong	Zhongshan	4420	1	1
Shanghai	Shanghai	3101	1	1	Guangdong	Chaozhou	4421	1	0
Jiangsu	Nanjing	3201	1	1	Guangdong	Jieyang	4424	1	0
Jiangsu	Wuxi	3202	1	1	Guangxi	Nanning	4501	1	1
Jiangsu	Xuzhou	3203	1	0	Guangxi	Liuzhou	4502	1	0
Jiangsu	Changzhou	3204	1	1	Guangxi	Guilin	4503	1	1
Jiangsu	Suzhou	3205	1	1	Guangxi	Wuzhou	4504	1	0
Jiangsu	Nantong	3206	1	1	Guangxi	Beihai	4505	0	1
Jiangsu	Lianyungang	3207	0	1	Guangxi	Yulin	4506	1	0
Jiangsu	Yancheng	3209	0	0	Guangxi	Baise	4507	0	0
Jiangsu	Yangzhou	3210	1	0	Guangxi	Hechi	4508	1	0

Table B-1. List of cities (continued)

Province	City	Code	TCZ	SPZ	Province	City	Code	TCZ	SPZ
Jiangsu	Zhenjiang	3211	1	1	Guangxi	Qinzhou	4509	0	0
Jiangsu	Taizhou	3212	1	0	Guangxi	Fangchenggang	4512	0	0
Jiangsu	Suqian	3217	0	0	Guangxi	Guigang	4513	1	0
Jiangsu	Huaian	3221	0	0	Guangxi	Hezhou*	4516	1	0
Zhejiang	Hangzhou	3301	1	1	Hainan	Haikou	4601	0	1
Zhejiang	Ningbo	3302	1	1	Chongqing	Chongqing	5001	1	0
Zhejiang	Wenzhou	3303	1	1	Sichuan	Chengdu	5101	1	1
Zhejiang	Jiaxing	3304	1	0	Sichuan	Zigong	5103	1	0
Zhejiang	Huzhou	3305	1	0	Sichuan	Panzhihua	5104	1	0
Zhejiang	Shaoxing	3306	1	0	Sichuan	Luzhou	5105	1	0
Zhejiang	Jinhua	3307	1	0	Sichuan	Deyang	5106	1	0
Zhejiang	Quzhou	3308	1	0	Sichuan	Mianyang	5107	1	1
Zhejiang	Zhoushan	3309	0	0	Sichuan	Guangyuan	5108	0	0
Zhejiang	Lishui	3310	0	0	Sichuan	Suining	5109	1	0
Zhejiang	Taizhou	3311	1	0	Sichuan	Neijiang	5110	1	0
Anhui	Hefei	3401	0	1	Sichuan	Leshan	5111	1	0
Anhui	Wuhu	3402	1	1	Sichuan	Yibin	5114	1	0
Anhui	Bengbu	3403	0	0	Sichuan	Nanchong	5115	1	0
Anhui	Huainan	3404	0	0	Sichuan	Yaan	5117	0	0
Anhui	Maanshan	3405	1	0	Sichuan	Guangan*	5122	1	0
Anhui	Huaibei	3406	0	0	Guizhou	Guiyang	5201	1	1
Anhui	Tongling	3407	1	0	Guizhou	Liupanshui	5202	0	0
Anhui	Anqing	3408	0	0	Guizhou	Zunyi	5203	1	0
Anhui	Huangshan	3409	1	0	Guizhou	Anshun	5207	1	0
Anhui	Fuyang	3410	0	0	Yunnan	Kunming	5301	1	1
Anhui	Liuan	3413	0	0	Yunnan	Zhaotong	5303	1	0
Anhui	Xuancheng*	3414	1	0	Yunnan	Qujing	5304	1	0
Anhui	Chaohu	3415	1	0	Yunnan	Yuxi*	5306	1	0
Anhui	Chizhou*	3416	0	0	Yunnan	Simao*	5309	0	0
Fujian	Fuzhou	3501	1	1	Yunnan	Baoshan	5312	0	0
Fujian	Xiamen	3502	1	1	Yunnan	Lijiang*	5314	0	0
Fujian	Putian	3503	0	0	Yunnan	Lincang*	5317	0	0
Fujian	Sanming	3504	1	0	Shaanxi	Xian	6101	1	1
Fujian	Quanzhou	3505	1	0	Shaanxi	Tongchuan	6102	1	0
Fujian	Zhangzhou	3506	1	0	Shaanxi	Baoji	6103	0	1
Fujian	Nanping	3507	0	0	Shaanxi	Xianyang	6104	0	1
Fujian	Ningde	3508	0	0	Shaanxi	Weinan	6105	1	0
Fujian	Longyan	3509	1	0	Shaanxi	Hanzhong	6106	0	0
Jiangxi	Nanchang	3601	1	1	Shaanxi	Ankang	6107	0	0
Jiangxi	Jingdezhen	3602	0	0	Shaanxi	Shangluo*	6108	1	0
Jiangxi	Pingxiang	3603	1	0	Shaanxi	Yanan	6109	0	0
Jiangxi	Jiujiang	3604	1	0	Shaanxi	Yulin*	6110	0	0
Jiangxi	Xinyu	3605	0	0	Gansu	Lanzhou	6201	1	1
Jiangxi	Yingtan	3606	1	0	Gansu	Jiayuguan	6202	0	0
Jiangxi	Ganzhou*	3607	1	0	Gansu	Jinchang	6203	1	0
Jiangxi	Yichun	3608	0	0	Gansu	Baiyin	6204	1	0
Jiangxi	Shangrao	3609	0	0	Gansu	Tianshui	6205	0	0
Jiangxi	Jian	3610	1	0	Gansu	Jiuquan	6206	0	0
Jiangxi	Fuzhou	3611	1	0	Gansu	Zhangye	6207	1	0
Shandong	Jinan	3701	1	1	Gansu	Wuwei	6208	0	0
Shandong	Qingdao	3702	1	1	Gansu	Dingxi*	6209	0	0
Shandong	Zibo	3703	1	1	Gansu	Longnan*	6210	0	0
Shandong	Zaozhuang	3704	1	0	Gansu	Pingliang	6211	0	0
Shandong	Dongying	3705	0	0	Gansu	Qingyang*	6212	0	0
Shandong	Yantai	3706	1	1	Qinghai	Xining	6301	0	0
Shandong	Weifang	3707	1	1	Ningxia	Yinchuan	6401	1	0
Shandong	Jining	3708	1	0	Ningxia	Shizuishan	6402	1	0
Shandong	Taian	3709	1	0	Ningxia	Guyuan*	6404	0	0
Shandong	Weihai	3710	0	1	Xinjiang	Urumqi	6501	1	1
Shandong	Rizhao	3711	0	0	Xinjiang	Karamay	6502	0	0
Shandong	Dezhou	3713	1	0					

Note : Cities marked with * are excluded from the regressions which control for GDP per capita due to missing or unreliable GDP information. SPZ denotes the presence of a special policy zone following Wang and Wei (2008).

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