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ABSTRACT

China's rapid economic growth has been fueled by industrialization and urbanization. Given its export focus, this industrialization was spatially concentrated in the coastal eastern cities. Over the last decade, a spatial transformation has taken place leading to a deindustrialization of the rich coastal cities and sharp industrial growth in the inland cities. This survey examines recent work that studies the economic geography of industrial production, per-capita income, pollution and quality of life in China's cities. We focus on the interaction between firms, local governments and the central government that together determine the new economic geography of industry and pollution within China.

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1. Introduction

Growing at a nearly 10% average annual rate for three decades, China has become the second largest economy in the world since 2010. Industrialization and urbanization have reinforced each other in this rapid economic development of China. For example, 40% of the world's clothes are "Made in China".[1] The proportion of the population living in urban areas increased from less than 20% in 1980 to 52% in 2012. As the "The World's Factory", China's industrialization has largely been driven by the fast growth of export-oriented and labor-intensive industries in the coastal areas in Eastern China. In the mid-2000s, more than 90% of total exports and roughly 60% of industrial output was produced in those coastal cities (National Bureau of Statistics of China, NBSC[2]).

Since the mid-2000s, the rising congestion costs associated with the industrial agglomeration in large coastal cities began to drive the shift of the nation's industrial geography. Labor and land costs have been increasing dramatically in these cities. The 2008 global financial crisis shrank international demand. As a result, many large cities in China's Eastern Region have undergone de-industrialization, while the less developed inland cities in the Central and Western Regions are experiencing fast industrialization. Many labor-intensive firms in large coastal cities either upgraded their capital and technology, or moved to nearby small cities and inland cities such as Wuhan and Zhengzhou. According to Qu et al. (2012), for twelve labor-intensive manufacturing industries, the output ratio between coastal cities and inland cities peaked at 8.04 in 2004, and then declined to 5.53 in 2008. The employment share of labor-intensive industries in coastal cities also started to decline since 2008. The manufacturing share of GDP in the Central and Western Regions (inland region or inland area) grew from 36% in 2004 to 44% in 2010, but declined in the Eastern Region (coastal region or coastal area) after 2008 (Figure 1). Since 2005, the urbanization share in China's Western Region has grown by 1.4 percentage points per year (NBSC).

This changing geography of industrial production has important urban implications. This change has been altering the spatial distribution of pollution and

[1] Source: China Textile Industry Development Report 2010-2011. Published by China Textile & Apparel Press, 2011.

[2] All NBSC data in this paper comes from China Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook and the website http://data.stats.gov.cn/index.

affecting the spatial income distribution across China. In China, industrial production is the main source of both local and global pollutions. In 2011 the industrial sector was responsible for 89.3% of total end-use energy consumption while the residential sector only consumed the rest 10.7% (NBSC). Industrial production contributes emissions to air and water, therefore industrial relocation and migration changes the economic geography of industrial pollution. Public health researchers have documented the health consequences of exposure to pollution (Ratcliffe et al., 1996), and environmental and urban economists have also documented that urban pollution is a major component of local quality of life (QOL) (Gyourko and Tracy, 1991; Zheng and Kahn, 2013a).

Cities featuring high air and water pollution must pay compensating differentials measured in terms of higher wages and lower real estate rents in order to attract workers to live in such cities (Rosen, 2002). Empirical studies have documented that, all else equal, real estate prices across and within Chinese cities are higher in areas that are less polluted (Zheng and Kahn, 2008; Zheng et al., 2013a). Given that a clean environment is a normal good, the richer and more educated urban households in China's Eastern Region value it more than their counterparts in Western and Central Regions.

The economic geography of industrial pollution is an emergent property of the locational choice of industrial plants. Where firms locate is both a function of the natural advantages of different geographic areas and the regulatory policies and incentives offered by different local governments. Local governments who are aware of this strategic dynamic must decide whether to enforce regulations and pay the price of losing some footloose dirty jobs or to enjoy the environmental gains of deindustrializing. In richer coastal cities, the local governments are enforcing stricter environmental regulations. A U.S literature on regulation's unintended consequences has documented that differential enforcement of pollution regulation encourages industrial migration to areas featuring more lax regulation (Kahn, 1997; Becker and Henderson, 2000; Greenstone, 2002; Kahn and Mansur 2013).

Booming industrial activity brings new economic opportunities but cause environmental deterioration in China's inland region. This paper surveys recent research to understand this tradeoff between regional convergence in income and the spatial distribution of industrial pollution. How does the relocation of industrial activity alter the spatial distribution of income, pollution and local quality of life?

We review the related literature and present new evidences on these key questions related to China’s changing urban standard of living.

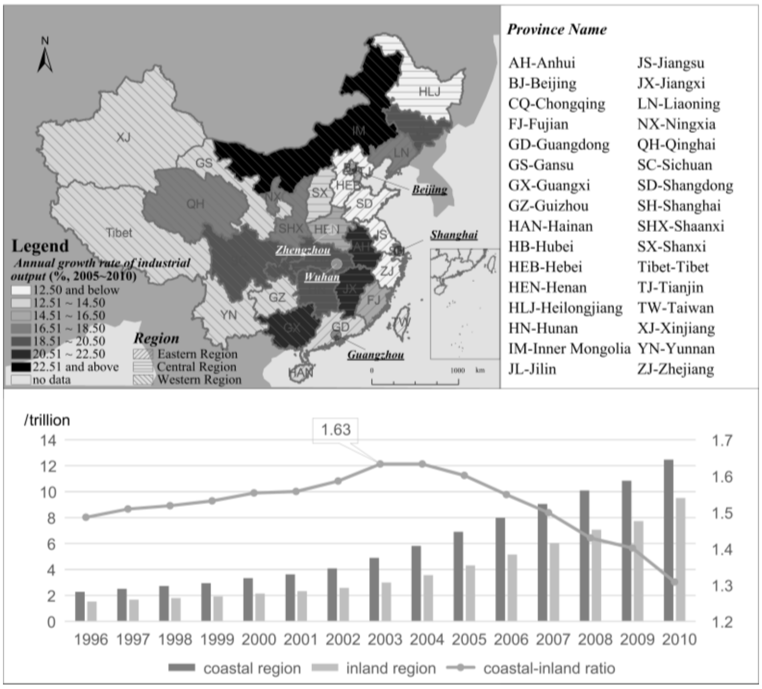
A series of studies investigate how China's exports affect importing nations (Broda et al., 2009; Feenstra and Wei 2009; Bloom et al., 2011; Autor et al., 2013; Atristain, 2012). Those studies focus on the external effects of China’s industrial production dynamics. In contrast, we focus on how China's spatial equilibrium is affected by industrial production dynamics.

The remainder of the paper is organized as follows. Section 2 presents the spatial dynamics of industrial location in the last 30 years in China. Section 3 discusses the urban implications of the recent geographic change in industrial activities on spatial disparities in income, pollution and local QOL. Section 4 concludes.

2. The Changing Geography of China’s Industrial Production

2.1 Descriptive Statistics

Starting in the 1980s, with the transition in China from the central-planned economy to a market economy, transportation costs have played a key role in determining profit maximizing firms’ locational choice. Consistent with the theory of New Economic Geography (NEG) (see Krugman, 1991 and Neary, 2001), China’s coastal cities in the Eastern Region with good access to the global market became the most attractive location for private manufacturing firms. State-Owned Enterprises (SOEs) lack the flexibility of choosing their locations, but the existing manufacturing SOEs in coastal cities also enjoyed the benefits of a booming economy and expanded, while many in Western and Central Regions had a weak performance and some went bankrupt. In the mid-2000s, more than 65% of manufacturing employment in above-scale (with annual sale above 5 million RMB) industrial firms was located in the coastal region, as compared to 42% in 1980. Shanghai, Tianjin, Beijing, Guangzhou and Suzhou were the top five cities with the highest manufacturing employment (NBSC). The bar graph in Figure 1 shows the manufacturing sector’s value-added in both the coastal and inland regions between 1996 and 2010 (at constant 2010 RMB). The coastal region had a higher growth rate than the inland region during 1996-2004, but this trend flipped over since 2005 and the ratio of the two has kept declining since then in this period.

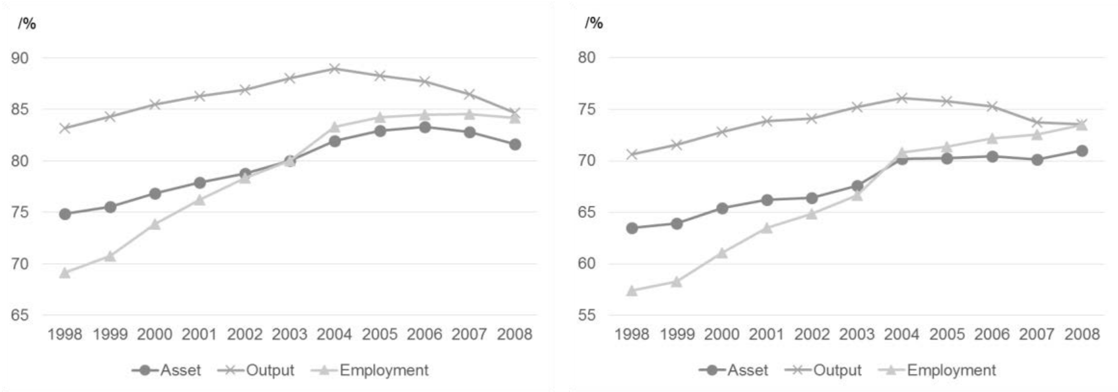


Source: NBSC

Figure 1. Manufacturing output in the coastal and inland regions

Many empirical studies show that during the early years of China's industrial export growth, the economic activity was highly spatially concentrated. Wen (2004) calculates industrial local Gini coefficients for three-digit manufacturing industries using value-added data, and finds that large- and medium-sized manufacturing firms were highly geographically concentrated with nearly all of the industries recording a Gini coefficient greater than 0.50 (with one third of them over 0.80) in 1995, and most industries were clustered in the Guangdong and Jiangsu provinces. He also finds that this concentration trend rose from 1980 to 1995. Using three measures of industrial concentration, Long and Zhang (2012) find similar patterns between 1995 and 2004, especially for those export-oriented industries.

Since the mid-2000s, the sharply rising labor and land costs in coastal cities have pushed labor-intensive manufacturing firms either to upgrade their capital and technology or to move out. The shrinkage of international market demand after 2008 Global Financial Crisis also reduced the relative location advantage of the coastal cities. In Figure 1, the annual growth rates of manufacturing value-added (at constant 2010 RMB) in the coastal and inland regions between 2004 and 2010 were 19% and 25%, respectively, and the ratio of these two switched from increasing in 1996-2003 to declining in 2004-2011. Qu et al. (2012) report that the share change in employment, assets and output values for all manufacturing industries (especially for labor-intensive industries) in the coastal area have slowed down or even decreased since 2004 (see Figure 2). Bao et al. (2012) find that this changing geography of industrial production mostly happened for labor-intensive industries, and the coastal area is still the home of high-tech industries.



All Manufacturing Labor-intensive industries

Source: Qu et al. (2012)

Figure 2. The share of manufacturing activity in the coastal region

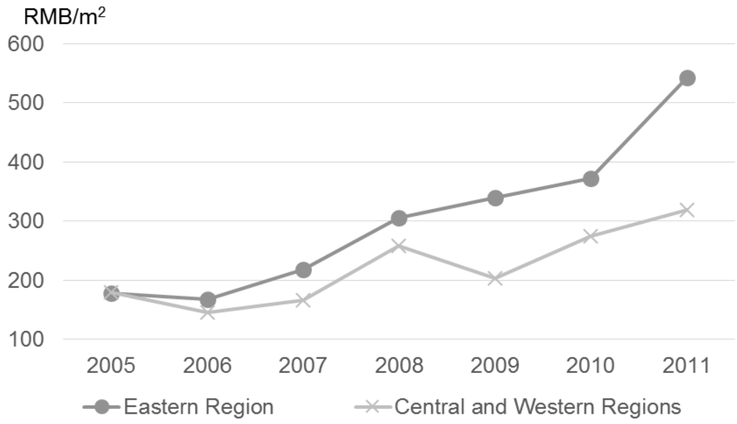
2.2 Market Fundamentals and Industrial Spatial Geography Dynamics

The initial geographic concentration in coastal cities brought increasing return to scale and generated regional specialization among firms (Long and Zhang, 2012, He and Pan, 2013, Lu et al., 2013). Based on Annual Survey of Industrial Firms (ASIF) from 1998 to 2005, Li et al. (2012)'s instrumental variables estimation shows that an one-standard-deviation increase in industrial agglomeration index leads to increasing return to scale and thus results in a 0.34-standard-deviation increase in firm size. Li and Lu (2009) find that geographic concentration not only decreases delivered prices for inputs based on proximity to suppliers, but also encourages more specialization and less vertical integration, which are consistent with the findings in Goldstein and Gronberg (1984) and Helsley and Strange (2007).

Since mid-2000s, labor costs have been rising quickly in the coastal region (Gao, 2004; Qu et al., 2012). The wage gap between coastal cities and inland cities was almost zero in 1980 but grew to 1.5 in mid-2000s. Qu et al. (2012) use the ASIF dataset from 1998 to 2008 covering 31 provinces and 30 manufacturing industries to show that, from 2004, the size of the rural surplus labor has significantly decreased, and the large coastal cities started to face labor shortages and faster rising labor cost.

In these cities, firms chose to switch to capital-intensive and high-tech industries.

In recent years, land prices in coastal cities have soared. Manufacturing is land intensive and thus it is not surprising that these manufacturing industries were out bid by high-tech, finance and other high-skilled industries which attract more international capital inflows and are able to pay much higher land rent. In 2012, the auction price ratio of commercial/residential land over industrial land was 13.8 in coastal cities, but was 7.6 in inland cities. Therefore, large coastal cities face a large opportunity cost for manufacturing activity in their cities. Such manufacturing land could be used for higher value commercial and residential towers. In inland cities, there is not such a demand for residential and commercial real estate.



Source: China Land and Resources Statistical Yearbook

Figure 3. The annual auction price (at constant 2010 RMB) for industrial land across China's regions (2005-2011)

The average auction land price in coastal cities was roughly the same as that in inland cities in 2005 but later the former was about 170% of the latter in 2011 (Figure 3).[3] Figure 3 highlights the growing land price gap for industrial use between the Eastern Region and the Central and Western regions after 2008. Gao et al. (2012) estimate a dynamic panel data model using data for 35 major Chinese cities in 2000-2009 and find that rising real estate prices is one important factor explaining why manufacturing firms are moving from coastal areas and relocating to inland areas.

The inland cities also have a cost advantage in electricity price. For instance, the

[3] Data source: *China Land and Resources Statistical Yearbook*

industrial electricity price in Zhejiang province is roughly 15% and 7% higher than Henan province and Shaanxi province, respectively in 2012 (National Development and Reform Commission, NDRC). A U.S.-based research has documented that energy intensive firms are more likely to locate in geographic areas where electricity prices are lower (Kahn and Mansur 2013).

Given these push factors, the second tier and third tier cities in China's Western and Central Regions have become increasingly attractive destinations for labor and energy intensive manufacturing thanks to their low-price land and electricity, ample labor supply, improved transportation infrastructure and institutional environment.

2.3 The Role of Government in Determining the Geography of Industrial Production

A distinctive feature of Chinese cities is that the central and local governments both have a "visible" hand in influencing firm location choices, with fiscal and land policies as basic policy tools. At the beginning of China's Economic Reform, China's central government recognized the coastal area's locational advantage and designed several favorable policies, such as setting up Special Economic Zones (SEZs) in this area. Favorable short-term tax deduction and other favorable policies were set in those SEZs to attract foreign direct investments (FDI) and foster industrial clusters (Gao, 2004; Du et al., 2008). Labor migration restrictions (*hukou* system) from the countryside to cities were gradually relaxed and this allowed a huge flow of migrant workers to move to coastal cities and thus provided sufficient cheap labor to those labor-intensive manufacturing industries located there.

Local leaders have a strong incentive to foster the growth of their local economy. A booming economy increases local fiscal revenue, especially after taxation reform in 1994 (Lu and Tao, 2009). The local leaders compete with each other in their respective attempts to be promoted within the central government's promotion system (Qi, 2008). Each local leader knows that local GDP growth has been a key determinant of promotion (Zheng et al. 2013b, Qi and Zhang, 2013). Given that the industrial sector contributed a large share of GDP and tax revenue, local governments competed to offer cheap land, tax deductions, good infrastructure and favorable institutional environment to attract FDI and other firms that can produce high tax revenues in the long-term.[4] In Broadman and Sun (1997)'s study, FDI's location choice in China was determined by market size, proximity to port, infrastructure condition and favorable policies. They find those subsidies in SEZs provided enough incentives to attract FDI.

Some scholars argue that the changing geography of industrial production since the mid-2000s has been largely driven by government interventions (Lu and Xiang 2013). Unlike many western countries, China's central government has been pursuing a well-defined set of regional growth policies. The Western Development Program and "Rising of Central China" Program launched in 1999 and 2004, respectively, provide infrastructure aid and support for industrial adjustment to western and inland provinces. The Northeast Revitalization Program focuses on reinventing the poor cities in China's Northeast (Liaoning, Jilin and Heilongjiang) that once benefited from the emphasis on heavy industry under the central planning. The share of the land supply in inland regions had increased roughly 15% between 2003 and 2010 (Lu and Xiang, 2013), most of which came from taking agriculture land from farmers. Vast infrastructure investment in highways and high-speed railways has greatly shifted the industrial location patterns (Faber, 2013). Starting in 2007, China has introduced several new high-speed rails that connect large cities such as Beijing, Shanghai, Guangzhou, and Wuhan with nearby cities. Through facilitating market integration, high-speed rail stimulates the development of 2nd and 3rd tier cities and this will reduce discrepancies in income inequality across China's cities (Zheng and Kahn, 2013b). Once China's inland cities were connected to the rest of the nation, the inland mayors there then aggressively started to build SEZs and offer the traditional packages of SEZ incentives to lure firms to inland area.

Generous local government incentives can induce industry to move to less productive areas. By comparing several indicators including industrial output, labor distribution, firm size, capital-labor ratio, labor cost and labor productivity by region and year, Cai et al. (2009) find that many of these indicators did not show

[4] For example, in Zhejiang Province's "new technology zones", the government spent 100 thousand Yuan per mu (96 thousand US dollars per acre) on average to provide basic infrastructure to the industrial land, but the average sale price of such industrial land to firms was only 86 thousand Yuan per mu (83 thousand US dollars per acre), even less than the infrastructure cost. Half of the industrial land parcels were sold at the price less than 50% of the infrastructure construction cost. In some inland provinces that are keen to attract FDI and high-tax-revenue industries, some "new technology zones" sold their industrial land at a price of zero. See http://www.snzg.cn/article/2011/0318/article_22780.html

comparative advantage for industrial development in inland regions but industrial firms were moving there largely by the favorable incentives provided by governments.

This highlights that there can be a tension between central government goals of fostering overall economic growth while simultaneously seeking to reduce spatial income inequality. If poor cities are inherently less productive (perhaps due to geographic factors), then investing in such areas may yield a relatively low rate of return relative to investing in areas with better fundamentals. Conversely, standard convergence arguments might predict that the marginal returns to investment in such areas may be high (Barro and Sali-i-Martin 1991) .

3. Implications for Spatial Variation of Income, Pollution and Local Quality of Life

The initial concentration of manufacturing activities in coastal cities, and the much higher productivity within manufacturing sector in those places resulted in inter-regional income disparity between coastal and inland areas (Ge, 2006; Tsui, 1996). Using GDP and industry output data, Fujita and Hu (2001) find that the coastal/inland output ratios increased in all the eighteen manufacturing industries from 1983 to 1994, which accounted for more than 55% of interregional income variation. FDI-based enterprises with higher productivity locate close to the international market and significantly contribute to the spatial variation in income (Fujita and Hu, 2001; Ge, 2006). Wan et al. (2007) estimate that both international trade and inflows of FDI contributed to the rising inter-regional income Gini coefficient from 1987 to 2001.

To reduce this high income inequality between the coastal areas and inland areas, China’s central government made large fiscal transfer payments to under-developed inland regions. Such transfers had a short-term effect in reducing regional income inequality (Chen and Groenwold, 2010). But in the long-run, increasing the mobility of labor and firms is believed to be a better way to mitigate such income inequality issue. (Lu, 2013)

Since the mid-2000s, the growth of industrial production in inland cities has contributed to the spatial income convergence. For instance, the annual wage growth was 16.7% for manufacturing workers in the Eastern Region during 2006 to 2010, while this rate were 20.4% and 19.3% in the Central and Western Regions in the same period, respectively (NBSC). The labor income gap between coastal cities and inland cities shrank slightly from 1.4 in 2005 to 1.3 in 2010 (NBSC). However, the income increase in those inland cities has been accompanied with more industrial pollution emission there.

3.1 Pollution Production as a Consequence of Industrial Locational Choice

The geographic concentration of manufacturing activity has significant local environmental impacts. During the 1980s, black smoke from smoke stacks became the characteristic of Chinese industrial cities; subsequently, many southern cities began to suffer from extremely high levels of acid rain pollution, and large cities' air quality was greatly deteriorated due to nitrous oxides (NOx), carbon monoxide (CO) and other pollutants due to the combustion of coal (He et al., 2002). Cao et al. (2011) shows that the Eastern Region experienced heavier emissions of such air pollutants than the rest of the country, due to the large share of industrial activities and power plants located there. As the World Bank reported, twelve of the twenty most polluted cities in the world were located in China (World Bank, 2007). Industrial activities also led to a severe deterioration in water quality, and roughly 70% of the river water was unsafe for human consumption (World Bank, 2006) at the beginning of the century. Industrial firms produced more than 35 percent of pollutant discharges into Chinese rivers in 2007, including heavy metal and organic pollutants[5].

In Table 1, we present the annual percent change in different industrial emissions indicators for different Chinese regions. Between 2004 and 2010, both industrial SO_2 and COD emissions declined in the Eastern Region, but increased in the Central and Western Regions. The t-tests show that this spatial variation in the annual growth rates is statistically significant for both industrial emission types.

[5] Dataset of the First China Pollution Source Census

Table 1 Average annual percentage change in industrial SO_2 and COD[6] (2004-2010)

	Industrial SO_2	Chemical Oxygen Demand (COD)
The Eastern Region (μ_1)	-1.69%	-1.87%
The Central and Western Regions (μ_2)	1.74%	0.33%
t test (H_0: μ_2=μ_1)	2.029^{**}	1.578^{*}

Data source: NBSC

Note: $^{*}p < 0.10$, $^{**}p < 0.05$

Industrial pollution is highly correlated with energy consumption. Scale, composition and technique effects work together to determine the total energy consumption from a city's industrial sector (Copeland and Taylor, 2004). Scale refers to the sheer count of jobs and output located in a city while composition refers to a city's set of industries and the vintage of its capital stock. Technique represents emissions per unit of economic activity. If technique effect keeps constant over time, the increases in both scale and share of energy-intensive manufacturing industries in China's inland cities will lead to rising energy consumption and energy intensity (energy consumption per GDP dollar). The scale of industrial production in inland cities has been rising faster than that in coastal cities. In Table 2 below we do a simple decomposition exercise on energy intensity (energy consumption per GDP dollar) from the industrial sector in these two regions. The results reported in Table 2 show that the composition effect increases inland cities' energy intensity while it reduces that in coastal cities. Between 2006 and 2011, keeping technique effect constant, the change in manufacturing share in output contributed to a 3.17 tce (tonne coal equivalent) decline and a 6.83 tce increase in coastal and inland cities, respectively. The good news is that, technology upgrading had made a major contribution to energy intensity decline in both regions (Rock et al., 2013). Our own calculations show that the inland cities enjoyed a 19.8 tce energy intensity decrease which outweighed the positive composition effect so that the net change in energy intensity is negative for the Inland Area.

[6] COD is "chemical oxygen demand". The concentration of COD reflects the amount of organic compounds in water.

Table 2 Energy consumption, energy intensity changes in coastal and inland cities

	Year/Period	Coastal cities	Inland cities
Manufacturing share in output	2006	46%	41%
	2011	44%	45%
Composition effect (tce per million RMB)	2006-2011	-3.17	6.83
Technique effect (tce per million RMB)	2006-2011	-22.4	-19.8

Notes: (1) When we calculate the composition effect, we assume sector-specific energy intensity is constant (use nationwide numbers in the initial year 2001) and let a city's industrial composition change over time. This means: $\text{Composition effect} = \sum_i (S_{ij,2011} - S_{ij,2006}) \times EI_{i,2006}$; Similarly, when we calculate the technique effect, we assume a city's industrial composition is constant (use numbers in initial year 2001) and let nationwide sector-specific energy intensity change over time. This means: $\text{Technique effect} = \sum_i (EI_{i,2011} - EI_{i,2006}) \times S_{ij,2006}$. Where subscript *i* and *j* denote industry and region respectively, EI_i denote nationwide energy intensity of industry *i*, S_{ij} denotes industry *i*'s share in output in region *j*.

(2) tce refers to "tonne coal equivalent", which is a standard unit of energy consumption used in Chinese statistics.

Data Source: NBSC

This calculation highlights that the migration of industrial factories towards the west does induce a "zero sum pollution game". As coastal cities such as Shanghai grow cleaner due to deindustrialization, there are social marginal benefits from reducing the pollution exposure of millions of Shanghai wealthy residents to industrial pollution. A pessimist would posit that an equal amount of damage is created in the inland area where the factory moves. This logic is false because more people live in the large coastal cities such as Shanghai and thus exposing them to less pollution reduces the Pigouvian social cost of industrial production in China.

China's industrialization growth has taken place within a global economy. Access to global markets not only offers China export destinations and foreign direct investment but it also offers access to cleaner international technology. Such advanced technology offers the possibility of China's industry reducing its emissions per dollar of production, which may be the underlying reason for the large technique effects in both regions documented in Table 2. Some evidence is found in empirical studies. Wang and Jin (2007) find that foreign firms exhibit better environmental performance than state-owned and privately owned firms because the foreign firms use cleaner technology and are more energy efficient. Zheng et al. (2010) also report a negative correlation between a city's FDI inflows and its ambient air pollution level using IV regression strategy. Fisher-Vanden et al. (2013) examine the factors inducing the declining energy intensity in four Chinese industries (pulp and paper, cement, iron and steel and aluminum). The factors include rising energy cost, rising R&D investment, market-oriented reform and the import of foreign technology.

3.2 Energy Production as a Function of Industry Location

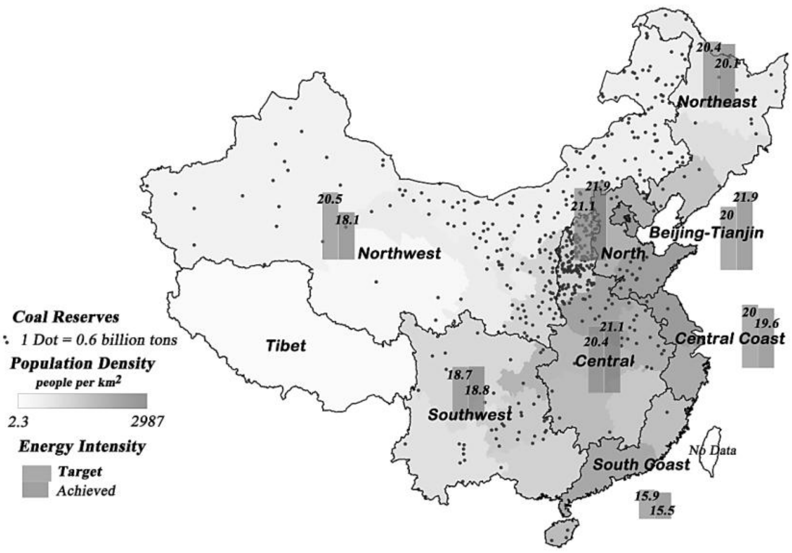
Electricity generation has provided a crucial input for China's rapid industrialization in the past decades. In 2010, more than 70% of total electricity was consumed by the industrial sector (NBSC). China has the third largest coal reserves in the world, and 80% of China's electricity is generated using coal (NBSC). Therefore, pollution hot spots emerge as a byproduct of the industrial production. When industrial production was concentrated in the coastal area, a large number of coal-fired power plants were located close to those industrial clusters to minimize transmission line loss. Since those industrial clusters are also large cities with high population density (Figure 4), this means that a large share of population has been exposed to the air pollution produced by the coal-fired plants.

With the evolving geography of industrial production, most of the newly-built coal-fired power plants emerged nearby inland cities. In this way, those plants can minimize transmission cost and coal transport cost simultaneously (see Figure 4 for the spatial distribution of coal reserves in China). In addition, some coal-fired power plants in coastal cities were shut down due to the stricter pollution regulation there. Since the 2000s, new coal-fired power plants are not allowed to locate near coastal cities. It is predicted that more than 80% of newly-built power plants will locate in inland cities in the near future.[7]

From an environmentalists' perspective this is mixed news. On the positive side, the densely populated coastal area will be exposed to less pollution. Another piece of good news is that the central government has requested coal-fired power plants, especially the newly-built ones, to install desulfurization equipment, such as SO_2 scrubbers (Xu et al., 2009). Figure 5 shows the install capacity of desulfurization

[7] Source: http://www.wri.org/blog/can-china%E2%80%99s-air-pollution-action-plan-slow-down-new-coal-power-development

equipment in coal-fired power plants. Unfortunately, with insufficient monitoring, there was much less focus on whether such SO_2 scrubbers are operated properly such that they actually reduce pollution. It was reported that, in some plants the equipment was left idle (Wang, 2013). The bad news, in terms of reducing China's greenhouse gas emissions, is that China is building new coal fired power plants and these power plants have a high carbon emissions factor.



Sources: Coal reserves and population density from NBSC, 2011; population density was calculated based on population and land area; energy intensity of 8 regions is integrated based on provincial energy and gross Regional Product data.

Figure 4. Population density and the distribution of coal reserves (2010)

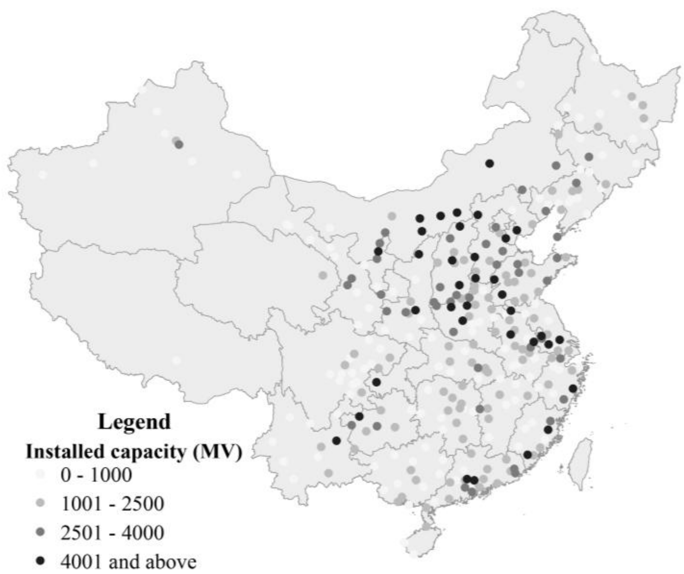


Figure 5. The installed capacity of desulfurization equipment in coal-fired power plants (2011)[8]

[8] Source: http://www.mep.gov.cn/gkml/hbb/bgg/201104/W020110420407642353906.pdf

3.3 Spatial Displacement Effects Caused by Differential Environmental Regulation

Chinese urbanites differ with respect to their willingness to pay to avoid pollution. People in richer cities are willing to pay more to face less pollution and this incentivizes their local leaders to pursue more stringent environmental regulation (Zheng and Kahn, 2013a). As shown in the case of the United States, if some cities adopt strict regulation while other cities have lax regulation then this will induce some dirty factories to seek out the lower cost-low regulation city (Henderson, 1996; Greenstone, 2002). In United States, Kahn and Mansur (2013) examines that energy-intensive industries concentrate in low electricity price counties and pollution-intensive industries locate in counties featuring relatively lax Clean Air Act regulation. In China, the coastal region's environmental regulation has become much stricter than before (Van Rooij and Lo 2010).

Environmental regulations in China can be divided into two types: One is administrative interventions such as stipulation of filter installment (Xu et al., 2009), and the other is economic incentives such as pollution levy (Wang and Wheeler, 2005; Lin, 2013).

Mayors of coastal cities tend to move dirty firms out of their cities, and at the same time, the city governments in under-developed area welcomed these firms for economic growth and employment opportunities which are now their "golden goose". Those inland city mayors have the incentives to tolerate large firms' heavy pollution in return for generating local tax revenue, creating job opportunities, and promoting economic growth (Jiang et al., 2013; Yu et al., 2013).

Consistent with the "pollution haven" hypothesis, many energy-intensive manufacturing firms relocated or started their new business in inland cities with lower production cost and laxer environmental regulation, which can be called a "domestic pollution haven". For instance, Beijing moved out a large amount of polluting firms to nearby cities in the Hebei province before the 2008 Olympic Games[9]. The media has claimed that these factories are a major reason for the aggravated environmental pollution in Hebei in recent years. Foxconn, one of the biggest Taiwanese manufacturers of Apple products, moved its factory from Shenzhen to Henan which

[9] Source: http://www.chinadaily.com.cn/business/2011-06/18/content_12729071.htm

also raised public concerns about pollution growth. A media report shows that 39 of 43 industrial projects with large pollutant emissions were introduced into the Western Region in 2000.[10] Ningxia, a province in the Western Region (see Figure 1), had a total export of 650 million dollars in 2004, 56.9% of which was contributed by energy-intensive and polluting firms.[11] Based on water pollution data, Zheng et al. (2013) conduct a case study on tracing the water pollution transfer associated with industrial transfer between Yangtze River Delta and Henan province, and find that several pollutants (such as the sulfonamides and steroids) could be detected in the water sample due to this industrial relocation.

In recent years, a common phenomenon is the within-province industrial relocation. For instance, Guangdong province is subsidizing polluting firms in the Pearl River Delta to relocate in the northern part of the province, and Jiangsu province is relocating those firms to the north-Jiangsu (Subei) area. This may be the provincial governments' intended strategy of trying to green the big city by moving dirty activity further from the major population centers and trying to spread income to the poor underperforming areas within the region (Zheng and Kahn, 2013a; Cai et al., 2013).

3.4 The Local Quality of Life Impact of Industrial Pollution Dynamics

Industrial emission directly affects a city's air and water pollution levels. Figure 6 shows the composition of various sources of Beijing's $PM_{2.5}$ concentration in 2011[12]. Coal combustion emission, local industrial emission and imported emission from nearby industrial hot spots accounted for 16.7%, 16.3% and 24.5% of the PM10 concentration, respectively. Zheng et al. (2013a) also estimate the size of this cross-boundary pollution and find that a 10% decrease in imported neighbor pollution is associated with roughly 1.7% increase in local PM_{10} concentration in 85 Chinese cities.

[10] Source: http://www.people.com.cn/GB/channel7/498/20000628/121718.html

[11] Source: http://china.qianlong.com/4352/2005/07/13/2001@2717046.htm

[12] Source: http://www.readdailynews.com/news-3843243-The-industrial-spray-set-haze-volt-the-PM25-sources-accounted-ranking-after-the-motor-vehicle-exhaust-and-coal-emissions.html

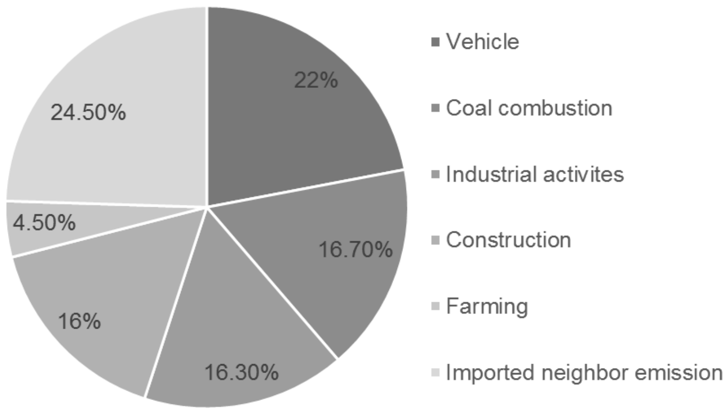


Figure 6. Proportions of different sources contributed on Beijing's $PM_{2.5}$ concentration

Industrial pollution has many negative impacts on local quality of life, such as lowering worker productivity, hurting children and the elderly, and reducing the desire to outdoor activities. Its negative externality on public health has been well documented (Chen et al., 2004; Guo et al., 2009; Kan et al., 2012; Venners et al., 2003). Ebenstein (2012) finds that industrial activity has led to a severe deterioration in water quality in China's lakes and rivers. He estimates that a deterioration of water quality by a single grade (on a six-grade scale) increases the digestive cancer death rate by 9.7%. His econometric strategy contrasts OLS estimates of site specific death rates on local water quality with IV estimates where he instruments for a site's water quality using variation in precipitation across the sites and variation in the distance from the site to the nearest river's headwaters. Currie et al. (2013) review the empirical literature providing both direct and indirect evidence that early childhood exposure to pollution significantly impacts later life outcomes. Chen et al. (2013) employ a quasi-experimental approach to provide clear evidence that China's coal-based winter heating policy cut life expectancy by over five years in northern China during the period 1981 to 2000.[13]

The urban quality of life literature emphasizes that spatial variation in wages and rents represents a compensating differential for place based local public goods (Rosen, 2002). This revealed preference methodology allows scholars to identify urban households' demand for non-market goods, including urban environmental amenities

[13] China's winter heating policy provides free heating via the provision of coal for boilers in cities north of the Huai River but denied heat to the south.

(Albouy, 2008; Albouy and Lue, 2011; Gyourko et al., 1999). In both intra-city and inter-city studies focusing on China (Zheng and Kahn 2008; Zheng et al., 2010, 2013a), it is found that home prices are lower in cities or in the locations within a city with higher ambient pollution levels or less green space. Recent research has found in China that the marginal valuation for green amenities is rising over time. Using the same data as that in Zheng et al. (2013a), we calculate the capitalization rates of PM_{10} concentration in home prices in China's inland and coastal cities, and their changes over time (Table 3), controlling for a rich set of city attributes (population, temperature, employment share of manufacturing sector, green space per capita, health care, education and other urban amenities). In both periods, the richer coastal cities have a higher willingness-to-pay for less PM_{10} pollution than the poorer inland cities, and both numbers are rising over time.

Table 3. Elasticity estimates of the real estate capitalization rates of PM_{10} concentration

Period	2006~2007		2008~2009	
Region	Coastal cities	Inland cities	Coastal cities	Inland cities
Capitalization rate (marginal willingness-to-pay)	-0.493	-0.323	-0.642	-0.466

From Table 3, we see that, all else equal, a 1% decrease in PM_{10} concentration is associated with a 0.32 – 0.64% increase in home price. There is no property tax in Chinese cities, and many cities rely on land sales for a large share of their annual revenues (around 60%) (Cai, Henderson and Zhang, 2009). This reliance on land sale revenues in Chinese cities may incentivize local governments to internalize quality of life effects because this will increase their land's value (Arnott, 2008). While Chinese cities rely on land sales for revenue today, it is likely that cities will run short of land at some time point in the future. This will encourage such cities to introduce a property tax system. Those cities with high quality of life and high real estate prices could enjoy high revenues under this scheme (Zheng and Kahn, 2013a).

4 Conclusion

Any American who has walked into a Walmart Superstore knows that China has been an industrial powerhouse producing many of the goods that consumers seek ranging from computers to American Flags. While China's industrial production has created great wealth, a byproduct of such massive production of heavy industry combined with a reliance on coal fired electricity has been a huge amount of urban pollution. Given that coal is a fossil fuel, this electricity generated for industrial production has also led to soaring greenhouse gas production in China.

This paper has surveyed several literatures to provide a comprehensive overview of the spatial evolution of industrial production, income, pollution and quality of life across China's cities over the last 30 years. The initial concentration of industrial activities in the coastal cities had driven the fast economic growth as well as deteriorated environmental quality there. Many empirical studies document the shifting geography of industrial production toward inland cities since the mid-2000, due to the rising congestion cost of labor and land in the coastal area. This trend has contributed to inter-regional income convergence, and also brought pollution and negative QOL impacts to the inland area. Though the scale and composition effects work together to increase the total energy consumption and energy intensity in inland cities, we detect a significant technique effect which helps the inland cities to reduce their energy intensity and become cleaner. This indicates that the new factories established there may employ more modern engineering technology. This may raise the possibility that the on-going geography dynamics of industrial production will not become a zero-sum pollution game. Instead, it may generate net social benefit as high-density coastal cities deindustrialize and hence reduce their population's exposure to pollution while new factories in inland cities use greener technology. This optimistic view hinges on whether the technique effect (i.e newer factories opening in the West using relatively low emissions per unit of production) out-weighs the scale and composition effects in the long-run in inland cities.

The fascinating feature of China is the mixture of classic natural advantage features and the strong hand of the local and central governments. The well-defined set of regional balance policies pursued by the central government contributed a lot to this spatial dynamics, and the inland city mayors have also been keen to attract dirty manufacturing firms which can bring them with economic growth, employment opportunities and tax revenue. The stricter environmental regulation in richer coastal cities where people have a stronger demand quality of life also pushed those dirty firms to the inland cities with laxer environmental regulation. Similar with what had happened in large coastal cities in the last twenty years, we can predict that, as the booming industrial activities continue to generate income growth in the inland area, urban households there will also have a higher willingness-to-pay for local quality of life, and will push local leaders to impose stricter environmental regulations. In a system of cities both within China and across country borders, it is possible that we will observe those industrial activities further migrate to the cities in less-developed countries, such as Vietnam, Philippines and Africa, which is consistent with the "pollution haven" hypothesis.

Throughout this survey, we have discussed a dynamic regional general equilibrium process without writing down a formal general equilibrium model. Future research should consider constructing such a model in which industrial production creates wealth and pollution. Local quality of life is a function of per-capita income and pollution. Locations differ with respect to their comparative advantage and alternative uses for manufacturing land. Such research would need to formally model the actions of a strategic national government simultaneously seeking to encourage macro growth, environmental progress and regional income convergence. This survey has demonstrated why such an endeavor is important and how the evolving empirical agenda has quantified many facts relevant for considering the tradeoffs that China's industrializing and deindustrializing regions now face.

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