EXPORTS AND AIR QUALITY IN CHINA: EVIDENCE FROM PROVINCIAL LEVEL

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Abstract

International trade has allowed the Chinese economy to boom and "Made in China" tags to dominate the world market. However, a number of studies have argued that the rapidly growing Chinese economy has placed great amount of pressure on its natural environment. The emphasis on export-led growth may bring in its wake, pollution to China. This thesis gives empirical evidence to the question that whether exports in China have caused environmental issues, especially air pollution. I use data from 31 provinces in mainland China over the period from 2002 to 2012. The results show that there is no strong relationship between air pollution in China and its exports, but the economic growth in general has hazardous impacts onto the environment.

KEYWORDS: (Exports, Air pollution, China)

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CHAPTER I

INTRODUCTION

In recent years, China has experienced rapid growth enhanced by a tremendous amount of benefits from exporting goods and services. After China joined the World Trade Organization (WTO) in 2001, the economic growth rate in China has been constantly exceeding seven percent (World Bank, 2012). The annual export growth rate had been exceeding twenty percent (IMF, 2012) before the recent economic crisis occurred in 2009. After the crisis, China was able to recover fast and the export growth rate hit 28 percent again in 2010. This miracle was absolutely astonishing and worth studying. However these great economic gains have come at costs. Seventeen of the twenty-five most polluted cities in the world can be found in China and an estimated 3,000,000 people die prematurely each year as a result of air pollution (Wang, 2007). Carbon dioxide emissions in China have been exceeding most of the Asian developing countries and reached 5.8 metric tons per capita (World Bank, 2009). If China is to alleviate its pollution and the health impacts due to environmental degradation, a detailed study of the economic factors that influence pollution is desired.

In this paper, I examine the relationship between environment, economic growth, export, and other economic factors that have been strongly influenced by export in China such as foreign direct investment (FDI). This study has three contributions towards the growth-environment literature. First, I focus specifically on the great strain that is placed onto the environment by China, the rapidly growing economy. There are few studies that focus on how growth affects environment. Second, given the rapid growth and strong recovering ability of export sectors in China, I analyze the contribution of export to China's pollution, which attracts less attention than it should due to numerous recent pieces of news stating the pollution caused by export in manufacturing section in China. Third, this study focuses on Chinese provinces and I believe the use of regional level statistics provides more potential explanatory power than the use of national level data due to the great variety within such a big country.

The remainder of this paper is organized as follows. Chapter 2 provides reviews on previous studies on export, environment, and growth. Chapter 3 introduces the data and variables that I use in the model. Chapter 4 sets up general model specification. Chapter 5 provides results of the general model for China as a whole and regional models for each of the Chinese provinces. Chapter 6 concludes.

CHAPTER II

LITERATURE REVIEW

Export-Led Growth Hypothesis

The discussion on the nature of the empirical and theoretical relationship between export growth and economic growth has produced little consensus. Whether the export-led growth hypothesis is correct or not remains inconclusive. Examining the data over the period 1955-1982, Darrat (1987) found export-oriented policies have been widely prescribed for developing countries as their appropriate development strategy due to the fact that export growth and GDP growth are positively related. However, normal time series analysis only reveals the presence of statistical correlation between export and economic growth, but has no bearing on the causal link between the two variables, and thus there is no significant support for the export-led growth hypothesis. Clearly export would mitigate the constraint on foreign exchange and result in a better resource allocation, as a result, productivity increases. Yet on the other hand, the flow from economic growth to export may also happen as the increase in production is generated internally and the flourishing industries would probably turn to foreign markets. Similar conclusions were drawn by Mahadevan (2009) as in the case study of Singapore he finds out that neither import nor export growth directly affects total factor productivity growth, although labor productivity growth is export as well as import-growth driven. This finding implies that inputs in the form of capital equipment or semi-finished intermediate products can increase GDP without necessarily increasing the efficiency of workers and thus, import is a conduit between export growth and GDP growth. Hausmann, Prichett and Rodrik (2005) looked for reasons of growth accelerations that are sustained for at least 8 years since the 1950s. Interestingly they found out that a typical country would have about a 25 percent chance of experiencing growth acceleration at some point in any given decade and less developed countries are more likely to experience such growth acceleration. Also the major driving forces of the growth acceleration are neither fundamental economic reform nor positive political regime changes, but idiosyncratic, and often small-scale, changes. Agarwal and Mitra (2010) concluded from their findings through examining data of China, Hong Kong, Japan, South Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand that openness may be more important in starting growth and becomes less important once countries start to grow. The different policies that different governments have adopted are the "invisible hands" in those East Asia countries.

On the other side, Fosu, as one of the supporters of the export-led growth hypothesis, studied the role of export composition in the economic growth process. Fosu (1990) examined cross-section data for 64 developing countries over the 1960-1980 periods. He suggests manufacturing contents in export may be the only major driving element of economic growth in less developed countries. Balassa (1977) examined data of developing countries during the period from 1960 to 1973 and concludes that export-oriented policies, which provide similar incentives to sales in domestic and in foreign markets, lead to resource allocation, allow for greater capacity utilization, permit the exploitation of economies of scale, generate technological improvements, and contribute to increased employment. These results from export-oriented policies clearly prove that export–oriented policies are superior to policies favoring import substitution since substituting domestic production for import entails rising costs due to the loss of economies of scale in small national markets and the relatively capital intensive nature of the products involved. As a result, the domestic resource cost of savings of foreign exchange through continued import substitution under protection will exceed the domestic resource cost of earning foreign exchange. Export growth favorably affects the rate of economic growth over and above the contributions of domestic and foreign capital and labor. Buffie (1992) believes in the export-led growth hypothesis and derived mathematically the conditions for export-led growth.

Despite those who took different sides on the existence of the export-led growth hypothesis, Anwer and Sampath (1997) concluded that the majority of the countries do not show any relationship between export and economic growth with data from 96 countries from 1960-1992. Their results show that only 8 out of 96 countries support the export-led economic growth hypothesis while causality from GDP to exports with positive relationship between them runs for only 9 countries. Through testing data from 1885 to 1990, Boltho (1996) also suggested in his case study that Japanese growth was not driven by exports, but by domestic demand instead. Japan benefited from a very rapid growth of domestic demand, from elastic supplies of both labor and capital, from a high degree of internal competition in manufacturing, and from appropriate post-war macroeconomic, industrial, and even export-promotion policies. Export played a significant role in earlier years, which improved efficiency needed to measure up to world competition, but later domestic demand became the major driving force of Japan’s rapid growth, and overall, export activities were not the engine of economic growth. Mah (2007) examined the duty drawback system of China, which is redemption of duty paid on imported inputs used in the production of exports and enables the producers to have export competitiveness. His result proves this export promotion action has little effect on economic growth due to the inefficiencies such as the prevalence of the false reporting practices, and uncertainties and delays in the reimbursement of duties.

Besides those distinct opinions on the export-led growth hypothesis, most of these studies agree on the positive correlation between export and economic growth. Hausmann, Prichett and Rodrick (2005) showed growth acceleration is always accompanied by an increase share of export and import in GDP since competitive firms will automatically self-select themselves into exporting while importing lowers the cost of production (Mahadevan, 2009). Boltho (1996) and Balassa (1977) agreed openness to external trade is crucial for growth: foreign competitive pressures improve resource allocation, impose technological progress and managerial efficiency, stimulate adaptability, promote scale economies, and generate externalities for other sectors, particularly via skill formation. All these factors contribute to both growth and export expansion.

Also interestingly, transitions to autocracy are more favorable in terms of economic growth than transitions to democracy (Hausmann, Prichett and Rodrick, 2005). This finding is supported by Agarwal and Mitra (2010) and Boltho (1996) since they argued government played an important role in directing allocation of factors of production. Mah (2007) also said the failure of China’s duty drawback system should be attributed to the weak administrative capacity compared with its large economic size. Thus a powerful role of the government is favored by both export and economic growth. The Asian Tigers including Singapore, Korea, Japan, and Hong Kong all have quite strong governments.

Growth in China

China has gone through multiple trade reforms since 1978, which contributes greatly to its openness to the world. At the same time, trading with the rest of the world has shaped China's policies toward both its supply and demand side. The reforms during the 1978-1992 periods were not enough to change much because the trade system suffered from disorder and even chaos because conflicts between regions and between different levels of authorities reached a trade-impeding extent. Then in the year of 1992, a new stage of China's economic reform began. Since then, China's trade system has been adapted to better reflect international norms and the process of trade liberalization has accelerated. The five routes adapted in the 1992 reform includes: first, China's government lowered trade tariff rates more broadly and more significantly. Second, nontariff trade barriers were reduced substantially, or even demolished altogether. Third, the government started a program of administrative reforms by both developing an adapted trade-related regulatory and international law system and making the international trade administration system much more transparent. Fourth, along with the liberalization of the international trade system, the reform program has been extended to services industries and FDI. Fifth, many exchange rate reforms have been implemented (Zhang and Witteloostuijn, 2004).

With such reforms, China has then been able to enjoy the great benefits brought by its outward oriented policies. Export raise productivity by giving rise to various benefits, such as more efficient use of resources, greater capacity utilization and gains of scale effects associated with large international markets. These facts suggest that international trade is an important way of facilitating technology creation, transfer and diffusion. Organization for Economic Co-operation and Development

(OECD) countries have higher technological capabilities and their productivity spillovers may concentrate on the enhancement of technological knowledge and competence in indigenous Chinese firms, and thus China can move to a higher development stage. (Wei and Liu, 2006) This opinion is echoed by Tsen (2006), who stated increase in exports could earn more foreign exchange, which makes it easier to import inputs to meet domestic production and output expansion. Economic reforms in China since 1978 have been moving toward market economy and more open economy, which promote more trade and encourage more FDI. In turn, FDI contributes significantly to economic growth. FDI allows import of technology and high-quality capital goods for use in domestic production, which increases productivity and efficiency. Import of consumer goods also acts as an important competitive force to stimulate the quality improvement of domestically manufactured goods in China. FDI not only provides knowledge spillovers, but also competitions. Moreover, export growth contributes to the increase in productivity through multiple ways besides high quality FDIs: specialization in the production of export products, reallocation of resources from the relatively inefficient non-trade sector to the higher productive export sector, improvement in technology and managerial skills, and education and training. Thus export is a more efficient way to meet development needs than foreign debt since the latter is subject to adverse shocks of currency that may lead to debt default. At the same time, promotion of export may also eliminate controls that result in an overvaluation of the domestic currency. Thus a higher degree of openness to international trade is associated with a higher level of economic growth in China. (Tsen, 2006; Mahadevan, 2009).

With over 50 billion U.S. dollars of FDI per year and more than 40% saving rate (Bosworth and Collins, 2007), Chinese exporters have developed not only low cost advantages, but also branding advantages (Zou, Fang, and Zhao, 2003). The technological knowledge spill overs also enhance the productivity and competence of Chinese producers (Wei and Liu, 2006). So far, China has made much greater progress in raising the educational skills of younger workers. According to the OECD (2005), illiteracy has essentially been eliminated among new entrants to the workforce (Bosworth and Collins, 2007). Thus the growth on supply side of the Chinese economy is warranted.

However, the story on the demand side is not that optimistic for China. As the export-led growth strategy seemed to have failed in the face of the economic crisis of Mexico in 1994, Asia in 1997, Russia in 1998, and Brazil in 1999, Asian countries have been attempting to switch from export-led growth to a more domestic demand-led growth (Tsen, 2006). Currently, the Chinese economy is highly vulnerable to export shocks and Chinese investment went ahead of consumption and the demand gap was filled by rapidly growing export (Akyuz, 2010). However, the recent stimulus package has pushed the investment rate further, to 50 percent of GDP, and aggravated the problem of excess capacity that had pervaded several sectors and increased the dependence of growth on export. Bosworth and Collins (2007) expressed the same idea as Akyuz's. Also, Akyuz (2010) pointed out China is likely to meet strong resistance in the future if it doesn't make any change as the U.S. is trying to expand its export. Tsen (2006) showed the share of domestic demand in GDP had decreased marginally over the period from 1978 to 2002 in China. The household consumption to GDP ratio in China was 49.0 percent per annum during the 1978-1979 period and increased to 51.8 percent per annum in the 1980-1989 period, but decreased to 46.7 percent in the 1990-1999 period and in 2002, the ratio was 43.4 percent. Nonetheless, household consumption tended to move in a closer direction with economic growth than the movements of export and government consumption with economic growth. In order to overcome this burden, China should focus on increasing its domestic demand and the share of household income in GDP (Akyuz, 2010). Akyuz provided some possible solutions to the current dilemma that China is facing. The solutions include lowering the foreign content of export so as to enhance their contribution to growth, raising domestic consumption much faster than has been the case so far, and increasing the share of household income in GDP and a corresponding decline in corporate profits, savings and investment. A more balanced economic growth path is needed as both export and domestic demand are important for sustainable growth (Bosworth and Collins, 2007; Tsen, 2006). Government guidance of investment should play an important role while restructuring the Chinese economy (Akyuz, 2010). Hausmann, Prichett and Rodrick (2005) echoed this finding by concluding that Chinese government still possesses strong power that facilitates its economic growth.

Growth, Exports, and Environment

Whether exports and economic growth cause environmental degradation has been under debate for years. Shafik (1994) argued that the relationship between income level and environmental quality is complex because it operates through a number of different channels. Income levels are often associated with increases in certain polluting activities. For example, large service sectors may generate less pollution than the development of heavy industry. Some environmental issues like access to clean water and sanitation may be resolved with income growth, but problems like solid wastes and carbon emissions worsen steadily with economic development. He also concluded that most countries choose to adopt policies and to make investments that reduce environmental damage associated with growth, but actions tends to be taken only where there are substantial private and social benefits. Where the costs of environmental degradation are borne by other countries, there are few incentives to change damaging behavior. What is more, Asici (2011) claimed that the human demand has led to an environmental degradation that surpasses the Earth's ecological capacity to regenerate already in the mid-1970s. And this "overshooting" is still growing as his model suggested there is a positive relationship between income per capita growth and per capita pressure on nature. The effect is stronger in middle-income countries than in low and high-income countries. Increasing prosperity leads to more consumption and thus, more pressure on nature especially in the form of damage caused by carbon emissions and mineral depletion. At the same time, increasing trade has negative impacts on environment as well.

However, by examining sulfur dioxide emissions data in 44 countries over the years 1971 to 1996, Antweiler, Copeland, and Taylor (1998) argued that free trade is good for the environment, which contradicts conclusions drawn by Asici (2011). They stated that increases in a country's exposure to international markets create small but measurable changes in pollution by altering the pollution intensity of national output through effects from expansion of economic scales and improvement in technology. Moreover, international trade raises the value of national output and income and such increases will impact on pollution concentrations as well. The empirical result indicated that if openness to international markets raises both output and income by one percent, pollution concentrations fall by approximately one percent. Similar results were found by Dean (2002). He examined provincial level data in China from 1987 to 1995 and concluded that improvements in the relative price of exports to imports do appear to cause increased emissions growth. Empirical results also indicate the growth of income leads to a reduction in emissions growth. Thus effect of income growth appears beneficial to the environment. Finally, emissions per unit of output would have grown more rapidly in all provinces between 1992 and 1995 had the reform of the exchange regime not taken place. Hence, it appears that the beneficial effects of trade liberalization may have outweighed the detrimental effects.

There are also other studies about environment in China with very different conclusions. The study conducted by Cole, Elliott, and Zhang used data in 2004 from 40 major Chinese cities and found out several facts. First, industrial output has a positive relationship with pollutants. Second, the share of industrial output in GDP is found to be a significant determinant of pollutants. Third, the growth rate of emissions of pollutants is declining with the rise of per capita income, suggesting that the efforts of Chinese policy makers to tackle pollution have had some impact. In general, development will result in more industrial emissions and domestic firms have the strongest detrimental effect on industrial emissions. However, the study did not provide information on whether those domestic firms were mainly facing international market or domestic market. In another study, Peng, Xu, Wang, and Zhang (2011) concluded that China is a net exporter of greenhouse gas (GHG), with a remarkable share of direct emission induced by international trade. The amount of GHG emissions in China's export is equal to 39.7 percent of the total direct domestic emission. Such effects are caused by the demands of coal and coal-electricity due to the fact that coal is still one of the major energy providers in China. Thus international trade is indeed detrimental to environment, especially air quality in China. Allenby, Chen, and Xu (2009) provided more details about negative impacts from exporting sectors in China. Using the bilateral trade data between China and the U.S. from 2002 to 2007, they suggested those consumable products exported to the U.S. are significant in generating hazardous environmental impacts in China. Given the current role of China as the "world factory", such negative environmental impacts will be significant if export trades with other countries were taken into account. They also suggested one possible solution may be China voluntarily setting quotas for export in order to reduce domestic energy consumption and environmental pollution. Thus we have reasons to believe that exports and economic growth affect environment in different ways since very different conclusions were provided by different researches. Since most people regard the economic growth in China is mainly export-driven, both exports and income growth are key factors that contribute to the change of environment in China.

CHAPTER III

DATA

The analysis draws on the data published by National Statistics Bureau of China (NSB) from 2002 to 2011. The data provide information on illiteracy rate among citizens who are at least 15 years old, natural population growth rate, household consumption index, export per capita annual growth rate, proportion of FDI in total investment in China, annual government spending growth rate, air quality, and regional gross domestic production (GDP) of 31 provinces in China, where Hong Kong, Macao, and Taiwan are excluded since they have different government systems and have gone through different development paths.

Among all descriptive statistics, both household consumption index and regional gross domestic production fix previous year's level at 100. Illiteracy rate among citizens who are at least 15 years old, natural population growth rate, export per capita annual growth rate, and air quality use percentage. The illiteracy rate is used in order to compensate for not measuring the benefits brought by technology spillovers, which is hard to quantify. The proportion of FDI in the total investment and annual government spending growth rate are also measured in percentage. The air quality is measured as percentage of days in a year which the air quality index (AQI) is below 100. Since the Chinese government does not use carbon dioxide emissions as an indicator of the air quality, and both sulfur dioxide and nitrogen oxides emissions are only measured in certain industries, it is not very convincing to use these data as indicators of the overall air quality. Hou, An, Wang, Tao, and Sun (2012) used particulate matter or particle pollution (PM_{10}) index to calculate the economic loss since PM_{10} level was the major factor used when calculating AQI in China (Ministry of Environmental Protection of China) and PM_{10} is extremely detrimental to human health (Dockery, Pope, Xu, Spengler, Ware and Fay, 1993). Thus the percentage of days that the AQI is below 100 is the standard[1] indicator of the air quality and thus is valid enough for the years 2003 through 2011 before the $PM_{2.5}$ was introduced into AQI calculations in China.

The air quality index in the year 2002 is missing because it was not reported by the NSB, so that the whole panel data set consists of 279 observations instead of 310.

There is also a trend variable added to the whole data set just in case there may be other omitted variables that also have significant impact onto the air quality.

[1] See the EPA brochure at http://www.epa.gov/airnow/aqi_brochure_08-09.pdf

CHAPTER IV

THEORY

The purpose of this study is to examine the relationship between air quality and economic factors including export growth, the GDP growth, the FDI, government spending growth, and education level, and to unveil how each of these factors affect the air quality in China.

The dependent variable is the air quality variable *env* and the independent variables are *hc*, which is the household consumption index; *illpop* is the illiteracy rate among citizens who are at least 15 years old; *gdp* is the regional gross domestic production; *pop* is the natural population growth rate; *M* is the proportion of the FDI in the total investment; *grate* is the annual government spending growth rate; *exrate* is the export per capita annual growth rate; *gdp2* is the square of variable *gdp*, it was added just in case there might be nonlinear relationships. Thus the general model looks like:

$$env = \alpha + \beta_1 hc + \beta_2 illpop + \beta_3 gdp + \beta_4 pop + \beta_5 M + \beta_6 grate + \beta_7 trend + \beta_8 exrate + \beta_9 gdp2 + \mu. \tag{4.1}$$

The α in the model is the constant term and μ represents the error term.

Since more consumption typically generates more emissions, the variable *hc* should be negatively related with the dependent variable. Similarly *grate* should have the same sign as *hc* as government spending is also a kind of consumption. Due to much of the China's development and export are made up of manufacturing and industrial products, which are products in typical polluting sectors (Allenby, Chen, and Xu, 2009), *gdp*, *gdp2*, and *exrate* should all have negative relationship with *env* as these sectors are heavily polluting (Wu, 2007). Normally population growth negatively contributes to the environment and thus a negative sign is expected in front of *pop*. Illiteracy rate should negatively affect air quality as the illiterate are often more interested in issues related to their daily survival than environmental management; this lack of interest and awareness often lead to more reckless environmental behavior which in turn breeds more environmental problems. The sign in front of *M*, which is the FDI percentage in the total investment, is hard to predict. Whether these investments go to manufacturing and industrial sectors, which are the typical polluting sectors, or high-tech and environmentally friendly sectors remains uncertain.

Besides the general model, each region should have different regional models as China has a lot of variety within it. We certainly cannot view Shanghai and Xizang (or Tibet) as the same since the former province is very developed with lots of interactions with the world while the latter one has remained relatively closed. Thus regional models are necessary. Also the variables that are statistically important in the general model do not imply that they are also statistically important in the regional model and vice versa.

The NSB of China breaks 31 provinces into six geological categories according to their locations. Since each category has certain conditions in common, I am going to follow this categorization when reporting results from regional models. Also since there are only limited numbers of observations for each regional model, the results might not be strongly persuasive. Each of the regional models looks the same as the general model:

$$envi = \varphi_i + \theta_{1,i}illpop + \theta_{2,i}gdp + \theta_{3,i}M + \theta_{4,i}trend + \theta_{5,i}exrate + \varepsilon_i. \qquad (4.2)$$

Each small *i* indicates a different province. However, I drop some variables in some regional models in order to relieve autocorrelation problems. Besides, if the variable *trend* turns out to be significant in certain regional models, it suggests there are other omitted variables that affect environment and further study about this specific province is needed.

CHAPTER V

RESULTS

General Model

The result of the general model is presented in the table below:

TABLE 5.1

GENERAL MODEL RESULT

R-sq: within = 0.371		
between = 0.123	F(9,239) = 15.670	
overall = 0.193	Prob > F = 0.000	
corr(u_i, Xb) = 0.0569		
AQI Percentage	Coefficients	Sandart Error
Household Consumption	- 0.035	0.077
Illiteracy Rate	0.238	0.163
GDP Growth Rate	- 1.744*	1.014
Population Growth Rate	0.316	0.518
FDI Percentage in Total Investment	0.069	0.042
Government Spending Growth Rate	- 0.012	0.044
Trend	1.634***	0.225
Export Growth Rate	- 0.004	0.012
GDP Growth Rate Squared	0.048	0.037
Constant	87.342***	10.629
F test that all u_i=0:	F(30, 239)= 28.940	Prob > F = 0.000

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

From the fixed effects regression analysis, it is not hard to tell that household consumption *hc*, population growth rate *pop*, government spending growth rate *grate*, export per capita growth rate *exrate*, and GDP growth rate squared *gdp2* are obviously not statistically important. Illiteracy rate and FDI percentage in total investment are not very important statistically in explaining the air quality as indicated by the relatively high p-value from the table. Moreover, since the p-value for both *illpop* and *M* are not that far away from 0.1, I still kept them in the following models as dropping some independent variables may increase the statistical significance of the rest. Besides, since I have been particularly interested in how export growth affects the air quality, even though *exrate* has a relatively low statistical significance, I still take it into consideration.

By dropping the independent variables that were not statistically important and re-running the fixed effect regression, I got:

TABLE 5.2

FIXED GENERAL MODEL RESULT

R-sq: within = 0.364		
between = 0.104	F(5,243) = 27.790	
overall = 0.178	Prob > F = 0.000	
corr(u_i, Xb) = 0.0496		
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	0.262*	0.158
GDP Growth Rate	- 0.535***	0.196
FDI Percentage in Total Investment	0.076*	0.039
Trend	1.623***	0.193
Export Growth Rate	- 0.005	0.012
Constant	77.10716***	3.695
F test that all u_i=0:	F(30, 243)=31.970	Prob > F = 0.000

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

Thus the actual general model looks like:

$$env = \alpha' + \beta_a illpop + \beta_b gdp + \beta_c M + \beta_d trend + \beta_e exrate + \mu'. \quad (5.1)$$

From the model result it is not very hard to see that the export growth rate is still statistically insignificant in explaining the air quality. The illiteracy rate has relatively weak explaining power since the p-value is really close to 10%. The rest independent variables behave quite well.

Regional Models

Since there are 31 regional model results, it is lengthy to list them all out in this part so I put the results of these models in the Appendix I.

The first category according to the NSB is north part of China, which consists of Beijing, Tianjin, Hebei, Shanxi, and Nei Menggu. Beijing is the capital city of China; it is one of the major exporting provinces as well as the political center. Thus it is not surprising to see the export growth rate is negatively affecting the air quality. The GDP growth rate also has a negative sign in front of it, which indicates the economic growth in the capital is not environmentally friendly. Tianjin is one of the major ports in China and has been quite influenced by foreign countries. Here illiteracy rate, the FDI percentage in total investment, and trend are all contributing to a better environment, which means though people with higher education have actually been causing pollution, yet the effects from FDI and other omitted factors have been leading Tianjin moving to a better way of development. Also since Tianjin is right beside the sea, this province may suffer less air pollution than inland provinces due to the sea wind. Hebei has large amount of labor force participating in exporting sectors and is known for its heavy industries[2]. Thus it is not surprising to see export growth is negatively affecting its air quality. However, again, the FDI is helping build a better

[2] See the webpage http://baike.baidu.com/view/4675.htm?subLemmaId=9875791&fromId= 4112 for further information.

living condition along with those well-educated people and other omitted factors in Hebei. Shanxi is the major coal mining province which provides coals to most provinces in China. Its importance has been dropping as policy makers in China have been trying to reform energy structure[3]. This province was quite polluted, and has been getting better these years with the help from the FDI and other factors including higher efficiency. Nei Menggu is a province which has little population, almost no industry, and has been heavily relying on natural resources[4]. Not surprisingly, none of the independent variables is statistically important.

The Northeast part of China consists of Heilongjiang, Jilin, and Liaoning. Heilongjiang is one of the agricultural and heavy industry centers in China and has abundant mineral resources. The regional model for Heilongjiang shows both GDP growth and export growth cause air pollution. The educated individuals, the FDI, and other omitted variables are improving the air quality. Jilin is a relatively small economy and thus none of the explanatory variables has statistical importance. Liaoning is one of the biggest heavy industrial product exporters in China and it is predictable to see the FDI here is negatively affecting the air quality. Also, literate population seems to pollute in Liaoning maybe because those people are not quite aware of the air quality due to the fact that they are used to living in areas polluted by heavy industry and do not receive much education in protecting environment.

The eastern part of China consists of Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong. This region is generally highly developed and very diverse. Shanghai, needless to say is the business center in China with great amount of openness. The regional model for Shanghai turns out to be quite consistent with

[3] See http://www.jx.chinanews.com/html/2013/0124/180323.html claiming that China will go through the process of changing energy structure by using more clean and sustainable resources to provide needed energy for development.

[4] More information about Nei Menggu is at http://en.wikipedia.org/wiki/Inner_Mongolia#Econo_my.

intuition: the GDP growth rate seems to have neutral effects on environment while highly educated population and the FDI are both helping improve the air quality. However, the export sectors in Shanghai are somewhat polluting. The variable trend turns out to be statistically insignificant and thus this regional model does not have much trouble caused by omitted variables.

Jiangsu is another major contributor to China's development and has lots of high-tech industries and large exporters. There are also lots of big international ports in this province. Interestingly, all of the independent variables in Jiangsu turn out to have no relationship with air quality which is confusing and does not fit my intuition. However, the R square in this regional model yields good result. Thus further studies about this developed province are needed. Zhejiang province is known for small businesses and exporting manufacturing goods. The regional model for Zhejiang again turns out to be interesting since only trend is statistically significant and export has nothing to do with the pollution. Anhui is a very mountainous province with little industry and relatively poor traffic conditions. This province is usually viewed as a tourist attraction by people in the eastern part of China. Thus the regional model for Anhui has no contribution to the general model at all and the dependent variable cannot be explained by any of the independent ones. Fujian is one of the major ports in China that specializes in exporting light industrial products. Export growth is positively affecting the environment, which is unique among all regional models. People of education generate more pollutants than illiterates in Fujian as indicated by the positive sign in front of illiteracy rate. The variable trend is significant, which indicates there are omitted variables. Jiangxi is one of the major rice producers in China and has a little heavy industry. Its export growth generates air pollution while the GDP growth and the FDI are environmentally friendly. People of education again are causing more pollution than illiterates. Shandong is one of the newly emerged developing industry centers and is located right beside East China Sea. It should have quite an amount of connection to foreign nations and a relatively big economy size. However the model indicates none of the dependent variables is statistically significant.

The central and south parts of China have less GDP contribution compared to those areas mentioned above. This part consists of Henan, Hubei, Hunan, Guangdong, Guangxi, and Hainan. Henan is a province with lots of historical sites. The development of Henan relies on agricultural products and tourism. Also Henan has a lot of immigrant workers, which further hampers the development local economy due to brain drainage. The regional model for Henan implies there is omitted variable issue and nothing else can explain the air quality conditions. Both models for Hunan and Hubei province turn out to be failures: autocorrelation issues are not very significant and trend in both models are statistically insignificant, yet all coefficients are jointly insignificant and the R-square value is fairly high. Thus the air pollution issues in these two provinces are caused by some mysterious factors and more detailed studies and more data are needed. Guangdong is a very important province with many important ports in China, and is highly developed with lots of FDI inflow as well. However, the model for Guangdong shows almost no explanatory power, and yields poor results. Since the autocorrelation is not a very important issue here, the air quality change in Guangdong should be caused by other variables behind the scene. The insignificance of regional model for Guangxi province in fact fits my intuition as this province is usually viewed as a reserved resident area for lots of minorities by Chinese people. Thus environment and culture protection are the major themes here, but not development. I am not surprised that this regional model has no explanatory power. The independent variables in the regional model for Hainan province again shows little statistical significance as this province is an island located in South China Sea. Hainan has wind blowing from the sea almost every day dissolving the pollutants in the air and thus the AQI here never goes above 100. According to this fact, there is no surprise to see nothing in the model can explain the dependent variable. Generally, the results for the central and south part of China are quite disappointing, but somehow fit my intuition as these provinces are quite special in either economic or geological conditions.

Southwest China is even less developed compared to the central and south parts of China and thus regional models are expected to have relatively low explanatory power due to the small scale of economy sizes. Chongqing, Sichuan, Guizhou, Yunnan, and Xizang (or Tibet) belong to this area. Chongqing is famous for its good food but not economy, and thus only trend is statistically significant and contributes positively to the air quality. Sichuan has the largest economy scale in this area but the variable GDP growth rate is dropped in order to fix autocorrelation issues. Sichuan does not have many industries that face outwards and most of its products are sold in domestic markets[5]. The illiteracy rate in Sichuan has some power in explaining the air quality and it turns out to have negative impacts. Guizhou and Yunnan are provinces that have been relying on tourism for decades. Guizhou has quite famous wine producer named *Maotai*, which has been regarded as the "national wine of China", however, most part of this area remains quite rural and natural. The regional model for Guizhou shows the only major factor is the FDI and it has a positive relationship with the air quality. Yunnan is even more rural comparing with Guizhou and only trend and illiteracy rate are related with the air quality. Educated people in

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[5] For more information about Sichuan, see the webpage at Wikipedia page: http://zh.wikipedia.org/wiki/%E5%9B%9B%E5%B7%9D%E7%9C%81#.E7.BB.8F.E6.B5.8E.

Yunnan have been making the air quality worse. Xizang is expected to have no significant independent variables since it is closed and remains undeveloped. However, the GDP growth rate in Xizang seems to positively affect the air quality but the FDI inflow has a negative relationship with the dependent variable. This fact possibly means the Chinese government is aware of protecting the environment in Xizang while helping this province develop.

The northwestern part of China consists of Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang, and is usually viewed as the least developed area. The only useful regional models in this area are Qinghai, Xinjiang, and Ningxia. Qinghai province is one of the major salt producers and mineral providers in China. This province has large amount of unpopulated areas and similar to Xizang, has almost no industry. In Qinghai's model, illiteracy rate have positive relationship with air quality and surprisingly, GDP growth rate is also contributing towards the environment[6]. The FDI investment rate in the model for Xinjiang turns out to be significant and is negatively affecting environment, which is very rare among all 31 regional models since in most regional models, the signs in front of the variable M are always positive. The FDI is an important factor in Xinjiang's development since it was advocated by the State Administration for Industry and Commerce of the People's Republic of China[7]. Because Xinjiang is one of the major producers of oil and natural gas, the FDI may be utilized for mining and thus causes air pollution. The FDI percentage in total investments in Ningxia province turns out to be contributing to a better air quality, which is surprising because in most Chinese people's impression, this province has almost nothing but deserts and the FDI should not be interested in flowing into this

[6] It is surprising because mining is usually viewed as a polluting industry. But in Qinghai, mining seems do not have significant negative impacts onto the air quality.

[7] Read more at http://politics.people.com.cn/GB/1027/11980083.html about Foreign Direct Investment policies in Xinjiang

province. The models for the rest of this area, Shaanxi and Gansu are not quite significant because these two provinces have been suffering from desertification since the last century. Residents of Shaanxi and Gansu have been consistently moving out of these two provinces either because they intend to do so or they were forced by the government regulations. The trend in Shaanxi shows some other factors are improving living conditions in this province.

CHAPTER VI

DISCUSSION AND IMPLICATIONS

The general model fits my predictions above quite well. The GDP growth rate has negative impact on the air quality since China's development has not been quite environmentally friendly. Exports in China also have negative effects on the air quality though these effects might not be very significant overall as indicated in the model. Yet the story between export and environment may be different in those major exporting provinces as I will show in the regional models in the next part. FDI percentage in the total investment turns out to be positively affecting the air quality, which implies that those investments from other nations are quite aware of the environment in China and has been helping China head toward a cleaner way of development. The most surprising outcome is that the variable illiteracy rate is positively related with the dependent variable which means the higher illiteracy rate is, the better the environment is. This might be explained by illiterate population in China is indeed aware of their living conditions and do not recklessly pollute. Also part of this myth may be explained by the fact that illiterate people normally reside in rural or suburbs, which are relatively clean compared to big cities where well-educated individuals live.

Due to no contributions to the general model at all, I dropped 11 regional models; they are the models for Nei Menggu, Jilin, Jiangsu, Anhui, Shandong, Hubei, Hunan, Guangdong, Guangxi, Hainan, and Gansu. The following discussion is based on the remaining 20 regional models.

Illiteracy Rate

Among all 20 regional models, the variable illiteracy rate turned out to have statistical significance in 10 of them. In Hebei, Heilongjiang, Shanghai, and Sichuan, illiteracy rate has negative impacts onto the environment while in Tianjin, Liaoning, Fujian, Jiangxi, Guizhou, Yunnan, and Qinghai, the higher illiteracy rate is, the better the environment is, which does not fit most people's intuition. In the general model, illiteracy rate also turns out to positively affect the air quality, and thus these results implicate that overall, the educated consumers in China are not quite aware of the pollution around them and the illiterate population do not recklessly pollute. Policy makers should be aware of these facts and advocate protecting the environment, and incorporate environmental protection into the education system in order to make Chinese people become aware of the impacts of their behavior onto the environment.

GDP Growth Rate

There are 5 provinces which show statistical significance of GDP growth rate on air quality. Among them, Beijing showed a negative relationship while Heilongjiang, Jiangxi, Qinghai, and Xizang showed positive relationship. Beijing is a much larger economic body than Heilongjiang, Jiangxi, Qinghai, and Xizang, and thus it is not surprising to see in the general model, GDP growth turned out to be polluting. Beijing is already at a very high development stage while both Heilongjiang and Jiangxi are reforming their economic structure. Qinghai and Xizang are less developed. So it may be implying that economic growth at different stages affect the environment differently in China. These results provide directions for future studies: breaking down economic growth to different development stages and examining the impacts of each stage onto the environment. There may be some interesting stories if such studies were conducted. As for now, those developed provinces in China should pay more attention to environment protection since they may have higher chances of facing environmental issues from exporting sectors.

FDI Percentage in Total Investment

Eleven out of 20 regional models show statistical significance of the variable FDI percentage in the total investment. In Tianjin, Hebei, Shanxi, Heilongjiang, Liaoning, Shanghai,Jiangxi, Guizhou, Ningxia, Xinjiang, and Xizang. In the models for Tianjin, Hebei, Shanxi, Heilongjiang, Liaoning, Shanghai, Jiangxi, Guizhou, and Ningxia, the FDI percentage in total investment has a positive relationship with air quality. Most of these provinces are in the 1^{st} tier (first ten) or 2^{nd} tier (second ten) of the export per capita ranking, and thus are more open than those provinces whose FDI percentage is negatively impacting the environment. In general, FDI's are more willing to go to sectors that do not cause serious environmental issues and are contributing towards building better environment. Thus attracting more FDI is a way to relieve pressure from pollution. Especially leading the FDI to go to sectors such as clean and sustainable energy is extremely helpful since the technology spillovers brought by the FDI will likely increase the efficiency of these sectors.

Export Growth Rate

Among all regional models, six out of 20 showed significant relationships between export growth rate and air quality and in the general model export growth rate turned out to be an insignificant factor. However we cannot ignore the fact that most major exporting provinces including Beijing, Shanghai, Heilongjiang, Jiangxi, and Hebei showed export growth is negatively affecting the air quality. Interestingly, one of the major exporters, Fujian, showed a positive relationship between export growth and air quality. Generally speaking, those exporting provinces, especially the major ones such as Beijing and Shanghai should pay more attention to their exporting sectors. They may want to look at the export sectors in Fujian province and learn from its growth patterns in order to reduce the damages caused by pollution. Overall, export growth is not the major factor that causes air pollution in China.

Conclusion

We have to admit that the development path adopted by China has been a huge success in terms of economy, yet environmentally it is not as good as it looks. The negative sign in front of GDP growth rate warns policy makers that seeking a more efficient and environmentally friendly way of development is necessary. Also the statistical significance of the variables trend in both general model and regional models suggest further studies on the problem of pollution in China is needed. One possible way is to break down the GDP components and examine them individually at the regional level, and then to study the relationship between the environment and each component of GDP growth. The other direction is, as I mentioned above, to examine the impacts of different development stages on the environment in each of the 31 provinces. Both ways may have some interesting stories. Besides, gaining more data for each province will also help unveil the true story of pollution in China.

Through examining data from the regional level, the models show that the negative relationship between export growth and air quality may not be statistically significant. However, policy makers still cannot just sit back and conclude that export have no negative impacts on the environment in China. The export growth rates in important exporting provinces including Beijing, Hebei, Heilongjiang, Jiangxi, and Shanghai turned out to have negative signs in front of them. Generally, more evidence is to be found at regional level in further studies in order to come up with more convincing and persuasive results. Moreover, evidence from FDI percentage in total investment seems to suggest that openness is good not only from economists' aspects, but also from environmentalists'.

Thus overall, becoming more open and involved in globalization is beneficial both economically and environmentally overall since the models suggested export growth does not seriously harm the environment while the FDI significantly helps build a cleaner China.

APPENDIX A

RESULTS FOR REGIONAL MODELS

TABLE A1

REGIONAL MODELS FOR THE NORTH PART OF CHINA

Beijing		
Number of obs	9	
Prob > F	0.004	
R-squared	0.989	
Adj R-squared	0.969	
AQI Percentage	Coefficents	Standard Error
Illiteracy Rate	- 2.522	1.770
GDP Growth Rate	- 1.093*	0.438
FDI Percentage in Total Investment	0.246	0.124
Trend	0.275	0.973
Export Growth Rate	- 0.131*	0.042
Constant	75.679***	9.360
Tianjin		
Number of obs	9	
Prob > F	0.007	
R-squared	0.984	
Adj R-squared	0.957	
AQI Percentage	Coefficents	Standard Error
Illiteracy Rate	6.730**	1.870
GDP Growth Rate	1.130	0.637
FDI Percentage in Total Investment	5.434**	1.012
Trend	0.490***	0.062
Export Growth Rate	0.037	0.022
Constant	-26.621	22.060
Hebei		
Number of obs	9	
Prob > F	0.0001	
R-squared	0.9957	
Adj R-squared	0.9914	
AQI Percentage	Coefficents	Standard Error
Illiteracy Rate	- 3.660***	0.667

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A1 – Continued

FDI Percentage in Total Investment	1.612***	0.110
Trend	3.909***	0.348
Export Growth Rate	- 0.112***	0.017
Constant	41.051***	5.331
Shanxi		
Number of obs	8	
Prob > F	0.000	
R-squared	0.998	
Adj R-squared	0.995	
AQI Percentage	Coefficents	Standard Error
Illiteracy Rate	2.771	2.071
GDP Growth Rate	- 0.417	0.241
FDI Percentage in Total Investment	0.533***	0.077
Trend	5.247**	1.055
Constant	21.270	17.353
Neimenggu		
Number of obs	9	
Prob > F	0.028	
R-squared	0.958	
Adj R-squared	0.887	
AQI Percentage	Coefficents	Standard Error
Illiteracy Rate	- 0.444	1.477
GDP Growth Rate	0.100	0.613
FDI Percentage in Total Investment	0.089	0.210
Trend	1.683	1.542
Export Growth Rate	- 0.030	0.042
Constant	80.144**	20.175

Soucrce: NSB Yearbook 2002 to 2011

Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A2

REGIONAL MODELS FOR NORTHEAST CHINA

Heilongjiang		
Number of obs	8	
Prob > F	0.000	
R-squared	0.999	
Adj R-squared	0.999	
AQI Percnetage	Coefficents	Standard Error
Illiteracy Rate	- 0.431**	0.068
GDP Growth Rate	0.486*	0.161
FDI Percentage in Total Investment	0.269***	0.016
Trend	1.158***	0.038
Export Growth Rate	- 0.013***	0.001
Constant	66.388***	1.589
Jilin		
Number of obs	9	
Prob > F	0.796	
R-squared	0.428	
Adj R-squared	0.523	
AQI Percnetage	Coefficents	Standard Error
Illiteracy Rate	- 0.351	0.334
GDP Growth Rate	- 0.016	0.195
FDI Percentage in Total Investment	0.011	0.018
Trend	- 0.056	0.184
Export Growth Rate	- 0.003	0.009
Constant	95.259***	1.802
Liaoning		
Number of obs	9	
Prob > F	0.050	
R-squared	0.937	
Adj R-squared	0.833	
AQI Percnetage	Coefficents	Standard Error
Illiteracy Rate	4.412*	1.870
GDP Growth Rate	1.527	0.700
FDI Percentage in Total Investment	- 0.848**	0.156
Trend	- 0.808	0.522
Export Growth Rate	0.025	0.037
Constant	101.348	10.528

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A3

REGIONAL MODELS FOR THE EAST PART OF CHINA

Shanghai		
Number of obs	9	
Prob > F	0.000	
R-squared	0.997	
Adj R-squared	0.993	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 1.501**	0.375
GDP Growth Rate	- 0.051	0.100
FDI Percentage in Total Investment	0.263***	0.031
Trend	- 0.062	0.239
Export Growth Rate	- 0.033**	0.008
Constant	75.609***	2.518
Jiangsu		
Number of obs	9	
Prob > F	0.121	
R-squared	0.883	
Adj R-squared	0.689	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	0.021	0.901
GDP Growth Rate	- 2.231	1.272
FDI Percentage in Total Investment	0.452	0.200
Trend	0.197	1.498
Export Growth Rate	- 0.034	0.045
Constant	82.861*	27.275
Anhui		
Number of obs	9	
Prob > F	0.877	
R-squared	0.344	
Adj R-squared	- 0.749	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.868	1.914
GDP Growth Rate	- 0.967	5.377
FDI Percentage in Total Investment	0.158	1.123
Trend	- 1.292	3.681
Export Growth Rate	- 0.077	0.188
Constant	115.7367*	45.179
Fujian		
Number of obs	9	
Prob > F	0.028	
R-squared	0.814	

Soucrce: NSB Yearbook 2002 to 2011

Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A3 – Continued

Adj R-squared	0.702	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	1.677**	0.481
Trend	3.275***	0.750
Export Growth Rate	0.141*	0.063
Constant	56.434***	9.790
Jiangxi		
Number of obs	8	
Prob > F	0.041	
R-squared	0.984	
Adj R-squared	0.942	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	1.145*	0.319
GDP Growth Rate	2.054*	0.599
FDI Percentage in Total Investment	0.409**	0.080
Trend	3.038**	0.425
Export Growth Rate	- 0.032*	0.008
Constant	26.245	13.358
Shandong		
Number of obs	8	
Prob > F	0.132	
R-squared	0.945	
Adj R-squared	0.808	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 1.670	4.229
GDP Growth Rate	4.194	3.414
FDI Percentage in Total Investment	2.997	3.080
Trend	12.045	12.736
Export Growth Rate	- 0.125	0.248
Constant	-143.588	229.459
Zhejiang		
Number of obs	9	
Prob > F	0.024	
R-squared	0.909	
Adj R-squared	0.817	
AQI Percentage	Coefficients	Standard Error
GDP Growth Rate	0.482	0.652
FDI Percentage in Total Investment	- 0.193	0.159
Trend	1.299**	0.392
Export Growth Rate	- 0.117	0.067
Constant	83.699***	8.844

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A4

REGIONAL MODELS FOR THE CENTRAL AND SOUTH PARTS OF CHINA

Henan		
Number of obs	9	
Prob > F	0.075	
R-squared	0.917	
Adj R-squared	0.779	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.182	1.378
GDP Growth Rate	0.708	1.435
FDI Percentage in Total Investment	0.586	0.468
Trend	2.852*	0.931
Export Growth Rate	- 0.061	0.040
Constant	49.150*	16.374
Hubei		
Number of obs	9	
Prob > F	0.327	
R-squared	0.754	
Adj R-squared	0.344	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	5.701	4.853
GDP Growth Rate	2.973	4.675
FDI Percentage in Total Investment	- 2.921	1.875
Trend	- 5.230	4.940
Export Growth Rate	0.165	0.169
Constant	116.532**	36.080
Hunan		
Number of obs	8	
Prob > F	0.105	
R-squared	0.957	
Adj R-squared	0.848	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	0.500	4.317
GDP Growth Rate	1.692	3.975
FDI Percentage in Total Investment	0.658	0.686
Trend	6.327	2.591
Export Growth Rate	- 0.056	0.107
Constant	- 0.353	79.346
Guangdong		
Number of obs	8	
Prob > F	0.041	
R-squared	0.983	

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A4 – Continued

Adj R-squared	0.941	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	0.447	2.561
GDP Growth Rate	- 0.34300683	1.156
FDI Percentage in Total Investment	0.235	0.151
Trend	2.375	2.080
Export Growth Rate	0.064	0.128
Constant	61.631	37.998
Guangxi		
Number of obs	9	
Prob > F	0.4566	
R-squared	0.6748	
Adj R-squared	0.1328	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	1.009	0.584
GDP Growth Rate	0.664	0.468
FDI Percentage in Total Investment	- 0.033	0.080
Trend	0.599	0.432
Export Growth Rate	- 0.052	0.041
Constant	80.588***	8.072
Hainan		
Number of obs	9	
Prob > F	0.360	
R-squared	0.734	
Adj R-squared	0.290	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.076	0.0336
GDP Growth Rate	- 0.024	0.0193
FDI Percentage in Total Investment	0.004	0.0025
Trend	- 0.046	0.020
Export Growth Rate	0.000	0.001
Constant	100.905***	0.366

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A5

REGIONAL MODELS FOR SOUTHWEST CHINA

Chongqing		
Number of obs	9	
Prob > F	0.015	
R-squared	0.973	
Adj R-squared	0.927	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 1.500	1.339
GDP Growth Rate	- 2.843	1.896
FDI Percentage in Total Investment	0.590	0.448
Trend	3.136**	0.745
Export Growth Rate	0.002	0.019
Constant	95.178**	26.613
Sichuan		
Number of obs	9	
Prob > F	0.099	
R-squared	0.685	
Adj R-squared	0.497	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.731*	0.349
FDI Percentage in Total Investment	0.016	0.131
Trend	- 0.096	0.394
Constant	93.332***	5.181
Guizhou		
Number of obs	9	
Prob > F	0.119	
R-squared	0.885	
Adj R-squared	0.694	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	0.260	0.130
GDP Growth Rate	- 0.179	0.239
FDI Percentage in Total Investment	0.246*	0.058
Trend	1.093*	0.270
Export Growth Rate	- 0.001	0.012
Constant	82.467***	3.606
Yunnan		
Number of obs	9	
Prob > F	0.162	
R-squared	0.856	
Adj R-squared	0.616	
AQI Percentage	Coefficients	Standard Error

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A5 – Continued

Illiteracy Rate	0.469*	0.187
GDP Growth Rate	- 0.482	0.273
FDI Percentage in Total Investment	0.128	0.127
Trend	1.558*	0.519
Export Growth Rate	0.028	0.018
Constant	84.651***	8.642
Xizang		
Number of obs	9	
Prob > F	0.017	
R-squared	0.741	
Adj R-squared	0.655	
AQI Percentage	Coefficients	Standard Error
GDP Growth Rate	0.593**	0.212
FDI Percentage in Total Investment	- 0.206**	0.068
Constant	93.443***	2.765

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A6

REGIONAL MODELS FOR NORTHWEST CHINA

Shaanxi		
Number of obs	9	
Prob > F	0.004	
R-squared	0.838	
Adj R-squared	0.784	
AQI Percentage	Coefficients	Standard Error
FDI Percentage in Total Investment	0.154	0.114
Trend	2.182***	0.454
Constant	62.349***	5.107
Gansu		
Number of obs	9	
Prob > F	0.658	
R-squared	0.393	
Adj R-squared	- 0.213	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.253	0.699
GDP Growth Rate	3.137	3.513
FDI Percentage in Total Investment	- 0.292	0.481
Export Growth Rate	- 0.095	0.065
Constant	39.554	42.314
Qinghai		
Number of obs	8	
Prob > F	0.0477	
R-squared	0.9806	
Adj R-squared	0.9323	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	1.730*	0.485
GDP Growth Rate	2.062**	0.354
FDI Percentage in Total Investment	- 0.117	0.066
Trend	3.593*	0.989
Export Growth Rate	0.012	0.015
Constant	4.906	15.516
Ningxia		
Number of obs	9	
Prob > F	0.007	
R-squared	0.810	
Adj R-squared	0.747	
AQI Percentage	Coefficients	Standard Error
FDI Percentage in Total Investment	0.118**	0.045
Trend	1.294***	0.258

Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

TABLE A6 – Continued

Constant	77.266***	2.317
Xinjiang		
Number of obs	9	
Prob > F	0.083	
R-squared	0.910	
Adj R-squared	0.762	
AQI Percentage	Coefficients	Standard Error
Illiteracy Rate	- 0.055	0.585
GDP Growth Rate	- 0.513	0.694
FDI Percentage in Total Investment	- 0.875**	0.181
Trend	0.559	0.467
Export Growth Rate	0.016	0.025
Constant	81.903	7.542

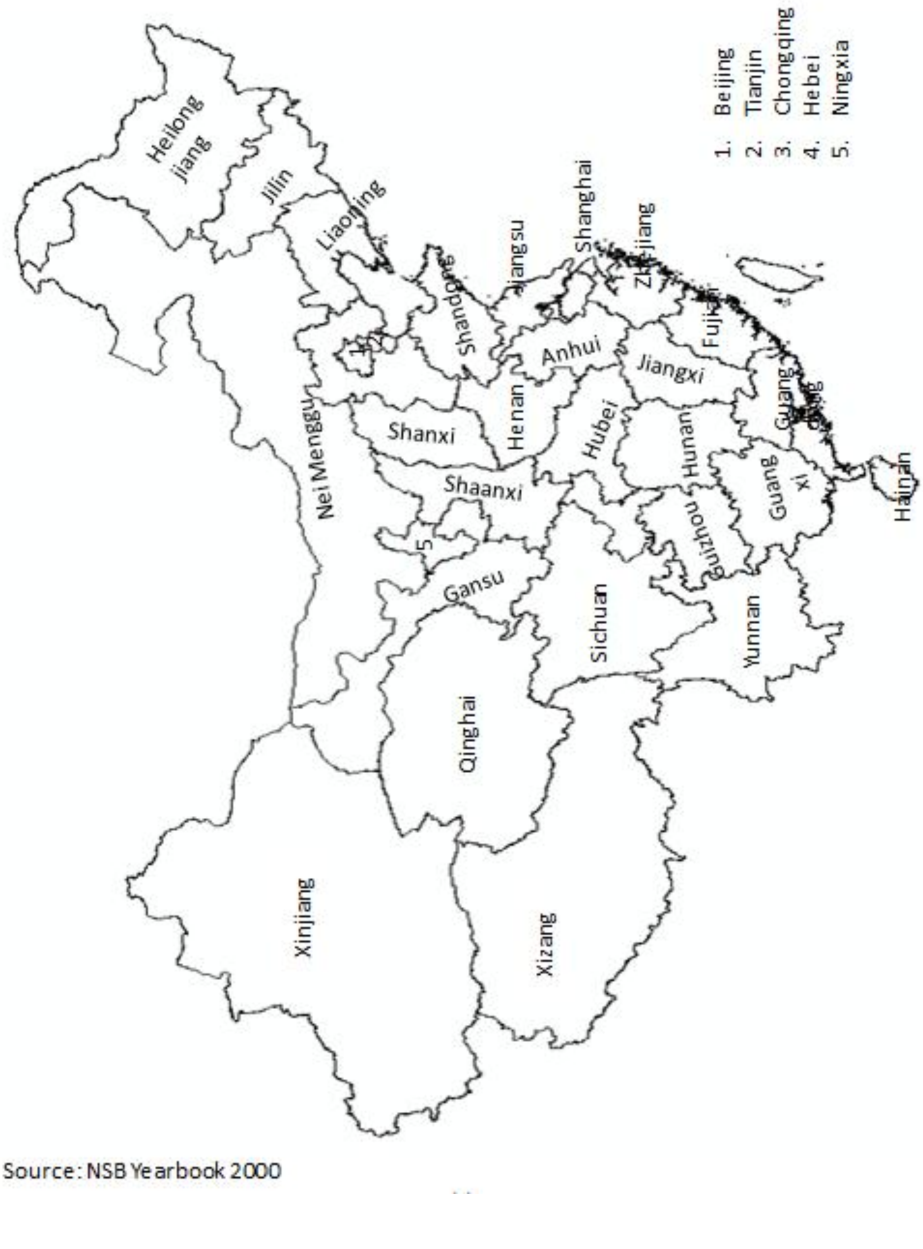
Soucrce: NSB Yearbook 2002 to 2011
Coefficients of the variables are given with standard errors in the right column. Asterisks show statistical significance. * = 10%, ** = 5%, *** = 1%.

APPENDIX B

MAPS AND FIGURES OF CHINA

FIGURE B1

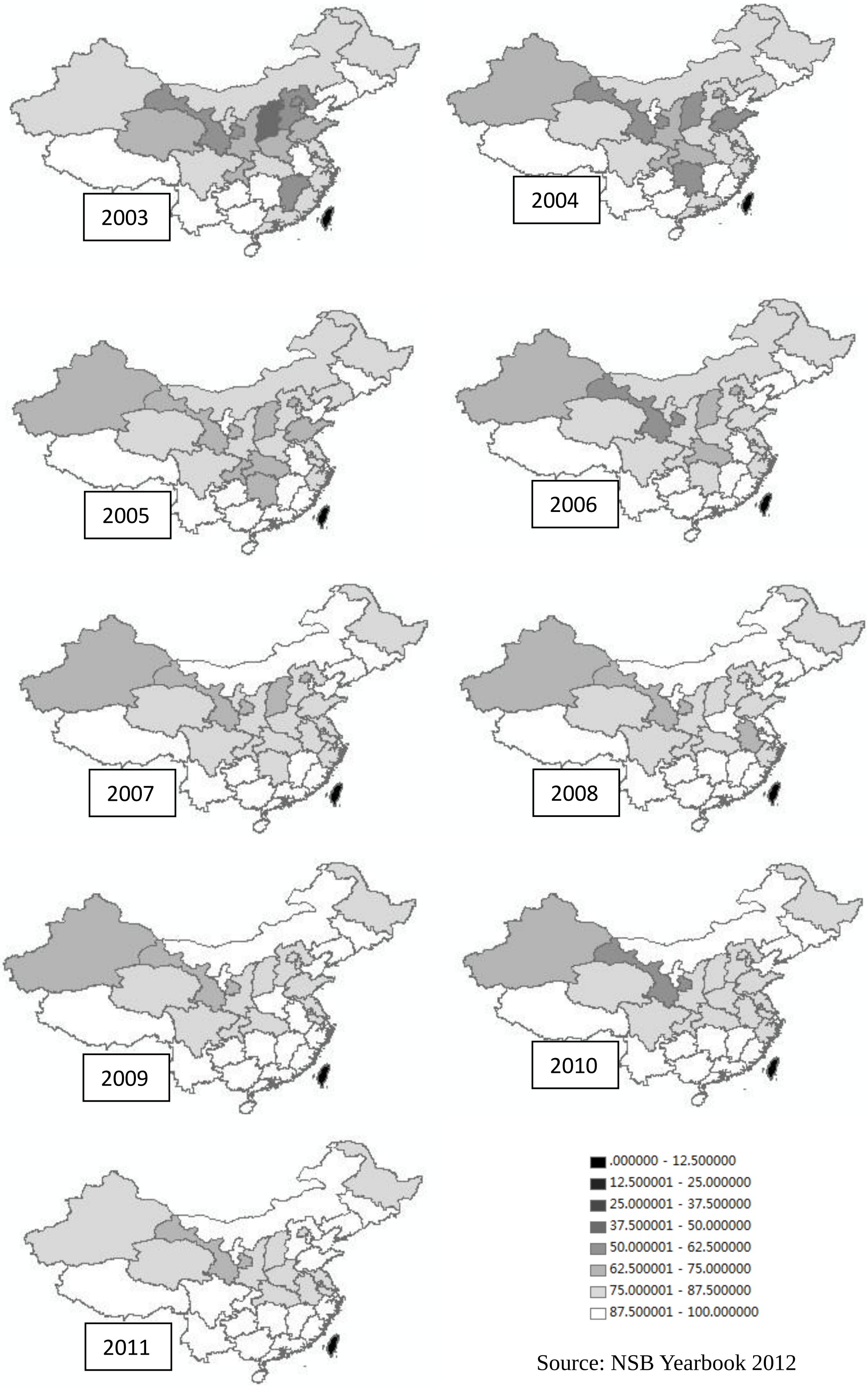
MAP OF CHINA



Source: NSB Yearbook 2000

FIGURE B2

PERCENTAGE OF DAYS THAT AQI IS LOWER THAN 100



Source: NSB Yearbook 2012

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