THREE ESSAYS ON ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY IN CHINA

by

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ABSTRACT

HUALIU YANG Three essays on economic growth and environmental quality in China
(Under the direction of DR. YANG CAO)

This dissertation employs an interdisciplinary perspective to examine the relationship between economic development and environmental quality in China. The first essay investigates how the distribution of gross domestic product (GDP) between the government and its citizens affected the environmental Kuznets curve (EKC) in China using province-level data from 2001 to 2010. The results show that economic development, as measured by GDP per capita, has a non-linear impact on the two industrial pollution emissions: SO2 and waste water. The results also support the hypothesis that the more GDP goes to the government would increase the emission level of industrial SO2. The second essay demonstrates that the government hierarchical administrative system affects the income-pollution relationship at the city level in China. Cities occupying higher level positions in this system have administrative and political resources advantages favored by this hierarchy and therefore are able to keep a comparatively less pollution intensive industry within their jurisdictions. The hierarchy allows higher-level cities to maintain better institutional environment under which industrial pollution emission is more constrained by both the local governments and the markets. The third essay investigates the relationship between environmental concern and economic growth with survey data (cross-sectional) from China. The results from multi-level analyses indicate that income has a weak relationship with individual environmental concern in China. Expansion of personal knowledge is the key to increasing Chinese people's environmental concern.

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INTRODUCTION

The market-oriented economic reform in China, begun in the late 1970s, has brought about a 10% annual GDP growth rate in the period from 1980-2012[1]. China is now the world's second largest economy. The rapid economic growth has pulled many residents of China out of poverty. Nonetheless, along with economic growth pollution problems also become severe in many areas in China. These pollution issues hurt Chinese people's welfare. For some Chinese people, their wellbeing may not be improved by economic growth because they receive small monetary benefits but bear the burden of pollution. Thus, the general question about economic growth, environmental quality, people's wellbeing, and the equality issue embedded in these issues motivate me to investigate this dissertation topic.

Air and water pollution issues have been especially notorious since the early 2000s. Not only does such pollution damage the ecological system, but it also directly hurts the Chinese people's health. According to a 2007 World Bank report, the estimated cost of health problems due to air pollution is estimated about 3.8 percent of the GDP of China, and the costs imposed by water pollution is around 147 billion yuan a year. Acid rain, caused mainly by SO2, costs 30 billion Chinese yuan in crop damage and 7 billion in material damage annually (The World Bank, 2007). According to a 2014 report by the Ministry of Water Resources of China, low quality underground water accounts for 84.8 percent of all monitored spots in the northern 17 provinces and municipalities. These pollutions directly hurt Chinese people's health in the long run, if not immediately. The

[1] The number is calculated based on data from the Chinese Statistical Yearbook.

costs inflicted by these pollutions in the future would be high for the Chinese people. The benefits accrued to the people from economic growth would eventually be largely counteracted by negative effects from pollutions. Will economic growth eventually bring about a better environmental quality? The purpose of this dissertation is to diagnose this relationship through three empirical studies using an interdisciplinary perspective.

Both theoretical and empirical studies from various disciplines have investigated this relationship. One pessimistic view of the relationship between economic growth and environmental quality is called the “treadmill of production” theory, developed mainly by sociologist Allan Schnaiberg and his colleagues (see Gould, et al., 2008). It states that economic production is the dominant institution in a capitalist economy. Even though technology advancement is able to increase the efficiency of utilizing natural resources and reduce pollution emissions per unit, the total quantity of natural resources is decreasing and total pollution is increasing with ever expanding production. Thus, this theory postulates that environmental devastation is inevitable in an economic production system. In contrast, the ecological modernization theory holds an optimistic view. It states that along with economic development there will be environmentally-induced transformations of institutions and social practices in industrialized societies to improve environmental quality (Mol, 2002). The establishment of governmental departments dealing with environmental issues, the growing number and influences of environmental NGOs, and the emergence of green parties are all signs of ecological modernization.

The environmental Kuznets Curve (EKC) is a hypothesis proposed and mainly studied by economists but conceptually closely related to the ecological modernization theory. It offers a direct answer to the general question of this dissertation. All three essays of this dissertation relates to the EKC to some degree. The EKC states that environmental degradation increases at the early stage of economic growth and decreases after economic growth reaches a certain level—a development path which forms an inverted-U shape. The EKC is named after Simon Kuznets who originally described the relationship between economic growth and income equality as an inverted-U shape (i.e., Kuznets, 1955). The EKC is an attractive hypothesis to both government and the people. It gives government another legitimate reason to focus on economic growth, while giving people who live in polluted environment hope. Many pollutants have showed a trend described by the EKC in industrialized countries. Most industrialized countries also have good environmental quality in general. A three-decade rapid economic growth coupling with a general poor environmental quality in China seem to satisfy the two conditions of a turning point hypothesized in the EKC. Based on this observation, this dissertation will investigate the following question: have EKCs occurred, at least for some pollutions, in China?

Chinese governments have been trying to rebalance their duties in the economic reform era—reducing its economic role and focusing more on market regulation. Nonetheless, Chinese governments still play a leading role in economic growth. They also benefit well from economic growth. In fact, both academic studies and news coverages show that the governments' income and GDP have been growing at a faster rate than that of the Chinese people (Chen & Yao, 2011). What remains unclear, however, is whether or not this feature of GDP distribution affect environmental quality in China.

Other than the GDP distribution issue, pollution intensive factories seem to be located more often in lower-level jurisdictions within the government hierarchical system. For example, prior to the 2008 Beijing Olympics, the large steel company, Beijing Shougang, was relocated to a small neighboring city about 160 miles away to reduce air pollution in Beijing. Incidences of heavy metal pollution of land and water occur in the rural area in the news from time to time, and the term “Cancer Village” is used to describe the serious health consequences found in severely polluted areas (Liu, 2010; Chin & Spegele, 2013). These phenomena raise the following question: does the Chinese hierarchical administrative system affect pollution in a jurisdiction?

Increasing environmental concern with economic growth is an often cited support for the occurrence of EKCs. GDP/GNP per capita or household income is usually the proxy of economic growth in ECK studies. Nonetheless, studies of environmental concern have yet to depict a clear picture of this relationship. Studies based on the World Values Survey (WVS) and the International Social Survey Programme (ISSP) found a positive relationship between these two variables (e.g., Kemmelmeier, et al., 2002; Franzen & Meyer, 2010). However, other studies found that people in rich countries have a comparatively lower environmental concern (e.g., Givens and Jorgenson, 2011). Studies on China also showed mixed results. For example, the study by Yu (2014) indicated no statistically significant relationship using their own survey data from 2011. So far, probably the most comprehensive study of Chinese citizens’ environmental concern is done by Xiao, et al. (2013), and they also failed to find a statistically significant effect of personal income on environmental concern. Given such conflicting findings, the following question still awaits further investigation: does environmental concern increase with economic growth in China?

The three essays in this dissertation will shed light on these questions from an interdisciplinary perspective. Throughout these essays I use the terms economic growth and economic development interchangeably to refer to a transformation of the socioeconomic and political structures of a country. Economic growth and economic development are two distinctive concepts in many disciplines, but not in mainstream economics (Brinkman, 1995). Economic growth often refers to a quantitative increase in GNP/GDP per capita, but economic development is about transformation of social and economic structure and institutions which include noneconomic factors (Brinkman, 1995). The mainstream economist Simon Kuznets describes economic growth as a "... thorough transformation of a country's economic and social framework ..." (Kuznets, 1966, p.462). His concept of economic growth is the same as economic development. For the growth models (i.e., the Solow model and the endogenous growth models) in neoclassical economics, economic growth is decided by capital and technology. For the endogenous growth model, technology advancement is due to the investments in human capital and technology.

Economic growth for neoclassical economics therefore is not only about the quantity of GNP/GDP per capita. Nevertheless, neoclassical economic growth models do not study the dynamics of the underlying factors that affect technology advancement (Brinkman, 1995). This is where the debate on the two concepts originated. For neoclassical economists, those underlying dynamics are too complex to incorporate into a model, but other disciplines emphasize these dynamics (Brinkman, 1995). All in all, the common ground is that economic growth is not just about the number of GDP per capita but also about its underlying factors.

EKC studies from mainstream economics also show growing efforts to investigate structural factors of economic growth. The early EKC studies only include GDP per capita as a measurement of economic growth (e.g., Sharfik, 1994,). Then scholars begin to structurally decompose GDP per capita, which captures policy change, technology advancement and economic structural change (Panayotou, 1997). EKC studies also explore the influences of political factors (Eriksson & Persson, 2003), international trade (He, 2009), and income inequality (Torras and Boyce, 1998; Magnani, 2000).

The first essay investigates how the distribution of GDP between the Chinese government and the citizens affects the EKC in China. To answer this question, this essay first decomposes GDP per capita into four components that contribute to the final demand in a simple EKC model (please see Figure 1). The purpose is to investigate how each of these four components affects industrial pollution. The focus is on the Chinese governments and households. The next step is to use a GDP structural decomposition EKC model (i.e. economic scale, structure, and technology; see Grossman, 1995; He, 2009) to investigate how the GDP distribution between the provincial governments and the Chinese households influences industrial pollution. The data is at provincial level, compiled from the Chinese Statistical Yearbook for the period of 2000-2012. Policy implications from this study include: adjusting GDP distribution between the Chinese governments and its people may be an effective way to reduce industrial pollution emissions; continue on increasing the importance of pollution related criteria in the cadre evaluation system; and improve the power and autonomy of local environmental protection bureaus.

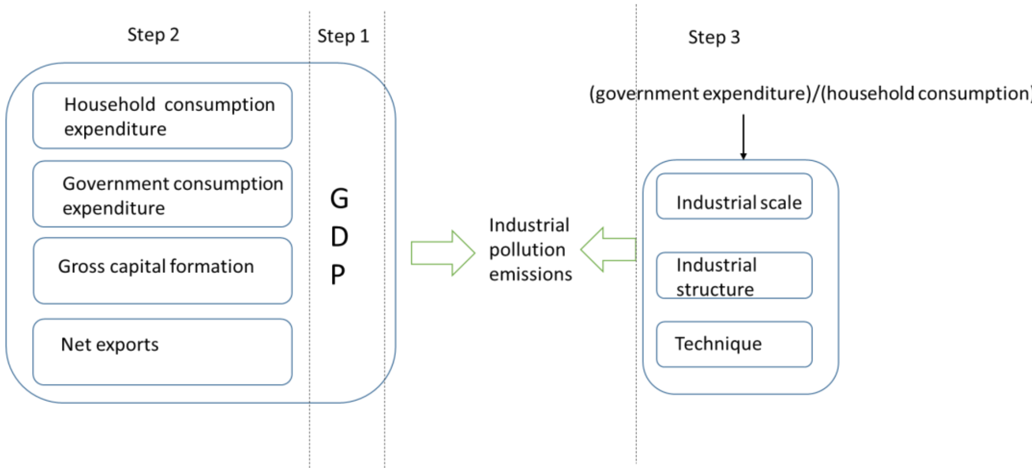

Figure 1: Investigation procedure of the first essay.

The second essay investigates how China's administrative hierarchy influences industrial pollution emissions. The argument is that lower ranked cities would have a higher industrial pollution level even if they reach the same income per capita level as higher ranked cities. This essay will investigate two channels through which administrative rank affects a local industrial pollution. First, a higher level city with more resources are able to attract less pollution intensive firms (industry structure), achieve higher production efficiency (technology), and perform better on pollution regulation enforcement leading to a local market with less pollution intensive industries. The other channel is the institutional quality of a city. Administrative rank enhances the quality in governance institutions (i.e., the local government and the local market) due to the resources advantage. The higher institutional quality leads to more efficient local spending and a spending structure towards more to the public services that are able to internalize the market externalities. The Chinese city-level data from 2003-2010 will be used to test these two channels through which the city administrative rank matters to the local industrial SO2 emissions. The policy implication from this study is that the Chinese central government needs to keep its efforts on containing this inequality within the administrative hierarchy for the benefits of itself (i.e., stability) and the benefits of the people located at lower level cities.

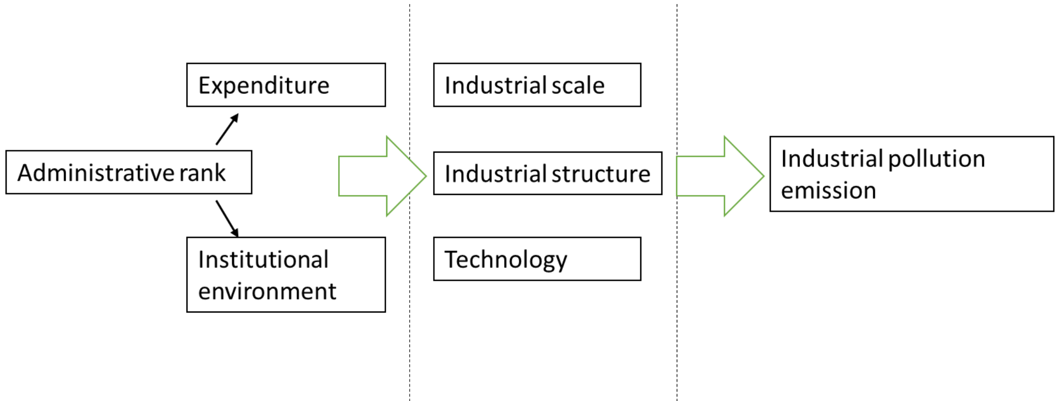

Figure 2: The relationship between administrative rank and industrial pollution emissions

The third essay investigates the relationship between economic growth and environmental concern in China. The direct benefits of economic growth is a richer country and higher personal income. In general, rich countries have better environmental quality than poor countries. A positive relationship between individual environmental concern and GDP per capita and individual income is thus likely to be proposed. Nevertheless, environmental concern studies revealed conflicting results. The main purpose of this study is to test this income and environmental concern relationship. I argue that this relationship is weak—not only due to the conflicting empirical results but theories also imply this weak connection.

The affluence hypothesis (i.e., Franzen & Meyer, 2010) states a positive relationship between national income and individual environmental concern, but its theoretical argument based on economic theories is problematic. Economic theories predict individual behaviors but not concerns, attitudes, or values. Inglehart's postmaterialist value theory states that more people own postmaterialist values in the high income industrialized countries and therefore more people with high level of environmental concern (Inglehart, 1995). Nevertheless, economic prosperity is only the precondition for people to have postmaterialist values. Education, information sharing, and generational replacement are the direct factors of people forming postmaterialist values. This means that economic variables are likely to be insignificant after considering these direct factors.

The second purpose of this study is to test the effects of these human-development-factors on environmental concern. This essay applies a hierarchical linear model to capture influences from both the province level and the individual level with survey data collected in of Chinese General Social Survey (CGSS) in 2010. The policy implication is that education and knowledge, but not income, are the key to improve people's environmental concern in China.

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CHAPTER 1: ECONOMIC GROWTH AND INDUSTRIAL POLLUTIONS IN CHINA: THE GENERAL PUBLIC VS. THE GOVERNMENTS

1.1 Introduction

The environmental Kuznets curve (EKC) hypothesis states that environmental degradation increases at the early stage of economic growth (or GDP per capita)[2] and decreases after economic growth reaches a certain level, which forms an inverted-U shape. One strand of the EKC studies (e.g. Torras & Boyce, 1998; Magnani, 2000; 2001; Plassmann & Khanna, 2006) focuses on how various factors related to environmental demand (e.g., income inequality and demographic characteristics) affect the EKC relationship. Following this line of work, this essay first decomposes GDP per capita into four components that contribute to the final demand in a simple EKC model. The purpose is to investigate how these four components affect industrial pollution. The focus is on the Chinese governments and people. Both academic studies and news coverages point to the issue that Chinese people's income is growing slower than the income of the governments and also the GDP (Chen & Yao, 2011). The next step is to use a GDP structural decomposition EKC model (i.e. economic scale, structure, and technology; see Grossman, 1995; He, 2009) to investigate how the GDP distribution between the

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[2] Some studies directly use GDP per capita in their EKC statements, but some use economic growth/development.

provincial governments and the Chinese households influences industrial pollution. The data is at the province level from the Chinese Statistical Yearbook with the time period from 2000-2012.

A free, competitive market provides a powerful explanatory model, but the reality is that the market is heavily influenced by its government. In Western developed countries, their governments ensure a comparatively efficient market by imposing a comprehensive system of regulations. The government's regulatory power affects the rent seeking ability of economic organizations (i.e., Stigler, 1971), and the development of market institutions (Fligstein, 1996).[3] Although the role of Chinese governments in economic development has been gradually changing from the dominant actor to more of a market regulator through economic reform in the past three decades, it still plays a key role in transforming the economic structure and in capital investments (Nee, Opper, & Wong, 2007; Lin, 2011). The governments' direct and indirect influences on economic growth and industrialization affect industrial pollution emissions.

I employ the institutional perspective to analyze how this orientation of "industrialization and economic growth first" ("growth-first" hereafter) is strengthened both for the Chinese governments and the Chinese people.[4] Institutions are evolving,

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[3] The crony-capitalism index created by the Economist analyzed the likelihood of business prosper with political connection, and they rank China at 19, United States at 17, and Britain ranks at 15. Please see Economist (2014).

[4] Institutional theories here refer to both institutional theories of economics (e.g., North, 1990; Williamson, 1995) and institutional theories of sociology (DiMaggio & Powell, 1983). They both emphasize how institutions affect behaviors of individuals and organizations, however, with different incentives. The institutional theories of economics argue that the institutions are adopted or changed to improve efficiency—a rational behavior perspective. The institutional theories of sociology argue that the institutions are adopted or changed to improve legitimacy but not efficiency. The rational perspective is able to explain the economic institutions adopted in China, but the environmental protection institutions are better explained by the perspective of legitimacy.

however, here I emphasize that both formal and informal institutions are dominated by growth-first rather than environmental protection in the economic transition era. Environmental protection has always been a very important policy agenda for Chinese governments in the reform era, but not so much in implementation under the institutional environment.

This study contributes to the EKC literature from an interdisciplinary perspective. One policy implication is that adjusting GDP distribution between the Chinese governments and its people is one way to reduce industrial pollution emissions. The structure of this paper is organized as follows. Section Two introduces the two industrial pollutants in this essay and their applicability to the EKC. Pollutants are heterogeneous: Their growth and decline vary with economic growth and some may not fit to an EKC relationship. Section Three explains the different influences on industrial pollution from the Chinese governments and the people. Section Four introduces the data and methodology used in this study. Section Five shows the results. The last section concludes this study with a discussion on policy implications.

1.2 Industrial Pollutants and EKC

Environmental goods are heterogeneous; thus, their relationship with economic growth varies.[5] Beckerman (1992) questioned the concept of "sustainable" growth and argued that "…probably the only way to attain a decent environment in most countries is to become rich." (p. 482). The "environment" he referred to includes sanitation, safe drinking water, and other issues that directly hurt people's welfare, not those global

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[5] Both theoretical and empirical studies have reached the conclusion that EKC is not a developmental path for every country and every pollutant (e.g., Dasgupta, Laplante, Wang, & Wheeler, 2002; Stern, 2002).

pollutants with intergenerational concerns (e.g., CO_2). The results from empirical EKC studies are consistent with Beckerman's argument from a social welfare perspective. They (e.g., Sharfik, 1994; Shen, 2006; He, 2009) often support the inverted-U curve for pollutants with local and explicit negative externalities (e.g., SO_2, toxic pollutants), but rarely do they (e.g., Sharfik, 1994) support for the same relationship for a global pollutant (i.e., CO_2). It is therefore necessary to introduce the pollutants first when investigating the EKC relationship. This study investigates the emissions of industrial SO_2 and industrial waste water. Industry here refers to "… the material production sector which is engaged in the extraction of natural resources and processing of minerals and agricultural products …" (National Bureau of Statistics of China, 2011a). It is composed of manufacturing and the production and supply of electric power, heat power and water.

The precondition for an inverted-U curve between economic growth and industrial pollution is industrialization. Industrial pollution is one major component of pollution that degrades the environment globally. The EKC would not apply if a country develop its economy not by industrialization. For example, some countries may mainly depend on tourism or natural resources. China, however, does use industrialization as its major strategy to develop its economy. The priority of the central government was to invest in the industrial development and modernization in the Second to the Fifth Five-Year Plan (1958-1980). Although the Chinese government has been encouraging the development of service sector in recent years, the industry steadily contributes to around forty percent of GDP since the economic reform based on the China Statistical Yearbook. Industrial structure change and technology advancement would lead to a declining industrial pollution emissions with the economic growth and therefore conform to the EKC hypothesis.

The two industrial pollutants here, namely, industrial SO_2 and industrial waste water, have characteristics found in the empirical EKC studies that are likely to conform to the EKC hypothesis. In general, economists differentiate pollutants into three types: pure public goods, local spillover effect public goods or club goods, and local public goods (Samuelson, 1954). Pure public goods are nonexcludable and nonrival. These two properties of public goods cause externalities which are the reason why the market cannot efficiently offer them. Externalities are benefits or costs not captured by the market system. Thus, public goods are likely to be under supplied by the market because their market prices are usually low or non-existent. They need either governments or some collaborations to provide them, such as assigning prices for them or directly taking actions to offer them. Global climate change is very close to this type of pure public goods. Industrial SO_2 and industrial waste water are usually categorized as local public goods because their externalities are restricted in a regional area and/or a short time frame. The benefits and costs induced by these industrial pollutions can be quantitatively attributed to certain people than the pure public goods. Thus, this type of pollution issue can be effectively alleviated with comparatively small scale collective action. Empirical studies, in general, support the EKC hypothesis for the pollutants with properties of local public or necessity goods, but not for the pollutants (e.g., CO_2) with more of a type of pure public or luxury goods (Shafik, 1994; He, 2009). These findings conform to the theory of public goods.

Environmental quality is often considered as normal goods, which is further categorized into necessity and luxury goods. Air quality should be more of a necessity good since it is easier to be observed, and it hurts people's health directly. Asymmetric information is one major factor of failing to provide public goods. This high visibility and immediate uncomfortable feeling caused by polluted air are able to draw people's attention; therefore, they induce people's willingness to take actions to deal with air pollution. He (2009) investigated industrial SO2 in China and showed that it had an inverted-U curve in the period from 1992-2003. Thus, I expect industrial SO2 conforming to the EKC.

Water quality directly affects people's health; thus, people's willingness to pay for it is high even though they may not have high income. However, a caveat is that this high demand for water quality may only apply to their daily drinking water. River water quality is more of an aesthetic type of environmental goods, which relates to water recreation. People are fine without it as long as they have safe water to use. Industrial waste water decreases the quality of water ecosystem, but this decreased quality affects people indirectly. It directly affects people by decreasing the aesthetical quality of a river, which is more of a luxury good. Thus, the EKC relationship for industrial waste water is not as clear as it is for industrial SO2, which is also purported by the mixed findings from the empirical studies (Dinda, 2004).

In summary, three factors support an inverted-U curve for industrial SO2: industrialization as the strategy for China's economic growth, the economic theories of public goods and normal goods, and the results from the empirical EKC studies. I expect industrial SO2 emissions to conform to the EKC hypothesis. Industrial waste water is more complicated due to itself as a complex indicator in which various specific pollutants are included (e.g., lead, mercury, and nitrogen compounds).

H1: The emissions levels of the two industrial pollutants increase with economic growth first and start to decrease after economic growth reach certain high level.

1.3 Governments vs. People on Industrial Pollution Emissions

1.3.1 Individual Demand and Industrial Pollution

Individuals affect the emissions of industrial pollution mainly through two channels: everyday consumption and indirect influence on environmental abatement efforts induced by policy. Chinese people's consumption has gradually gone up, but at a slower pace than the GDP growth (He & Cao, 2007; Chen & Yao, 2011). In the next few paragraphs I discuss the following three elements: Chinese people's preferences, their growing purchasing power, and their influence on both industrial and environmental policy.

Although each individual's preference is different, at the aggregate level Chinese people have a stable and consistent preference of industrialization and economic growth over the environmental quality in the economic reform era. This preference is shaped and strengthened by economic marketization. First, the development of a market economy increases the Chinese people's consumption ability. The Chinese central government emphasized the development of the heavy industry prior to the economic reform. This strategy did lead China into a rapid economy growth. However, the growth of capital intensive heavy industry was unable to materially benefit most Chinese people. People's consumption level was low even though the economic growth rate was high (Lin, Cai, & Li, 1996). Under the market allocation, the comparative advantage of low cost labor enables the rapid growth of light industry (Lin et al., 1996). This industrial structural change initiated by the government and accelerated by the development of market contributed to the rapid growth of Chinese people's income and consumption.

Second, the growing market economy pushes people to compete for monetary benefits. Under the command economy, the state allocates resources mainly based on the criteria of political favoritism and distributive egalitarianism. Price is heavily distorted under the command economy. Consumption is allocated based on a person's rank in a work unit, but not the market price. Hence, before China's market reform, Chinese people were mainly motivated by contributing to the development of the nation-state and demonstrating political loyalty. Political conformity was the first requirement for a person to get jobs, promotions, and even education (Walder, 1988). Under the market economy, however, everything (e.g., housing, education, and health service) has an explicit price, people are motivated to make income in order to have a better life or simply to afford rising living costs.

Third, people's attitude has changed from being reluctant to explicitly pursue economic benefits in the era of command economy to "getting rich is glorious" in the economic reform era (especially after the 1990s). The development of a market economy changed Chinese people's work relationship from "iron rice bowl" to the market-based labor contract; thus, uncertainty is increased. This high uncertainty and high market return have effectively stimulated people to work harder to pursue economic benefits as much as they can. In addition, Chinese people's values and social norms are also changing with the economic institutions. Rich people are respected even though they do not perform well in other areas. Monetary wealth is not only an instrument to satisfy people's material demand, but itself has become an indicator/symbol of a person's social status.

The rest of this section will analyze the two mechanisms through which industrial pollution is affected by the Chinese people. They are consumption and collective actions. The major influence from Chinese people on industrial pollution is through purchasing industrial productions. The growing consumption of industrial productions keeps increasing the total amount of industrial pollution. Industrial SO2 emits through fuel burning and the industrial production (physical and chemical) process. Fuel burning, however, is the major of the two which is responsible for 85 percent of industrial SO2 emissions (NBS, 2011b). Chinese residents account for about 45-55% of total energy consumption (Feng, Zou, & Wei, 2011).

Chinese people indirectly affect the industrial structure through consumption. This indirect influence is negligible under the traditional planning economy where personal investment is impossible and consumption is depressed. The industrial structure adjustment coupled with the development of market system in the economic reform period enhanced this influence. Although the total consumption of energy should have been increasing with growing residents' income, the energy intensity (energy use per Chinese yuan) is decreasing with increasing income as supported by several studies (i.e., Feng et al., 2011; Wei, Liu, Fan, & Wu, 2007). Based on official data for 2004-2008[6], these studies revealed that growing income causes more diversity in the energy

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[6] The studies on resident consumption and energy use (e.g., Feng et al., 2011; Wei et al., 2007) categorize direct and indirect effects from individual consumption. The direct influences include home energy use and personal travel; and indirect influences include food, closing, medical services, and other miscellaneous commodities and services (Wei et al., 2007).

consumption, and it causes more indirect energy consumption. These studies and also the study of Wei et al. (2007) revealed that urban residents have been using more electricity and natural gas rather than coal, and more consumption of education and recreation services rather than food. The changing consumption structure toward a less pollution intensive composition along with increasing income suggest a possibility of delinking between consumption and SO2 emissions.

The Chinese political system is often criticized as allowing very limited public participation in policy making; however, Chinese people do have certain level of influences on environmental policy implementation through complaints, litigations, and other collective actions (e.g., Tang & Zhan, 2008). Mass demonstrations had occurred when pollution had either realized or anticipated damages to the locals. Non-government organizations (NGOs) are another instrument for Chinese people to express their preferences collectively (e.g., Wu, 2013). Although NGOs in China are highly regulated and dependent on Chinese governments for resources, their negotiation efforts cannot be ignored. Their actions are allowed as long as they do not directly confront the governments (Ho & Edmonds, 2008; Tang & Zhan, 2008). For example, the size of hydropower project on the Nu River was reduced from 13 dams to four due to the efforts of the environmental NGOs (i.e., Han, Swedlow, & Danny, 2014).

In summary, the main effects of Chinese residents' behavior on the emissions of the two industrial pollutants are likely to show an inverted-U shape. Increasing consumption contributes to an increase of total industrial pollution. The consumption pattern, however, is changing from pollution intensive to less intensive induced by increasing income. This changing consumption pattern decreases the growth speed of pollution. The collective action against pollution intensive firms also serves to contain local industrial pollution.

H2: The two industrial pollutants increase with the increase of Chinese people's consumption and decrease after consumption reaching certain high level.

1.3.2 Chinese Governments: Public Service and Industrial Pollution

Chinese governments affect industrial pollution emissions through two channels: their efforts in pollution abatements and their involvement in economic growth. This section only focus on the first channel and the second channel will be discussed in the next section. Pollution abatements and environmental protection are components of their public services. Government final consumption of GDP represents the spending on public services (OECD, 2000). Intuitively, more public services would lead to enhanced efforts in pollution abatements at the local level. Nevertheless, this may not be the case because of their institutional environment. Although China has established a comprehensive system of environmental protection policies since the economic reform, growth-oriented institutions dominate local government behaviors and render this environmental policy system symbolic. This motivates local governments to spend more on growth-oriented public services (e.g., urban maintenance) but not on industrial pollution reduction. The net effect of the public service spending therefore could be positive to industrial pollution.

The Chinese central government places economic growth, industrialization, and political stability as the top priorities with the purpose of gaining and maintaining its governance legitimacy. Different from the local governments, the essential goal of the central government is to maintain its legitimacy in order to survive and keep a stable governance. Improving economic efficiency is one way to gain its governance legitimacy. In pursuance of rapid economic growth, the Chinese central government chose industrialization with the focus on the heavy industry prior to the economic reform. Its legitimacy did not increase with this strategy because the heavy industry did not benefit directly to the people in the short run. The focus of political movement following this unsuccessful economic growth strategy did not strengthen its legitimacy neither. The Chinese government therefore went back to focus on a growth strategy that promotes the people's wellbeing in the economic reform era. As I discussed earlier, the development of a market economy has enhanced the Chinese people's orientation toward growth-first in general (i.e., make income to survive). This individual preference re-strengthen the legitimacy of growth-first. Chinese governments will tolerate pollution as long as the majority Chinese people do not act collectively in response to pollution, or it does not directly damage economic growth in the short run.

The central government applied two formal institutional designs to align local interests. First, the position of the local environmental protection bureau in the governmental hierarchy renders this bureau little autonomy. This institutional design gives local governments a high-level flexibility in environmental policy implementation. Second, the local officials' promotion is mainly based on growth-first criteria. This central personnel control system has successfully aligned the local governments' interests to the priorities of the central government (Li & Zhou, 2005; Landry, 2008).

The studies on environmental management in China conclude that the main issue of an ineffective environmental protection system is not due to policy making but policy implementation (e.g., Jahiel, 1997; Qi & Zhang, 2014). Indeed, China has developed a comprehensive environmental protection system and policy since the inception of the economic reform (i.e., Beyer, 2006; Lu & Tsai, 2006). National environmental protection policies are there, but local governments have little incentive to implement and enforce them. The fragmented design of the environmental protection system is a sign of lower priority of environmental protection for the central government.

The ineffective environmental policy implementation at the local level is encouraged by the fragmented environmental management system. Scholars have revealed that the Chinese central control is often ineffective and use the term "fragmented authoritarianism" to describe this ineffective hierarchical control (Lieberthal & Oksenberg, 1988; Mertha, 2009). China's environmental protection system is a classic example of this fragmented authoritarianism. The difference, however, is that this fragmentation is not a bureaucratic control failure from the central government's perspective. The central government is very likely to purposely design this system as fragmented in order to devote more resources to economic growth. In the hierarchical government system, an environmental protection bureau is positioned at each level of government. These bureaus are branches of the environmental protection bureau at the central government. In design, they should follow the central government's direction or the bureau a level higher. In reality, these local-level bureaus have a high level of shirking probability due to the fragmented system. They are mainly funded by local governments. They are also staffed by the assignment of local governments. The central government has elevated its environmental protection bureau to ministry level in 2008 and named it as the Ministry of Environmental Protection (MEP), but this fragmented management system has not changed. The elevation in the central level thus has little effect on local implementations.

The central government applies a hierarchical personnel control system to motivate local economic growth and industrialization. China's administrative hierarchy forms a career ladder for public officials. In order to get a promotion, officials are evaluated by higher-level officials (Landry, 2008). The promotion of government officials is mainly dependent on political loyalty prior to the economic reform. In economic reform era, meritocracy is rising (e.g., Cao, 2000), and cadre performance evaluation system is implemented. These two institutions rendered political loyalty only as one, but not the only one, fundamental criterion. Local economic performance and its indicators take up the most items on the local governmental officials' evaluation sheet even in recent years with the increased focus on environmental protection and harmonic society (e.g., Heberer & Trappel, 2013). Although different levels of local government officials and different types of officials (i.e., some officials have little possibility of promotion) are affected by these two institutions in various degrees (e.g., Heberer & Trappel, 2013; Landry& Lu, 2015), empirical studies support the effectiveness of this growth-first incentive system. Li'an Zhou and colleagues revealed that this personnel control system effectively stimulated provincial officials pursuing local economic growth (Li & Zhou, 2005). Results from the study of Lu and Landry (2014) showed that the more promotion competition among a province the higher the local taxation under this personnel control system at the county level. Landry and Lu (2015) found that this economic performance criterion even played a greater role at the lower-level government.

With this personnel control system, local governments, especially the levels below prefecture, strive to accomplish the hard targets required by the central government, but are more likely to manipulate other requirements because they have less influences on local officials' performance evaluation (Heberer & Trappel, 2013). On the one hand, the central government has limited resources to monitor local governments on accomplishing the most fundamental tasks. The degree of resource limitation increases with the bureaucratic distance, which means that the maneuver space increases as we move downward along with the governmental hierarchy. On the other hand, local governments have limited resources and can only attend to several tasks in a certain time. Xueguang Zhou and numerous other scholars have studied the pervasive local governmental collusion behaviors on implementing policies (Zhou, 2010; Zhou, Lian, Ortolano, & Ye, 2013). He and colleagues have specifically proposed a local bureaucratic behavior of "muddling through" based on a case study of implementing environmental protection policies. Multiple policy goals imposed on a local government push local officials to take actions to deal with the most pressing ones while ignoring the others. Environmental protection is one of the less pressing tasks assigned from above; therefore, it is implemented with little effort. Such maneuver is still possible even with the environmental performance indicators listed under the category of "one item veto rule" on the evaluation sheets (Zhou, et al., 2013).

In sum, the relationship between local spending on public services and industrial pollution is affected by the weak environmental protection implementation under the institutional setting. The initial promulgation of the environmental protection policies was supposed to stimulate local governments to spend more efforts on reducing pollution.

However, the dominant economic institutions would later distract their efforts until pollution once again reach certain high level. This relationship, thus, should be nonlinear. The following case gives a clearer picture of this nonlinear relationship.

1.3.2.1 The Case of Chinese Governments on Industrial SO2 Emissions

The adaptive behavior of the Chinese governments in order to gain governance legitimacy is manifested in their handling of SO2 emissions. Chinese governments have paid special attention to SO2 emissions since the mid-1990s[7] and accomplished their early reduction goals. They, however, failed to achieve the SO2 reduction goal of 2005 set in the 10th Five-Year Plan. It represents a classic case of trade-off between economic growth and pollution reduction. With increasing pollution issues, Chinese governments are able to achieve SO2 reduction goals through more spending during the time period of the 11th Five-Year Plan.

Electricity production is the main source of industrial SO2 emissions. About 55.6 percent of industrial SO2 emissions is from production and distribution of electric power and heat power in 2010 (NBS, 2011a). Coal is the major source used for electricity generating in China, which accounts near 80% of electricity in 2000s. Chinese governments, therefore, decided to close down small scale power plants and small scale coal mines in order to reduce SO2 emissions in the late 1990s. They also require power plants to use low-sulfur coal. These governmental actions reduced the emissions of SO2. Nevertheless, the electricity shortage issue due to rapid urbanization and industrialization in the period from 2002-2004 forced their policy into inaction later on. The planned

[7] For example, the "Two Control Zones" was established in the 1990s; and clear SO2 reduction goals are set since the 10th Five-Year Plan. Please see Gao, et al. (2009) for a comprehensive discussion on the Chinese government's policies on controlling SO2 emissions.

close-down of small coal power plants and small coal mines were delayed, and even many new establishments were built to meet the increasing demand (Gao et al., 2009).

Two policies ensured the reduction of industrial SO2 emissions in the 11th Five Year Plan: the rapid installation of flue-gas desulfurization equipment (FGD) (i.e., SO2 scrubbers) in coal-fired power plants and subsidies to operate FGDs. With the unsuccessful effort to reduce SO2 in the 10th Five Year Plan period, the Chinese government required coal-fired power plants to install SO2 scrubbers (FGDs can reduce SO2 emissions up to 90%). The installation and operation cost of FGDs are very high to a power plant (Xu, 2011), but the benefits are spread to the whole region. The power plants, therefore, have no incentives to install and operate FGD without the requirements and subsidies from Chinese governments. Although Chinese governments have required the installation of FGD for certain power plants since 1990s, the share of coal-fired power plants with SO2 scrubbers was only a little more than 10% in 2005 (Xu, 2011). They were rapidly deployed after the failed reduction goal in SO2 emissions in the 10th Five Year Plan. The share increased to 48% in 2007 and further increased to 71% in 2009 (Xu, 2011).

Power plants in China are state-owned, and the government certainly played an important role in financing FGD installation. Government subsidies are also the main cause of continuous operation of FGD. Although there were substantial installments of FGDs from 2004 to 2009, most of them were not in operation at power plants (i.e., Xu, 2009, 2011). The reason is simple: The cost of operating scrubber is much higher than the fine by governments (Xu, 2011). Power plant managers, therefore, have little incentive to actually run them. The Chinese government then employed economic-incentive policy to fine the plants who do not use or use FGD not frequently and reward those who run FGD continuously (Xu, 2009). The reward is that the electricity can be sold at a higher price. This subsidy effectively increased the actual usage of FGD. In 2008, 78.7% of SO2 emissions was removed from associated coal power plants.

In summary, both the institutional analysis and the case above support a possible nonlinear relationship between a local government's spending on public services and industrial pollution. The SO2 case supports a possible three-stage relationship. First, a local government's public service spending decreases industrial pollution due to the implementation of the newly established environmental protection related institutions. Second, the dominant institutions in economic growth and political stability would distract local governments' effort in pollution reduction. With the expanding industrial production, industrial pollution emissions could increase together with the spending on public services. The last stage is the increased local effort in pollution reduction due to the increasing spending capacity and the accumulation of pollution in the environment. The following hypothesis is proposed:

H3: The public service spending of the Chinese governments has an inverted-N shaped relationship with industrial pollution emissions.

1.3.3 Inequality Distribution and Industrial Pollution

The analysis above reveals that the Chinese people and the governments should have different effects on industrial pollution emissions. The distribution of GDP between these two groups, therefore, should affect the level of industrial pollution emissions. Boyce and colleagues (1994; 1998; 2007) theoretically argue and empirically test the idea that income distribution affects environmental quality. The powerful groups make policies. They would favor more pollution if they benefit more from the pollution-generating productions. The behavior of a government is more complicated than their general reference of a powerful group due to its formal role in offering public goods. Chinese governments do actively involve in economic production that benefits themselves. This economic role will be explained here in order to have a comprehensive understanding of Chinese governments' influences on industrial pollution.

Chinese governments affect industrial pollution emissions through their direct economic activities in the market. Both the central and the local governments in China are active economic actors in the market (Naughton, 2010; Gabriele, 2010). A government does not necessarily play a dominant role in its economic growth and industrialization, but Chinese governments do. Scholars use the term "developmental state" to describe the active economic role of Chinese governments and other governments in East Asia. Studies from economics, sociology, and political science have all used various labels to describe this character of the local governments: local state corporatism (Oi, 1992), local state developmentalism, or clientelism (Ong, 2012). Although these terms refer to different economic behaviors of the local government and are applied to different time periods, the common point is that they strive for economic growth and economic benefits.

Chinese governments are major economic actors in the market through controlling SOEs. The development of the market and the reform policy of "zhuada fangxiao" (grasping the big and let go of the small) applied in 1997 had greatly reduced the number of SOEs; therefore, the direct role of governments in the market is weakened. The governments, however, control the large and strategically important SOEs through joint owned or wholly owned forms (Brodsgaard, 2012; Gabriele, 2010). These large SOEs are in strategically important sectors, which include energy and power, industrial raw materials, military industry and large-scale machinery-building, and transport and telecommunications. These SOEs have a large impact on industrial pollution, especially SO2 emissions, since the majority of industrial SO2 emissions is due to electric power companies. This control is also realized through the aforementioned centralized personnel control system. The CCP controls the appointment of the major leaders of these large SOEs. These business elites are effectively motivated by this personnel system because they can be promoted not only within SOEs but also within government hierarchy (Naughton, 2010; Brodsgaard, 2012).

The Chinese government contributes to the increase of industrial pollution emissions through encouraging capital investments of the SOEs. The reform of SOEs has largely reduced direct governmental involvements in SOEs' everyday management work. Nevertheless, in order to develop strong SOEs that can compete globally, the governments allow the SOEs to retain the after tax profits for investments (Naughton, 2010). Capital investment per se can either increase or decrease the industrial pollutions; however, these investments should have a net negative effect on the environment. These investments are mainly for expanding their operation due to their profit maximizing motivation and the encouragement from the governments. For example, half of the stimulus package (3 trillion yuan) in 2008 were planned to invest in transport and power infrastructure (Naughton, 2009). This relationship will not be directly tested with empirical data in this essay, but will be implied from the general relationship between capital formation and industrial pollution emissions. Capital formation will be briefly discussed in the independent variable part.

The net effect of government spending is not clear, but the investment behaviors of the governments would counteract their efforts in pollution reduction (at least in the short run). In addition, from people's consumption perspective, the more GDP goes to the governments implies that the less goes to the people. This would slow down the occurrence of the negative effect on the industrial pollution from people's consumption. The weak demand for less pollution from the people would cause the governments respond to more pressing issues. The GDP distribution favoring the governments, therefore, would prolong the reducing procedure of industrial pollution. The following hypothesis is therefore proposed:

H4: The more GDP distributed to provincial governments the more industrial pollution emissions.

1.4 Research Design

1.4.1 Data

This study uses a secondary data based on various years of the China Statistical Yearbook, and the time period is from 2000 to 2012. It is collected and published by the National Bureau of Statistics of China. The unit of analysis is province. There are 31 provinces in the data. They compose of a panel data set with the total sample size of 403 and 13 years. The National Bureau of Statistics of China only collected data for industrial enterprises with an annual sales income over 5 million yuan.

1.4.2 Dependent Variables

Industrial SO2 emissions and industrial waste water emissions are the two industrial pollutants discussed in this paper. Please see Table 1.1 for the descriptive statistics for the variables. Comparing to other pollution measurements, an advantage of emissions data is that it directly measures economic activities (He, 2009). The EKC hypothesis does not clarify on the measurement level of environmental quality, thus this paper uses three measurements of industrial pollutants as the dependent variables. To measure the relationship between total emissions and economic growth, total industrial SO2 emissions measured in metric tons and total industrial waste water measured in million metric tons are used as the dependent variables. Following most EKC studies, per capita industrial SO2 and waste water emissions are used as the dependent variables. Industrial pollution emissions density is also included as the dependent variable, which is created by the ratio of the total pollution emissions to the area of the province. One advantage of emissions density is that it "… preserves the dynamic characteristics of total industrial SO2 emissions for each province" due to the area of each province is generally constant (He, 2009, p. 230).

Table 1.1: Descriptive statistics

Variable	N	Mean	Standard Deviation	Measurment
Industrial SO2	403	602423	401152	metric ton
SO2 per capita	403	15.55	10.49	kg per capita
SO2 density	403	5.32	7.01	metric ton per square kilometer
Industrial water	403	725	638	million metric ton
Water per capita	403	16193	9458	kg per capita
Water density	403	7390	12039	metric ton per square kilometer
Provincial GDP per capita	403	22421	16461	yuan per capita
Gonvernment consumption per capita	403	3423	2716	yuan per capita
Household consumption per capita	403	7701	5218	yuan per capita
Net export of products and services	403	-971	3335	yuan per capita
Gross capital formation per capita	403	12403	9657	yuan per capita
Population density	403	0.37	0.44	thousand people per square kilometer
Ratio of expenditure to household consumption	299	0.50	0.22	
Industry scale	299	5.63	12.08	million yuan per square kilometer
Industry structure	299	0.25	0.08	
Trade intensity	299	0.27	0.36	(exort+import)/GDP

1.4.3 Independent Variables

GDP per capita is the main independent variable used to test the EKC hypothesis. It is measured by Chinese yuan per capita, as it is used in most EKC studies. In the reduced form models, GDP per capita captures the net effect of various production determinants, which include industrial scale, industrial structure, technology, and pollution abatement efforts. It is also a variable capturing endogenous government environmental regulations, as pointed out by Panayotou (1997, p. 473): GDP per capita

"… captures the endogenous or income-induced environmental regulations and public expenditures."

GDP per capita is then decomposed into household final consumption expenditure per capita, government final consumption expenditure per capita, gross fixed capita formation per capita, and net export of goods and services per capita. These are the four components based on the expenditure approach of accounting GDP. These four components are able to provide an aggregate examination of the respective influences from the governments and the people in China on the industrial pollution emissions. The disadvantage is that the underlying factors are not diagnosed. The policy implications, thus, are limited.

Household consumption expenditure "… refers to the total expenditure of resident households on the final consumption of goods and services" (NBS, 2011a). It is further divided into urban and rural household consumption. Other than the goods and services directly purchased by households, it also includes imputed consumption, which includes: in kind payment and transfer; goods and services produced and consumed by the households themselves, and financial intermediate services provided by financial institution (NBS, 2011a).

Government consumption expenditure "… refers to the consumption expenditure spent for the provision of public services provided by the government to the whole country and the net expenditure on the goods and services provided by the government to households free of charge or at reduced prices" (NBS, 2011a). It mainly includes expenditures within the "scope of budget" and the "scope of extra-budget". It is applied to measure a local government's spending on public services. It is expected to have a nonlinear relationship with the two industrial pollutants. Figures in Appendix A show the relationship between the major independent variables introduced above and industrial SO2 emissions per capita through scatter plots.

The ratio of the provincial government expenditure to the household consumption expenditure is applied to measure the distribution of GDP between the governments and the people. The provincial government expenditure is used instead of the government consumption expenditure. The reason is that the expenditure measures a net effect on the industrial pollutants from the provincial government.

Gross capital formation "… refers to the fixed assets acquired less disposals and the net value of inventory" (NBS, 2011a). It consists of two parts: gross fixed capital formation and changes in inventories. Its growth is one main contributor in carbon emissions and energy intensity from demand perspective based on the studies with the structural decomposition analysis (SDA) (e.g. Zhang, 2009; Zeng, et al., 2014).[8] Its growth, therefore, should increase industrial pollution. Both households and governments involve in capital investment. Households, however, are often involuntarily involved in capital investment as comparing to governments.

Net export of goods and services "… refers to the exports of goods and services subtracting the imports goods and services" (NBS, 2011a). It measures a net effect of international trade or globalization. International trade is a prominent factor affecting the EKC. Both theoretical and empirical EKC studies, however, support a conflicting influence on the environment from trade. The diffusion of technology, skills, and

[8] SDA is a method using input-output information to analyze the direct and indirect sources of emissions. The direct effect is from production pattern. The indirect effect on energy intensity is caused by the final demand change.

management system would improve the productivity; therefore, it decrease the emissions per output. Pollution haven or displacement argues that international trade causes pollution intensive industries moving to developing countries where environmental policies are weak and hunger for investments. Net export measures only the net effect of export on the pollutants. Neither does it explain the total effect of trade, nor the respective effect from export and import. It should increase pollution emissions as showed by the empirical studies on energy intensity and emissions (e.g., Zhang, 2009; Zeng et al., 2014).

The measurement of industrial scale is created by dividing the provincial industrial GDP over its area. It is a common measurement in EKC studies (e.g., Panayotou, 1997; He, 2009). The increase of industrial scale would increase industrial emissions due to escalated level of industrial production.

Industrial structure is measured by the proportion of the gross output value of the four most pollution intensive industries to the total industrial gross output value of a province. Pollution intensiveness is measured by the ratio of SO2 to industrial gross output value. The four most pollution intensive industries in SO2 emissions are: manufacture of paper and paper products, production and supply of electric power and heat power, manufacture of raw chemical materials, and smelting and pressing of ferrous metal. A large ratio refers to a high-level pollution intensiveness of a local industry which generates more pollution emissions.

Trade intensity is measured by the total export and import of a province over its GDP. It is a popular measurement used to investigate the influences from international trade on environmental quality (e.g., He, 2009). He (2009) revealed a direct beneficial effect on environmental quality from international trade in China, but it enlarged economic scale which increased pollution. He et al. (2010) also found this inconclusive effect from trade: a positive effect from trade to economic scale and a beneficial effect to technology advancement.

Population density is a common control variable in the EKC studies. Its effect on the industrial pollution is not clear. Panayotou (1997, p. 472) gave two reasons for this obscurity: Higher population density means higher pollution, but it also means higher demand for better environmental quality. A linear time trend variable is included to "capture exogenous (not income-induced) advances in technology and/or increases in environmental awareness" (Panayotou, 1997, p. 471).

1.4.4 Model and Estimation Technique

Considering the heterogeneity among Chinese provinces, this study applies both fixed effects models (FE) and random effects models (RE). In order for the OLS estimator to be unbiased, the conditional mean of the error term need to be zero. The unobserved heterogeneity, however, would likely to violate this assumption. Both FE and RE models address this issue of unobserved heterogeneity. The FE estimator is consistent if the unobserved heterogeneity is correlated with other independent variables in the model. The RE estimator is consistent and more efficient than the FE estimator only if the unobserved heterogeneity is not correlated with the other independent variables. Hausman test is used to compare the appropriateness of these two models.

Equation (1) is a popular base model applied in empirical EKC studies. If the EKC hypothesis is supported by the sample, then the cubic term is not statistically significant, and $\alpha_1 > 0$ and $\alpha_2 < 0$. The turning point is $Y^* = -\alpha_1/2\alpha_2$. The relationship between income and industrial pollution will be linear if quadratic and cubic terms are not statistically significant. The cubic term of GDP per capita is often included in empirical studies to capture other types of nonlinear relationship. The two turning points are calculated with the following equation: $Y^*_{1,2} = \left(-\alpha_2 \pm \sqrt{\alpha_2^2 - 3\alpha_1\alpha_3}\right)/(3\alpha_3)$.

$$P_{it} = \alpha_1 Y_{it} + \alpha_2 (Y_{it})^2 + \alpha_3 (Y_{it})^3 + \alpha_d D_{it} + \alpha_t T + c_i + u_{it} \quad (1)$$

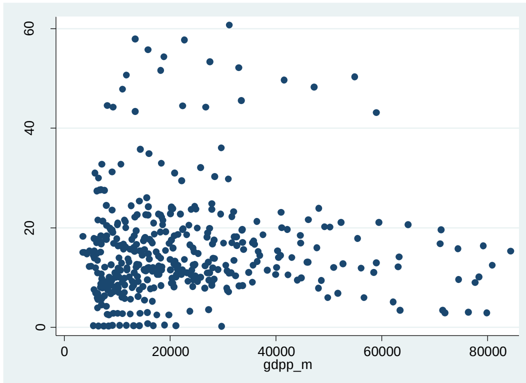
Equation (2) includes the decomposed effects of GDP.

$$P_{it} = \alpha_{h1} HC_{it} + \alpha_{h2} (HC_{it})^2 + \alpha_{h3} (HC_{it})^3 + \alpha_{g1} GC_{it} + \alpha_{g2} (GC_{it})^2 + \alpha_{g3} (GC_{it})^3 + \alpha_{c1} CF_{it} + \alpha_{c2} (CF_{it})^2 + \alpha_{c3} (CF_{it})^3 + \alpha_{n1} NE_{it} + \alpha_{n2} (NE_{it})^2 + \alpha_{n3} (NE_{it})^3 + \alpha_d D_{it} + \alpha_t T + c_i + u_{it} \quad (2)$$

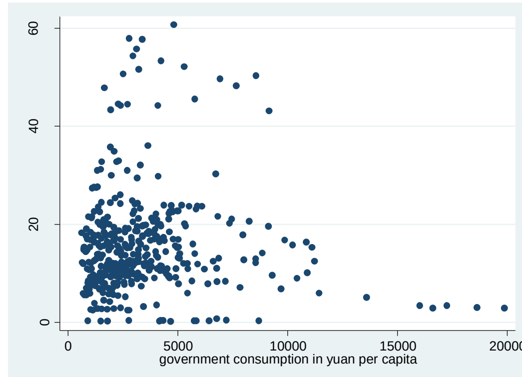
Subscript i and t refers to province i and year t respectively. The composite error term in a FE/RE model includes two parts: (1) c_i denotes unobserved variables that differ across cities but do not change over time; and (2) u_i denotes the idiosyncratic errors, which are assumed identically and independently distributed (i.i.d). P_{it} denotes the dependent variables which include industrial SO2 and industrial waste water. Y_{it}, D_{it}, and T denote per capita GDP of a province in 2010 real value adjusted by the national-level Consumer Price Index (CPI), population density of a province, and time trend T, respectively. In equation (2), HC refers to household consumption per capita; GC refers to government consumption per capita; CF refers to gross capital formation per capita, and; NE refers to net export of goods and services per capita.

All variables are natural logarithm transformed except net export due to negative values. In the EKC studies, the models are established either with log transform (e.g., Stern, 2001; Shen, 2006) or with the original measurement. The log transformation is made mainly based on the relationship between the dependent variables and the independent variables. The relationship between the SO2 emissions per capita and GDP per capita, household consumption per capita, and government consumption per capita is not linear as it is showed in the scatter plots in Figure 1.1a-c. The relationship is more linear after the log transformation as it is shown in Figure 1.1d.

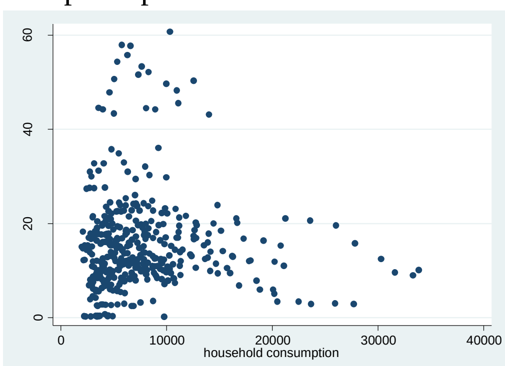
a. GDP per capita and SO2 per capita



b. Government consumption per capita and SO2 per capita



c. Household consumption per capita and SO2 per capita



d. GDP per capita (logged) and SO2 per capita (logged)

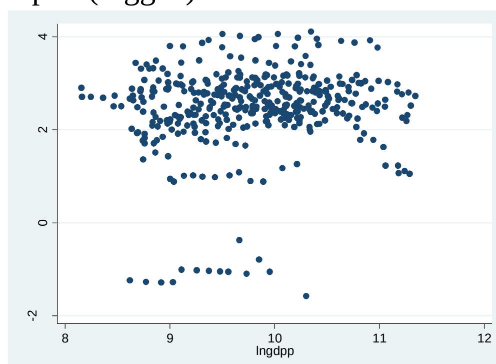


Figure 1.1: Relationship between the key independent variables and the dependent variable

Equation (3) is used to test the hypothesis 4 in a GDP decomposed model:

$$P_{it} = \beta_1 R_{it} + \beta_2 Y_{it} + \beta_3 Scale + \beta_4 Structure + \beta_5 Trade + \beta_d D_{it} + \beta_t T + c_i + u_{it} \qquad (3)$$

This model is established based on the structural decomposition model developed by He (2009). She established it based on the model developed by Grossman (1995). All variables are natural logarithm transformed. R_{it} refers to the ratio of government expenditure over household consumption expenditure. Y_{it} is still GDP per capita. It mainly measures technological effect after the separation of scale and structure effects (i.e., Panayotou, 1997; He, 2009). It should have a negative effect on the industrial pollution. Scale refers to industrial scale, and its coefficient should be positive. Structure refers to industrial structure and should have a positive coefficient. Other variables are the same as those in the model 2. Trade refers to trade intensity which is measured by the total export and import over the area (i.e., He, 2009). This model is only applied to industrial SO2 in this essay.

The limitation of this single-equation (equation (1) & (2)) or so called reduced model as pointed out by Grossman and Krueger (1995) is that the causal relationship between income and pollution is unclear. Panayotou (1997) further explained this issue: It assumes unidirectional causality from the economy to the industrial pollution, but neglects the negative feedback (such as impacts on health, soil erosion, etc.) from pollution to the economy. The estimates from this model can be biased by this feedback effect. This feedback, however, should be very small in this study. Industrial SO2 emissions and industrial waste water emissions are a part of the whole environmental degradation issue. Their negative influences on people's health and production should be small. Studies also try to control for the influences from the past economic growth or the past level of pollution emissions. These past influences are likely to be small because the dependent variables are pollution emissions. They are the direct byproducts of industrial production, but not pollution concentrations in the environment. Their levels, therefore, are less influenced by the past.

1.5 Estimation Results

The estimation results for different pollution indicators are very similar in quantity and with no qualitative difference. Thus, only the estimation results for industrial SO2 emissions per capita and industrial water emissions per capita are reported. Both FE and RE models are estimated for all the equations. Hausman test revealed different results for different models, however, the results from the FE and the RE models are similar. Thus, I focus on discussing the results from the FE models because their estimates are consistent.

The results for equation (1) are reported in Table 1.2. The models are generated with the higher order terms of GDP per capita adding to them gradually. All the coefficients for the cubic terms of GDP per capita are statistically significant at 5 per cent level or higher. These results support a nonlinear relationship between GDP per capita and the two industrial pollutants. Comparing the results from the two pollutants, the coefficients show a higher statistically significant level for industrial waste water emissions. Their nonlinear relationships are shown in Figure 1.2, which is generated with the sample data. The industrial SO2 emissions level reaches the highest level when GDP per capita increases to 22,026 yuan (in 2010 real value); then it starts to decline thereafter. The average GDP per capita for provinces has been larger than this turning point value since the year 2007, however, only ten provinces' GDP per capita is higher than that value in 2007. This number of provinces increases to twenty-seven in 2012.

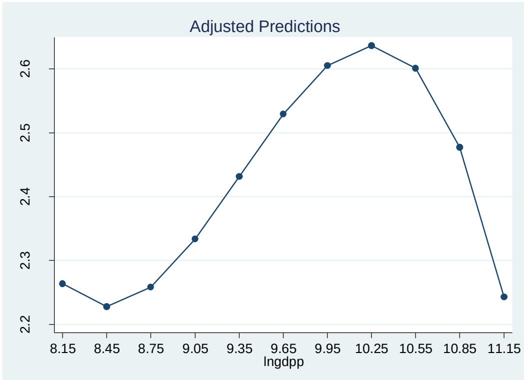
Table 1.2: Results for equation (1)

	SO2 per capita		Water per capita	
	FE	RE	FE	RE
ln(gdpp)	-28.9 (14.8) *	-35.6 (14.8) **	-38.0 (13.19) ***	-41.4 (12.57) ***
[ln(gdpp]²	3.11 (1.54) *	3.85 (1.53) **	3.98 (1.38) ***	4.35 (1.30) ***
[ln(gdpp]³	-0.111 (0.054) **	-0.137(0.053) ***	-0.137 (0.048) ***	-0.151 (0.045) ***
ln(populationdensity)	0.392 (0.745)	0.123 (0.223)	-0.239 (0.715)	0.159 (0.051) ***
Constant	90.2 (47.7) *	111.6 (47.9) **	128.8 (42.6) ***	139.3 (40.6) ***
R squared	0.94	0.12	0.88	0.40
Hausman test	4.1		9.56 **	
Province turning point 1, yuan	5,876	4,041	5096	
Province turning point 2, yuan	22026	33,876	50571	
N	403		403	
Provinces	31		31	

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

The robust standard error is in the parentheses

a. SO2 per capita from FE model



b. Industrial water per capita from FE

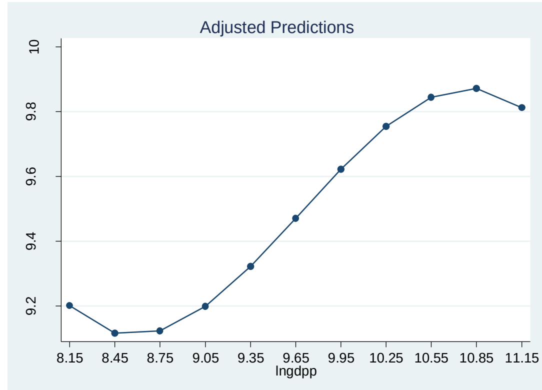


Figure 1.2: GDP per capita and industrial pollution emissions

The declining point for industrial waste water is much higher than it is for SO2. The industrial waste water level is the lowest when GDP per capita is 5,096 yuan (in 2010 real value); it reaches the highest level when GDP per capita increases to 50,571 yuan (in 2010 real value); then it starts to decline thereafter. Nevertheless, there is only a slightly declination within the sample data range. Average provincial GDP per capita was about 39,908 in 2012, and only seven provinces had a higher number. This much higher declining point estimated from the sample is not surprising. Industrial waste water pollutes rivers; therefore, it directly affects the view and the recreational function of rivers. Chinese people have low demand for river recreation because of its high costs. In addition, the modern technology protects people's drinking water safe away from the industrial waste water pollution. These two major factors cause people to have a lower demand for reducing industrial waste water emissions in China.

Population density is, in general, not a significant factor affecting the two industrial pollutants based on the results. The coefficients are not statistically significant most time. However, it has a statistically significant positive effect for industrial SO2 density, which means that the higher the population density the higher the industrial SO2 emissions density is.

The results for equation (2) are reported in Table 1.3. The models are also generated step wisely by gradually adding higher order terms. The results in the table only show the models with the statistically significant higher order terms.

Table 1.3: Components of GDP and the two Industrial pollution emissions

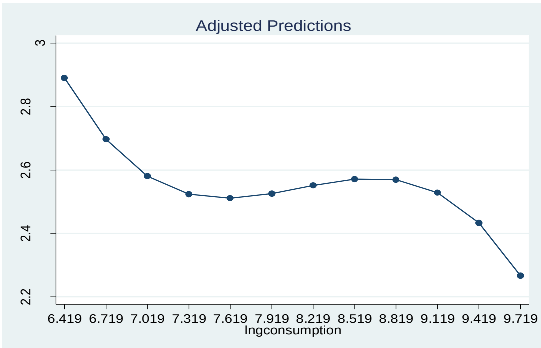
	Industrial SO2 per capita		Industrial waste water per capita	
	FE	RE	FE	RE
ln(gov_consumption)	-20.0 (8.88) **	-22.8 (8.75) ***	-19.7 (8.3) **	-19.4 (8.38) **
ln(gov_consumption)²	2.47 (1.10) **	2.86 (1.08) ***	2.52 (1.01) **	2.50 (1.02) **
ln(gov_consumption)³	-0.101 (0.045) **	-0.119 (0.044) ***	-0.108 (0.041) **	-0.11 (0.04) ***
ln(hou_consumption)	6.54 (2.18) ***	7.05 (2.23) ***	4.87 (2.10) **	4.42 (1.71) ***
ln(hou_consumption)²	-0.398 (0.124) ***	-0.42 (0.126) ***	-0.263 (0.122) **	-0.233 (0.096) **
Net export	-1.67e-06 (0.000012)	6.64e-06 (1.17e-05)	3.19e-05 (9.98e-06) ***	3.34e-05(1.12e-05) ***
ln(capital)	-1.91 (0.99) *	-1.61 (1.09)	-2.20 (1.16) *	-2.1 (1.04) **
ln(capital)²	0.099 (0.049)*	0.091 (0.056)	0.13 (0.061) **	0.13 (0.056) **
ln(population density)	-0.870 (0.565)	0.208 (0.189)	0.14 (0.62)	0.14 (0.05) ***
Constant	36.5 (19.3) *	40.7 (19.6) **	48.2 (21.2) **	48.1 (20.7) **
r-squared	0.95	0.14	0.90	0.50
Hausman		7.82		9.70
Turning point household	3700	4415	10499	13161
N		403		403
Provinces		31		31

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

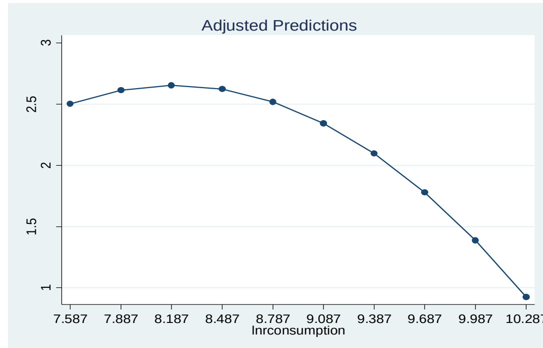
The robust standard error is in the parentheses

Provincial government gross consumption per capita has a statistically significant nonlinear effect on the pollutants. This nonlinear relationship is easier to understand with the graphs drawn based on the sample data. There are two reflecting points shown in Figure 1.3 a. This graph supports the inverted N-shape relationship between government spending on public services and industrial pollution emissions. Government gross consumption is for public services. Nevertheless, provincial governments have other higher priorities that can counteract the pollution reduction effect of government consumption. This general declining trend is much smoother (close to a straight line) for the industrial waste water indicators.

a. Government Consumption per capita



b. Household consumption per capita



c. Gross capital formation per capita

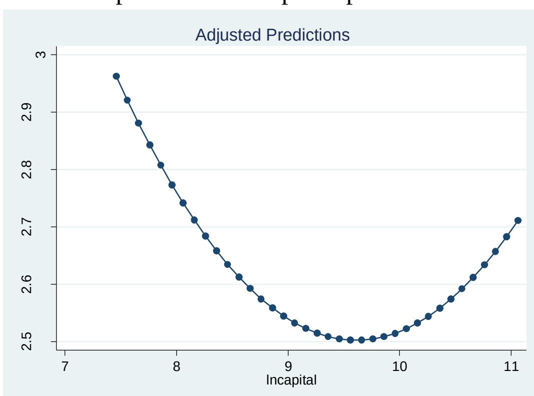
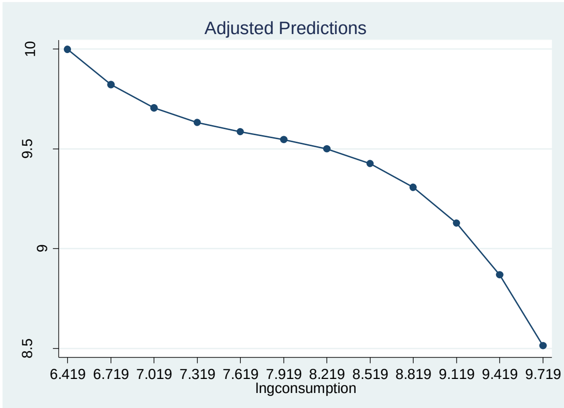
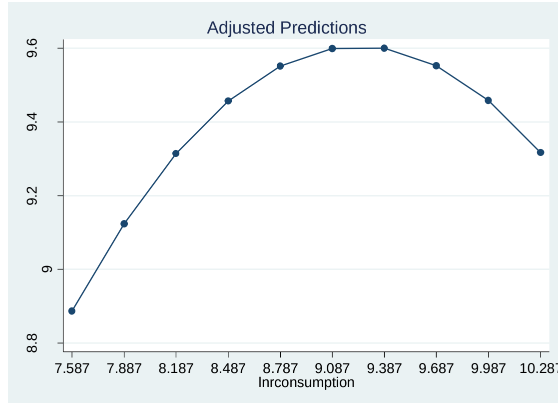


Figure 1.3: Predicted industrial SO2 emissions and components of GDP (FE)

a. Government consumption per capita



b. Household consumption per capita



c. Gross capital formation per capita

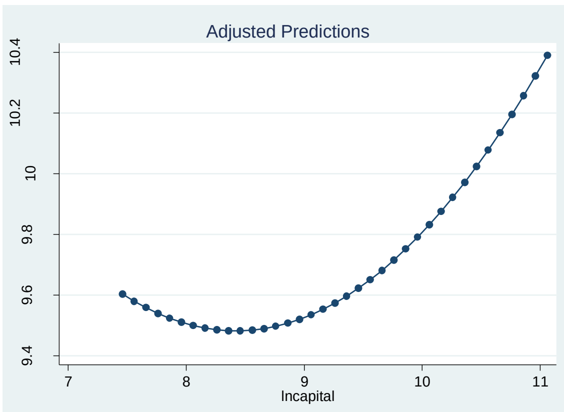


Figure 1.4: Predicted industrial waste water emissions and components of GDP (FE)

Household consumption per capita increases industrial pollution emissions first and then decreases them after it reaching certain consumption level. It forms an inverted-U curve as shown in Figure 1.3b and Figure 1.4b. The turning point for industrial SO2 is 3,700 yuan for the FE model or 4,415 yuan for the RE model as they are shown in Table 1.3. Only Tibet had an average household consumption per capita lower than 3,700 yuan in 2005, and it passed this number in 2009. The turning point for industrial waste water is 10,499 yuan for the FE model or 13,161 yuan for the RE model. Once again, the turning point for industrial waste water is much higher than industrial SO2 as expected.

Gross capital formation per capita has a marginal statistically significant effect (based on 5% statistical significance level) on industrial SO2, and its significance-level improved for industrial waste water. The relationship between capital formation per capita and industrial pollution emissions form a U curve. They are shown in Figure 1.3c and Figure 1.4c. The pollution emissions decline with capital formation per capita and then increase with it. The lowest level of industrial SO2 emissions is when gross capital formation per capita reaches about 15,467 yuan based on the FE models. The average amount of gross capital formation per capita has been larger than this turning point value since the year 2009. There were 12 provinces with a capital formation value larger than this turning point value in 2009. This number kept increasing to 26 provinces in 2012 based on the data. The lowest level of industrial waste water emissions is when gross capital formation per capita reaches about 4,722 yuan based on the FE models. This amount of capital formation per capita is low. The minimum amount has passed this value since the year 2008, which means that all provinces have been experiencing increasing industrial waste water emissions induced by capital formation since then.

Net export has no statistically significant effect on industrial SO2 emissions, but it does have a positive effect on industrial waste water emissions. The results for waste water from the FE models indicate that on average a 1,000-yuan increase of net export per capita will increase industrial waste water emissions by 3.2 per cent, while holding other independent variables constant. This positive result makes sense since China is well known as the “World Factory”. It does not have a significant effect on industrial SO2 emissions, and it is most likely due to the installation of scrubbers.

The results for equation (3) are reported in Table 1.4. The distribution of GDP between the provincial governments and people has a stable positive and statistically significant effect on the emissions of industrial SO2. Although the governments may be able to spend more on improving environmental quality related areas, these positive effects are counteracted by the other negative effects induced by distribution difference. More GDP allocated to the governments would decrease the environmental quality demand from the people due to the slowed increase in people's income. People's consumption structure also changes slower due to the less income increase.

Table 1.4: The ratio of government expenditure over household consumption and Industrial SO2 per capita

	Industrial SO2 per capita	
	FE	RE
Ln (GDP per capita)	-1.780 (0.888)**	-1.474 (0.476)***
Ln (expenditure/Hconsumption)	0.347 (0.154)**	0.413 (0.169)***
Ln (industry scale)	1.077 (0.522)**	1.370 (0.360)***
Ln (industry structure)	0.113 (0.279)	0.279 (0.220)
Ln (trade intensity)	-0.348 (0.143)**	-0.140 (0.077)*
Ln (population density)	-2.620 (0.829)***	-1.232 (0.364)***
Constant	14.87 (7.308)*	14.97 (4.119)***
R-squared	0.9308	0.5059
Hausman	38.43***	
N	299	
Provinces	31	

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

The robust standard error is in the parentheses

After controlling for industrial scale and structure, GDP per capita in this model measures technical effects, and the results support that technology reduces industrial SO2 emissions. The coefficients of industrial scale and industrial structure support the expected relationships. Trade intensity shows a negative effect on industrial SO2 emissions. This result implies that international trade reduces industrial SO2 emissions.

In summary, the results estimated based on the three equations in general support the hypotheses proposed earlier. The major findings are: Chinese provincial governments and people affect industrial pollution emissions differently; the more GDP distribution toward the governments would cause more industrial SO2 emissions.

1.6 Conclusions and Policy Implications

This study revealed a common nonlinear trend between the two industrial pollutants and GDP growth. This trend is a little bit more complicated than the inverted-U curve, but it is within a common shape found in the empirical EKC studies. Scholars have long argued that there does not exist the EKC for all the countries. The income-environment relationship is dependent on how the economy is developed. China chooses industrialization and involving in the world market to grow its economy. Industrial pollution, as a byproduct of industrial production, should have a general trend of increasing with economic growth if everything else keeps unchanged. Technology advancement is one main factor in reducing industrial pollution as argued by most EKC studies. It lowers emissions per GDP. It is able to reduce industrial pollution emissions without any other changes as argued by many EKC theoretical studies.

Nevertheless, government policy can help increase the process of technology adoption and speed up the declination of pollution emissions. The technology of FGD has matured in 1970s. Japan installed FGDs for most of its coal-fired plants in 1970s. On the other hand, plants in China have no incentive to install it (the cost of pollution is borne by all the people) until the government’s requirement. They do not run the installed FGDs until the governments give monetary incentives. The installation and the running of these FGDs are two major factors contributing to the decline of industrial SO2 emissions along with the economic growth in China. One caution about technology advancement is that it may increase pollution or deteriorate the environmental quality. Technology advancement increases people’s ability to exploit the natural resources; it increases the possibility of isolating the people from the natural environment; therefore, it decreases the demand; and it may cause new types of pollutants. Chinese governments need to prepare for these possible negative effects on the environment from technology advancement.

Chinese governments have been transforming its functions toward providing more public services. Local governments do spend more of its budget on controlling industrial pollutions with its increasing revenues in the long run. This increase, however, may not be linear with the increase of the budget because that other policy agendas related to economic growth and social stability take a higher priority. The governments' efforts on reducing pollution emissions can also be counteracted by their economic incentives. Chinese governments' pro-economic growth behaviors through direct investments can increase industrial pollution emissions. Chinese governments need to keep their efforts on their function transformation from the perspective of improving environmental quality.

Chinese people's interest does matter to industrial pollution. People have a diminishing marginal effect on industrial pollution emissions through consumption. This effect is due to the consumption structure change with growing household income—a larger proportion of income will be on less pollution intensive goods, such as education, services, and luxury goods. People's voice of an "acceptable environment" can be heard by the governments, and respondent actions are implemented. These two effects plus the technology advancement enable a decline of industrial pollution with economic growth.

The proportion of Chinese household consumption to the GDP is low comparing to other countries. The absolute consumption level is much lower when comparing to the developed countries. The Chinese people, therefore, are very environmentally friendly from the consumption perspective. They have less environmental impact when comparing to the people in the developed countries. Chinese governments should keep adjusting its economic development to benefit more to the Chinese people.

A lasting high investment rate is commonly considered as one underlying factor of China's rapid economic growth. This general high investment rate indicates that in general Chinese people are very patient, which means that they put a comparatively high value on the future and sacrifice today's consumption. This patience also explains Chinese people's high tolerance with difficulties in which environmental degradation is included. This tolerance prolongs the environmental quality improvement with economic growth.

From the EKC perspective, China's GDP per capita is still low and it is much lower than the turning points estimated by many empirical studies. Pollution emissions is not the pollution concentration in the environment. Ecosystem is much more complex than several environmental indictors. There will be a long way ahead in improving the environmental quality. The poor status quo of the environment in China justifies this long challenge. The turning points for some environmental indicators would be much lower than the empirical estimations if the Chinese governments keep its reforming direction—narrowing its functions with focuses on regulations and public services. This high level of patience is a Chinese tradition. It is also the consequence of the special era: Economic transition increases the uncertainty with which people have to face.

The relationship between economic growth and pollutants varies based on existing empirical studies. This study reinforces this point. Comparing the trend of industrial waste water with SO2 emissions, it tells us that a clearly defined pollutant with a noticeable direct negative effect on people's wellbeing will be reduced faster with economic growth.

The results based on the first two equations are limited by the simple EKC model. Studies have criticized that the shape of an EKC is artificially affected by the models and the statistical methodologies used in the studies. The shapes and the turning points in this study only give a general sense of the relationship between the interested factors with the industrial pollutants. A structural model with various causal mechanisms written out in equations will offer a better investigation on the relationships between the various factors. The implications of this study is further constrained by four components of GDP aggregated at the provincial level. The underlying dynamics (e.g., education level, the structure of expenditure, and specific policies) cannot be revealed in this study. The consumption of household and government only measure a net effect of their influences on the changes of industrial scale, structure, technology, and policy. Thus, the policy implications are limited. Future study needs to investigate how the structure change of a local government spending affects industrial pollution emissions. Further study needs to diagnose local-level variations within a province or a prefecture-level city with both qualitative and first-hand quantitative data.

CHAPTER 2: GOVERNMENT ADMINISTRATIVE RANK AND INDUSTRIAL POLLUTION IN CHINA

2.1 Introduction

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

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

This inequality in the EKC shape is also present within a country. In developed countries, environmental inequality exists between areas: poor areas are often more polluted (Daniels & Friedman, 1999) and have weaker environmental policy enforcement (Konisky, 2009). In China, a locality's income-environment relationship is affected by its place in the government administrative hierarchy (or bureaucratic hierarchy). Not only does a higher ranked city have a higher income per capita, its economic and industrial structure is also less pollution intensive. In general, a lower ranked city would experience a higher pollution level even when it reaches the same income per capita level as higher ranked cities.

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

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

2.2 Administrative Rank and Resources Inequality

2.2.1 City Administrative Rank

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

There are currently four administrative ranks for cities within this Chinese government hierarchy. The centrally administered municipalities are province-level cities (i.e., Beijing, Tianjin, Shanghai, and Chongqing). Sub-province-level cities are a half-level lower than the centrally administered cities, and most of them are the capital of a province. There were 15 of them after the year 2000. Prefecture-level cities are positioned one rank lower than the sub-province-level, and there were 268 of them in 2010 (NBS, 2011c). They most often encompass counties and county-level-cities and districts, all three of which are county level jurisdictions. There were 370 county-level cities in 2010 (NBS, 2011c). Most of them are under administration of prefecture-level cities.[9]

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

2.2.2 Resources Inequality

This section will briefly introduce the characteristics of a hierarchy from organizational theories, and will then focus on investigating the unequal resource distribution within the government hierarchy. Organizational studies have investigated

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

common characteristics of a hierarchy. Here, I briefly introduce the most relevant ones. In general, a hierarchy has these two advantages: it provides order and stability, and it offers benefits (e.g., career, financial rewards, and privileges) along with the vertical positions in the system (Diefenbach, 2013, pp. 3-4). In addition to these two advantages, economists Ronald Coase (1937) and Oliver Williamson (1995) explained the need for a hierarchy from an efficiency perspective: it reduces transaction cost induced from bargaining and contracting in the market. The main disadvantage is that it creates and institutionalizes unequal relationships along the top-down line: “Hierarchy systematically enables and guarantees unequal distribution of and access to institutions and resources, power differentials and opportunities, privileges and prerogatives, and tasks and duties” (Diefenbach, 2013, p. 4).

The Chinese central government would favor this hierarchical structure because its advantages improve the performance of the organization/government as a whole. Nevertheless, from a local government perspective, it is legitimately discriminated in this hierarchical structure—a constraint it cannot stretch beyond. I emphasize the inequality in political and administrative resources here. The two types of resources are intertwined together both practically and theoretically.[10] Political resources here specifically refer to the leading policymaking power and personnel control of the Communist Party of China

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

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

(CPC). Administrative resources mainly refer to the human and the financial resources utilized by a local government to implement policies.

2.2.2.1 Administrative Resources

The administrative rank allocates more administrative resources to higher-level cities. First, it determines the number and the size of its government offices and employees (Ma, 2005; Chung, 2007), which are fundamental for policy implementation and public service. There are around eighty permanent departments and fifty temporary units for the province-level cities. Normally, there are sixty to seventy permanent departments and temporary units for a prefecture-level city. The size is reduced to fifty to sixty permanent departments for county-level cities. Thus, a higher rank city has more human resources and functional departments to offer more public services than a lower-level city (Li & Wu, 2012).

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

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

According to the World Bank, China is the most decentralized country in the world when measured by the local governments' funding to public goods and services (Fock and Wong, 2008). From another perspective, it also places a heavy burden on local governments. Wang, et al. (2011) investigated various ways to finance urban infrastructure in the reform-era of China. They pointed out that city governments of different administrative ranks were delegated with different levels of autonomy and faced different fiscal constraints. Several studies found that fiscal condition is especially severe at county and town-level governments as a consequence of the tax-for-fee reform in 2002 and the repeal of the agricultural tax (e.g. Chen, 2007; Oi, Babiarz, Zhang, Luo, & Rozelle, 2012; Ong 2011; Zhou, 2012). Chen (2007, p. 159) showed that "In 2002, 95 percent of villages in Jiangsu and 72 percent of the 249 surveyed villages in Shandong were in debt."

2.2.2.2 Political Resources

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

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

There is a local Party Committee at each level of a city. There are two heads of a city: the Party Secretary, who is the leader, and the mayor, who is usually also the Vice Party Secretary. The Party Secretary is officially in charge of Party affairs, and the mayor is officially responsible for administration. However, the Party Secretary is in charge of the most important decisions and indirectly involved in administration since local officials are often members of the CPC (Landry, 2008). The Party Committee is thus the actual leader of the local policy making. Its Standing Committee controls the core political power. Its members are voted and elected by the Party congress at its own level.[11] However, the elected members need to be confirmed by the next higher-level Party Committee.

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

Higher administrative level cities may have legislative power but lower-level cities do not. The Legislation Law of the People's Republic of China, promulgated in the year of 2000, assigned legislative power to all province- and sub-province-level cities. For all prefectural or higher-level cities, "… only 49 have legislation powers: 27 capitals of provincial regions, four special economic zones and 18 big cities approved by the State Council." (Xinhua, 2014, para 3). These cities may make stricter regulations on pollution emission standards and require modern management systems and skills to increase

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

production efficiency. For example, the “Ordinance of the Beijing on the Prevention and Control of Atmospheric Pollution” adopted in 2014 has a higher standard than the national one. Pollution intensive factories with low added value may thus prefer to stay or open new branches in the lower-level city without stricter regulations or other lower requirements to reduce costs.

2.3 Administrative Rank and Industrial Pollution

One strand of the EKC study (i.e., Grossman, 1995; Panayotou, 1997; He, 2009) decomposes the effect of economic growth on environmental quality into three factors: economic scale, economic structure, and technology. This study only investigates industrial pollution which is affected by industrial production; thus, these three factors are industrial scale, industrial structure, and technology. Industrial structure and technology together affect the general pollution intensiveness of a local industry. Administrative rank affects all these three pollution production factors because it causes systematic differences in administrative and political resources at different levels of cities/governments. This section investigates how these resource differences affect industrial pollution. The two channels to be explained and tested are: 1) that additional resources would lead to less pollution intensiveness in a city (i.e., less pollution intensive factories and better production technology) and 2) that higher institutional quality due to increased resources would improve the effectiveness of local government spending to reduce industrial pollution.

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

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

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

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

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

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

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

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

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

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

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

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

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

2.4 Research Methods

2.4.1 Data

This study uses secondary data from China City Statistical Yearbook. It is collected and published by the National Bureau of Statistics of China (NBS). The unit of analysis is city. The time period is from 2003 to 2012. There are 284 cities in the data. Prefecture-level cities that they either were established after 2003 or had been merged with other cities during the studied time period are excluded. The remaining cities constitute an unbalanced panel data due to missing data (maximum 35 observations missing depending on the model). The reason for these missing values is not explained in the Statistical City Yearbook. Thus, it is not clear if they are missing randomly or on purpose.

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

2.4.2 Dependent Variables

A city's industrial SO2 emission is the industrial pollutant that will be used to measure industrial pollution. An advantage of emission data is that it directly measures economic activities (He, 2009). To measure the relationship between total emission and economic growth, total industrial SO2 emission measured in metric tons is used as dependent variables. Following most EKC studies, per capita industrial SO2 is used as a dependent variable. Industrial pollution emission density is also included as a dependent variable. It is created by the ratio of total pollution emission to the area of a city. Table 2.1 lists the basic descriptive statistics for the included variables. Figure 2.1 shows the time trend for the major variables categorized by administrative rank, and please see Table 2.1 for the unit of the vertical axis.

Table 2.1: Descriptive statistics

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

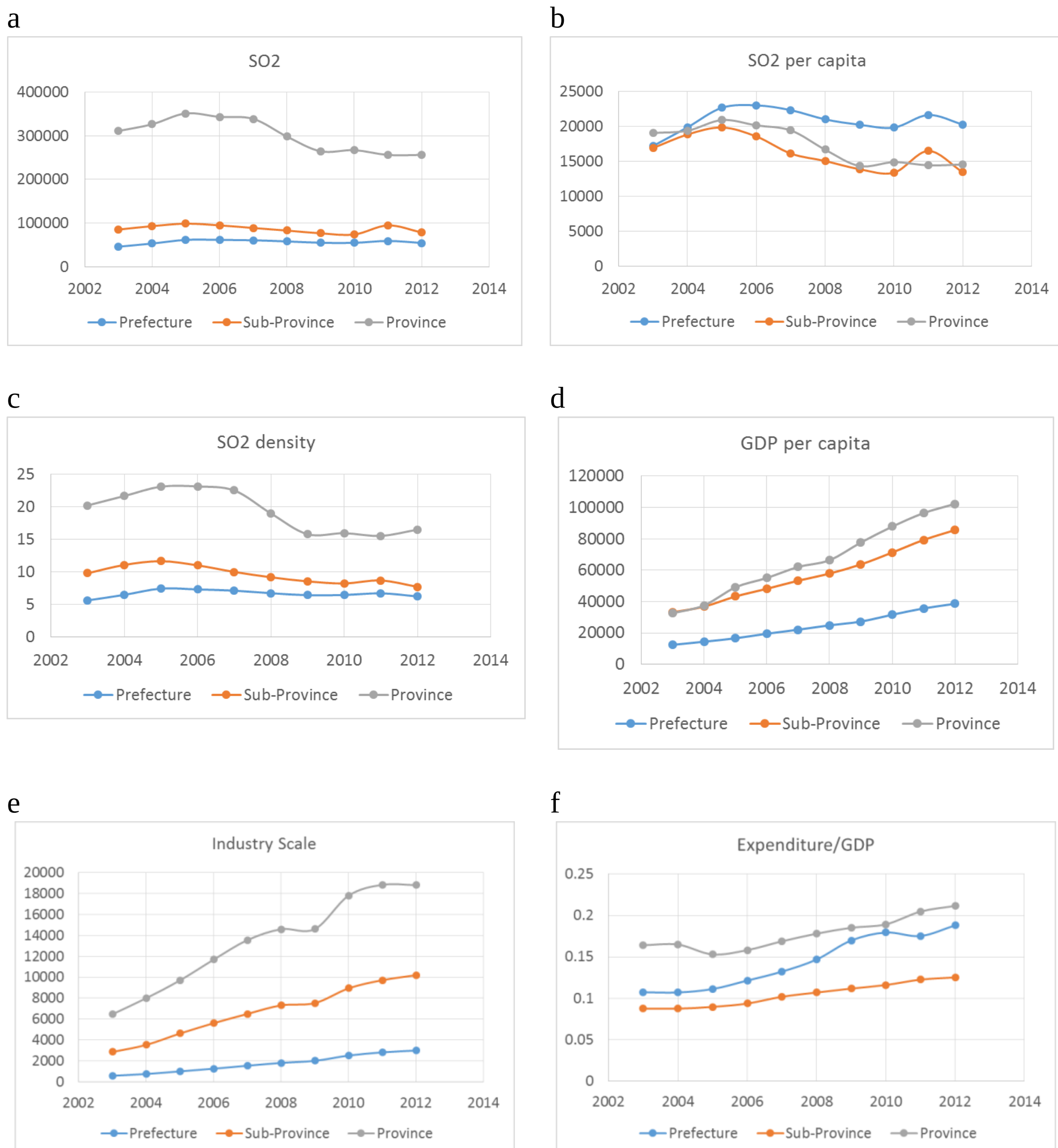

Figure 2.1: Time trend of the included variables for each administrative rank

2.4.3 Independent Variables

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

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

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

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

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

2.4.4 Models

Equation (1) is established to test H1.

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

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

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

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

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

2.5 Estimation Results

The results for equation (1) with different measurements of industrial SO2 emission are reported in Table 2.2. Both fixed effects (FE) and random effects (RE) models are estimated. Considering the possible heteroscedasticity issue, all models are estimated with robust standard errors. Hausman tests are statistically significant; thus, the results from the FE models are more consistent than the results from the RE models. Nevertheless, the results show no qualitative differences between the two estimation models. GDP per capita and industrial SO2 pollution conform to the EKC relationship at the city level in China. The slope of EKC shows a statistically significant difference between the prefecture-level city and the province-level city. Figure 2.2 presents the EKC curves for cities at the three levels. It shows that the increase of GDP per capita reduces industrial SO_2 density for sub-province-level and province-level cities with the sample data. The increase of GDP per capita still increases industrial SO_2 density for the prefecture-level city.

Table 2.2: Statistical results for the simple EKC model

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

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

The robust standard error is in the parentheses

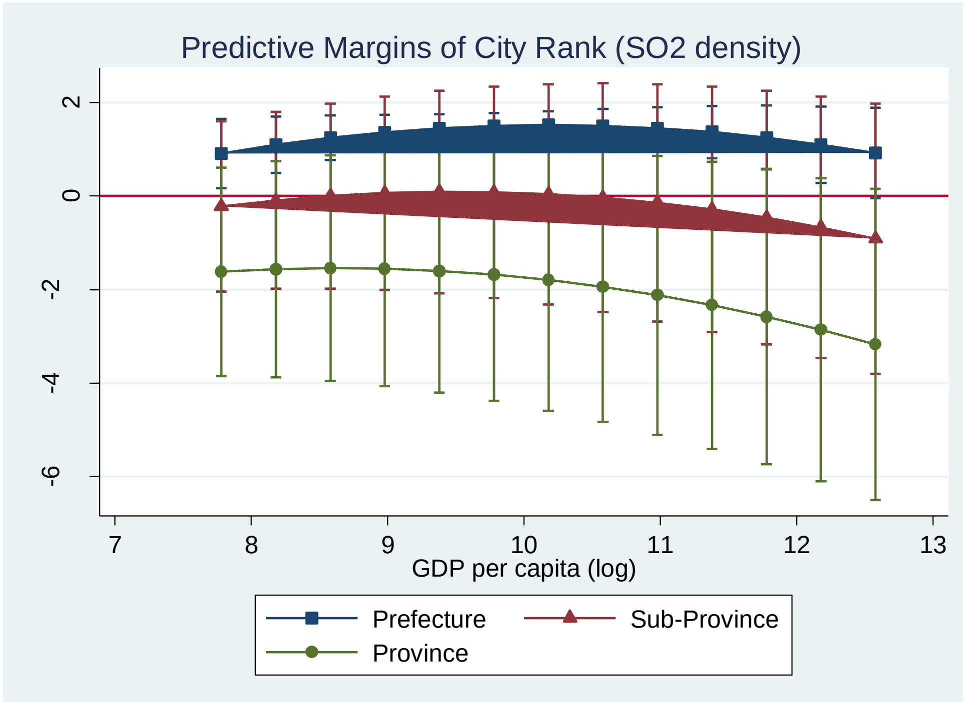

Figure 2.2: The EKC curves for the three level cities

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

More variables are added as I move from Equation (1) to the full models based on Equation (2). The purpose is not to select the best fitting model but for investigating the relationships between the variables given the potential issue of high multicollinearity. Table 2.3 includes the estimation results for industrial SO2 per capita from these gradually built FE models. GDP per capita is dropped in the final model based on the results: It is not statistically significant any more after including industrial scale, and it is highly correlated with industrial scale. Other variables in the models show consistent results in different models. This consistency reduces the possibility of high multicollinearity. Column (5) of Table 2.3 shows the estimation results from the same model as them showed in equation (2). The difference is, however, that these results are estimated with missing data. The estimation results show no qualitative differences in terms of the sign and statistical significance of coefficients comparing to the estimation results in Table 2.4.

Table 2.3: Statistical results for model comparison

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

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

The robust standard error is in the parentheses

Table 2.4: Statistical results from equation (2)

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

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

The robust standard error is in the parentheses

Table 2.4: (continued)

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

* significant at 10%, ** significant at 5%, *** significant at 1%
The robust standard error is in the parentheses

The results for equation (2) with different indicators of industrial SO2 emission are reported in Table 2.4. Both FE and RE models are estimated. Hausman tests are statistically significant and thus the results from FE models are more consistent than the results from RE models. The estimation results are consistent with the previous results. The results for the main individual variables are consistent and similar in terms of the sign and the significance level for industrial SO2 emissions per capita, density, and total quantity. Industry scale and SO2 emission conform to the EKC type of relationship, which is often revealed in other empirical EKC studies (e.g., Panayotou, 1997). Administrative rank has a statistically significant effect on this EKC relationship: Higher ranked cities have a smoother inverted-U curve, as they are shown in Figure 2.3 and

Figure 2.4. These results support the hypothesis that higher-level cities have a market with a less pollution intensive industry due to their administrative and political advantages.

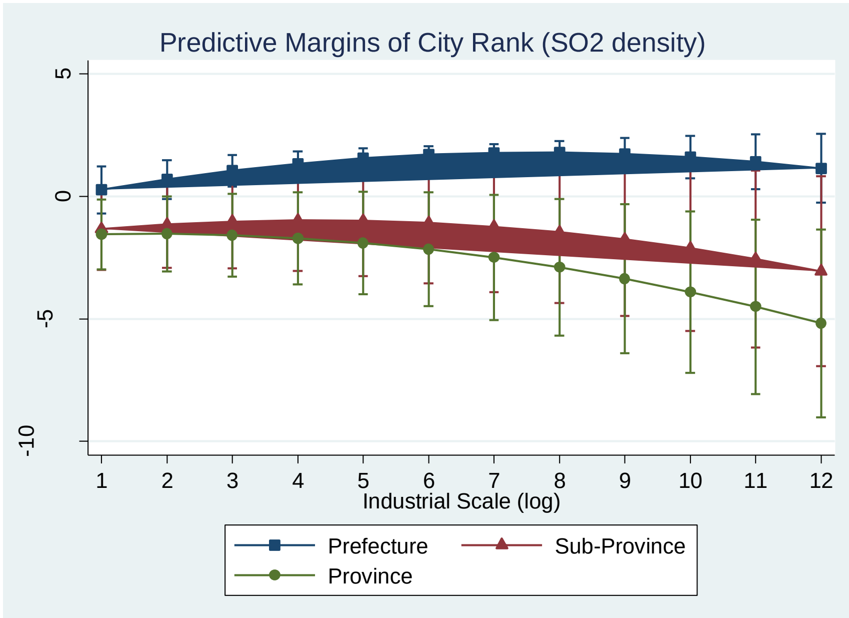

Figure 2.3: Marginal effects of industrial scale and government size on industrial SO2 emission for the three-level cities

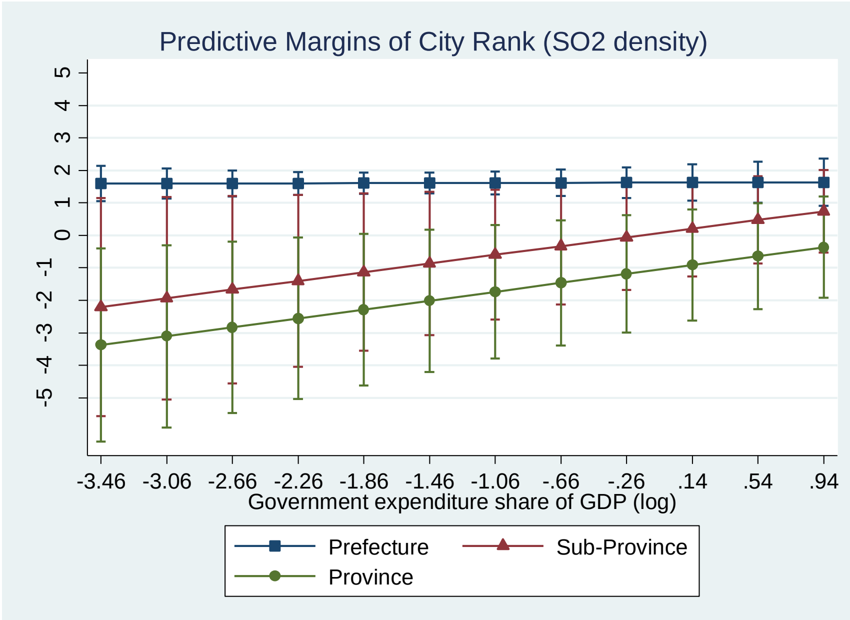

Figure 2.4: Marginal effects of government spending size on industrial SO2 emission for the three-level cities

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

Administrative rank affects a local government's spending behavior based on the results in Table 2.4. Its effects are also shown in Figure 2.3. A higher-level local government's expenditure increases its industrial SO2 emission. Nevertheless, when it comes to group comparison, the higher-level cities and their spending do reduce more industrial SO2 emission comparing to the lower-level cities. This group difference supports the proposed hypothesis.

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

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

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

2.6 Conclusions and Policy Implications

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

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

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

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

CHAPTER 3: ECONOMIC DEVELOPMENT AND ENVIRONMENTAL CONCERN IN CHINA

3.1 Introduction

China has become the world's second largest economy since the economic reform took off in the late 1970s. Poverty is no longer an issue for majority of the Chinese people, and many of them are able to enjoy a prosperous life. Nonetheless, along with economic growth, pollution problems also have become severe in numerous areas in China. Air and water pollution issues have been especially notorious since the early 2000s. They directly decrease the life quality of Chinese people. In the meantime, studies have revealed that Chinese people in general have a high-level of environmental concern (Harris, 2008; Xiao, et al., 2013). This increased environmental concern along with economic development are often cited as support for the occurrence of an environmental Kuznets curve (EKC). Income per capita, either GDP per capita (e.g., Panayotou, 1997; He, 2009) or household income (i.e., Plassman & Khanna, 2006), is usually the proxy of economic development applied in empirical EKC studies. The question then is: Does growing income (both at aggregate and individual levels) increase individual environmental concern in China?

Environmental concern studies have yield conflicting findings on the relationship between income and individual environmental concern. Studies based on the World Values Survey (WVS) and the International Social Survey Programme (ISSP) found a positive relationship between these two variables (e.g., Kemmelmeier, et al., 2002; Franzen & Meyer, 2010). However, other studies found that people in rich countries express a comparatively lower environmental concern (e.g., Givens and Jorgenson, 2011). The results from studies on China are inconclusive. For example, the study by Yu (2014) indicated no statistically significant relationship using their own survey data from 2011. Xiao, et al. (2013) applied a comprehensive measurement of environmental concern of Chinese citizens, but they did not reveal a statistically significant effect of personal income neither.

The main purpose of this study is to test this income and environmental concern relationship. I argue that this relationship is weak—not only due to research design and measurement issues in empirical studies, but because theories also imply a weak, if not nonexistent, connection. The affluence hypothesis (i.e., Franzen & Meyer, 2010) states a positive relationship between national income and individual environmental concern, but its theoretical argument, based on economic theories, is problematic. Economic theories predict individual behaviors but not concerns, attitudes, or values. Inglehart's postmaterialist value theory or Postmaterialism states that a higher proportion of people have postmaterialist values in industrialized countries; therefore, a higher percentage of people would have a higher level of environmental concern (Inglehart, 1995). Nevertheless, economic prosperity is only the precondition for people to have postmaterialist values. Education, information sharing, and generational replacement are the direct factors shaping people' postmaterialist values. Economic variables are likely to be statistically insignificant after considering these direct factors; thus, the second purpose of this study is to test the effects of education and information on environmental concern.

This study applies a hierarchical linear model to capture the effects from both province and individual levels with data from the Chinese General Social Survey (CGSS) 2010. The policy implication from this study is that the higher income brought by economic development has little direct influence on individual environmental concern. The increase in education level and accessibility of information induced by economic development are the most important factors that increase the Chinese people's environmental concern.

The structure of this study is organized as follows. Section Two briefly introduces the concept of environmental concern. Section Three examines the theoretical grounding for the income and environmental concern relationship. This section also briefly discusses the relationship between individual environmental concern and level of education and accessibility of information. Section Four introduces the data and the research methodology. Section Five will reports the statistical results. Section six presents conclusions and policy implications.

3.2 Defining and Measuring Environmental Concern

Environmental concern is a concept, as many others, with ambiguity. Concern is a word frequently used in daily life to express one's worries about, or interests in a phenomenon. These interests and worries are revealed through both verbal and behavioral expressions. Academic definitions of environmental concerns are similar to its daily usage. Sociologists Dunlap and Jones (2002, p. 485) define it as "…the degree to which people are aware of problems regarding the environment and support efforts to solve them and or indicate the willingness to contribute personally to their solution." This conceptualization is inclusive and general: concern refers to various forms of expressions

(Xiao, et al., 2013). This general definition is implied in empirical environmental concern studies in which concerns, attitudes, awareness, beliefs, and consciousness are often used interchangeably (e.g., Xiao & Dunlap, 2007; Xiao, et al., 2013). Social psychologists often loosely equate environmental concerns with environmental attitudes, which narrow the boundary of environmental concerns (e.g., Weigel & Weigel, 1978; Schultz, 2000, 2001; Milfont & Duckitt, 2010). The concept of attitude is itself debatable, but here I use the definition from Rokeach (1968, p. 112): “a relatively enduring organization of beliefs around an object or situation predisposing one to respond in some preferential manner.” This attitude definition is similar to the definition of environmental concern proposed by sociologists. One reason is that attitudes, values, belief, and intentions are distinctive concepts in social psychology, but they are closely related. Their boundaries are not clearly defined, and this ambiguity is one reason that sociologists and scholars from other disciplines often use them interchangeably.[12]

The dimensionality of environmental concern is controversial both theoretically and empirically. The dimension of environmental concern is usually concluded based on a factor analysis with survey data generated from certain environmental issue related questions. Studies (i.e., Xiao, et al., 2013) usually categorize questions into several facets, such as local and global environmental issues, willingness to pay for environmental protection, and general beliefs on the environment. Then they conclude environmental concern is one dimension if all these questions have high factor loadings on one underlying factor (e.g., Guber 1996; Xiao & Dunlap, 2007; Xiao, et al., 2013). Other

[12] Please see Rokeach (1968) for some discussion on these concepts.

studies (e.g. Shultz, 2001) revealed more than two dimensions. The issue with this approach is that the dimensionality of environmental concern is highly dependent on the sample data used for the study.

Existing empirical studies mainly use survey questions to measure environmental concern, but in general there are two types. One type of environmental concern study tries to use a comprehensive measurement scale to measure the general underlying construct of a person's environmental concern (e.g. Xiao & Dunlap, 2007; Xiao, et al., 2013). Another common type of study includes only one or a few questions on certain specific environmental issues (Kemmelmeier, et al., 2002; Gelissen, 2007; Givens & Jorgenson, 2011).

In summary, environmental concern is still a controversial concept. Sociologists take it as a common construct underlying an individual's values, beliefs, attitudes, awareness, and behaviors. Social psychologists consider it as a type of attitude. Empirical studies revealed either one or several dimensions of environmental concern. Such variability in definition and measurement is one of the causes of the uncertain relationship between income and environmental concern.

3.3 Economic Development and Environmental Concern

3.3.1 Individual Income and Environmental Concern

At the individual level, income is usually not a particularly interesting variable in environmental concern studies, especially if the studies are from the social psychological perspective. Empirical studies revealed conflicting results on this relationship. Kemmelmeier et al (2002) revealed a positive relationship. Xiao and colleagues (2013) applied a comprehensive environmental concern indicator, but the results revealed a statistically insignificant relationship between income and environmental concern at the individual level. These conflicting empirical results are likely to reflect weak theoretical foundation for the positive relationship.

The issue with some studies on income and environmental concern is that they often combine the theoretical discussions on environmental behaviors with environmental concerns. They, therefore, implicitly assume the relationship between income and environmental behaviors can be applied to income and environmental concerns. Kemmelmeier et al (2002) argue a direct relationship between income and environmental concern with the following support: “The time, energy, and money spent on costly environmental behaviors may prevent those whose resources are barely enough to cover basic expenses from significantly improving their own standard of living” (p. 260). This argument is more about income and environmental behavior than about concern. Givens (2011) also combines the arguments of concern with behavior: “A common assumption regarding environmental concern is that only those who are affluent enough to care about concerns beyond immediate survival are able to devote energy to environmental problems and to engage in actions that demonstrate such concerns” (p. 76). Nevertheless, environmental concern or attitudes and environmental behaviors are different. Environmental concern is about a person’s beliefs and attitudes, not about actually demonstrating them through behaviors.

At the individual level, environmental concern studies (e.g., Kemmelmeier et al, 2002) also apply Maslow's (1954) hierarchy of needs theory to support a positive relationship between income and environmental concern. The hierarchy of needs includes five levels (from the lowest to the highest): physiological, safety, love/belonging, esteem, and self-actualization. Environmental problems may be related to both lower level and higher level needs in this hierarchy. These problems should be included in the safety needs if pollution directly influences people's health; however, for such problems as global climate change, most people do not directly feel the impact yet. This type of environmental issue can be included in the higher level of needs or even the highest level because it is about morality and problem solving. Income, as an instrument to achieve lower-level needs of survival and safety, is not a main component of personal needs once the basic needs are satisfied. So, we can apply this hierarchy of needs theory to predict a positive relationship between an individual's economic condition and his/her environmental concern. Nonetheless, the hierarchical needs also indicate that income has no strong relationship with environmental concern after the accomplishment of safety needs, i.e., people pay less attention to income after they advance to the higher needs.

In sum, the relationship between individual income and environmental concern has a weak theoretical support, and inconsistent empirical results are a sign of this lack of support from these theories. Only Maslow's hierarchical needs theory supports a likely positive relationship between income and environment concern. Based on his theory this study hypothesizes that:

H1: The higher an individual income is, the more environmental concern he/she has.

3.3.2 National Income and Environmental Concern

Environmental concern studies (e.g., Kemmelmeier et al, 2002; Gelissen, 2007; Duroy, 2008) often apply the affluence hypothesis proposed by Axel Franzen and his colleagues (Franzen, 2003; Franzen & Meyer, 2010) and Inglehart's Postmaterialism theory to argue a positive effect from national income on environmental concern. Nonetheless, as will be explained later, the theoretical foundation of the affluence hypothesis is not a proper support for this proposition. Inglehart's Postmaterialism theory indirectly connects economic prosperity with environmental concern. This connection would disappear once the direct factors (e.g., values, education, and information) are considered.

One issue with the affluence hypothesis is that Franzen and Meyer (2010) applied the income-demand relationship for environmental goods to the income and environmental concern without further justification. Environmental concern is related to, but different from, environmental demand. In economics, demand is loosely defined as the quantity people buy at some certain price in the market or shadow price. It indicates people's actual behaviors with income change. It consists of two parts: desire to buy (or taste) and ability to pay. Conventional economic theories of human behavior assume stable taste or preference in order to study the relationship between income and demand.[13] Income, as part of ability to pay, is a key component of demand. Thus, income is closely related to (as a constraint of) demand. With the income constraint, price signals, and utility maximization, economic theory is able to predict behaviors of a rational individual with a stable preference. However, its relationship with environmental concern is not as explicit as it is with demand because concern can be expressed through both subjective expressions and objective behaviors. Income should have a stronger

[13] Preferences or tastes are usually not the study topic of mainstream economics but social psychology.

relationship if the environmental concern is measured by actual behaviors. Otherwise, other salient factors involved in this relationship should play the dominant role.

Another key concept they (i.e., Franzen & Meyer, 2010) applied is “willingness to pay” which is defined as “[t]he maximum amount consumers are willing and able to pay for a particular quantity of a good or service” (Hackett, 2011, p. 47). In economics, it is a concept closely related to demand: the area under a demand curve. Income directly affects a person’s willingness to pay. Nevertheless, environmental concern, in general, is not confined by income. Economic theories cannot be applied to explain this income-concern relationship without further justification.

Ronald Inglehart's postmaterialist value theory directly connects a national wealth to individual values and indirectly connects wealth to individuals’ environmental concern under the condition of value change (1977; 1990; 1995; 1997). It states that “[t]he values of Western publics have been shifting from an overwhelming emphasis on material well-being and physical security toward greater emphasis on the quality of life” (Inglehart, 1997, p. 3). High environmental concern is a consequence, or a component, of postmaterialist values (e.g., quality of life and self-expression). Inglehart (1977) proposed two assumptions in order to establish his postmaterialist value theory: (1) basic economic scarcity is not an issue and (2) values are shaped through socialization in early childhood and stay stable in adulthood. The first hypothesis emphasized the wealth of a nation as the precondition of emerging postmaterialist values. The second hypothesis has two implications. First, it refers that the value change as a long-term intergenerational replacement, meaning that younger people with postmaterialist values and grow into older people with the same values. The other implication is that value changes are a socialization process, which is affected both by economic and such social factors as education.

Inglehart's postmaterialist value theory explains environmental concern as a component of postmaterialist values or as an attitude formed based on these fundamental values. Nonetheless, economic security is not the only source of value change; it is only the precondition. The connection between national income and environmental concern may disappear after considering the level of postmaterialist values a person has. Empirical studies also revealed conflicting results on this relationship. Studies have provided empirical evidence of a direct positive relationship between income and environmental concern at the national level (e.g., Gellisen, 2007; Franzen & Meyer, 2010); while other studies revealed a negative relationship (e.g., Givens & Jorgenson, 2011).

In sum, the most cited theory and the hypothesis do not support a strong positive relationship between national income and environmental concern. In order to test this relationship, the following hypothesis is proposed in the context of China:

H2: The higher a provincial GDP per capita is, the more environmental concern the individual has.

Another hypothesis is proposed based on Inglehart's Postmaterialism theory.

H3: The stronger an individual's postmaterialist value is, the more environmental concern he/she has.

3.3.3 Personal Development and Environmental Concern

Inglehart considers economic safety as a foundation for people to form post-materialist values. Nevertheless, the other developments induced by economic prosperity are main sources that change people's values. They are the expansion of education and the development of mass communications. These sources are essential instruments for human development—the single underlying process of social economic modernization, value changes, and democracy (Inglehart & Welzel, 2005, p. 2). Individual environmental concern is, therefore, affected by these factors that contribute to personal development.

Inglehart uses education to explain postmaterialist value changes. Education "…reflects a modern scientific orientation, openness to change, and possession of the cognitive skills necessary to understand new practices" (Pampel & Hunter, 2012, p. 7). Environmental concern, as an attitude, includes a cognitive component (Maloney & Ward, 1973). A direct connection, thus, is established through attitude theories from social psychology (e.g., Maloney & Ward, 1973; Fishbein & Ajzen, 1975). Inglehart also considers education as an instrument to improve individual intellectual and social independence; therefore, individual autonomy is increased. This individual independence facilitates people to pursue goals other than basic economic safety (Inglehart & Welzel, 2005). Education is, therefore, often considered as positively affecting individual environmental concerns and behaviors. Empirical studies (e.g., Lee & Zhang, 2008; Givens & Jorgenson, 2011; Xiao, et al., 2013) also support this positive relationship.

The improvement of mass communications is another source for human development emphasized by Inglehart's postmaterialist value theory. It refers to the accessibility of information for a person. Information is also the basis for a person to form his/her environmental concerns or attitudes because it directly relates to the three components of attitudes: affective, cognitive, and conative (intensive) components

(Maloney & Ward, 1973; Fishbein & Ajzen, 1975). It also increases a person's postmaterialist values through enhancing individual autonomy.

In sum, economic development usually brings forth improvements in education and accessibility to information. These changes can facilitate people to own postmaterialist values. They also affect the three components of environmental concern/attitudes. Two hypotheses are therefore proposed:

H4: The higher an individual's education level is, the more environmental concern he/she has.

H5: The more information a person has, the more environmental concern he/she has.

3.4 Research Design

3.4.1 Data

This study uses a cross-sectional secondary data set—the Chinese General Social Survey (CGSS) 2010. CGSS is a first national level, comprehensive, and successive social survey program, which started in 2003. Its sample includes individuals from 125 counties (districts), 500 streets (villages and towns), 1,000 neighborhoods, and 10,000 households. The total sample size for the part about environmental questions is 3672. The sample size of this study is 1239 after dropping all missing values. Here are the steps used to generate the sample for this study. First, I choose only respondents who reside in urban regions (N=2351). This decreases the heterogeneity in the sample: Yu (2014) showed that rural people are in general less environmentally concerned (measured by the NEP scale) than urban people in China. Second, some respondents did not give the amount of their incomes. They fell into the "don't know," "refuse to answer," and "not applicable" categories. I deleted the observations with these answers and other missing values. In the education question, four people answered "others." This answer is not consistent with the general order of the answers for this question; thus, I delete them. Province-level data of GDP and population density came from the Chinese City Statistical Yearbook 2011.

3.4.2 Dependent Variables

This study applies two scales created through exploratory factor analyses to measure environmental concern: willingness to pay for improving the environmental quality (WILLING) and the new ecological paradigm (NEP) scale. Please see Table 3.1a and 3.1b for the items for these two scales. The scale WILLING is generated through exploratory factor analyses based on eleven items that tap into individual environmental concern and is used in other environmental concern studies (i.e., Franzen & Meyer, 2010). The four willingness to pay items have a good loading (higher than 0.5) to a single factor. The Cronbach's alpha (0.8) reveals a high reliability to create a scale with these four items. Items 6 and 7 in Table 3.1a also have a good factor loading on a single factor, however, the Cronbach's alpha (0.39) is low, so these items are not reliable to compose a scale.

Table 3.1a: Environmental concern--WILLING (item1-4)

1	How willing would you be to pay much higher prices in order to protect the environment?
2	How willing would you be to pay much higher taxes in order to protect the environment?
3	How willing would you be to accept cuts in your standard of living in order to protect the environment?
4	I do what is right for the environment, even when it costs more money or takes more time.
5	Modern science will solve our environmental problems with little change to our way of living.
6	We worry too much about the future of the environment and not enough about prices and jobs.
7	People worry too much about human progress harming the environment.
8	In order to protect the environment the country needs economic growth.
9	It is just too difficult for someone like me to do much about the environment.
10	Almost everything we do in modern life harms the environment.
11	Economic growth always harms the environment.

This study also applies the NEP scale—another popular scale used in environmental concern studies (e.g., Xiao, et al., 2013). There are 15 items for this scale (Table 3.1b) designed with the intention to measure a coherent environmental belief or worldview (Dunlap, et al., 2000). Nevertheless, the NEP scale often reveals two or three dimensions—which are dependent on the specific samples—in empirical studies (Dunlap, et al., 2000). The factor analyses revealed two dimensions in this sample. This essay applies only one factor since it includes the eight items (all odd number items) that cover a comprehensive view on the relationship between humans and the natural environment. The Cronbach’s alpha (0.76) reveals a high reliability of the created scale based on these eight items. Please see Table 3.2a for the descriptive statistics.

Table 3.1b: Environmental concern—NEP scale

1	We are approaching the limit of the number of people the earth can support.
2	Humans have the right to modify the natural environment to suit their needs.
3	When humans interfere with nature it often produces disastrous consequences.
4	Human ingenuity will insure that we do NOT make the earth unlivable.
5	Humans are severely abusing the environment.
6	The earth has plenty of natural resources if we just learn how to develop them.
7	Plants and animals have as much right as humans to exist.
8	The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9	Despite our special abilities humans are still subject to the laws of nature.
10	The so-called "ecological crisis" facing humankind has been greatly exaggerated.
11	The earth is like a spaceship with very limited room and resources.
12	Humans were meant to rule over the rest of nature.
13	The balance of nature is very delicate and easily upset.
14	Humans will eventually learn enough about how nature works to be able to control it.
15	If things continue on their present course, we will soon experience a major ecological catastrophe.

Table 3.2a: Descriptive statistics

Variable	N	Mean	Std Dev
WILLING	1239	2.21	0.61
NEP	1239	2.14	0.30
Gender	1239	0.50	0.50
Party member	1239	0.20	0.40
Adjusted family income	1239	36440	85119
Education	1239	6.44	3.13
Reading	1239	2.83	1.24
Internet	1239	2.71	1.74
Postmaterialism	1239	0.51	0.56
Province GDP per capita	1239	40375	18681
Subjective environmental quality	1239	3.76	0.27
Population density	1239	0.61	0.68

3.4.3 Independent Variable

Following Franzen and Meyer (2010), individual income is measured by household income adjusted by the square root of the size of the household in 2010, which is a continuous variable. It is measured in Chinese yuan. Household income comprises the households’ salary, pension, dividend, interest, insurance, and gifts. This adjusted household income, used by OECD studies, tries to capture the economy of scale effect on a household. In Table 3.2b, the correlation coefficients between adjusted family income and the two dependent variables represent a weak but positive relationship.

Table 3.2b: Correlation coefficients for the major variables

Pearson Correlation Coefficients, N = 1239

	WILLING	NEP	Gender	CCP	Adjusted family income	Education	Reading	Internet	Postmaterialism	Gdp per capita	Environment quality	Population density
WILLING	1											
NEP	0.14 ***	1										
Gender	-0.09 ***	-0.02	1									
CCP	0.08 ***	0.04	-0.21 ***	1								
Adjusted family income	0.03	0.03	0.015	0.13 ***	1							
Education	0.06 **	0.13 ***	-0.09 ***	0.28 ***	0.36 ***	1						
Reading	0.13 ***	0.16 ***	-0.22 ***	0.24 ***	0.16 ***	0.32 ***	1					
Internet	0.008	0.11 ***	-0.05 *	0.12 ***	0.29	0.53 ***	0.22 ***	1				
Postmaterialism	0.06 **	0.03	-0.06 **	-0.05 *	0.03	0.09 ***	0.03	0.13 ***	1			
GDP per capita	-0.02	0.10 ***	0.02	-0.0008	0.0006	-0.01	0.01	-0.03	0.002	1		
Environment quality	0.20 ***	0.10 ***	-0.03	0.09 ***	0.006	-0.01	0.005	-0.02	-0.0009	0.18 ***	1	
Population density	0.04	0.13 ***	0.005	0.01	-0.0006	-0.005	0.003	-0.02	-0.009	0.72 ***	0.25 ***	1

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

Provincial GDP per capita measures a provincial income. It has an indirect but positive relationship with environmental concern based on Inglehart's postmaterialist value theory. The correlation coefficients show a statistically significant and positive relationship with the NEP scale but a weak negative relationship with the WILLING scale.

The measurement of Postmaterialism is standardized and based on four questions. Two questions represent post-materialist values and the other two represent materialist values. Postmaterialism is then coded as follows: 0 = the respondent has no postmaterialist values based on the questions; 1 = the respondent answered "yes" to one Postmaterialism question; and 2 = the respondent answered "yes" to two Postmaterialism questions. In table 3.2b, individual Postmaterialism is positively correlated the two dependent variables but only statistically significant with WILLING.

Education is an ordinal variable with thirteen categories. The higher the number is, the higher is the education level. In the sample of this study, education shows a statistical positive correlation with individual-level income but a weak negative correlation with GDP per capita. It also shows statistically significant correlations with the two dependent variables in Table 3.2b.

Accessibility of information is measured by two variables: usage of internet and reading. Other than formal education, an increasing proportion of people obtain their information or knowledge from the internet. Internet, as an open source, contains broader information, perspectives, and values than the traditional media (e.g., newspapers, TV programs, and radio). Thus, an individual's use of the internet should affect his/her cognitions about the world on which the environmental concern is based. The frequency of using the internet in the past year is used to measure this information instrument. The other variable measuring a person's level of information is reading news related papers, magazines, and books. It is measured with a five-level ordered scale where a higher value indicates a higher frequency of reading. In Table 3.2b, they both show statistically significant correlations with the two dependent variables.

3.4.4 Control Variables

Environmental concern, a construct consisting of attitudes, beliefs and awareness, is socially forged. Thus, the main variables (both individual- and societal-level) used to explain these concepts should be included to explain individual environmental concern. Individual-level factors include gender, the Party membership, and the respondent's age at the individual level. These are the regular socio-demographic variables included by most studies in this area. Please see the descriptive statistics in Table 3.2a.

Gender is a binary variable, which includes 1 = female and 0 = male. Scholars revealed different empirical effects of gender on environmental concern. Some findings support that women in general are more concerned about environmental issues than men are (e.g., Shen & Saijo, 2008; Wong & Wan, 2011; Xiao & McCright, 2012). The explanation is that men focus on working and making money to sustain their families, but the role of women is a care giver: They take care of the family and nurture their children. Thus, women are more sensible than men to environmental issues and protection. Nevertheless, men could have a higher level of concern too: They are more likely to be politically active, more involved with community issues, and normally have higher levels of education than women. Xiao and Hong (2012) revealed that in general men in urban

China processed a higher level of environmental concern than the women based on the data of CGSS 2003.

Age is originally measured in number of years, but it is further coded as six dummy variables to capture the possible cohort effects. The reference cohort is the group with age older than 65. Social psychologists believe that people's values are shaped in their early age, and they maintain stable throughout people's life time. Inglehart's postmaterialist value theory also assumes this property of value, and argues that young people are more likely to have postmaterialist values. The generational replacement (one assumption of Inglehart's theory), therefore, eventually leads to a nation with a high proportion of people with postmaterialist values. Van Liere and Dunlap (1980) explain that younger people are less integrated into dominant social order to which solutions to environmental problems often are viewed as threatening. Many studies also support this negative relationship between age and environmental concern (e.g., Gelissen, 2007; Xiao & Dunlap, 2007; Franzen & Meyer, 2010). Nevertheless, some Chinese studies have showed either weak or positive effects from age (i.e., Shen & Saijo 2008; Xiao, et al., 2013).

Population density and a subjective environmental quality variable are included at the province level to control for their influences on individual environmental concern. Franzen and Meyer (2010) applied population density to indicate the environmental quality and the degree of urbanization of a country. They reasoned that a high population density caused more environmental conflicts; therefore, it caused a higher level of environmental concern. It shows positive correlation coefficients with the two dependent variables in Table 3.2b supporting their reasoning.

The provincial mean value of the personal experience with environmental issues is included as an indicator for a general environmental quality of a province. This variable is measured by the question "To what degree do you agree with: Environmental issues directly affect your daily life?" The answer includes a five-level scale, which is from totally disagree to totally agree. It is expected to increase individual environmental concern. People are directly affected by the environmental quality around them. They would express more concern about it if the environmental quality is low. Numerous studies (e.g., Brechin & Kempton, 1994; Dunlap & Mertig, 1995; Inglehart, 1995; Brechin, 1999) have demonstrated this positive relationship and named it as "poor people's environmentalism." Its strong positive correlation coefficients with the two dependent variables also support this expectation.

3.4.5 Model and Estimation Technique

The hierarchical linear model (HLM) is applied in order to include both individual- and province-level factors. This model generates less biased estimates than a regular linear model because individuals are nested within provinces in this data set. Provinces are heterogeneous. The distribution of individuals could be affected by the province-level characters; therefore, it could cause bias estimated by pooled data regressions. One possible cross-level effect is included in the models: A location's GDP per capita may affect the effect of individual income on individual environmental concern. Province-level variables are centered on the grand mean—the average value of all observations.

Other than dummy variables, individual-level independent variables are centered on the group mean—the average values within a province. To center individual-level variables is for a meaningful interpretation of the intercept. The intercept refers to the expected value of the dependent variable when all the independent variables valued at zero. Nevertheless, it is practically meaningless to assign zero value to some variables (e.g., education). The following rationale analyzed by the other two articles (Hoffman & Gavin, 1998; Enders & Tofighi, 2007) support the group mean center used in this study: The first priority of this study is individual-level income; and cross-level interaction between GDP and personal income is of substantive interest.

The individual level model is written out in equation (1). The subscript j indicates province, and subscript i indicates observations within the province j. At the province level, only random intercept model (equation (2)) is shown here. This study tried random individual-level coefficient models, but they were not statistically significant. Thus, the models and their results are not shown. Random coefficients are tested for adjusted family income and education.

$$\text{Environmental Concern}_{\text{ij}} = \alpha_{0\text{j}} + \alpha_1 sex_{\text{ij}} + \cdots + \alpha_{12} postmaterialism_{\text{ij}} + \text{e}_{\text{it}} \quad (1)$$

$$\alpha_{\text{oj}} = \beta_{00} + \beta_{01} GDPP_{\text{j}} + \beta_{02} Pdensity_{\text{j}} + \beta_{03} Environquality_{\text{j}} + \text{u}_{0\text{j}} \quad (2)$$

3.5 Results

The results from HLM regressions are in Table 3.3a (WILLING) and 3.3b (NEP). I first ran the intercept only model (model 1 in the two tables) before adding other independent variables in the models. All intercepts are statistically significant, and this means that the variances between provinces have a significant effect on individual environmental concern. I then ran the model (model 2) with only a few individual-level variables to investigate the influence of the adjusted family income on environmental concern. Model 3 shows a model with all individual-level variables included. Model 4 includes the first province-level variable—GDP per capita. Model 5 is the full model with the other province-level variables included.

Table 3a: Determinants of individual willingness to pay with CGSS 2010 data

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	2.2***	2.3 ***	2.3 ***	2.3 ***	2.30 ***
Individual-level variables					
Gender		-0.09 ***	-0.05 (0.03)	-0.05	-0.05 (0.034)
Age (15-24)		-0.09	-0.10 (0.08)	-0.1	-0.08 (0.08)
Age (25-34)		-0.06	-0.06 (0.07)	-0.06	-0.06 (0.07)
Age (35-44)		-0.03	-0.02 (0.06)	-0.02	-0.02 (0.06)
Age (45-54)		-0.09	-0.11 (0.06) *	-0.11 *	-0.11 (0.06) *
Age (55-64)		-0.04	-0.04 (0.06)	-0.04	-0.04 (0.06)
Chinese Communist Party member			0.03 (0.05)	0.03	0.03 (0.04)
Natural log of adjusted family income		0.02	0.004 (0.015)	0.004	0.004 (0.015)
Education			0.007 (0.007)	0.007	0.007 (0.007)
Reading			0.05 (0.02) ***	0.05***	0.05 (0.015) ***
Internet surfing			-0.01 (0.01)	-0.01	-0.01 (0.01)
Postmaterialism			0.07 (0.03) **	0.07**	0.07 (0.03) **
Province-level variables					
Natural log of GDP per capita				-0.07*	-0.16 (0.11)
Population density					0.05 (0.09)
Environmental disturbance					0.36 (0.12) ***
Variance of intercept : place-level	0.041***		0.042***		0.028***
Explained variance intercept: place-level	11.08%		11.52%		8.05%
-2*Log Likelihood	2191.8	2150.6	2291.3	2150	2140.8
N of individuals	1239	1239	1239	1239	1239
N of Groups	30	30	30	30	30

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

Table 3b: Determinants of NEP with CGSS 2010 data

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	2.1***	2.1 ***	2.1 ***	2.1***	2.1 ***
Individual-level variables					
Gender		-0.02	0.003	0.003	0.004 (0.017)
Age (15-24)		0.08 **	0.02	0.02	0.03 (0.035)
Age (25-34)		0.05*	0.009	0.01	0.01 (0.035)
Age (35-44)		0.08***	0.05	0.05*	0.06 (0.033) *
Age (45-54)		0.03	0.01	0.01	0.01 (0.031)
Age (55-64)		0.08 ***	0.08 **	0.08 **	0.08 (0.032)**
Chinese Communist Party member			-0.01	-0.01	-0.01 (0.02)
Natural log of adjusted family income		0.008	-0.007	-0.007	-0.007 (0.0078)
Education			0.01 ***	0.01 ***	0.01 (0.004) ***
Reading			0.03 ***	0.03 ***	0.03 (0.008) ***
Internet surfing			0.009	0.009	0.009 (0.007)
Postmaterialism			0.008	0.008	0.008 (0.015)
Province-level variables					
Natural log of GDP per capita				0.05	0.01 (0.048)
Population density					0.09 (0.052)
Environmental disturbance					0.04 (0.038)
Variance of intercept : place-level	0.006				0.004
Explained variance intercept: place-level	6.57%				5.14%
-2*Log Likelihood	525.3		468.6	466.6	462.8
N of individuals	1239	1239	1239	1239	1239
N of Groups	30	30	30	30	30

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

The results from all the models show that family adjusted income does not affect a person's environmental concern. This supports the weak link between them discussed in the literature review. The results also support a weak relationship between GDP per capita and individual environmental concern. It is only statistically significant, but negatively, for model 4 in Table 3a. This statistical significance is gone after adding the other two province-level variables. In particular, the subjective measurement of a province’s environmental quality has a statistically significant positive effect on individual willingness to pay as expected. Population density shows a positive influence as expected but not statically significant.

The variables (education and information) which contribute to human development are better than the economic indicators as predictors of environmental concern. Education has a strong positive relationship with NEP but not with willingness to pay. Reading news is statistically significant in all the models for the two environmental concern indicators. In general, reading more newspapers and magazines increases a person’s environmental concern. Surfing the internet does not have a statistically significant effect on environmental concern. One possible explanation is that this question does not indicate surfing internet for news or some other type of things. People may surf internet only for fun. Unlike people who like to read news, these people may not gain information about the recent situations of the outside world.

Postmaterialism is statistically significant for the environmental concern measured by the scale of willingness to pay. This result supports Inglehart’s postmaterialist value theory. Environmental concern, as a value, should be a component of these postmaterialist values. A specific environmental concern toward a certain subject, as an attitude, can also be partially explained by postmaterialist values. Kemmelmeier et al. (2002) tested whether postmaterialism acted as a moderator between individual income and environmental concern measured by willingness to pay questions. Their finding is that postmaterialism is a more significant effect on environmental concern comparing with individual income. The results of this study add to the empirical evidence that postmaterialist values are important factors affecting a person's environmental concern.

The results for gender show an unclear picture. The only statistically significant result indicates that women have less environmental concern while holding the other variables constant. The age variable coded as six cohorts also shows a mixed picture. The reference group of age cohort is the people who are older than sixty-five. For the concern about willingness to pay to improve environmental quality, the younger generations manifest a lower-level of concern than the oldest generation. This finding is congruent with the results from two Chinese studies (i.e., Shen & Saijo, 2008; Xiao, et al., 2013). For NEP, the younger generations show a higher-level environmental concern than the oldest generation. Nevertheless, the youngest cohort (15-24) does not have a statistically significant higher environmental concern than the oldest. In sum, the results for age cohort does not show a generational trend assumed in Inglehart's postmaterialist value theory: The younger have more postmaterialist values due to economic prosperity, and the intergenerational replacement would lead to a society with a high proportion of people having postmaterialist values. The economy of China has been grew fast and steady since the late 1970s. A large proportion of people who were born around that time and after should enjoy economic safety all through their life time. This means that many people whose age is younger than about forty should pursue higher than materialist needs based on Inglehart's theory. Nonetheless, the results do not support this reasoning very well.

3.6 Conclusions and Policy Implications

The results estimated from the hierarchical linear models support the arguments of this essay: There is a weak relationship between income and environmental concern; education and information are important to improve people's environmental concern in China. Adjusted family income is not statistically significant at all for both environmental concern indicators. It even shows a negative insignificant relationship with the NEP scale. Provincial GDP per capita is a better predictor of environmental concern in this study, but its influences are not statistically significant after controlling the other two province-level variables. Education has a statistically positive influence on the NEP scale, and reading positively affect both environmental concern indicators. These findings support that environmental concern, as an attitude or belief, is consistently shaping by a person's knowledge and the information about his/her environment.

China has been experiencing rapid economic growth for several decades. Although the economic development level is still far away from developed countries, economic security is not an issue for the majority of Chinese people. The increase of GDP and personal income offers the precondition for Chinese people to pay more attention to other issues. Nonetheless, this saved personal energy/attention would not necessarily be put into forming postmaterialist values or higher environmental concern. Education and reading are important instruments for human development. They often improve with economic development, but not necessarily in perfect tandem. China has been emphasizing education since the economic reform. Nevertheless, this effort needs to be sustained or further strengthened with the Chinese government's consistent investments in education and in mass communications.

The results of this study are limited by the cross-sectional data. The relationships are estimated based on the differences between people. The results only show that there is statistical difference on income and environmental concern between the high income Chinese people and the low income in the year 2010. The causal relationship between reading and environmental concern is questionable. It could be that people who are more concerned about the environment like to read. The future study will need to apply longitudinal data to investigate the change of individual environmental concern with income change.

CHAPTER 4: POLICY IMPLICATIONS

This section gives a further discussion on policy implications based on the results from the three studies. I first discuss policy implications related to the environmental Kuznets curve (EKC) hypothesis because all three essays are related to it. I then discuss policy implications from each chapter.

The EKC hypothesis does not consider irreversibility issues in both human and natural resources. China's GDP per capita is still very low compared to the turning points revealed in empirical studies for various pollutants. However, the environmental quality is already severe in many areas. Some environmental damages will take many years to recover and others such as those to people's health are irreversible. Thus, one general policy implication is that Chinese governments need to actively work toward a better shaped EKC curve (i.e., with a smaller slope and lower turning point) through policies and also adjusting their behaviors through formal institutions.

The EKC also does not consider equality issue. The people who lives in smaller cities and counties have gained less in terms of economic benefits from economic growth but share a greater burden of pollution. China's environmental protection policy has been biased towards large cities. This policy is sound from an economic efficiency perspective because of the high population density in large cities. Nevertheless, from the environmental justice perspective, Chinese governments need to reduce industrial pollution in these smaller areas too.

The first study revealed that industrial SO2 emission tends to decrease if Chinese governments account for a smaller portion of GDP. The direct policy recommendation would be to distribute more GDP to the people. Nevertheless, the proportion of Chinese government spending to its GDP is much lower than the proportions of the OECD countries which are more than thirty percent. This statistical comparison and the institutional analysis presented in this study together suggest that the fundamental issue is not to reduce Chinese governments' income. The spending behavior of Chinese governments would increase the industrial SO2 emission under the current institutional setting which is dominated by growth-oriented institutions. This institutional environment motivates local governments to pursue economic growth without sufficient consideration of environmental degradation. Chinese governments, therefore, need to reform the two institutions discussed in the first two studies in order to reduce industrial pollution: the personnel/cadre evaluation system and the structure of the environmental protection system.

Chinese governments need to keep their efforts to maintain and increase environmental-related items on their cadre evaluation sheets. The cadre evaluation system, a part of the Chinese Communist Party (CPC) personnel control system, has been effectively motivating local government officials to pursue economic growth and social stability. With the decreasing environmental quality, the Chinese central government has tried to utilize this cadre evaluation system since the 11^{th} Five-Year plan (2006-2010). However, the still poor environmental quality shows that this so called "environmental cadre evaluation system" (Wang, 2013, p. 365) is not effective yet. Wang (2013) gave the explanation that these environmental quality related evaluation criteria were only implemented to the extent they supported the two top priorities: economic growth and social stability. Eaton and Kostka (2014) made another argument based on their two-year field study: The quick turnovers (3 or 4 years) of leading cadres lead local officials to emphasize short term economic gain but offer only weak incentives for improving environmental quality which often requires a long time to be reflected in measurable outcomes. Although this top-down approach of reforming cadre evaluation system has not been very effective, this is a beneficial policy in terms of reducing industrial pollution. This effort needs to be enhanced.

The key issue with Chinese environmental protection system is implementation, but the authority of the direct policy enforcement agency, the local environmental protection agency, has been weak since its establishment. Improving the power and autonomy of local environmental protection agencies will enhance the implementation of the environmental cadre evaluation system and reduce industrial pollution. The authority of personnel appointment and budgeting of a local environmental protection agency should be controlled by the higher level environmental protection agency instead of the local government in order to achieve better environmental protection.

The major policy implication from the second study is that the Chinese government needs to balance its resources allocation within its hierarchy. The lower-level localities within this hierarchy have been discriminated in terms of both political and administrative resources. Limited resources constrain a city's capacity in offering public service, and they also limit a local economic development which directly affect local industrial pollution and indirectly affect local public service due to poor fiscal condition. The Chinese government has been using intergovernmental transfer to keep the poor area with a minimum level of public service since tax reform in 1994, and this effort needs to be maintained and enhanced. The reason is simple: it is common for large cities to exploit their subordinate county-level cities and counties. The city–administering-county policy implemented in 1982 needs to be abandoned from the environmental justice perspective.

Another way to reduce industrial pollution emissions is to increase household consumption in China. The proportion of Chinese household consumption to the GDP is low comparing to other countries. The absolute consumption level is much lower when comparing to the developed countries. This low level of consumption is not only due to a general low GDP per capita, but also a high household saving rate. The precautionary saving theory attributes this high saving rate to the uncertainty about future income. This uncertainty is increased partly by the low-level of public service offered by Chinese governments. For example, Yang, Zhang and Zhou (2012) revealed that older people have a higher saving rate than the average rate in China. The explanation is that older people need prepare for their health cost. Sound pension and health care systems are able to lower the personal saving for this type of future uncertainty. The Chinese government has been actively reforming its pension and health care systems, and it needs keep its efforts.

Education can increase people's income and environmental concern. Chinese people have the tradition of valuing education. The investment from the Chinese government in education has been increasing slowly (Heckman, 2005). Comparing to developed countries, education investment in China, especially when measured in per capita, is still low (OECD, 2011). Chinese governments, therefore, need to spend more on education for economic development and also for promoting people's environmental concern.

A general policy implication for the Chinese government is to enhance state-building, i.e., "the creation of new governmental institutions and strengthening of existing ones" (Fukuyama, 2004). State-building can improve the quality of state intervention in its economy by enforcing the rule of games for the market to function. Economist Joseph Stiglitz emphasizes the importance of an effective government intervention in the market in his critics on the negative role of the IMF in the Asian financial crisis:

> There is now overwhelming support for the hypothesis that premature capital and financial market liberalization throughout the developing world, a central part of IMF reforms over the past two decades, was a central factor not only behind the most recent set of crises but also behind the instability that has characterized the global market over the past quarter century (Stiglitz, 2001, p. 14).

The Chinese governments need to reduce its scope of activities but strengthen their capacity (i.e., policy making, implementation, and evaluation) within reduced narrow but more appropriate scope. Fukuyama (2004) argues that the U.S. has an extraordinarily strong state due to its strong but legitimate coercive power within a restricted scope—a limited government. The Chinese governments need to make more efforts to increase its administrative capacity, to reduce direct involvement in the market as an economic actors, and to improve market regulations.

Transforming the Chinese governments' role is not to isolate it from the market, but it should instead increase its presence as a regulator. In developed countries, the market is regulated and protected by their governments. Property rights are well written and protected by government agencies including the police and the court. The need for China’s state-building requires an even larger proportion of GDP distributed to the governments. The key issue is that the government needs to increase spending on public services and facilitating economic structure change to less pollution intensive industries in order to reduce industrial pollution.

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APPENDIX A: SCATTER PLOTS OF INCOME AND INDUSTRIAL SO2 EMISSIONS BY PROVINCE

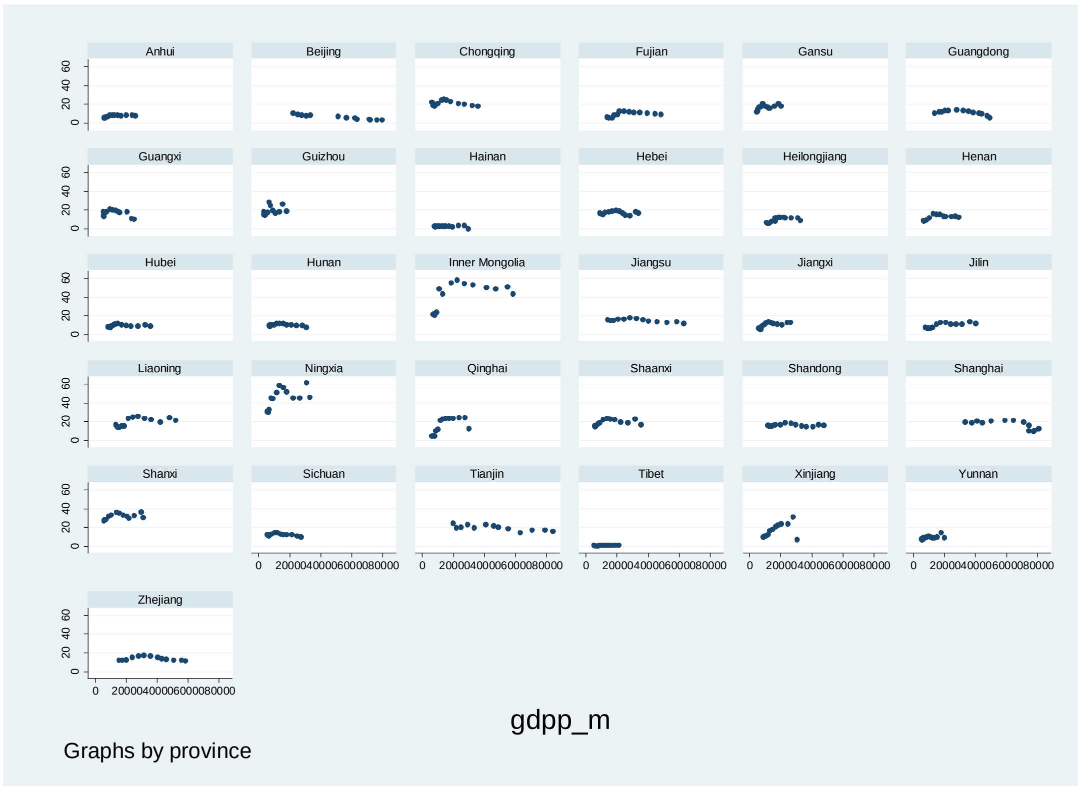

Figure A1: GDP per capita and SO2 emissions per capita by province

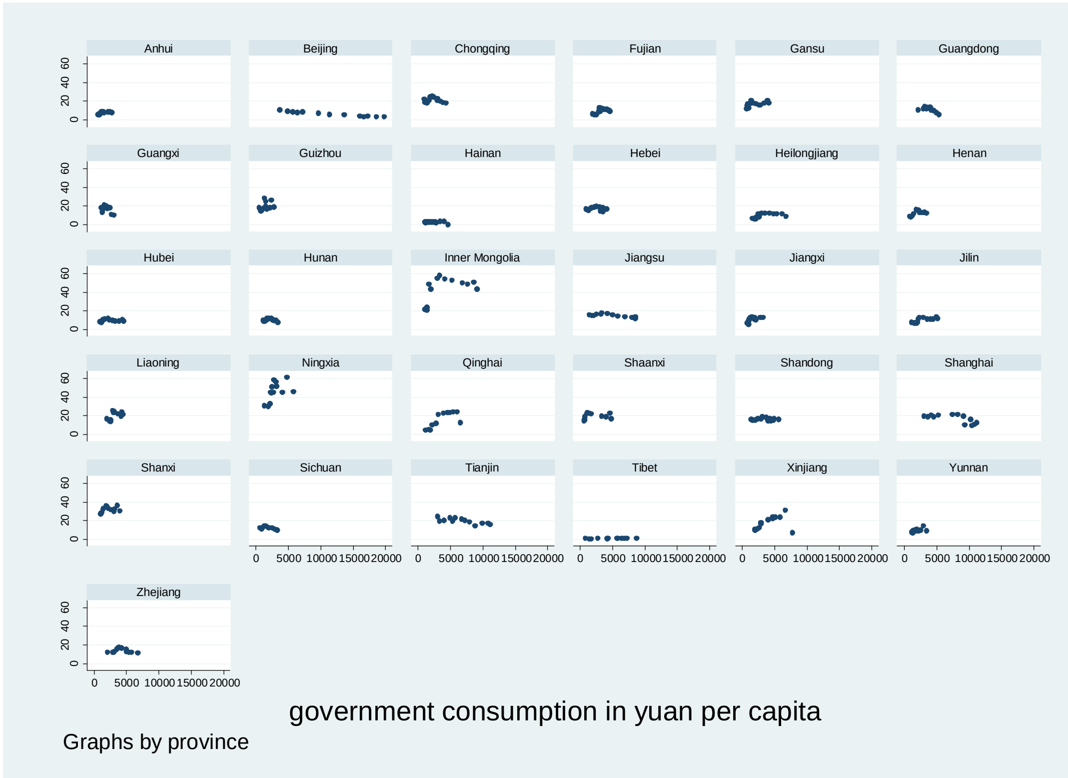

Figure A2: Government consumption per capita and SO2 emissions per capita by province

Figure A3: Household consumption per capita and SO2 emissions per capita by province