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Decentralization and Environment in China

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Canfei He

Peking University – Lincoln Center

College of Urban and Environmental Sciences, Peking University

Fenghua Pan

College of Urban and Environmental Sciences, Peking University

Leo KoGuan Building, Suite 508, Peking University, Beijing 100871, China

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Decentralization and Environment in China

Canfei He Fenghua Pan

College of Urban and Environmental Sciences, Peking University
Peking University-Lincoln Institute Center for Urban Development and Land Policy
E-mail: hecanfei@urban.pku.edu.cn

Abstract

Economic reform has resulted in considerable decentralization and exceptional economic growth in China. It has however posed a serious contradiction for China's environmental protection efforts. This study empirically investigated the environmental effects of market and power decentralization using data on industrial SO₂ emission and dusts at the city level. Statistical results indicate that SOEs have significantly contributed to the environmental degradation in Chinese cities. Market decentralization has been harmful to urban environment, especially in the central and western regions and in the small and medium cities. Power and fiscal decentralization has induced the race to the bottom competition by lowering environmental regulations to attract taxable and high value added pollution intensive industries, which is more remarkable in the coastal and central regions and in the medium and small cities. Evidently, there is a tradeoff between environmental degradation and economic growth associated with decentralization in China. The policy shall minimize the environmental impacts of decentralization using economic leverages.

Key Words: Market Decentralization, Fiscal Decentralization, SO₂ Emission, Industrial Dusts, China.

Decentralization and Environment in China

Introduction

Economic reform in China is indeed a dual decentralization process, that is, power decentralization from the central government to the locales and decision-making decentralization from governments to firms and households (Qian and Weingast, 1997). The devolution of political and administrative power to lower level governments has led to improved economic efficiency and thus has augmented economic growth in China (Lin and Liu, 2000; Shi and Zhou, 2007). Marketization allows firms and households to make the best decisions about the utilization of resources and has promoted industrial and regional growth in China (Chen and Feng, 2000; Liu and Li, 2001; Demurger et al., 2002; Anderson and Ge, 2004). Economic reform has however posed a serious contradiction for environmental protection efforts in China (Jahiel, 1997). There are almost daily media reports of rivers and lakes poisoned by pollution, farmlands tainted by industrial pollution and cities choking on smog in China (Dean and Lovely, 2008). The high-growth, resource-intensive and export-oriented development strategy that China has pursued, coupled with the norms and institutional relationships designed to support this development strategy, have no doubt played a critical role in deteriorating urban environment (Jahiel, 1997, 1998; Chan and Yao, 2008). As Naughton (2007) noted “the challenges of water availability, resilience of the natural environment and atmospheric degradation and climate change are among the most serious that China confronts”.

Institutionally, market and power decentralization may be responsible for the contradiction. Marketization has gradually introduced market forces and allowed multiple ownerships in the Chinese economy. Theoretically, state-owned enterprises (SOEs) have more bargaining power than privately owned enterprises and strong connections with local governments and have less incentive to reduce their air pollution. On the contrary, SOEs may take more social impacts into their decision-making processes and their environmental performance could be theoretically better than private sectors. Non-SOEs are profit-oriented and have less incentive to internalize the environmental costs under the context of decentralization. More market decentralization would be associated with more pollution. Non-SOEs however are in a disadvantaged position to bargain with local government agencies and would encounter stricter enforcement of environmental regulations and punishments for environmental pollution and would have better environmental performance. As a consequence, market decentralization may generate mixed environmental results because of distinguished environmental behaviors of different types of industrial enterprises. Power decentralization has however given local officials the means and incentive to develop their local economies. The pervasive emphasis on development, consumerism and profit in government proclamations has further provided local governments to intervene against regulations such as environmental protection - deemed unfavorable to growth (Oi, 1995). Fiscal decentralization would trigger “race to the bottom competition”, in which cities lower their environmental standards to compete for capital and even attract pollution intensive industries. Power decentralization would thereby lead to environmental degradation in Chinese cities.

Using data on SO₂ emission and industrial dust at the prefecture cities in China during

2003-2008, this study is to test the environmental impacts of market decentralization and power decentralization in China. Results suggest that SOEs have deteriorated China’s environment. Market decentralization has been harmful to urban environment, especially in the central and western regions and in the small and medium cities. Power decentralization has also contributed to environmental degradation and is more remarkable in the coastal and central regions and in the medium and small cities. Evidently, there is a tradeoff between economic growth and environmental degradation in China. Market decentralization coupling with administrative decentralization leads to the tradeoff.

The paper is structured as follows. After this introduction, the next section discusses the environmental impacts of market decentralization and power decentralization in China. The third session reports the structural and spatial pattern of industrial pollution. This paper then investigates the determinants of industrial pollution intensity and concludes with a summary of major findings.

Decentralization and Environment in China

China’s economic reform is a two-pronged decentralization process, market decentralization and power decentralization. Market decentralization returns decision-making power to household and enterprises while power decentralization shifts power from the central government to the locales. Power and fiscal decentralization has induced local governments to implement lax environmental regulations, reducing the incentives of industrial enterprises to internalize environmental costs. The dual decentralization process may result in poor environmental performance (Figure 1).

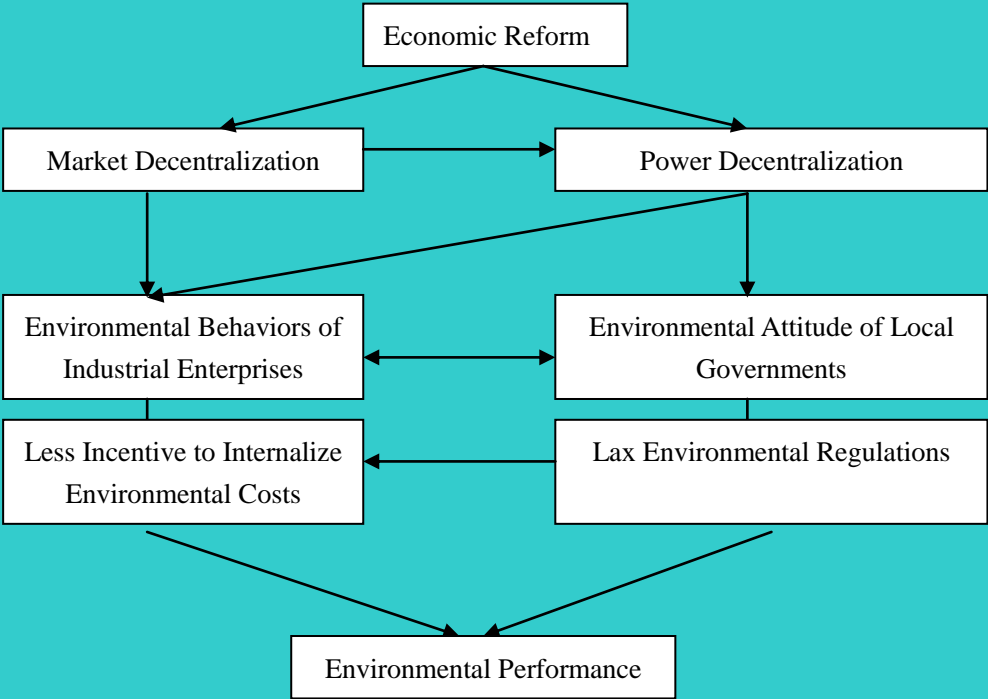


Figure 1 Theoretical Framework: Decentralization and Regional Environmental Performance in China

Market Decentralization and Environmental Behavior of Industrial Enterprises

Economic reform is to transform the Chinese economic system to a market-oriented economy. In the command economy, firms were executors of state-orders. As economic transition proceeds, markets play an increasingly important role in resource allocation. Firms gain more decision-making power to manage their own operations. Market decentralization has encouraged the development of many types of non state-owned enterprises, including collectively owned, privately owned, cooperative-enterprises, jointly owned, limited liability enterprises, shared holding enterprises and foreign-owned enterprises. In China, different types of industrial enterprises may differ in their environmental behaviors due to economic and political reasons.

State owned enterprises (SOEs) might have their incentives to internalize the environmental costs resulting from their pollution discharge in order to obtain higher national or local social welfare. SOEs normally take more social impacts into their decision-making processes and their environmental performance could be theoretically better than private sectors. SOEs are more likely to be equipped with advanced technology to deal with air pollution. As a consequence, the dominance of SOEs may provide opportunities to clean the air in Chinese cities. Largely on the contrary, SOEs have stronger bargaining power with central and local governments regarding environmental regulations in contrast to the privately owned enterprises (Wang et al., 2001). Furthermore, SOEs have strong connections with the governments and some managers of SOEs hold higher political status than the local environmental authorities. As a result, SOEs are able to elicit a lower pollution payment or punishment and have less incentive to decrease their pollution. Existing studies do provide evidence to support the argument that the dominance of SOEs in a city may deteriorate its environmental quality and fuel the environmental degradation. For instance, using plant level data, Wang and Wheeler (2000) found that SOEs are more likely to pollute than private enterprises in China. Wang and Jin (2002) reported that foreign-own enterprises and collectively owned enterprises have better environmental performance in terms of water pollution discharge intensity while SOEs and privately owned enterprises in China are the worst performers.

Privately owned enterprises (POEs) are able to utilize resources more efficiently and generate less air pollution with the same resources. They may have lower bargaining power with local environmental authorities with respect to the enforcement of pollution charges and regulations (Wang et al., 2002). A better environmental quality could be achieved with greater existence of non state-owned sector. For instance, using annual data for 44 developing countries from 1987 to 1995, Talukdar and Meisner (2001) showed a significantly negative relationship between the degree of private sector involvement in terms of its investment in the total domestic investment, national GDP, or its value of output share in the national GDP and Co₂ emission levels, suggesting that an increased role by the private sector in an economy is more likely to help the environment of the economy. However, although non SOEs may have higher efficiency in resource utilization, they are more profit-oriented and may not seek to internalize environmental externalities and may compromise the environment to avoid the potential cost of environmental investments (Eiser et al., 1996). Under the fiscal decentralization, local governments eagerly seek revenues. The decentralization of environmental protection agencies makes it possible to implement environmental regulations. China's non state-owned sector has been the most rapidly growing, which implies that it will

become increasingly difficult to enforce policy as institutional channels of state control over industry become weaker and weaker (Jahiel, 1997). As a result, it is likely that market decentralization results in more pollution.

Foreign enterprises have played a critical role in diversifying China's industrial structures. The environmental behavior of foreign enterprises is also debatable. Assuming that regions are identical except for exogenous differences in pollution policy, the pollution haven hypothesis proposes that it is cheaper to produce dirty goods in the region with weaker environmental regulation. Investments induced by environmental regulation differences create a pollution haven in the poor regions. Pollution intensive industries would migrate to regions with weaker environmental regulations mostly to save production costs. Foreign enterprises thereby may be harmful to the environment of developing countries whose environmental regulations are relatively weak. However, foreign enterprises are likely to help the environment in developing regions through technique effects. Foreign investment would bring advanced technological and managerial innovations beneficial to environmental improvement as well as economic progress, facilitating an international ratcheting up of environmental standards. Investment liberalization can provide favorable conditions for the diffusion of global environmental norms and standards by creating opportunities and necessities for environmental institution building and policy processes in the host economies (Shin, 2004). FDI may induce policy changes as a responding strategy of developing countries to cope with possible environmental damage. Wang and Jin (2002) found that foreign invested firms have better environmental performances than state-owned and privately owned firms. They suggest that foreign firms pollute less because they use superior technology in production and are more energy efficient. Shin (2004) examined the effects of trade and investment liberalization on the environment in two Chinese cities—Shenyang and Dalian, and found that economic openness positively affected domestic environmental policy by providing the necessity and opportunities for strengthening environmental institutions. He (2006, 2009) however provided convincing supportive evidence for pollution haven hypothesis and more FDI in a province was associated with more air pollution.

There are other types of industrial enterprises, including collectively owned enterprises (COEs), cooperative-enterprises (CEs), jointly-owned enterprises (JOEs), limited liability enterprises (LLEs) and shared holding enterprises (SHEs). Those enterprises are owned by multiple owners, some of which are local governmental agencies. The environmental behaviors of the multi-owners enterprises depend on the nature of owners. If local governmental agencies were partially involved, the industrial enterprises would act like SOEs. If private owners dominate, they would have similar environmental behaviors of privately owned enterprises.

Power Decentralization and Environmental Attitudes of Local Governments

Economic reform in China has resulted in considerable decentralization of power from the central government to a more regional locus. As a result, local governments have a primary responsibility and great autonomy for economic development in their jurisdictions. Since the late 1980s, the Chinese central government has also given much autonomy and responsibility in environmental policy to local authorities so that each provincial and municipal government has to compete with each other in environmental as well as economic performance (Jahiel, 1997, 1998). Environmental protection agencies now report to the

administratively higher levels of the national environmental protection apparatus and the local governments where they reside. Environmental decentralization has removed central government guarantees of financial resources for floundering localities and has deprived localities of the financial security they once had. Local governments provide environmental agencies with their annual budgetary funds, approve institutional advancements in rank and determine increases in personnel and even allocation of such resources as cars and office buildings. Increasingly hard budgets particularly make the local environment protection agencies difficult. As a consequence, China's environmental protection apparatus has suffered from insufficient authority and lack of co-ordination between institutional actors (Jahiel, 1998). Fragmented authority structure undermines the effective enforcement of environmental policies in China. Van Rooij and Lo (2010) found considerable regional variations in the enforcement of environmental pollution violations with coastal areas having more and higher punishments than those inland in China and such factors as central government support, community pressure, local government commitment, enforcement capacity, regulated firm characteristics and general economic conditions are responsible for the variations. The root of enforcement problems of environmental policies lies with the institutional arrangement in which the local governments pay and directly manage China's main local environmental enforcement authorities (Jahiel, 1998; Van Rooij and Lop, 2010).

Fiscal decentralization has enhanced the importance of local revenues (Zhao and Zhang, 1999; Young, 2000). Under the central planning system, local governments had no authority over the structure of local expenditure and no particular incentive to collect revenues. In 1980 China introduced a revenue-sharing system called the 'fiscal contracting system' because the central and provincial governments started to tap different revenue bases rather than 'eating from one big pot'. The Chinese government initiated a new tax-sharing system that introduced a clear distinction between national and local taxes in 1994. The new system proposed value added tax (VAT) the major indirect tax to be collected by the central government and shared by local governments at a fixed ratio of 75:25. Fiscal decentralization inherently and explicitly emphasized autarchic development because the localities had to self-finance their budgets and their own development (Zhao and Zhang, 1999).

The effect of environmental and fiscal decentralization has been that many local officials have become entrepreneurial trying to promote growth in their particular locality. While this entrepreneurship by local leaders have translated into an economic boom for many localities, its effect on environmental regulations has been far less beneficial. With the transformation from administrators to entrepreneurs, local governments are shifting from regulators to advocates of their local enterprises (Oi, 1995). Meanwhile, fiscal decentralization has induced fierce interregional competition, which may trigger the "race to the bottom competition" in which regions lower environmental standards to compete for investments and firms. Decentralization of economic decision-making to local governments and factory managers, combined with calls for rapid economic growth and production for profit, has created further incentive for local governments and managers to pursue economic growth and profitability at the expense of environmental degradation (Jahiel, 1997). For local governments, there is strong incentive to circumvent those policies that might constrain local growth, such as environmental regulations (Lieberthal, 1995). Reform incentives thus "have actually distorted the role of local governments as agents of the central state", making the local authorities more

lax with enforcement of environmental regulations (Jahiel, 1997). Destructive regulatory competition in the form of a race to the bottom would lower environmental quality with decentralization. Using UN's GEMS/Water data in 47 countries, Sigman (2009) found higher levels of the regional pollutants of biochemical oxygen demand and fecal coliform with more environmental and fiscal decentralization. Existing studies have reported that China's local governments have consistently undermined pollution enforcement in order to protect local economic interests (Ma and Ortolano 2000; Jahiel 1998, 1997; Sinkule and Ortolano 1995; Tang, Lo, Cheung, and Lo 1997; Swanson, Kuhn, and Xu 2001; Tang, Lo, and Fryxell 2003; Van Rooij 2006). With fiscal and environmental decentralization, pollution intensive industries gain opportunities to grow in regions facing hard budgets with limited local revenues. Regional decentralization thereby is harmful to environment through scale and composition effects in China.

Overall, market decentralization has significantly stimulated economic growth and changed the ownership structure of Chinese economy with growing share of non state-owned enterprises and decreasing status of SOEs. Power and fiscal decentralization has stimulated industrial growth and triggered race to the bottom competition with regard to environmental regulations. Although market decentralization may generate mixed environment performance, power and administrative decentralization would lead to environmental degradation in China. There may be a tradeoff between decentralization and environmental degradation in China. This study is to test the theoretical propositions.

Empirical Analysis

Variables and Models

To test the environmental impacts of decentralization, this study conducts a systematic investigation of determinants of industrial air pollution applying for a panel data regression model. The explanatory variables include proxies for marketization and fiscal decentralization controlling for industrial composition. The model is as follows,

$$\begin{aligned} LnTSO2_{it} (or LnTDUST_{it}) = & \beta_1 LnPGDP_{it} + \beta_2 (LnPGDP_{it})^2 + \beta_3 LnSOES_{it} + \beta_4 LnCOES_{it} \\ & + \beta_5 LnCOOP_{it} + \beta_6 LnJOIN_{it} + \beta_7 LnLIMD_{it} + \beta_8 LnSHARE_{it} + \beta_9 LnPRIV_{it} + \beta_{10} LnHTM_{it} \\ & + \beta_{11} LnFDI_{it} + \beta_{12} LnLEXRE_{it} + \beta_{13} LnVTAX_{it} + \sum_{k=1}^9 \alpha_k LnINDU_{itk} + \lambda_t + v_{it}, i = 1, \dots, N, t = 1, 2, 3, 4 \end{aligned}$$

That is, the pollution intensity (TSO2 or TDUST) in city i in year t is a function of theoretically discussed variables. i and t denotes city and time, λ_t the unobservable time effect, v_{it} the remainder stochastic disturbance term. Note that λ_t is city-invariant and it accounts for any time-specific effect that is not included in the regression. The inclusion of per capita GDP and its square is to test the existence of environmental Kuznets Curve (EKC) at the city level. The use of per capita GDP and squared per capita GDP to capture scale and technique effects is consistent with the environmental Kuznets curve literature, within which the inverted U shaped relationship between per capita GDP and pollution is explained largely in terms of the dominance of scale effects at low levels of income and the dominance of technique effects at high income levels.

The particular interest of this study is the environmental effects of decentralization. As discussed, market decentralization has played a significant role in changing industrial pollution intensity in Chinese cities although the net effect is unclear. The consequence of

market decentralization is to diversify the ownership structure of the Chinese city, with growing shares of non SOEs. We entertain the percents of different types of enterprises in gross industrial output to test the environmental impacts of market decentralization, including State-owned enterprises (SOES), collectively-owned enterprises (COES), cooperative enterprises (COOP), jointly owned enterprises (JOIN), limited liability corporation (LIMD), sharing hold enterprises (SHARE), privately-owned enterprises (PRIV), industrial enterprises from Hong Kong, Taiwan and Macao (HTM) and foreign enterprises (FDI). Power decentralization is difficult to quantify. The race to the bottom competition in environmental regulations however is associated with decentralization, which has created incentives for local governments to attract or develop pollution intensive industries. This study employs two variables to proxy for the effect of fiscal decentralization. One is the percent of local expenditure in local revenue (LEXRE) and the other is the percent of value-added tax in local revenue (VTAX). Both variables are expected to have positive coefficients.

Finally, this study intends to control industrial composition in Chinese cities by including the percents of gross industrial output of the pollution intensive industries (INDU). They include mining, papermaking and paper products, petroleum refining and coking, chemical materials and products, chemical fiber, nonmetal mineral products, ferrous metal smelting and pressing, nonferrous metal smelting and pressing, and power, natural and water production. All variables are summarized in table 1.

Table 1 Definitions of dependent and independent variables

Variable	Definitions
TSO2	Total industrial SO2 emissions/gross industrial output
TDUST	Total industrial dust/gross industrial output
PGDP	GDP per capita
SOES	Share of state-owned or controlled enterprises in gross industrial output
COES	Share of collectively-owned enterprises in gross industrial output
COOP	Share of cooperative enterprises in gross industrial output
JOIN	Share of jointly owned enterprises in gross industrial output
LIMD	Share of limited liability corporation in gross industrial output
SHARE	Share of share holding enterprises in gross industrial output
PRIV	Share of privately-owned enterprises in gross industrial output
HTM	Share of enterprises from Hong Kong, Macao and Taiwan in gross industrial output
FDI	Share of foreign enterprises in gross industrial output
LEXRE	Local expenditure/local revenue
VTAX	Share of value-added tax in local revenue
INDU	Share of individual pollution intensive industries in gross industrial output, including mining (INDU1), papermaking and paper products (INDU2), petroleum refining and coking (INDU3), chemical materials and products (INDU4), chemical fiber (INDU5), nonmetal mineral products (INDU6), ferrous metal smelting and pressing (INDU7), nonferrous metal smelting and pressing (INDU8), and power, natural and water production(INDU9)

Empirical Results

Owing to the significant declining trend of industrial air pollution intensity during 2004-2007, this study applied the time fixed effect model to estimate the coefficients of explanatory variables. The panel data regression results for both industrial So2 and industrial dusts intensities are presented in table 2. The Breusch-Pagan tests indicate the existence of heteroscedasticity and all estimates are corrected for heteroscedasticity.

Statistical results provide strong evidence to support the EKC effect in Chinese cities. There is a statistically significant inverted U shaped relationship between LnPGDP and LnTSO2 (Or LnTDUST) controlling for industrial structure. Air pollution intensity is lower in under-developed cities. As cities grow economically, their economies become increasingly pollution intensive. When per capita GDP reach a certain level, air pollution intensity gradually reduces owing to technique effects. The result could largely explain the spatial pattern of pollution intensity, with smaller intensities in the coastal cities but high intensities in the central cities (Figure 6 and Figure 8). The finding indicates the dominance of scale effects at low levels of income but dominance of technique effects at high-income levels. There is certainly structural effect. Resource-based industries including mining, chemical materials and products, ferrous and nonferrous metal smelting and rolling processing industries, power, and natural gas and water production significantly bring up pollution intensity in Chinese cities. Interestingly, papermaking and paper products and chemical fibers are negatively associated with air pollution intensities. The EKC effect suggests that economic development and economic restructuring would do good to improve the environmental quality in Chinese cities.

There is evidence to show that market decentralization has deteriorated China's environment controlling for industrial structural effects and the EKC effect. On the one hand, LnSOES is highly and positively associated with industrial pollution intensity in Chinese cities controlling for industrial structures. The dominance of state owned enterprises in Chinese cities would lead to higher So2 emissions and dusts per industrial output and deteriorate the environment. This is consistent with Wang and Wheeler (2000), which found that SOEs are more likely to pollute than privately owned enterprises. It is indeed true that SOEs, especially those under the administration of upper levels of governments, have stronger bargaining power with local governments regarding environmental regulations in contrast to the privately owned enterprises and SOEs are able to elicit a lower pollution payment or punishment and have less incentive to decrease their air pollution (Wang et al., 2001). Meanwhile, the power decentralization has granted local governments incentives to protect SOEs under their administration, which are the base of political power, as well as sources of private benefits and fiscal revenues (Bai et al., 2004; He et al., 2008). The local protectionism in turn has created incentive for SOEs to perform poorly in environmental protection. The poor environmental performance of SOEs is the result of fiscal and environmental decentralization.

Table 2 Regression Results for Industrial Dusts and SO2 Intensity

	LnTSO2			LnTDUST		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LnPGDP	1.7097**	3.1147***	1.7481**	2.1621**	4.7135***	3.0353***
LnPGDP*LnPGDP	-0.1114***	-0.1867***	-0.1109**	-0.1501***	-0.2777***	-0.1832***
LnSOES	0.1197***		0.1327***	0.1618***		0.1892***
LnCOES	-0.0036		0.0009	0.0166		0.0300
LnCOOP	-0.0411		-0.0333	-0.0827		-0.0707
LnJOIN	-0.0772		-0.0793	-0.0547		-0.0508
LnLIMD	0.4488***		0.4548***	0.4307***		0.4507***
LnSHARE	0.0212		0.0359	0.1031***		0.1156***
LnPRIV	-0.0146		0.0057	0.1306**		0.1454***
LnHTM	-0.0411		-0.0367	-0.1200***		-0.0888*
LnFDI	-0.0185		-0.0045	-0.0228		-0.0027
LnLEXRE		0.1661*	0.1116		0.5125***	0.4353***
LnVTAX		0.2476***	0.2472***		0.1202*	0.1625**
LnINDU1	0.1969***	0.2290***	0.1823***	0.2298***	0.2823***	0.2198***
LnINDU2	-0.1095**	-0.1510***	-0.1004**	-0.1253**	-0.1678***	-0.1115**
LnINDU3	-0.0202	-0.0284	-0.0183	0.0134	0.0098	0.0173
LnINDU4	0.1081***	0.1193***	0.1096***	0.0551	0.0915**	0.0647
LnINDU5	-0.1048**	-0.1324***	-0.1060**	-0.0504	-0.0755	-0.0481
LnINDU6	-0.0515	-0.1021*	-0.0356	0.0456	-0.1364	0.0447
LnINDU7	0.0661***	0.0865***	0.0683***	0.0897**	0.0823***	0.0630**
LnINDU8	0.0760***	0.1057***	0.0751***	0.0145	0.0524*	0.0258
LnINDU9	0.0685*	0.0992**	0.0607	0.0080	0.0086	0.0189
Time Dummy	Included	Included	Included	Included	Included	Included
# Observations	1144	1144	1144	1144	1144	1144
Adjusted R2	0.4511	0.3935	0.4584	0.5232	0.4747	0.5319
F-Value	41.85	47.36	39.69	55.54	65.55	52.96
Breusch-Pagan χ^2	207.84	120.22	227.94	207.84	95.81	95.62

Notes: *, p<0.10; **, p<0.05; ***, p<0.01. Results are corrected with heteroscedasticity.

On the other hand, some market-driven industrial enterprises are significantly positively related to air pollution intensity in Chinese cities. The coefficient on LnLIMD is positive and significant in both SO₂ and Dust models while coefficients on LnPRIV and LnSHARE are positively and significant in the Dust models. More output by limited liability corporations is associated with higher SO₂ intensity in Chinese cities and more industrial outputs by privately owned and sharing holding enterprises are associated with higher dust intensities. The results indicate that limited liability corporations, privately-owned enterprises and sharing holding enterprises may emit more SO₂ or industrial dust and contribute to the environmental degradation in Chinese cities. Indeed, Wang and Jin (2002) found that SOEs and privately owned enterprises in China are the worst performers in terms of water pollution discharge. The profit-driven enterprises have less incentive to internalize environmental costs when facing lax environmental regulations. Foreign funded enterprises seem to clean air quality in Chinese cities. Both LnHTM and LnFDI have negative coefficients in the models of SO₂ and

dusts and LnHTM is significant in the dust models. The net environmental effect of foreign enterprises is positive, which is consistent with Shin (2004), which found that economic openness positively affected domestic environmental policy by providing the necessity and opportunities for strengthening environmental institutions in Shenyang and Dalian. It also agrees with Wang and Jin (2002), which found that foreign enterprises have better environmental performance than state-owned and privately owned enterprises. The findings fundamentally reject the notion of pollution heaven in developing economies.

As expected, fiscal decentralization has indeed played a significant role in deteriorating China's environment. Both LnLEXRE and LnVTAX are positively associated with air pollution intensity controlling for pollution intensive industries. LEXRE is applied to quantify the difficulty of local budgets. VTAX measures the dependence of local revenues on industrial development. The results suggest that the harder the local budgets means more air pollution and more dependence on value added tax also means more air pollution. Fiscal decentralization requires the localities to self-finance their budgets and their own development (Zhao and Zhang, 1999). Fiscal decentralization and designated local tax structures create strong pressure and incentives to develop pollution intensive industries and to enhance local revenues. Fiscal decentralization might have triggered the race to the bottom competition to lower environmental regulations and standards to attract highly taxable and value-added pollution intensive industries. Cities suffering from hard budgets are also more lax with the enforcements of environmental regulations, giving opportunities for pollution intensive industries to develop. Meanwhile, local governments also protect the high value added pollution intensive industries.

Overall, the statistical results based on the full sample provide confirming evidence to support that decentralization has contributed to the deterioration of environmental quality in Chinese cities. Market decentralization together with power decentralization has reduced the incentives for market-driven enterprises to internalize environmental costs, leading to a less pollution effective economy. Fiscal and power decentralization grants authorities and responsibilities to local governments, which have developed a passive attitude towards environmental protection, leading to an environment unfriendly development model.

Environmental impact of decentralization in different regions

There are remarkable regional differences in economic development, geographical location, industrial structure, technology, institutional environment and government policies in China. There may be significant regional differences in environmental performance in the coastal, central and western regions. To see the regional differences in the environmental effects of decentralization, this study divides Chinese cities into three groups: cities located in the coastal, central and western provinces^{*}. The statistical results are reported in table 3. All models are highly significant. The models perform the best in the coastal cities and poorest in the western cities. The results show significant regional differences in the environmental behaviors of industrial enterprises and the environmental attitudes of local governments.

^{*} Coastal provinces include Liaoning, Hebei, Beijing, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, Hainan; Central provinces cover Heilongjiang, Jilin, Inner Mongolia, Shanxi, Henan, Anhui, Jiangxi, Hubei, Hunan; Western provinces include Xinjiang, Tibet, Qinghai, Shaaxi, Gansu, Ningxia, Sichuan, Chongqing, Guizhou, and Yunnan.

Table 3 Regression Results for Pollution Intensity in the Coastal, central and western Cities

	Costal Region		Central Region		Western Region	
	LnTSO2	LnTDUST	LnTSO2	LnTDUST	LnTSO2	LnTDUST
LnPGDP	-5.9364***	-5.3650***	3.1919*	3.5652*	0.0470	-1.4757
LnPGDP*LnPGDP	0.2617***	0.2216***	-0.1634*	-0.1844*	-0.0252	0.0586
LnSOES	0.1503***	0.2596***	0.1869***	0.0352	-0.0864	-0.0723
LnCOES	0.2212***	0.1369	-0.2031***	-0.1139**	-0.0347	-0.1545
LnCOOP	-0.0448	-0.1525	-0.0321	-0.0995	0.0435	0.3636***
LnJOIN	-0.0882	0.0535	0.0350	-0.0812	0.3950**	0.3882**
LnLIMD	0.2616***	0.2803***	0.4418***	0.3375***	0.5445***	0.3093***
LnSHARE	0.0970*	0.1621**	0.0457	0.0139	-0.1152**	-0.0957
LnPRIV	0.0028	0.2350**	0.1780**	0.2333***	-0.1627	-0.0698
LnHTM	-0.1244**	-0.0994	0.0677	0.0216	0.0822	-0.0570
LnFDI	0.0961	0.0878	-0.0767*	-0.0369	0.0318	0.1022
LnLEXRE	0.1680	0.3925*	0.2910***	0.5954***	-0.2870	0.1075
LnVTAX	0.3292**	0.0478	0.2885***	0.1381	0.2070	0.2388
LnINDU1	0.1526***	0.1534***	0.2207***	0.2573***	0.0099	0.0475
LnINDU2	0.0362	-0.1257	-0.0183	0.1009	-0.2091*	-0.0930
LnINDU3	-0.0580*	0.0088	-0.0311	0.0539*	0.0587	0.0555
LnINDU4	0.1679***	0.1584**	0.017	-0.0278	0.0859	0.0896
LnINDU5	-0.0412	0.0198	-0.0401	0.0603	0.2059*	-0.0666
LnINDU6	-0.2138***	-0.0831	0.0200	-0.0452	0.1878*	0.1806
LnINDU7	0.1245***	0.1536***	0.0608***	0.0716***	0.0404	0.0811
LnINDU8	0.0823*	0.0832	0.0859***	-0.0043	-0.0445	-0.0335
LnINDU9	-0.0497	-0.2052***	0.1367**	0.0991*	0.1536**	0.1785
Time Dummy	Included	Included	Included	Included	Included	Included
# Observations	460	460	440	440	244	244
Adjusted R2	0.4903	0.5730	0.4440	0.4576	0.3186	0.3570
F-Value	18.66	25.63	15.02	15.82	5.55	6.40
Breusch-Pagan χ^2	239.87	139.66	70.50	103.32	44.29	35.03

Notes: *, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.01$. Results are corrected with heteroscedasticity.

There is a U-shaped rather than inverted U shaped relationship between LnPGDP and LnTSO2 and LnTDUST in the coastal cities. The EKC effects are likely to occur in the central cities. Controlling for the effects of decentralization and industrial composition, no significant relationship between LnPGDP and pollution intensity can be found in the western cities. The inverted EKC effect is possibly related to the recent heavy industrialization in some coastal cities by developing petroleum refining and coking, ferrous metal smelting and processing, chemical materials and products, and machinery and equipment. The heavy industrialization is justifiable economically. First, facing rising costs of labor and land, coastal cities have been pursuing a strategy of industrial upgrading, promoting the development of heavy industrialization; second, the coastal cities are well prepared to develop heavy industries with the capital accumulation through labor and resource based intensive industries in the 1980s and 1990s; third, the international industrial relocation is

moving heavy industries to China for markets; finally, there are huge market potential for heavy industries as China continues to grow. There has been a heated debate about whether China's coastal region needs heavy industrialization in the last couple of years. The heavy industrialization has however imposed serious environmental challenge in the coastal region and this challenge could last a long time. The west does not observe a significant relationship between economic development and air pollution intensity controlling for industrial structure. The underdevelopment may have discouraged the technique effect of economic development on environment in the west region.

There observed significant differences in the environmental behaviors of industrial enterprises in the different regions. First, results indicate that SOEs hurt the environment in the coastal and central regions but are likely to clean the air in the west. In the coastal and central cities, SOEs are largely in the heavy industries such as chemical materials and chemical products, and ferrous metal mineral smelting and processing, equipment and machinery. They are more likely to pollute than labor intensive industries. What's more important, industrial enterprises in those heavy industries are major contributors of local economies and local revenues, giving SOEs more bargain power to elicit a lower pollution punishment. Second, coefficients on LnCOES are positive in the coastal models and but only significant in the So2 model, implying that collectively owned enterprises in the coastal cities are environmentally harmful. Some collectively owned enterprises in the coastal cities are previous township enterprises, relatively small and poorly equipped compared with SOEs and foreign enterprises. They are not environment effective. LnCOES is negative and significant in both SO2 and DUST models in the central cities but is insignificant in the western cities. In the less developed central cities, the state still controls the heavy and high value added pollution intensive industries. Collectively owned enterprises are largely in the market driven light industries and thereby more pollution effective.

Third, cooperative enterprises and jointly-owned enterprises have no significant environmental impacts in the coastal and central cities but are environment unfriendly in the western cities. Limited liability corporations have significantly contributed to the environmental degradation in all three regions. Share holding enterprises and privately-owned enterprises are environmentally harmful in the costal and central regions but are likely to help the environment in the west. Comparatively, the inland region is weak in the community pressure, local government commitment, enforcement capacity and general economic conditions and may be lax in the enforcement of environmental regulations and environmental pollution violations (Van Rooij and Lo, 2010). Market-driven enterprises in the inland regions lack sufficient incentives to internalize environmental costs and produce more air pollution. Surprisingly, limited liability corporations, share holding enterprises and privately-owned enterprises are also harmful to the urban environment in the coastal region, which in general has more and higher punishments than those in inland China (Jahiel, 1998; Van Rooij and Lo, 2010). In the economically liberalized coastal region, those market-oriented enterprises are also the major contributors to local revenues and local economic growth. With fiscal decentralization, local governments have incentives to accommodate them and implement lax environmental regulations. In addition, HTM enterprises and foreign enterprises are associated with lower So2 emission intensity in the coastal region and the central region, respectively. The poor environmental performance of

market-driven enterprises provides convincing evidence to support the proposition that market decentralization is responsible for China's environmental degradation.

There are regional differences in the environmental attitudes of local governments. Both LnLEXRE and LnVTAX are insignificant in the western region but are expectedly significant in the central region. There is only weak evidence on the environmental impact of fiscal decentralization in the coastal region. Incentives in economic development and pressure in local revenues would induce the development of pollution intensive industries in the central cities. In the past couple of years, the central region has gained favorable policy support from the central government and thereby realized rapid economic growth. The central cities have competed to attract the relocated industries from the coastal region, which are often forced to relocate because of environmental pollution. Although facing budgetary challenges, the western region has consistently received a significant amount of financial transfer from the central government, reducing the fiscal pressure of local governments. In addition, the central government has made enormous investments by implementing the strategy of "Develop the West". The western region is extremely environmentally vulnerable and the central government has imposed more pressure on local governments to protect local environment.

Environmental impact of decentralization in different scale of cities

Cities differ in scale and technology. Environmental impacts of decentralization may differ across different city groups. This study divides Chinese cities into three groups based on the population in 2004, including large cities with population greater than 5 millions, medium cities with population of 2-5 millions and small cities with population smaller than 2 million. The panel regression results are presented in table 4. All models are highly significant, with R^2 larger than 0.50.

First, No significant evidence for EKC is observed in the small cities but industrial dusts quickly drop as per capita GDP increase in the large and medium cities, which are able to adopt more advanced technology in their industrial production. As a result, the technique effects in large and medium cities are expected to be more significant. The variations in the relationship between per capita GDP and SO₂ intensity are mainly across three groups of cities. Both scale and technique effects have not played their roles in influencing the environment in the small cities, which may have less capacity to utilize advanced technologies.

Second, decentralization is mainly good to the environment quality in large cities while medium and small cities largely suffer from decentralization. As usual, LnSOES have positive coefficients in all model specifications but the coefficients are significant in both So₂ and dust models only in the medium cities. SOEs are significantly and positively associated with industrial dust intensity in the large cities. The good news is that market-driven enterprises are negatively associated with air pollution intensity in the large cities. Large cities have incentives to improve their natural environment to attract high-tech industries and professional services to upgrade their industrial structures. As a consequence, large cities may enforce stricter environmental regulations on market-driven enterprises, which typically have lower bargaining power with local environmental authorities with respect to the enforcement of pollution charges and regulations (Wang et al., 2002). Foreign enterprises are also likely to contribute to environment improvement, rejecting the pollution heaven hypothesis. Foreign

enterprises, which are able to enter large cities, are likely to be major multinational corporations, which belong to capital and technology intensive industries. They may bring environment friendly advanced technologies and management and implement higher environmental standards. For instance, foreign investments dominate in the electric and electronic industries in Beijing, Shanghai, Tianjin, and Shenzhen, reducing air pollution intensity.

Table 4 Regression Results for Pollution Intensity in the Large, Medium and Small Cities

	Large Cities		Medium Cities		Small Cities	
	LnTSO2	LnTDUST	LnTSO2	LnTDUST	LnTSO2	LnTDUST
LnPGDP	0.9002	2.5934	-0.3914	1.6059	1.6188	-1.1164
LnPGDP*LnPGDP	-0.0832	-0.1892**	-0.0109	-0.1153*	-0.1013	0.0148
LnSOES	0.0101	0.1755**	0.3690***	0.4089***	0.0283	0.0818
LnCOES	-0.2121***	-0.0991	0.1296***	0.1550***	0.0751	0.0957
LnCOOP	-0.2176***	-0.2862***	-0.1686**	-0.1422*	0.4649***	0.3344***
LnJOIN	0.0597	0.0613	-0.3164*	0.0646	-0.1266	-0.3208*
LnLIMD	0.2664***	-0.0287	0.6271***	0.7149***	0.3312***	0.4260***
LnSHARE	0.0580	-0.1232*	0.2134***	0.2935***	-0.0915	0.0446
LnPRIV	-0.0481	-0.0551	0.1356**	0.2592***	0.0509	0.2800**
LnHTM	-0.0616	-0.1975***	0.0658	0.0559	-0.2355**	-0.2790**
LnFDI	-0.1343**	-0.0730	0.1866***	0.1758***	0.1256	0.0951
LnLEXRE	-0.2270	-0.0448	-0.0282	0.4121***	0.1471	0.2232
LnVTAX	0.1021	-0.2040	-0.0688	-0.1216	0.8029***	0.8140***
LnINDU1	0.1471***	0.1396***	0.1616***	0.2238***	0.1127*	0.1075*
LnINDU2	0.1140	0.1724*	0.0228	-0.0595	-0.2840***	-0.2147**
LnINDU3	0.0222	0.0401	0.0037	0.0404	0.0269	0.0689
LnINDU4	-0.1655***	-0.3047***	0.1179**	0.1358**	0.2252**	0.1631*
LnINDU5	-0.0731	0.0123	-0.0690	-0.0100	-0.2670	-0.1861
LnINDU6	0.0209	0.1431	-0.1167*	-0.0692	-0.0191	-0.1037
LnINDU7	0.1446***	0.2278***	0.1011***	0.0462	0.0606	0.0848*
LnINDU8	0.0981**	0.0541	-0.0133	0.0013	0.1123*	0.0015
LnINDU9	-0.1422**	0.2296***	0.1019**	-0.1084**	0.0786	0.0860
Time Dummy	Included	Included	Included	Included	Included	Included
# Observations	340	340	576	576	228	228
Adjusted R2	0.5866	0.6154	0.5022	0.5366	0.5143	0.6227
F-Value	20.24	22.70	24.21	27.64	10.61	15.98
Breusch-Pagan χ^2	72.82	85.45	217.69	98.99	116.67	30.24

Notes: 1. *, p<0.10; **, p<0.05; ***, p<0.01. Results are corrected with heteroscedasticity.

2. Large cities with population greater than 5 millions, medium cities with population between 2-5millions and small cities with population smaller than 2 millions.

LnCOES, LnLIMD, LnSHARE, LnPRIV and LnFDI all have significant and positive coefficients in the medium cities. Only cooperative enterprises and jointly owned enterprises are negatively associated with air pollution in the medium cities. LnCOOP, LnLnLIMD and

LnPRIV are positively associated with air pollution intensity in the small cities. The results suggest that market-driven enterprises may result in more air pollution in medium and small cities, which bear larger pressure in economic growth and are in the process of fast industrialization and urbanization. LnVTAX is positively significant in small cities. LnLEXRE is positive and significant in the dust model of medium cities. With power and fiscal decentralization, local governments in the medium and small cities are more likely to fall in the “race to the bottom competition” so as to implement lax environmental regulations. Market-driven enterprises have less incentive to internalize environmental negative externalities and are able to elicit a lower pollution payment or punishment in medium and small cities. It is worthwhile to point out that HTM enterprises are able to improve environmental quality in small cities. HTM enterprises in small cities are largely in the traditional labor intensive industries, such as food manufacturing, garments, shoes and hats making, toy making, leather, fur and down products. Compared with domestic enterprises in the small cities, HTM enterprises may be equipped with better equipment and advanced technologies, also contributing to environmental improvement.

Overall, large cities are likely to benefit from market and power decentralization environmentally while medium and small cities may suffer from decentralization.

Summary

Economic reform in the last three decades has remarkably liberalized the Chinese economy, resulting in exceptional economic growth. It however has posed a serious contradiction for environmental protection efforts in China. This study empirically investigated the environmental effects of decentralization using data on industrial SO₂ emission and dusts at the city level.

China’s industrial production has been cleaner, with decreasing pollution intensity during the last decade. Pollution intensive industries particularly have made significant achievements in reducing pollution intensity. Industrial pollution is clustered in some Chinese cities. The Yangtze River Delta, the Shandong Peninsula, the Capital region, the Central-Northern China, Northeastern China, the Sichuan Basin, and the Pearl River Delta are the hotspots. The coastal region is much less pollution intensive compared to the inland region.

Statistical results confirm the EKC effect in Chinese cities, implying that economic development is possible to mitigate industrial pollution through technique effects. SOEs have contributed to environmental degradation in Chinese cities. Market-driven enterprises are positively associated with air pollution intensity, indicating that market decentralization may be harmful to urban environment, especially in the central and western regions and also in the small and medium cities. Power and fiscal decentralization has induced the race to the bottom competition by lowering environmental regulations to attract taxable and high value added pollution intensive industries, which is more remarkable in the coastal and central regions and in the medium and small cities. The environmental impacts of decentralization in China are associated with the environmental behaviors of different types of industrial enterprises and different environmental attitudes of local governments.

To a certain degree, China’s economic achievement is at the expense of environmental degradation. Existing studies found the effects of scale, technology and structure on environmental pollution. This study highlighted the importance of regional decentralization.

On the one hand, decentralization is a critical part of economic reform and consists of a significant institutional advantage for China's economic development since the late 1970s. On the other hand, decentralization is proved to result in environmental degradation, not only in the coastal region but also in the western region. Meanwhile, the SOEs clearly are harmful to urban environment. The environmental effects of SOEs and decentralization are associated with lower environmental standards and lax environmental enforcement and implementation. Evidently, there is a tradeoff between economic growth and environmental degradation associated with decentralization. It is critical to increase the incentives for industrial enterprises to internalize environmental costs by strengthening the enforcement of environmental regulations, which depends on the environmental attitudes of local governments. As a consequence, the fundamental solution to China's environmental degradation depends on the effort of local governments, which demands a set of reforms, including changing structures of local revenues and the performance evaluation of local officers and improving the status of environmental enforcement agencies.

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