Government Administrative Rank and Industrial Pollution in China

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1 Introduction

The purpose of this essay is to investigate how the administrative hierarchy influences industrial pollution emissions in China. I argue that lower ranked cities would have a higher industrial pollution level even if they reach the same income per capita level as the higher ranked cities. The EKC hypothesis states that environmental degradation increases at the early stage of economic growth and decreases after economic growth reaches a certain high level, which forms an inverted-U shape. Both theoretical analyses (e.g., McConnell, 1997; Mol, 2002) and empirical studies (e.g., Sharfik, 1994; Stern, 2002; He, 2009) support this hypothesis, which is promising for the polluted areas. Nevertheless, EKCs vary greatly for different pollutants and environmental issues (Sharfik, 1994; Webber & Allen, 2010). The turning point is very high, or even non-exist, for global pollutants (i.e., CO2). Other than the pollutants, qualitative differences exist in this relationship due to institutional setting differences, and they are revealed at different measurement levels.

Globally, the empirical EKC studies revealed different EKC shapes for different countries due to differences in natural endowments, political institutions, and market institutions (e.g., Stern, 2002). In general, developing countries experience a much tougher path to reach a good economy and a nice environmental quality than what developed countries have experienced. Stern (2001) revealed that the SO2 turning point for the 23 OECD countries is much lower than the turning point for all countries included in his study: $9,239 versus $101,166. All in all, people need products made from the pollution intensive industries. Developed countries are able to afford moving these industries through the change of their economic structures; only some of the developing countries are able to achieve this transformation. Nevertheless, other countries have to operate these pollution intensive industries.

This inequality in the EKC shape also presents within a country, a city, or a community. In developed countries, environmental inequality exists: poor areas are often more polluted (Daniels & Friedman, 1999) and have weaker environmental policy enforcement (Konisky, 2009). Urban gentrification usually only replaces the lower with the higher class of people. People with few resources (e.g., financial, social networks, and ethnicities) are still poor and so is the environmental quality of their neighborhoods. In China, a locality's income-environment relationship is affected by its place in the government administrative hierarchy (or bureaucratic hierarchy). Not only does a higher ranked city have a higher income per capita, its economic and industrial structure is also less pollution intensive. In general, a lower ranked city would experience a higher pollution level even when it reaches the same income per capita level as higher ranked cities.

While the majority of EKC studies occurred in mainstream economics, this study adopted a multidisciplinary perspective and applied organizational theories to support the above arguments. This essay will investigate two channels through which the administrative rank affects a local industrial pollution. First, a higher-level city with more resources is able to attract less pollution intensive firms (industry structure), and higher production efficiency (technology) as well as perform better on pollution regulation enforcement. The consequence is a local market with less pollution intensive industries. The other channel is that the higher quality in governance institutions (i.e., the local government and the local market), due to the resources advantage, leads to more efficient local spending and more public services that are able to internalize the market externalities. The Chinese city-level data from 2003-2010 will be used to test these two channels through which the city administrative rank matters to the local industrial SO2 emissions.

This study contributes to the topic of the environment injustice study and the discussion on the reform of the "city administering county system" in China. The structure of this paper is organized as follows. Section Two briefly introduces the city's administrative rank in China and the unequal administrative and political resources within it. Section Three discusses the consequences of these resource differences on industrial pollution emissions, and three hypotheses are proposed. Section Four introduces the data and the research methodology. Section Five investigates the statistical results. The last section includes a brief discussion and possible policy implications.

2 Administrative Rank and Resources Inequality

2.1 City Administrative Rank

The administrative rank of cities is a part of the Chinese government hierarchy. The contemporary five-level administrative hierarchy of the government was formed after economic reforms in the 1980s: central, province, prefecture, county and township. All levels below the central are local governments and they are the subordinates of the central government.

There are currently four administrative ranks for cities within this Chinese government hierarchy. The centrally administered municipalities are province-level cities (i.e., Beijing, Tianjin, Shanghai, and Chongqing). Sub-province-level cities are a half-level lower than the centrally administered cities, and most of them are the capital of a province. There were 15 of them after the year 2000. Prefecture-level cities are positioned one rank lower than the sub-province-level, and there were 268 of them in 2010 (China City Statistical Yearbook, 2011). They most often encompass counties/county-level-cities and districts. At the county-level, there are counties, districts, and county-level cities. There were 370 county-level cities in 2010 (CCSY, 2011). Most of them are under administration of prefecture-level cities.[1]

The current four layers in the city hierarchy were formed after the "city administering county" policy implemented in 1982 (Ma, 2005; Chung, 2007). This policy subordinates county-level governments to the prefecture-level. Not only has one layer been added to this administrative hierarchy, but the total number of cities has been increased significantly after the economic reform. This increased number has enlarged the influence of this city administrative hierarchy simply because more people and areas are placed under it. In the previous planning economy, the strategy of the state is only developing a few large cities (Lin, 2002). The number of cities increased from 193 in 1978 to 668 in 1998 due to the relaxed policy of city designation in 1984 and economic reform policies of rural industrialization, marketization, and globalization (Lin, 2002).

2.2 Resources Inequality

This section will briefly introduce the characteristics of a hierarchy from organizational theories, and then focus on investigating the unequal resource distribution within the government hierarchy. Organizational science studies have investigated the common characteristics of a hierarchy. Here, I briefly introduce the more relevant ones. In general, a hierarchy has these two advantages: it provides order and stability, and it offers benefits (e.g., career, financial rewards, and privileges) along with the vertical positions in the system (Diefenbach, 2013, pp. 3-4). In addition to these two advantages, economists Ronald Coase (1937) and Oliver Williamson (1995) explained the need for a hierarchy from the efficiency perspective: it reduces transaction cost induced from bargaining and contracting in the market. The main disadvantage is that it

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[1] Some county-level cities are directly administered by their respective provincial government. For more discussion on this issue, please see: Li, & Wu (2014).

creates and institutionalizes unequal relationships along the top-down line: “Hierarchy systematically enables and guarantees unequal distribution of and access to institutions and resources, power differentials and opportunities, privileges and prerogatives, and tasks and duties” (Diefenbach, 2013, p. 4).

The Chinese central government would favor this hierarchical structure because its advantages improve the performance of the organization/government as a whole. Nevertheless, from a local government perspective, it is legitimately discriminated in this hierarchical structure—a constraint it cannot stretch beyond. I emphasize the inequality in political and administrative resources here. The two types of resources are intertwined together both practically and theoretically.[2] Political resources here specifically refer to the leading policymaking power and personnel control of the Communist Party of China (CPC). Administrative resources mainly refer to the human and the financial resources utilized by a local government to implement policies.

2.2.1 Administrative Resources

The administrative rank allocates more administrative resources to higher-level cities. First, it determines the number and the size of its government offices and employees (Ma, 2005; Chung, 2007), which are fundamental for policy implementation and public service. There are around eighty permanent departments and fifty temporary units for the province-level cities. Normally, there are sixty to seventy permanent departments and temporary units for a prefecture-

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[2] Strictly speaking, the term ‘government’ in China refers to the state administrative organ, which is separated from the Chinese Communist Party (CPC) in the structural design of the state. The Chinese government reform since the economic reform has always been separating politics from administration to improve administrative efficiency. However, they are deeply interconnected since local governmental leaders have positions in both administration and the Party.

In the U.S., there is a long history of debate in the dichotomy of public administration and politics since the time of Woodrow Wilson who emphasized the professionalism of public administration. Nevertheless, this dichotomy is not popular in academic study anymore because they cannot be independent each other.

level city. The size is reduced to fifty to sixty permanent departments for county-level cities. Thus, a higher rank city has more human resources and functional departments to offer more public services than a lower-level city (Li & Wu, 2012).

Financial resource are another advantage for a city with a higher rank (Li & Wu, 2012). Other than the budget transfers from the central government, a local government's budget mainly depends on the local economy from which a large proportion of its expenditure is drawn. The administrative hierarchy has led to a better economy in the higher ranked cities (Ma, 2005); therefore, they should have a larger budget in absolute numbers.

Not only is the absolute number of expenditure larger at higher-level cities, their general fiscal condition is also healthier. The hierarchical government system coupled with the current tax system cause this issue. The current tax system, implemented in 1994, has led to a problematic trend: the lower the administrative rank the tighter the budget of the government (e.g., Guo, 2008). The 1994 reform was called "fenshuizhi" (tax-sharing) system and was aimed at strengthening macroeconomic management of the central government by increasing the authority and transparency of the tax system. The central government collects its share of tax through local branches of the national tax agency, and local governments run local tax agencies for themselves. The central government has increased its revenue and enhanced its ability for macroeconomic adjustment through intergovernmental transfers. Nevertheless, the spending responsibilities of local governments are not reduced under this tax system.

According to the World Bank, China is the most decentralized country in the world when measured by the local governments' funding to public goods and services (Fock and Wong, 2008). From another perspective, it also places a heavy burden on local governments. Wang, et al. (2011) investigated various ways to finance urban infrastructure in the reform-era of China.

They pointed out that city governments of different administrative ranks were delegated with different levels of autonomy and faced different fiscal constraints. Several studies found that fiscal condition is especially severe at county and town-level governments as a consequence of the tax-for-fee reform in 2002 and the repeal of the agricultural tax (e.g. Chen, 2007; Oi, Babiarz, Zhang, Luo, & Rozelle, 2012; Ong 2011; Zhou, 2012). Chen (2007, p.159) showed that "In 2002, 95 percent of villages in Jiangsu and 72 percent of the 249 surveyed villages in Shandong were in debt."

2.2.2 Political Resources

Political power intertwines with the administrative hierarchy, and they reinforce each other. Political power is not able to efficiently reach downward from the top without the hierarchy. The chain of command is not able to be effective without the political power embeddedness. The degree of political control during the economic reform era has led to intense debates about the Chinese government structure. Some scholars emphasize the reduced central political control as a consequence of policies implemented for the economic reform and use terms such as, "Chinese style federalism" or "market-preserving federalism" (e.g., Montinola, Qian, & Weingast, 1995; Jin, Qian, & Weingast, 2005) to describe the government structure. Other scholars emphasize the still dominant political power of the CPC and the effective hierarchical government with the terms, such as "decentralized authoritarianism" (Landry, 2008) and "central managed capitalism" (Lin, 2011). Nevertheless, the common tone in these studies is that the central government and the CPC still have an effective political control and a government hierarchy.

Political power decreases downward along the administrative hierarchy. This power allocation is achieved through a political control system closely embedded in this hierarchy.

Terry Moe (1990, p. 221) states that “Politics is fundamentally about the exercise of public authority and the struggle to gain control over it.” He further argues that public authority is not controlled by anyone, but it is vested in the public offices in the modern states. Thus, the CPC maintains and allocates its political power through appointing public positions in the vertical administrative hierarchy.

There is a local Party Committee at each level of a city. There are two heads of a city: the Party Secretary, who is the leader, and the mayor, who is usually also the Vice Party Secretary. The Party Secretary is officially in charge of Party affairs, and the mayor is officially responsible for administration. However, the Party Secretary is in charge of the most important decisions and indirectly involved in administration since local officials are often members of the CPC (Landry, 2008). The Party Committee is thus the actual leader of the local policy making. Its Standing Committee controls the core political power. Its members are voted and elected by the Party congress at its own level.[3] However, the elected members need to be confirmed by the next higher-level Party Committee.

Although at the prefecture level or above, cities are not subordinates of higher-level cities, this hierarchical political control does give the higher-level city more leverage than the lower-level city. Provincial and sub-provincial leaders are directly appointed by the Organization Department of the Communist Party of China Central Committee (Chan, 2004). The top officials at provincial-level cities are often the members of central politburo. They have political influences on national-level policies. The leaders at the vice province-level cities are often the members of provincial committee who make province-level policies. A county or county-level

[3] These rules are from the Constitution of the Communist Party of China.

city is often directly subordinated to its prefecture-level city or above (except the province administered counties/county-level cities) by which its behaviors are directly affected.

Higher administrative level cities may have legislative power but lower-level cities do not. The Legislation Law of the People's Republic of China, promulgated in the year of 2000, assigned legislative power to all province- and sub-province-level cities. For all prefectural or higher-level cities, "… only 49 have legislation powers: 27 capitals of provincial regions, four special economic zones and 18 big cities approved by the State Council." (Xinhua, 2014, para 3). These cities may make stricter regulations on pollution emissions standards and require modern management systems and skills to increase production efficiency. For example, the "Ordinance of the Beijing on the Prevention and Control of Atmospheric Pollution" adopted in 2014 has a higher standard than the national one. Pollution intensive with low added value factories may thus prefer to stay or open new branches in the lower-level city without stricter regulations or other lower requirements to reduce their costs.

3 Administrative Rank and Industrial Pollution

Environmental quality is not only affected by the absolute economic growth level (i.e., GDP per capita), but it is also affected by the economic structure and technology (Grossman, 1995; Panayotou, 1997). Applying them to industrial pollution, these three factors are: industrial scale, structure, and technology. Industrial structure and technology together affect the general pollution intensiveness of a local industry. Administrative rank affects all these three pollution production factors because it causes systematic differences in administrative and political resources at different levels of cities/governments. This section investigates how these resource differences affect industrial pollution. Two channels to be explained and tested are additional resources would lead to less pollution intensiveness in a city (i.e., less pollution intensive factories and better production technology) and higher institutional quality due to increased resources would improve the effectiveness of local government spending to reduce industrial pollution.

An area's industrial pollution intensiveness depends on its industrial structure and technology. A higher number of pollution intensive factories with subpar production and management techniques would lead to higher emissions per output. Local administrative and political capacity affect both of them. The lack of administrative and political resources at the lower-level city would decrease their policy implementation capacity which is the most important factor in unsuccessful environmental protection in China (Jahiel, 1997; Qi, & Zhang, 2014). Environmental protection or industrial pollution containment is a complex work in which various government departments, non-government organizations, and private firms are coordinated together. The lack of administrative resources would decrease a local government's ability to coordinate an effective policy implementation.

The mismatch between revenue and spending in local governments has been attributed by scholars from various disciplines to the under supply of local public goods (e.g. Oates, 1999; Ping & Bai 2005; Whiting, 2007). With the governments' ideology dominated by economic growth (a positive incentive for local government to increase budget), the restrictive budget gives no or even negative incentives to the lower-level local government to accomplish the environmental protection duty required by the central or the higher-level government.

Another consequence of a generally poor fiscal condition is that it compels lower-level cities to attract business even though they are pollution intensive. From the local government perspective, it needs revenues to offer public services required by the upper-level government. The government officials have a higher likelihood to earn promotion if they can raise their budget revenues (Lu & Landry, 2014). This relationship is even stronger at lower-level governments (Landry & Lu, 2015). In addition, local residents also need income to increase consumption. One qualitative study showed the entire progression of the local villagers' mind changing from resisting and fighting against the pollution factory to becoming complicit with the polluters through economic compensation (Lora-Wainwright, Zhang, Wu, & Rooij, 2012). The local government needs revenue from the factory and plays a mediator role between the villagers and the factory. Villagers are vulnerable to the local government and the large factory; given their limited knowledge of the pollution, they are satisfied with limited economic benefits.

Political power also works toward locating pollution intensive factories at lower-level cities. This political power is imposed through two channels: One is the political power influences between city governments; the other is the political power bargaining between a city government and a company.

The leaders of a higher administrative-rank city are able to facilitate a pollution intensive firm located at a lower ranked city through direct political coercion. The effectiveness of this coercive power is further improved by the CPC political/personnel control system embedded in the administrative hierarchy. The CPC political control has effectively stimulated the local governments to compete for economic growth because economic growth and political and social stability are its top priorities (e.g., Li & Zhou, 2005). In order to win promotion in the internal job market formed by the administrative hierarchy, local officials strive for GDP growth. A lower-level government, therefore, may not feel coerced because it needs investments for a higher GDP and employment opportunities even though they are pollution intensive.

This political coercive power also affects companies' behaviors on industrial pollution. The performances of business, especially the large corporations, are influenced by politics in general. The more political connections a business has the more benefits it can obtain: enhanced financial performance especially for the heavily regulated industry in the U.S. (Hillman, 2005), increased likelihood to be bailed out globally (Faccio, Masulis, & McConnell, 2006), and extended channels to receive loans from banks in China (Li, et al., 2008). This is why big companies fund political campaigns in developed countries—in exchange for beneficial policies. In China, this business-politics relationship is not as formally institutionalized as it is in developed countries because private business has less formal channels to influence policy makings. Nevertheless, political connections are able to reduce the intensity of the regulation enforcement imposed on a firm. The higher the administrative rank the more political power a city has and the less effectiveness a firm's political connections.

This political influence is institutionalized in the state owned enterprises (SOEs) in China—their top leaders also have administrative ranks. A local government owns enhanced bargaining power if its administrative rank is high. The top managers of the central SOEs are at the province or vice province level. Local governments would be in a weaker position if this type of firms are located in their area since they are at lower ranks. This increases the transaction costs between the local government and the SOEs located within their jurisdictions. The bargaining between the city government of Lanzhou, a capital city, and the local branch of PetroChina is a classic example of the involvement of the political power in the decision of a firm's location (Meng, 2015). The government officials of Lanzhou blame the heavy pollution from the oil refining. The local branch doubts government officials' motivation as an excuse to move the factory to the newly developed area located much further away from the center city. Nevertheless, there is no bargaining reported between the city and the company when it comes to the relocation of Shougang, a steel company, out of Beijing which is the capital city of China.

In summary, the advantages in both administrative and political resources cause higher-level cities have higher capacity in environmental protection implementation, and higher capacity to regulate the firms located within their boundaries. The consequence is the less pollution intensive at higher-level cities even their GDP per capita level or industrial scale are the same as they are at lower-level cities. Thus, I propose the following two hypothesis:

H1: A city with a higher administrative rank has industries with less pollution intensity; therefore, its EKC should be smoother (i.e., smaller slope) than a lower-level city.

H2: A city with a higher administrative rank has industries with less pollution intensity; therefore, its industry scale per unit produces less industrial pollution.

Studies (Lopez, Galinato, & Islam, 2011; Halkos & Paizanos, 2016) have revealed that a government expenditure affects all the three underlying factors that produce industrial pollution. Its net effects on industrial pollution emissions thus is complex. As discussed in the above, administrative rank affects a city's budget in terms of the absolute amount. Administrative rank also affects a local government's fiscal condition/gap. The increase of this gap would decrease the spending on industrial pollution since environmental protection is not a top priority in general. Other than these two situations, the effects of a government expenditure on pollution also depends on its institutional environment (both political and economic). The superior institutional quality would increase the local government's spending efficiency and structure; and an efficient market would increase production efficiency. Halkos & Paizanos (2016) revealed that political institutions moderate the effects of expenditure on pollution.

Higher-level cities should have better political (coercive power) and economic institutions (property rights and regulations that internalize externalities) because of their advantages in administrative and political resources. With abundance in administrative and political resources, formal regulations and rules are strictly enforced at higher-level cities. In addition, higher-level cities are closer to the direct political control of the central government. Their officials and staff therefore are pressured to conform to the rule of law. With the resource advantages, higher-level governments are able to enforce and develop market institutions (e.g., property rights, contracts, and regulations). High quality market institutions tend to attract businesses because of the low transaction costs. Thus, the governments are less dependent on particular firms due to the richness of the local market. They are able to be independent and function as a market regulator. Thus, I have the following hypothesis:

H3: The higher the administrative rank a city has the higher quality of its political and economic institutions under which the effect of the local government's spending on industrial pollution reduction is increased.

4 Research Methods

4.1 Data

This study uses secondary data from China City Statistical Yearbook. It is collected and published by the National Bureau of Statistics of China. The unit of analysis is city. The time period is from 2003 to 2012. There are 284 cities in the data. Some prefecture-level cities are excluded because they have missing values due to that they are established after 2003, and some cities are merged with other cities during the study time period. They compose an unbalanced panel data due to missing data (maximum 35 observations missing depends on the model). The reason for the missing values is not explained in the Statistical City Yearbook. Thus, it is not clear if they are missing randomly or on purpose.

The strategy used in this study to deal with this issue is to compare results from running models with original data with the results from data with the missing values substituted. The missing values are replaced with different methods conditional on situations. A missing value is replaced with an average value prior and after it if there is a trend (i.e., increasing or decreasing) in the observations. If a missing value is the first or last year for a city, then replace a lower or higher value comparing to its adjacent value depends on the trend. If there is no obvious trend in the values for a city, then the first or last value is replaced with the same value as its adjacent value.

4.2 Dependent Variables

A city's industrial SO2 emissions is the industrial pollutant that will be used to measure industrial pollution. An advantage of emissions data is that it directly measures economic activities (He, 2009). To measure the relationship between total emissions and economic growth, total industrial SO2 emissions measured in metric tons is used as dependent variables. Following most EKC studies, per capita industrial SO2 is used as a dependent variable. Industrial pollution emissions density is also included as a dependent variable. It is created by the ratio of total pollution emissions to the area of a city. Table 1 lists the basic descriptive statistics for the included variables. Figure 1 shows the time trend for the major variables categorized by administrative rank, and please see Table 1 for the unit of the vertical axis.

Table 1: Descriptive statistics

Variable	N	Mean	Std. Dev.	Description
Industrial SO2	2840	63008	62941	ton
SO2 per capita	2840	20337	27784	kilogram per capita
SO2 density	2840	7.15	8.91	ton per square kilometer
Expenditure/GDP	2840	0.14	0.08	
City GDP per capita	2840	28138	32888	Chinese Yuan per capita
Expenditure/revenue	2840	2.69	1.86	
Industrial scale	2840	2392	6255	ten thousand Yuan per square km
Population density	2840	418	320	person per square km

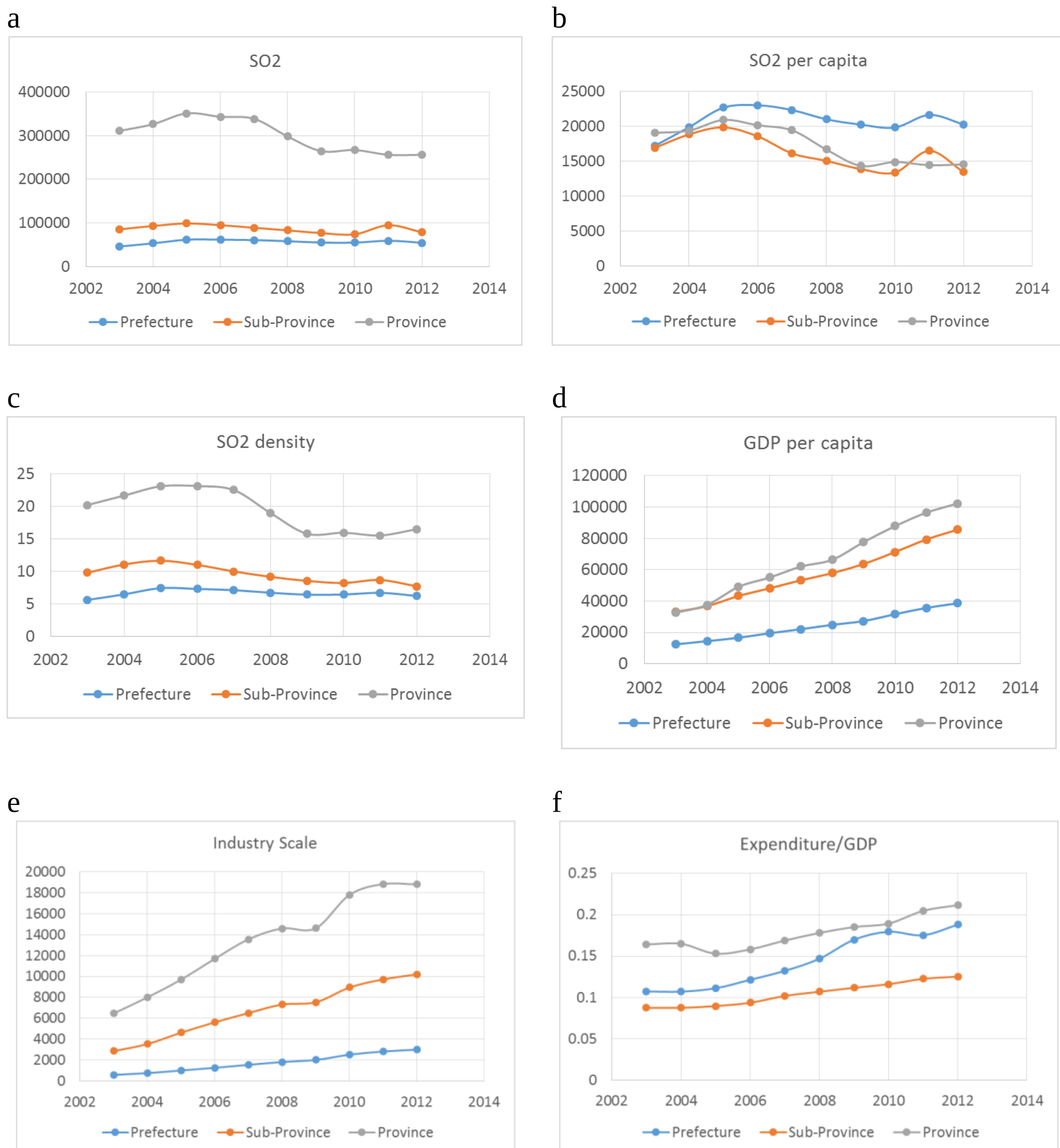

Figure 1: Time trend of the included variables for each administrative rank

4.3 Independent Variables

The main independent variable is the administrative rank of cities, which includes three levels: 1. Prefecture-level; 2. Sub-province-level; and 3. Province-level. There are 252 prefecture-level cities, 28 sub-province-level cities, and 4 province-level cities. GDP per capita is used to test EKC hypothesis in a simple model. The following variables are included to control for the underlying factors affecting the industrial pollution.

The proportion of a city's budget expenditure to its GDP is applied to measure its general spending effects on industrial pollution. This measurement is popular in studies on the relationship between government spending and pollution (i.e. Lopez et al., 2011; Halkos & Paizanos, 2016). Its net effect is complex. Nevertheless, it should show a negative effect on the industrial SO2 emissions after control the fiscal condition or the fiscal gap, and the industrial scale and structure effects.

The ratio of a local government expenditure to its revenue is applied to measure local fiscal gap. This gap measures the pressure of meeting the local public services. A large gap indicates that the local government depends the intergovernmental transfers to provide public services. Comparing to growing economy, paying for its staff, and maintaining social stability, reducing industrial pollution is a lower priority for a local government. Therefore, the higher the ratio is, the less expenditure is allocated to environmental protection.

According to the measurement of economic scale in the EKC studies emissions (e.g., Panayotou, 1997; He, 2009), industrial scale is measured by a city's industrial output value over its area. It is expected to increase industrial pollution emissions. The interaction term between industrial scale and administrative rank is to capture systematic differences in industry pollution intensiveness within hierarchy proposed in H2. It captures both industrial structure and technology effects.

Population density is a standard control variable included in the EKC studies (e.g, Panayotou, 1997; He, 2009). However, its influence on environmental quality found in empirical studies is inconsistent. Panayotou (1997) reasoned that it could have both a positive and a negative relationship with the environmental quality. A positive relationship may indicate that more people use energy in an area. A negative relationship indicates that people's concern for the environment is strong in the high population density areas. His research's results showed that their relationship is an inverted-U shape. He (2009) expected and showed a negative relationship between them. In urban studies, they also use this variable to measure the level of urbanization (e.g., Wang, Da, Song, & Li, 2008). The relationship between urbanization and environmental quality is controversial. For industrial SO2, especially in terms of per capita, it should show a negative relationship with urbanization. In China, urbanization level is systematically related with a city's administrative rank. The higher-level cities are better urbanized. High pollution intensive industries would relocate to other less urbanized areas.

4.4 Models

Equation (1) is established to test H1.

$$\ln P_{it} = \alpha_1 \ln Y_{it} + \alpha_2 (\ln Y_{it})^2 + \alpha_3 CityRank * \ln Y_{it} + \alpha_4 ln Pdensity_{it} + \alpha_5 T + c_i + u_{it} \quad (1)$$

where P_{it}, Y_{it}, and T denote pollutants which include industrial SO2, per capita GDP in 2010 real value adjusted by Consumer Price Index (CPI), and a time trend T, respectively. The covariate CityRank is a categorical variable and coded 1 as prefecture-level cities, 2 as sub-province-level cities, and 3 as province-level cities. The interactive term takes into account of slope changes of the EKC induced by the administrative rank. The variable, Pdensity, measures population density of a city. The composite error term includes two parts: (1) c_i denotes unobserved variables that differ across cities but do not change over time; and (2) u_i is the idiosyncratic errors, we assume they are identically and independently distributed (i.i.d).

Equation (2) is used to test H2 and H3.

$$\ln P_{it} = \alpha_1 \ln(\frac{Exp}{GDP})_{it} + \alpha_2 \ln(\frac{Exp}{GDP})_{it} * CityRank + \alpha_3 \ln(\frac{Exp}{GDP})_{it} * lnFiscalGap_{it} + \alpha_4 lnFiscalGap_{it} + \alpha_5 lnIndustryScale_{it} + \alpha_6 lnIndustryScale_{it}^2 + \alpha_7 lnIndustryScale_{it} * CityRank + \alpha_8 lnPdensity_{it} + \alpha_9 T + c_i + u_{it} \quad (2)$$

Where Exp/GDP measures a local government's spending size, FiscalGap measures the fiscal gap of a city, IndustryScale measures the industrial scale of a city. All variables are natural log transformed for a better data fit. The two interaction terms with CityRank are used to test the two hypotheses. The interaction term between spending size and fiscal gap controls for the influences from fiscal pressure on the spending behavior. It is expected to be positive. Other variables are the same as they are in the previous model.

5 Estimation Results

The results for equation (1) with different measurements of industrial SO2 emissions are reported in Table 2. Both fixed effects (FE) and random effects (RE) models are estimated. Considering the possible heteroscedasticity issue, all models are estimated with robust standard errors. Hausman tests are statistically significant; thus, the results from the FE models are more consistent than the results from the RE models. Nevertheless, the results show no qualitative differences between the two estimation models. GDP per capita and industrial SO2 pollution conform to the EKC relationship at the city level in China. The slope of EKC shows a statistically significant difference between the prefecture-level city and the province-level city. Figure 2 presents the EKC curves for cities at the three levels. It shows that the increase of GDP per capita reduces industrial SO2 density for sub-province-level and province-level cities with the sample data. The increase of GDP per capita still increases industrial SO2 density for the prefecture-level city.

Table 2: Statistical results for the simple EKC model

	SO2 per capita		SO2 density		SO2	
	FE	RE	FE	RE	FE	RE
log GDP per capita	2.14 (0.69) ***	2.69 (0.67) ***	2.14 (0.69) ***	2.69 (0.67) ***	2.08 (0.68) ***	2.46 (0.67) ***
log GDP per capita squared	-0.11 (0.03) ***	-0.11 (0.03) ***	-0.11 (0.03) ***	-0.11 (0.03) ***	-0.10 (0.03) ***	-0.11 (0.03) ***
City rank * log GDP per capita						
Sub-province-level	-0.15 (0.13)	-0.13 (0.13)	-0.15 (0.13)	-0.13 (0.13)	-0.12 (0.13)	-0.11 (0.13)
Province-level	-0.33 (0.15) **	-0.39 (0.14) **	-0.33 (0.15) **	-0.39 (0.14) **	-0.33 (0.14) **	-0.39 (0.14) ***
log population density	-0.86 (0.37) **	-0.22 (0.06) ***	0.14 (0.37)	-0.22 (0.06) ***	-0.20 (0.35)	0.14 (0.07)**
Sub-province-level		1.13 (1.46)		1.13 (1.46)		1.45 (1.49)
Province-level		4.28 (1.33) ***		4.28 (1.33) ***		5.79 (1.51) ***
Constant	3.37 (3.72)	-5.17 (3.51)	-10.4 (3.7) ***	0.78 (0.06) ***	1.33 (03.66)	-3.9 (3.5)
Adjusted R squared	0.86		0.91		0.86	
Hausman	82 ***		82 ***		82 ***	
N			2840			

* significant at 10%, ** significant at 5%, *** significant at 1%

The robust standard error is in the parentheses

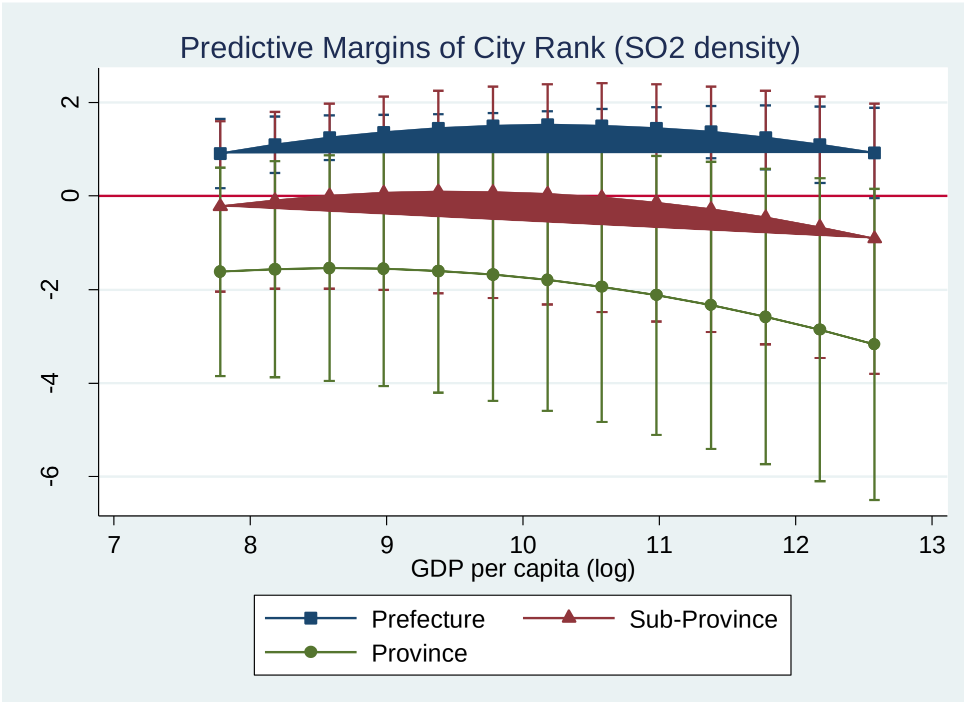

Figure 2: The EKC curves for the three level cities

The EKC turning points for the three-level cities based on the estimation results are 16,768 Chinese yuan per capita for the prefecture-level city, 8,480 yuan for the sub-province-level city, and 3,742 yuan for the province-level city. These numbers are extremely low. The estimation models is one reason because the shape of an EKC is affected by its model specifications. Another reason could be the sample data. The GDP per capita is higher for some cities in this sample data than in other data sources. For example, the city of Shenzhen has GDP per capita over three-hundred thousand Chinese yuan. One reason of this high number is the population statistics, which is much lower than some other sources. Resolving this possible data issue beyond the scope of the current study. Although the EKC turning points are not trustworthy, the estimation results support the hypothesis that administrative rank systematically affects a city's EKC.

The variables are gradually added in the equation (1) before the estimation of the full models based on the equation (2). The purpose is not to select the best fitting model but for investigating the relationships between the variables and the possible high multicollinearity issue. Table 3 includes the estimation results for industrial SO2 per capita from these gradually built FE models. GDP per capita is dropped in the final model based on the results: It is not statistically significant any more after including industrial scale, and it has a high multicollinearity with industrial scale. Other variables in the models show consistent results in different models. This consistency reduces the possibility of high multicollinearity. Column (5) of Table 3 shows the estimation results from the same model as them showed in equation (2). The difference is, however, that these results are estimated with missing data. The estimation results show no qualitative differences in terms of the sign and statistical significance of coefficients comparing to the estimation results in Table 4.

Table 3: Statistical results for model comparison

	SO2 Per capita				
	(1)	(2)	(3)	(4)	(5)
Log GDP per capita	-0.20 (0.97)	-0.29 (0.98)	-0.42 (0.93)	-0.31 (0.30)	
Log GDP per capita squared	-0.0008 (0.04)	0.002 (0.04)	0.005 (0.04)		
Log Industry scale	0.69 (0.17) ***	0.68 (0.17) ***	0.62 (0.18) ***	0.62 (0.18) ***	0.54 (0.12) ***
Log Industry scale squared	-0.04 (0.01) ***	-0.04 (0.01) ***	-0.04 (0.01) ***	-0.04 (0.01) ***	-0.035 (0.008) ***
Log Industry scale* City rank					
Sub-Province-level		-0.06 (0.09)	-0.07 (0.09)	-0.07 (0.09)	-0.21 (0.13) *
Province-level		-0.20 (0.12) **	-0.23 (0.12) **	-0.23 (0.12) **	-0.39 (0.13) ***
Log Government expenditure share of GDP		-0.05 (0.13)	-0.26 (0.27)		-0.09 (0.16)
Log expenditure/revenue			0.18 (0.22)		0.10 (0.18)
Log (Government expenditure share of GDP)*Log (expendigure/revenue)					0.17 (0.09) **
Log Government expenditure share of GDP*City rank					
subprovince					0.57 (0.34) **
province					0.58 (0.28) **
Population density	-0.88 (0.38) **	-0.87 (0.43) **	-0.88 (0.46) *	-0.88 (0.45) *	-0.65 (0.33) **
Constant	13.6 (5.3) **	14.1 (5.4) ***	15.0 (5.2) ***	14.5 (4.0) ***	11.4 (1.8) ***
N			2840		2805

* significant at 10%, ** significant at 5%, *** significant at 1%

The robust standard error is in the parentheses

Table 4: Statistical results from equation (2)

	SO2 Per capita		SO2 Density		SO2	
	FE	RE	FE	RE	FE	RE
Ln (Industry scale)	0.53 (0.12) ***	0.70 (0.10) ***	0.53 (0.12) ***	0.70 (0.10) ***	0.53 (0.12) ***	0.62 (0.11) ***
Ln (Industry scale) squared	-0.03 (0.009) ***	-0.03 (0.008) ***	-0.03 (0.009) ***	-0.03 (0.008) ***	-0.03 (0.009) ***	-0.03 (0.009) ***
Ln (Industry scale)*city rank						
subprovince	-0.24 (0.13) **	-0.16 (0.08) **	-0.24 (0.13) **	-0.16 (0.08) **	-0.21 (0.13) *	-0.15 (0.09) *
province	-0.41 (0.13) ***	-0.18 (0.13) *	-0.41 (0.13) ***	-0.18 (0.13) *	-0.41 (0.13) ***	-0.34 (0.11) ***
Ln (Government expenditure share of GDP)	-0.17 (0.19)	-0.16 (0.18)	-0.17 (0.19)	-0.16 (0.18)	-0.16 (0.19)	-0.19 (0.18)
Ln (expenditure/revenue)	0.18 (0.21)	0.14 (0.20)	0.18 (0.21)	0.14 (0.20)	0.16 (0.21)	0.15 (0.2)
Ln (Government expenditure share of GDP)*Ln (expendigure/revenue)	0.22 (0.11)**	0.22 (0.1)**	0.22 (0.11)**	0.22 (0.1)**	0.20 (0.11)**	0.2 (0.09) **
Ln (Government expenditure share of GDP)*City rank						
Sub-province	0.66 (0.35) **	0.62 (0.26) **	0.66 (0.35) **	0.62 (0.26) **	0.63 (0.35) **	0.54 (0.27) **
Province	0.67 (0.29) **	0.1 (0.39)	0.67 (0.29) **	0.1 (0.39)	0.67 (0.29) **	0.51 (0.29) **
Ln (Population density)	-0.66 (0.35) **	-0.65 (0.1) ***	0.34 (0.35)	0.35 (0.1) ***	0.02 (0.34)	-0.12 (0.11)
Sub-province		2.42 (1.07) **		2.42 (1.07) **		2.6 (1.2) **
Province		1.94 (1.41)		1.94 (1.41)		5.4 (1.1) ***

* significant at 10%, ** significant at 5%, *** significant at 1%

The robust standard error is in the parentheses

Table 4: (continued)

	SO2 Per capita		SO2 Density		SO2	
	FE	RE	FE	RE	FE	RE
Y2004	0.11 (0.03) ***	0.05 (0.03) *	0.11 (0.03) ***	0.05 (0.03) *	0.12 (0.03) ***	0.09 (0.03) ***
Y2005	0.27 (0.06) ***	0.15 (0.05) ***	0.27 (0.06) ***	0.15 (0.05) ***	0.28 (0.06) ***	0.22 (0.05) ***
Y2006	0.28 (0.07) ***	0.09 (0.06)	0.28 (0.07) ***	0.09 (0.06)	0.29 (0.07) ***	0.21 (0.06) ***
Y2007	0.27 (0.09) ***	0.03 (0.08)	0.27 (0.09) ***	0.03 (0.08)	0.29 (0.09) ***	0.18 (0.07) **
Y2008	0.23 (0.11) **	-0.06 (0.09)	0.23 (0.11) **	-0.06 (0.09)	0.25 (0.11) **	0.13 (0.09)
Y2009	0.18 (0.13)	-0.14 (0.11)	0.18 (0.13)	-0.14 (0.11)	0.21 (0.13) *	0.08 (0.10)
Y2010	0.13 (0.15)	-0.26 (0.12) **	0.13 (0.15)	-0.26 (0.12) **	0.17 (0.15)	0.05 (0.12)
Y2011	0.17 (0.17)	-0.26 (0.14) *	0.17 (0.17)	-0.26 (0.14) *	0.22 (0.17)	0.035 (0.13)
Y2012	0.10 (0.18)	-0.36 (0.14) **	0.10 (0.18)	-0.36 (0.14) **	0.15 (0.18)	-0.05 (0.14)
_cons	11.2 (1.9) ***	9.8 (0.6) ***	-2.3 (1.9)	-4.01 (0.57) ***	8.7 (1.8) ***	8.4 (0.6) ***
Hausman	101 ***		101 ***		36***	
adjusted R-sq	0.86		0.91		0.86	
N	2840					

* significant at 10%, ** significant at 5%, *** significant at 1%

The robust standard error is in the parentheses

The results for equation (2) with different indicators of industrial SO2 emissions are reported in Table 4. Both FE and RE models are estimated. Hausman tests are statistically significant and thus the results from FE models are more consistent than the results from RE models. The estimation results are consistent with the previous results. The results for the main individual variables are consistent and similar in terms of the sign and the significance level for industrial SO2 per capita, density, and total quantity. Industry scale and SO2 emissions conform to the EKC type of relationship, which is often revealed in other empirical EKC studies (e.g., Panayotou, 1997). Administrative rank has a statistically significant effect on this EKC relationship: Higher ranked cities have a smoother inverted-U curve, as they are shown in Figure 3 and Figure 4. These results support the hypothesis that higher-level cities have a market with a less pollution intensive industry due to their administrative and political advantages.

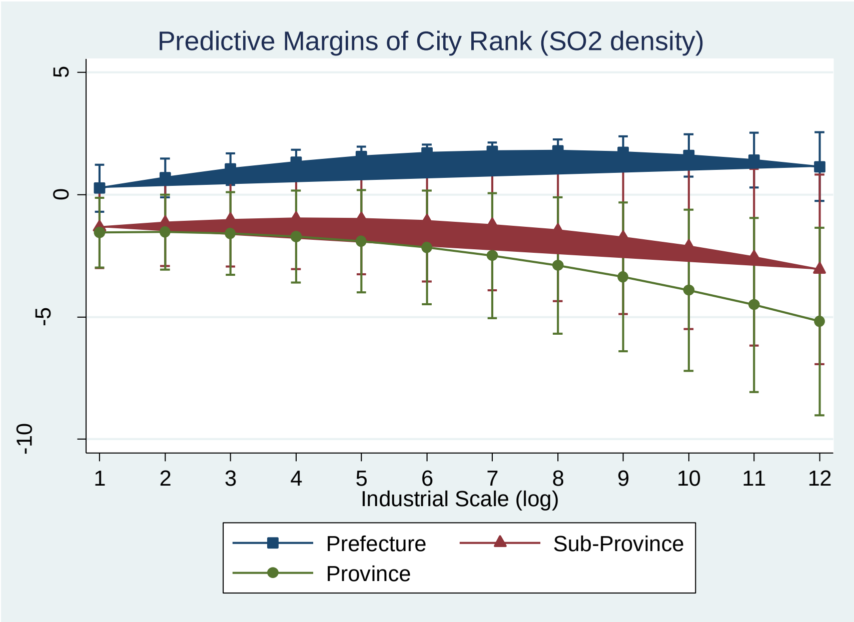

Figure 3: Marginal effects of industrial scale and government size on industrial SO_2 emissions for the three-level cities

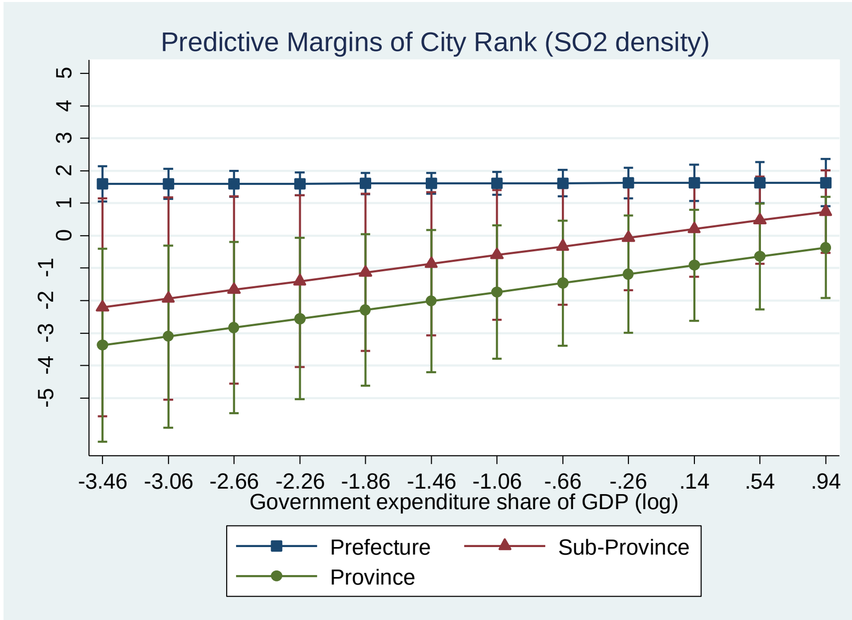

Figure 4: Marginal effects of government spending size on industrial SO2 emissions for the three-level cities

The turning points from the FE model with SO2 per capita for each type of city are 6,859 Chinese yuan per square kilometer for the prefecture-level city, 126 yuan per square kilometer for the sub-province-level city, and 7.4 yuan per square kilometer for the province-level city. The numbers for higher-level cities do not make much of intuitive sense either because they are too small. The turning points from the RE model with SO2 per capita are more plausible: 116,619 yuan per square kilometer for the prefecture-level city, 8,103 yuan per square kilometer for the sub-province-level city, and 5,806 yuan per square kilometer for the province-level city. The turning point for the prefecture-level city is too high for them to reach it. The average industrial scale for the sub-province-level city has surpassed the turning point in 2010. The average industrial scale for the province-level city has surpassed the turning point since the first year in the sample data.

Administrative rank affects a local government's spending behavior based on the results in Table 4. Its effects are also shown in Figure 3. A higher-level local government's expenditure increases its industrial SO2 emissions. Nevertheless, when it comes to group comparison, the higher-level cities and their spending do reduce more industrial SO2 emissions comparing to the lower-level cities. This group difference supports the proposed hypothesis.

The variable that measures a local government fiscal pressure does show the expected moderation effect on the government spending. The gap between the revenue and spending implies that a local government has a higher motivation to invest in revenue driven projects even they are pollution intensive. The gap also renders the local government offering less public services. These public services tend to reduce industrial pollution in the long run because they increase local workers' education level, technology, and direct pollution abatement efforts.

Population density shows inconsistent results in different models. Nevertheless, its coefficient is negative and statistically significant for SO2 density and per capita for all the FE models. This result supports the urbanization explanation that a higher level of urbanization would drive out pollution intensive industries.

The time effects estimated from the FE models show an increasing trend. Industrial SO2 emissions level was increasing prior to the year of 2008 as comparing to the emissions level in 2003. This increasing trend is not statistically significant after 2009.

6 Conclusions and Policy Implications

The statistical results support the argument of this study that administrative rank affects a city's industrial pollution emissions level. The higher the administrative rank a city has the less industrial pollution emissions per unit of the industrial output. The higher administrative ranked city also has a higher quality in its institutional environment, which refers to policy implementation, government accountability, and market institutions. Higher-level cities are able to allocate spending to internalize the externalities (e.g., industrial pollution emissions) due to the higher quality institutional environment.

Empirical studies in general support the EKC relationship between economic development and local pollutants, which have less externalities and higher observable costs. This is encouraging and has been used as a support for economic growth. This study, joining with numerous studies (e.g., Torras & Boyce, 1998; Magnani, 2000; 2001), reveals the inequality issue in this EKC relationship. Globally, there is a separation of so-called global North and global South. Will the EKC hypothesis predict all countries become Global North in the future? The answer from this lower-level analysis is “no”. In the U.S., a developed country, there could be a large environmental quality difference within a neighborhood in a city. This study shows that a lower level city would experience a higher industrial pollution level if it reaches the same level of GDP per capita or industrial scale as comparing to the higher-level cities in China due to the hierarchical government system.

The results of this study are generated from the city-level data, however, they should have implications for the whole government hierarchy. The variances and disparities in counties and villages are higher than in the higher level administrative jurisdictions. Large local government debts, prefecture city exploits its subordinate county-level cities and counties, less economic efficient in production of county/village factories, and cancel villages are all well know issues and studied in China. They provide empirical evidence that counties and villages located at the bottom of the Chinese administrative hierarchy have been experiencing tough development paths.

Nevertheless, this government hierarchy, as well as any other type of hierarchy, has benefited the top very well. It fits the development strategy of the central government: develop some locations first and then the rest. The central government of China has also gained an effective political control, a rapid industrialization, and a fast economic growth. Hierarchy is ubiquitous (i.e., firms, certificates, and rankings). It is justified in terms of economic efficiency (i.e., low transaction costs). Inequality within a hierarchy is a side effect innate with it. There is no way to solve it, however, this inequality needs to be contained within certain level for both the interests of the top (i.e., political stability and governance legitimacy) and the bottom (i.e., equal opportunities). The Chinese state has paid attention to the inequality caused by this hierarchy. The central government compensates the less developed areas through intergovernmental budget transfers, which is also reflected in the budget gap variable in this study. The debate about prefecture cities exploiting counties is also rich in academic studies. The state also experiments “province administering county” in some areas. The results of this study support that the central Chinese government need to keep taking actions on balancing the development within the hierarchy.

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