FOREIGN DIRECT INVESTMENT, GOVERNANCE, AND THE ENVIRONMENT IN CHINA: REGIONAL DIMENSIONS

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ABSTRACT

This thesis includes four empirical studies related to foreign direct investment (FDI), governance, economic growth and the environment. We firstly investigate the existence of the so called pollution haven hypothesis (PHH) in China, i.e. the impact of regional environmental regulations (ER) on FDI inflows. We then examine the other determinants of FDI: regional government effort to tackle corruption and government efficiency. It then extends the methodology of the first two studies and revisits the PHH issues by treating ER as endogenous. Finally, we observe the effects of economic growth and foreign direct investment on the environmental quality across Chinese cities. After addressing the weaknesses in previous literature, our findings provide the following results. First, an intra-country pollution haven effect does exist in China. Such an effect is also found when ER is treated as endogenous but not robust for the sensitivity checks using different instrumental variables and estimators. Second, FDI is attracted to regions that have made more effort on fighting against corruption and that have more efficient government. Third, government variables do not have a significant impact on ER. Fourth, economic growth has a negative effect on environmental quality at current income levels in China. Finally, foreign investment has positive effects on water pollutants and a neutral effect on air pollutants. Such effects vary across pollutants and investment from different sources.

For my parents and Chao

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AR	Autonomous Region
AR(1)	Autoregressive process of order one
BI	Business International
BLUE	Best linear unbiased estimator
BOD	Biochemical oxygen demand
CBS	Copenhagen Business School
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical oxygen demand
CPC	Communist Party of China
CPI	Corruption perception index
CSPP	China's Supreme People's Procuratorate
DM	Davidson-MacKinnon test
EKC	Environmental Kuznets Curve
EPL	Environment Protection Law
FCPA	Foreign Corrupt Practices Act
FDI	Foreign direct investment
FGLS	Feasible generalised least square
G2SLS	Generalised two-stage least square
GDP	Gross domestic product
GLS	Generalised least square
GMM	Generalised Method of Moment
IAACA	International Association of Anti-Corruption Authorities
ICAC	Independent Commission Against Corruption
ICRG	International Country Risk Guide
IMD	Institute for Management Development
IMF	International Monetary Fund
IV	Instrumental variable
MNC	Multinational corporation
NO_2	Nitrogen dioxide

NO_x	Nitrogen oxide
OECD	Organisation of Economic Co-operation and Development
OLS	Ordinary least square
PHH	Pollution haven hypothesis
PM_{10}	Particulate matter less than 10 microns in diameter
PPP	Purchasing power parity
R&D	Research and Development
RMB	Renminbi (currency of the mainland of China)
SEPA	State Environmental Protection Administration
SEZ	Special Economic Zone
SO_2	Sulphur dioxide
SPM	Suspended particulate matter
STD	The standardised value of government efficiency indices
TI	Transparency International
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
US	United States
USD	US dollar
WDR	Word Development Report

CHAPTER ONE

INTRODUCTION

The immediate motivation for this research is to investigate the impact of environmental regulation stringency and the governance quality on the cross-province foreign direct investment (FDI) inflows in China; and the impacts of economic development and foreign investment on the levels of industrial pollution emissions between Chinese cities.

Since 1978 the Chinese government has been reforming its economy from a centrally planned to a market-oriented economy, known as "socialism with Chinese characteristics". The results of this dramatic transformation have been the generation of wealth on a previous unimagined scale and the removal of millions from absolute poverty, bringing the poverty rate down from 53% in 1981 to 8% in 2001 (World Bank).[1] According to the International Monetary Fund (IMF), China is the second largest economy in the world when measured by purchasing power parity (PPP) gross domestic product (GDP), and is the fourth largest in the world when measured by nominal GDP, and is the fastest growing country with a consistent annual GDP growth rate above 10%.[2]

Much of China's success has been driven by a tremendous growth in exports coupled with equally impressive increases in FDI. According to the statistics from United Nations Conference on Trade and Development (UNCTAD), between 1980 and 2000, the volume of China's exports grew by 14.75% a year and at the end of 2004 China's global trade exceeded $1.15 trillion. From then on China became the world's third largest trading nation behind the United States (US) and Germany ($2.344 trillion and 1.629 trillion in 2004, respectively). In addition, China's trade surplus has been stable at around $30 billion from 1999. In terms of FDI, by 2005 Chinese inward FDI flows had reached $72.41 billion, up

[1] 'Fighting Poverty: Findings and Lessons from China's Success', World Bank, available online:- http://go.worldbank.org/QXOQI9MP30

[2] In 2006, the nominal GDP of China was $2.64 trillion (4th in the world), and $10.2 trillion (2nd) with PPP. Its per capita income was approximately $2,000 (104th), and $7,800 (86th) with PPP, and rising rapidly.

from an average of $30.10 billion between 1990 and 2000.[3] The stock of FDI has increased similarly, rising from $20.69 billion in 1990 to $272.09 billion in 2005.

The Chinese government launched a range of policies to encourage FDI inflows. In 1979, the government introduced legislation and regulations designed to encourage foreigners to invest in high-priority sectors and regions. The government eliminated restrictions and implemented permissive policies in the early 1980s. It then established Special Economic Zones and opened up coastal cities and development regions in coastal provinces in the mid-1980s. More favourable regulations and treatments have been used to encourage FDI inflows in these regions. In the 1990s, the policies began to promote the high-tech and capital intensive FDI projects in accordance with domestic industrial objectives. More preferential tax treatments were granted for the investment in selected economic zones or in projects encouraged by the government, such as energy, communications and transport. Such preferential policies have resulted in an overwhelming concentration of FDI and rapid economic development in the east. The spillover effects from coastal to the inland provinces are limited, and therefore, the regional development gap has widened.

The huge amount of FDI inflows and unbalanced geographical distribution of FDI have attracted several studies to investigate the determinants of FDI location choice in China (see e.g. Wei *et al.*, 1999; Coughlin and Segev, 2000; Cheng and Kwan, 2000; and Amiti and Javorcik, 2008). In addition to the preferential policies, many factors may have affected where foreign investors locate their production facilities within China, such as labour costs,

[3] Before 2005, the FDI data were only for the investment into non-financial sectors. From 2005, Chinese government relaxed the restrictions of the market access of foreign financial institutions and the FDI data started to comprise the investment into financial sectors. Therefore, the inward FDI in 2005 ($72.41 billion) includes the investment into financial sectors ($12.08 billion) and non-financial sectors ($60.33 billion). In addition, from 2005, the statistical scope of FDI was enlarged according to the principles in the IMF *Balance of Payment Manual* (Fifth Edition). Therefore, FDI data shows a jump in 2005. In 2006, the total FDI inflows decreased by 4.1% to $69.47 billion but the FDI in non-financial sectors grew to $63.02 billion.

potential market size, market access, supplier access, infrastructure, productivity, education level, location, and spatial dependence. However, these studies all omitted certain structural determinants of FDI in China, including environmental regulation stringency and government quality.

Some environmental economists and environmentalists claim that firms in developed countries may relocate their "dirty" industries to developing countries to take the advantages of the less stringent environmental regulations (see e.g. Pearson, 1987; Dean, 1992; and Copeland and Taylor, 1994). Such a point of view is known as "the pollution haven hypothesis" (PHH).

In China, the legal system has lagged far behind the overall economic development. Although China has established a comprehensive environmental regulatory framework with a range of laws, regulations and standards, the strength and the enforcement of the regulations are much weaker than those in developed countries. An important issue in the enforcement of environmental regulations is of the government itself violating the law. Some local governments will protect polluting enterprises in the name of local interest. Land appropriation, excessive mining and the failure to carry out environmental impact assessments: such situations continue due to the lack of the environmental awareness among local government officials. Environmental enforcement also suffers from a lack of public participation and social supervision, as well as low awareness of citizens (Ma, 2007). The differences in the performance of local government and the characteristics of the public have led environmental stringency to vary among regions.

Multinational corporations (MNCs) could be attracted by the weak environmental regulations in China. Ma Jun, director of the nongovernmental Institute of Public and

Environmental Affairs (IPE), announced in August 2007 that over 100 multinational corporations were punished by the government for their violation of the environmental laws and regulations in terms of water pollution from 2004. And in January 2008 this figure increased to 260 corporations for water pollution and more than 50 corporations for air pollution. The exposed companies include subsidiaries of world-renowned corporations such as American Standard, Panasonic, Pepsi, Nestle, 3M, Whirlpool, Bosch, Carlsberg, Samsung, Nissin and Kao. These corporations are mostly from Japan, US and Europe. One third of their polluting subsidiaries are located in Shanghai, and others scattered over the country. Liu (2006) reported that according to Lo Sze Ping, campaign director of Greenpeace China, the "words" of multinationals are often better than their deeds. Multinationals are more willing to invest in public relations than in actually cleaning up the manufacturing process. Local governments seek to attract more FDI and hence do not take strict measures to address pollution by multinational corporations. Lo also observes that since multinational corporations typically perform better than the domestic enterprises environmentally, their activities do not attract the attention of the environmental authorities, and hence avoid the supervision.

Therefore, the regional differences in environmental stringency may have a significant impact on the FDI location choice in China, i.e. an intra-country pollution haven effect may exist. Previous empirical studies have adopted different approaches to investigate the PHH (see e.g. Levinson, 1996a & 1996b; List and Co, 2000; Keller and Kevinson, 2002; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; Fredriksson *et al.,* 2003; Dean *et al.,* 2005; and Smarzynska-Javorcik and Wei, 2005). The results are mixed and do not provide robust evidence to support the existence of PHH. However, these studies have several methodological weaknesses and are mostly centred on US data, a few studies look at developing countries and only Dean *et al.* (2005) look at China. Therefore, this thesis, addressing weaknesses of previous studies, makes some contribution to the literature on PHH.

Rapid economic growth with the lagged development of the legal system has resulted in a serious social problem in China – corruption. The transition to a market-based economy has resulted in considerable changes to how firms operate within the new commercial business environment. The huge increase in opportunities in the private sector combined with the traditional power of local and national officials led to a proliferation of corruption at all levels of the Chinese economy. Corruption has been recognised as an emerging challenge to China's economy and social reforms.

Corruption is widely recognised as a deterrent of foreign investment but is only considered in a few empirical studies on a cross-country basis (see e.g. Wheeler and Mody, 1992; Hines, 1995; Wei, 2000; and Smarzynska and Wei, 2000). Although China has received a high volume of foreign capital, corruption has deterred FDI inflows, especially those from Europe and the US. Wei (1997) notes that FDI from the ten largest source countries in the world, all of them members of Organisation of Economic Co-operation and Development (OECD), accounts for a relatively small portion of total FDI going to China, because investors from the major source countries prefer to go to less corrupt countries. Similarly, the corruptibility of local government in China may affect the location of FDI. Moreover, corruption should not be considered in isolation and is strongly correlated with the quality of government (see Globerman and Shapiro, 2002 & 2003; Globerman *et al.,* 2006; and Fan *et al*., 2007). Thus, government quality is another important determinant of FDI inflows. Therefore, this thesis is the first to examine the effects of inter-regional differences in corruption and government quality on FDI location choice within a large developing country.

Rapid export driven economic growth enhanced by large investment inflows from abroad has come at a cost. A harmful by-product of globalisation has been increased pollution. The State Environmental Protection Administration reported that two thirds of Chinese cities are considered polluted according to the air quality data. Respiratory and heart diseases related to air pollution are the leading causes of death in China. Almost all of the nation's rivers are polluted to some degree and half of the population lacks access to clean water. Water scarcity occurs most in northern China and acid rain falls on 30% of the country. The World Bank estimated that pollution costs about 8-12% of China's GDP each year. Environmental degradation and the increase in poor health are all signs that China's current growth path is unsustainable.[4]

There have been numerous theoretical and empirical studies that examine the relationship between economic growth and various indicators of environmental degradation. The aim of the research is to examine the existence of the "Environmental Kuznets Curve" (i.e. the total amount of environmental impact of economic growth initially increases, reaches a peak and then falls), which is found firstly in Grossman and Krueger (1991). In addition, some researchers have started to use empirical methods to examine the effects of FDI on environmental quality, especially in developing countries. However, the majority ofstudies on both the environmental effects of economic growth and FDI, are cross-country analyses and the results are often inconsistent.

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[4] Sustainable development refers to development that "meets the needs of the present without compromising the ability of future generations to meet their own needs", which is defined in the UN Report of the World Commission on Environment and Development, 1987 (available online:- http://www.un.org /documents/ga/res/42/ares42-187.htm).

Therefore, in the case of China, the following questions are worthy of consideration. Does the environmental Kuznets curve hold for some pollutants? If it does, where is the threshold income level and how many regions have passed it? As an important driving force of economic growth in China, does FDI benefit/harm environmental quality? These questions have attracted relatively few research using different datasets and methodologies, with mixed results.

This thesis combines various aspects within the broad area of FDI, governance and the environment. It firstly examines the structural determinants of FDI, and then investigates the effects of economic growth and FDI on the environmental quality in China. The thesis is structured as follows.

Chapter two considers environmental regulatory stringency as a structural determinant of FDI. We test the so called pollution haven hypothesis using socioeconomic and environmental data for 30 Chinese regions over the period from 1999 to 2003. We address the methodological weaknesses in the previous literature and employ a feasible generalised least square method that controls for both autocorrelation and heteroskedasticity. The findings provide some evidence to support the existence of a pollution haven effect within China.

Chapter three re-examines the determinants of FDI by allowing regional government corruption and governance quality to have an impact on FDI inflows. However, the lack of a perceptive index of regional government corruption leads us to develop two objective indices, measuring the effort of local government in fighting against corruption and local government efficiency respectively. The empirical results show that government anti-corruption effort and efficiency are both significant determinants of FDI. We retain all the independent variables in Chapter two and obtain consistent results.

Chapter four methodologically extends the work in Chapters two and three. We revisit the pollution haven issue but treat environmental regulations as endogenous. We employ an instrumental variable approach, with the first stage regression examining whether government characteristics affect the environmental stringency. The results confirm the existence of an intra-country pollution haven effect in China but are not robust to a battery of sensitivity checks.

Chapter five examines the relationship between economic growth and a range of industrial pollution emissions in China using data for 112 major cities between 2001 and 2004. After separating foreign investment from Hong Kong, Macao and Taiwan from the investment of other foreign economies, we also observe the environmental effects of different ownership groups of investment. The results provide some evidence that economic growth induces more pollution at current income levels in China. And the environmental effects vary across investment groups.

Chapter six concludes with a review of the results, a discussion of the limitations and improvements in data and methodology, the contributions to the literature, and an outline of the potential for further research.

CHAPTER TWO

FDI AND ENVIRONMENTAL REGULATIONS IN CHINA: DO INTRA-COUNTRY POLLUTION HAVENS EXIST?

2.1 Introduction

Traditional international trade theory tells us that trade is governed by comparative advantage, which postulates that the efficient exchange of goods leads to optimal outcomes. Multinational firms, as agents of free trade, seek cost reductions and respond to market imperfections. Higher domestic costs therefore provide the motivation for multinational corporations to expand their geographical range into other areas.

Stringent environmental standards in developed countries will drive up production costs of those firms with higher sensitivity to the pollution abatement costs by, for example, prohibiting certain inputs and outputs, or where strict emission standards requires the use of specific technologies. It may, therefore, be in the firms' interest to close pollution-intensive plants at home and to relocate their production facilities to those developing countries with lower environmental regulations. The suggestion is that the profit-maximising, pollution-intensive multinational firms will move operations or part of operation to developing countries to take advantage of the less stringent environmental regulations. Such a strategy could trigger competition for lax environmental policies in order to gain competitive advantage in "dirty" goods production. A corollary is that developing countries may join a "race to the bottom" by undervaluing environmental damage in order to attract more FDI. Either way, the result is excessive levels of pollution and environmental degradation (Dean *et al*. 2005). This phenomenon is the so called "*race to the bottom*" hypothesis or *pollution haven* hypothesis.[5]

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[5] Aliyu (2005) summarises three dimensions of the pollution haven hypothesis. The first is the relocation of heavy pollution industries from developed countries with stringent environmental regulations to developing countries without or with lax or not enforced regulations. The second dimension is the dumping of hazardous wastes generated from developed countries to developing countries. The third is the unrestrained extraction of non-renewable natural resources in developing countries by multinational firms.

To date, one of the most contentious debates in the FDI and the environment literature focuses on whether inter-country differences in environmental regulations are turning poor countries into "pollution havens". This argument centres on the cost effect of environmental regulations and presumes that there are environmental regulation-induced production cost differentials that encourage a firm to relocate its production facility.[6] Theoretical models of pollution havens, including Pearson (1987) and Baumol and Oates (1988), illustrate that developed countries control pollution emissions whilst developing countries do not, and hence become pollution havens.

Thus far the empirical results for tests of the PHH are mixed. Levinson (1996b), Keller and Levinson (2002), List and Co (2000), and Fredriksson *et al.* (2003) all find evidence that environmental stringency has some impact on inbound FDI locations in the US. Xing and Kolstad (2002) find that environmental regulations in host countries have a significant impact on outbound FDI from the US for heavily polluting industries. In contrast, Levinson (1996a) finds little evidence for inter-state pollution havens in the US, and Eskeland and Harrison (2003) suggest it is difficult to find a robust relationship between pollution abatement and US outbound FDI. For the evidence of other countries, Samarzynska-Javorcik and Wei (2005) find that the overall results are relatively weak when they examine the relationship between FDI and environmental stringency for the firms in Eastern Europe and former Soviet Union; Dean *et al.* (2005) find environmental stringency only affects FDI projects in China that originate from Hong Kong, Macao and Taiwan. In general, previous empirical studies suggest that there is little evidence to support the pollution haven hypothesis.

[6] Esty and Gentry (1997) and Aliyu (2005) outline four types of FDI – market seeking, production platform seeking, resource seeking and low cost seeking FDI. Environmental policy/cost has less impact on the categories of market seeking and production platform seeking, but certainly has an effect on resource seeking and/or low cost seeking FDI.

China has, in recent years, been one of the largest recipients of worldwide FDI inflows. FDI has contributed significantly to economic growth in China since it adopted economic reforms from 1978. However, there remains a significant disparity in the geographical distribution of FDI inflows into China. The majority of the FDI has tended to concentrate in the eastern regions. However, environmental deterioration has become a serious problem associated with rapid economic growth, and industrial pollutant emissions are the major source of the environmental problem. Similarly, pollution emissions also vary across regions. Simultaneously, China's environmental regulation standards are relatively weaker than those in developed countries, and the strength of the enforcement of the environmental regulations is different across regions.

Using provincial socioeconomic and environmental data, this chapter investigates whether there exists an intra-county pollution haven effect for China. It therefore examines whether differences in the stringency of environmental regulations affects the location choice of FDI in China.

In this chapter, we employ three measures of regional environmental stringency that vary across time and province. The first measure is the level of industrial pollution treatment investment by province, the second is the number of administrative punishment cases related to environmental issues by province, and the third is the average level of pollution emission charges by province. In addition we include a standard set of control variables that capture provincial level differences in income, labour costs and quality, infrastructure, agglomeration, population density, etc.

Our results suggest that environmental stringency has a significant and negative effect on FDI, leading us to conclude that, *ceteris paribus*, FDI prefers to locate in regions with relatively weak environmental regulations and provides some support for the existence of a pollution haven consistent effect within China.

This chapter is organised as follows. Section 2.2 discusses the previous theoretical and empirical literature on FDI and the environment. In section 2.3, we describe FDI inflows into China and China's environment problems and environmental regulation system. Section 2.4 presents our methodology and data, while section 2.5 reports and discusses the empirical results. The final section concludes.

2.2 Literature Review

This section commences by reviewing existing theoretical and empirical studies of FDI and the environment. It then discusses some of the empirical findings of research into FDI patterns in China, and finally examines the weaknesses of the previous empirical literature.

2.2.1 Trade and Investment Theory and the Environment

According to the theory of comparative advantage, in order to allocate resources efficiently and hence maximise global output and income, countries should specialise in the production and export of products that use in their production a relatively large amount of the resources that the country has in relative abundance. Therefore, countries should produce and export products for which they have a comparative advantage, and they should import products in which they have a comparative disadvantage.

Pearson (1987) shows that the environmental media (air, water, soil) provides a supply of assimilative capacity for waste disposal. In a country with low income levels, the absence of industry or low competing demand for these environmental services, means that the demand for these services is low relative to supply, and therefore, the economic price of the waste disposal services should also be low. A low price means a relative abundance. Other things being equal, this country would have a comparative advantage in "dirty" production, and a comparative disadvantage in "clean" production. Conversely, countries where assimilative capacity is exhausted and incremental residual discharge has a high cost, would have a comparative disadvantage in dirty production and a comparative advantage in clean production. Thus, specialisation through comparative advantage and international trade (investment) efficiently allocates resources, increases production and improves world welfare. Therefore, the supply and demand for environmental services can be treated as an additional factor of production, and that an efficient pattern of world production will reflect that factor.

Baumol and Oates (1988) set up a simple partial equilibrium model that focuses on the environmental impacts of international trade in a two-country (one rich, one poor), two-good (one whose production can, but need not, be dirty and one whose production is non-polluting) world where the rich country successfully adopts an environmental control programme while the poor country does not. They find several results:

1) The decision to use a dirty production process for dirty goods in a poor country will reduce the world price of that good and hence results in excess of world demand for the dirty good.
2) The poor country will produce more of the dirty good by using a dirty production process.
3) As a result, total world emissions of pollutants will be higher.
4) The long-run consequence will be that the poor country will increase its comparative

advantage in dirty goods by using dirty production processes, while the rich country will specialise in the other, less polluting product.

Baumol and Oates (1988) then claim that developed countries control pollution emissions. Developing countries will, therefore, become "pollution havens". Other theoretical studies (for example, Copeland, 1994) support the findings of Baumol and Oates (1988). However, the resulting pattern of production and trade is based on a general presumption that developing countries neglect the environment and pursue a "pollution haven" strategy which according to Pearson (1987) is ill-founded.

The traditional approach to the trade-environment relationship declares that the environmental damage is a result of market and government failures, or the existence of externalities, rather than the trade itself. Therefore the best solution is to internalise the externalities, that is, prices should reflect both private and social costs. Internalised social costs will generate higher prices for the environmental damaging products, and as a result, will alter production, trade and investment patterns. However, the internalisation is difficult to implement in reality. Runge (1994) points out that it is far easier to recommend that environmental externalities be "internalised" than it is to implement and enforce internalisation.

2.2.2 Empirical Literature on FDI and the Environment

Recently, much of the literature on FDI has provided models of FDI that are concerned about the sensitivity of investment location decisions to different elements, such as factor costs, infrastructures, local demand, and labour quality. A multinational firm is treated as one that wants to invest capital somewhere to maximise its profit, i.e. to minimise production cost. The presumption is that production cost differentials are a sufficient inducement for a firm to relocate. Many empirical studies on FDI believe that stringent environmental regulations increase production costs by, for example, prohibiting certain inputs and outputs, paying levy rates for emissions that exceed certain standards, or using specific technologies to meet strict emission standards. Therefore, the multinational firm will locate in a region with weaker environmental standards. To examine the impact of environmental regulations on the location of FDI, we firstly introduce the frameworks in the FDI empirical research.

2.2.2.1 Three Frameworks of Foreign Direct Investment

In addition to the costs of the main factors of production which impact the investment location choice, are there any other potential determinants that can influence an investment decision? Eskeland and Harrison (2003) concluded that there are three frameworks that explain the potential determinants of foreign investment.

The first is that *factor proportions* explanations for trade can also be used to explain the pattern of foreign investment (Caves, 1982; Helpman, 1984; and Brainard, 1993). Holding everything else equal, foreign firms would like to locate in a country that has cheaper factors of production that they use in high proportions. Then the pattern of FDI can be captured through variables such as skill intensity, capital-labour ratio and wage differentials between countries.

Factor proportions alone, however, cannot satisfactorily explain foreign investment. Other foreign investment theories focus on the role of ownership. An important role is played by intangible assets such as superior knowledge and technology, and managerial abilities. This *intangible asset* theory of FDI is developed by Horstmann and Markusen (1989). To the extent that intangibles are usually linked to advanced technology, multinational firms may be better able to comply at a lower cost than local firms, thereby gaining a comparative advantage. Therefore, to capture the importance of intangibles as a motivation for FDI, factor productivity growth is used when data are available.

The third framework is the *proximity-concentration trade-off* between multinational sales and trade, which is described in more details by Brainard (1997). Some important factors (other than intangible assets and factor prices), such as tariff barriers and transport costs, will make firms locate near the target market. The protection of domestic markets has been one of important attractions for foreign investment. Some trade measures, for example, import penetration and export shares, are often employed to capture the importance of protected markets. Since there is trade-off between the advantages of proximity and the benefits of concentration of production in one location in sectors where there are economies of scale, measures of economies of scale/concentration (for instance, the numbers of employees per plant) are important in such models.

2.2.2.2 Empirical Evidence for the Pollution Haven Hypothesis

Although there are many articles focusing on trade and the environment, few studies have studied the relationship between foreign investment and environmental issues. Of those papers that do examine the relationship between FDI and the environment, most of them are centred on US data, only few studies looking at developing countries and even less that look at China.

Thus far, the empirical evidence for the existence of a pollution haven consistent effect is mixed. Generally, empirical studies suggest that there is little evidence to support the pollution haven hypothesis. Early non-parametric evaluations (Walter, 1982 and Pearson, 1987) find that there is FDI in pollution-intensive industries but little evidence that it is influenced by differing pollution abatement costs, or has flowed faster into developing countries relative to industrial countries. Leonard (1988) finds evidence that governments in developing countries used lenient environmental regulations to attract FDI in the 1970s but this incentive was not substantial enough to offset other main determinants of location such as the level of training of labour, infrastructure and stability.

Dean *et al.* (2005) and Smarzynska-Javorcik and Wei (2005) summarise three approaches which have been adopted in recent econometric studies on whether or not FDI flows are a result of pollution haven effects. They are 1) *inter-state plant location choice*; 2) *inter-industry FDI flows within a country* and; 3) *inter-country FDI location choice*. The results of these studies are mixed.

Using the first approach, Levinson (1996a) finds little evidence that inter-state differences in environmental regulations affect the US plant location choice. Levinson (1996b) employs a conditional logit model and finds only one of six environmental stringency indicators has a significant but small impact on the location choice of new branch plants in the US. A similar approach is adopted by List and Co (2000), who estimate the effect of state environmental regulations on foreign multinational corporations' new plant location decisions from 1986 to 1993, using four measures of regulatory stringency. They find that environmental stringency and attractiveness of a location are inversely related. Keller and Levinson (2002) test whether FDI to US states has responded significantly to relative changes in state's environmental compliance costs. Keller and Levinson (2002) address the main drawbacks in previous studies. They control for unobserved heterogeneity among states and use a panel of pollution abatement cost indices that control for states' industrial composition. It robustly documents moderate effects of pollution abatement costs on capital and employees at foreign-owned manufacturing affiliates, particularly in pollution-intensive industries, and on the number of planned new foreign-owned manufacturing facilities. Similarly, Fredriksson *et al.* (2003), which uses US state-level panel data from four industrial sectors over the period 1977-1987, finds that environmental policy plays a significant role in determining the spatial allocation of inbound US FDI and such effect depends critically on the exogeneity assumption of environmental policy.

There is a scarcity of research that assesses the relationship between the distribution of foreign investment and pollution intensity. One exception is the recent work of Eskeland and Harrison (2003), which adopts the second approach to examine the pattern of FDI across industries in Mexico, Venezuela, Morocco and Cote d'Ivoire. Their results suggest that it is difficult to find a robust relationship between pollution abatement and the volume of US outbound investment. They find a positive relationship between FDI share and air pollution-intensity of an industry but negative relationship between FDI share and both water pollution and toxic release-intensity. They also find foreign ownership is associated both with lower levels of energy use and the use of cleaner types of energy. In addition, the results suggest that any impact of abatement costs on the distribution of FDI is small, if not zero. It is suggested that these results are because pollution abatement costs are only a small fraction of overall costs.

A paper employing the third approach is Xing and Kolstad (2002), which presents a statistical test on how US FDI is influenced by the environmental regulations of foreign host countries. To be specific, they have examined the relationship between the capital outflows of six US manufacturing sectors – including industries with high pollution control costs (chemicals and primary metals) as well as industries with more modest pollution control costs (electrical and non-electrical machinery, transportation equipment, and food products) – and the environmental policy of 22 destination countries. They argue that environmental regulatory stringency is not directly observed and hence use an instrumental variable approach to examine the effect of environmental regulations. The results show that the laxity of environmental regulations in a host country is a significant determinant of FDI from the US for heavily polluting industries and is insignificant for less polluting industries.[7] Their findings provide indirect support for the pollution haven hypothesis. However, the small size of the data and the imperfect coverage of sulphur emissions data mean that care must be taken with the reliability of their results. A more recent paper, Smarzynska-Javorcik and Wei (2005) examines the relationship between cross country FDI flows and environmental stringency for 143 multinational firms in 25 countries in Eastern Europe and the former Soviet Union. In this paper they emphasise a number of omitted variables from previous studies, such as bureaucratic corruption, which deters FDI but at the same time is correlated with laxity of environmental protection. However, they find little evidence for the hypothesis that lower environmental standards attract investment, nor for the hypothesis that these countries are more attractive for pollution-intensive FDI. They find some evidence for the PHH when regressions employing Treaties as the proxy for environmental standards in a host country, but the overall evidence is relatively weak and does not survive numerous robustness checks using other proxies of pollution intensity or regulatory stringency.

[7] Xing and Kolstad (2002) find that there is a negative linear relationship between FDI of the US chemical industry and the stringency of environmental regulation in a foreign host country. Lax environmental policy tends to attract more capital inflows form the US for pollution intensive industries; whilst tough environmental regulations would tend to impede or discourage FDI from these industries.

2.2.2.3 Empirical Evidence on Chinese Data

Recent Empirical Evidence on Intra-Country FDI Location in China

Many researchers have focused on the geographical distribution of aggregate FDI flows among Chinese provinces. Wei *et al.* (1999) analyse the determinants of regional distribution of both pledged and realised FDI within China from 1985 to 1995. The unit root test results indicate the existence of a long run relationship between the spatial distribution of FDI and a number of regional characteristics. The error components (random effect) model results suggest that pledged FDI is positively affected by the level of international trade, the number of scientists and researchers in total employment, GDP growth, preferential investment policy, improvement in infrastructure, and advances in agglomeration; while negatively affected by wage rates and information costs. However, GDP growth, infrastructure and agglomeration do not have significant effects on realised FDI.

Using provincial data between 1990 and 1997, Coughlin and Segev (2000) examine the geographic pattern of FDI location within China. They extend the methodology of pervious studies by introducing some new control variables and test the existence of spatial heterogeneity and spatial dependence. The ordinary least square (OLS) and spatial error regressions both suggest that only spatial dependence exists, i.e. increased FDI in a province has positive effects on FDI in nearby provinces. Their findings on other control variables are consistent with past studies of FDI location choice among Chinese provinces and with studies of FDI location in general: economic size, productivity and coastal location are positive determinants of FDI location; wage and illiterate rate are negative determinants; and their infrastructure measures do not have significant effects on FDI.

Cheng and Kwan (2000) employ a dynamic model of foreign investment and use Generalised Method of Moment (GMM) estimator to investigate the impact of the determinants on the stock of FDI in 29 Chinese regions from 1985 to 1995, and find that a large regional market, good infrastructure, and preferential policies have positive effects but wage has a negative effect on FDI. The effect of education is positive but not significant. They also find a strong self-reinforcing effect of FDI on itself.

Gao (2002) concentrates on the effect of labour quality on the location of FDI within China from 1996 to 1999. Gao (2002) employs OLS, between effects, fixed effects and random effects models and finds that labour quality plays a significant and positive role in attracting FDI. The evidence in this paper also indicates that the location of FDI from developed economies, such as US and Japan, is more sensitive to labour quality than FDI from Asian developing economies. However, the wage is not found to be a significant determinant and even has a positive coefficient in some specifications.

In a similar paper, Fung *et al.* (2002) examine the determinants of US and Japanese FDI location among Chinese regions from 1991 to 1997 using a generalised least square estimator and compare the results with those investments from Hong Kong and Taiwan. GDP and certain policy variables are found to have significant positive impacts on inflows of FDI. Labour quality exerts a larger influence on Japanese investment than on US investment. Lagged wage is negatively related to FDI. However, compared with investment from Hong Kong and Taiwan, US and Japanese investments are more sensitive to the local markets because they are mostly producing for the domestic Chinese market while FDI from Hong Kong and Taiwan is mostly producing for export. Labour quality does not have a strong influence on FDI inflows from Hong Kong and Taiwan because such investment is more concentrated in labour-intensive industries that require relatively low labour skills.

Additionally, good infrastructure has a strong effect of FDI from Hong Kong and Taiwan but only a moderate effect on US investment and no effect on Japanese investment. Fung *et al.* (2003) examine the determinants of Japanese FDI in China using a regional dataset from 1990 to 2000 and form a comparison with investment from Hong Kong. The main results are similar to those in Fung *et al.* (2002).

Amiti and Javorcik (2008) is the latest paper which examines the determinants of entry by foreign firms using a comprehensive dataset that includes 515 industries in 29 Chinese provinces during 1998-2001. The analysis is based on a new economic geography model and focuses on the relative importance of market and supplier access within and outside the province of entry, as well as trade costs and factor costs. The non-linear least square results suggest that market access and supplier access are the key determinants of FDI inflows. The presence of customers and suppliers in the province of entry matters more than the market and supplier access to the rest of China, which is consistent with market fragmentation in China due to underdeveloped transport infrastructure and informal trade barriers. In addition, production costs also play an important role in determining the location of FDI, but the effects are only around a quarter of the market and supplier access effects.

Empirical Evidence on Intra-Country Pollution Havens in China

A recent study that searches for empirical evidence of intra-country pollution havens in China is Dean *et al.* (2005). In this study they estimate whether weak environmental regulations attract foreign investment in China. Dean *et al.* (2005) derive a location choice model containing firm's production and abatement decisions, agglomeration and factor abundance. They estimate a conditional logit model using a dataset that includes information on 2,886 manufacturing joint venture projects, effective environmental levies on water pollution, and estimates of Chinese emissions and abatement costs across 3-digit ISIC industries and provinces between 1993 and 1996. The results show that FDI flows to provinces with high concentrations of foreign investment, relative abundance of skilled labour, concentration of potential local suppliers, special tax incentives, and less state ownership. Environmental stringency just affects certain types of projects in highly polluting industries, with investment originating from Hong Kong, Macao and Taiwan seemingly attracted to provinces with relatively weak environmental controls. This finding is consistent with the pollution haven hypothesis but contradicts the notion that pollution havens are generated by industrial country investors. In contrast, investment from non-Chinese sources appears not to be attracted by low levels of pollution levies, regardless of the pollution intensity of the industry. This is opposite to the pollution haven hypothesis. In sum, the results suggest little evidence for the pollution haven hypothesis.

2.2.2.4 Weaknesses of Previous Work on Pollution Havens

The general lack of support for the pollution haven hypothesis in previous studies can be summarised as follows:

First, as Pearson pointed out, "environmental control costs are a small fraction of production costs in virtually every industry, and the effect on trade will be correspondingly small".[8] This is reinforced by the results of Eskeland and Harrison (1997), where the empirical results show that environment costs may be too small relative to overall costs to impact the location decision. Second, FDI may be combined with new techniques, including the latest abatement technologies, rendering the relative stringency of the host

[8] Pearson (1987), pp.124.

country's environmental regulations unimportant. Third, if firms are producing for export, then they may have to meet the environmental product standards of developed countries in order to gain the access to these markets. Finally, firms may predict that there will be future increases in environmental regulations, and hence choose a production process today that will meet the higher standards of the future (Dean *et al.*, 2002).

Smarzynska and Wei (2001) point out there are two possible ways to summarise the existing empirical studies on pollution haven hypothesis. "The first possibility is that the 'pollution haven' hypothesis is after all just a popular myth that does not hold in reality. An alternative view is that the 'pollution haven' hypothesis is valid but the empirical researchers have not tried hard enough to uncover this 'dirty secret'."[9] There exist several weaknesses in previous studies that may have impeded the exposure of the "dirty secret".

First, in some studies, the absence of some important variables, such as relative factor abundance and agglomeration, will lead to omitted variable bias. Markusen and Zhang (1999), Head and Ries (1996), and Cheng and Kwan (2000) have demonstrated the importance of these variables in explaining FDI incidence (Dean *et al.* 2005).

Second, it is difficult to quantify international differences in environmental regulations (Smarzynska and Wei, 2001; and Keller and Levinson, 2002). "This difficulty is further exacerbated by the possibility that laws on the book may not be the laws that are actually enforced".[10]

Third, Keller and Levinson (2002) & Levinson and Taylor (2008) both demonstrate that cross-section analyses cannot control for unobserved heterogeneity among countries.

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9 Smarzynska and Wei (2001), pp. 2.

10 op. cit. pp. 3.

These unobserved characteristics, such as unobserved resources and unobserved protection of polluting industries, may be correlated with both regulatory compliance costs and investment. If the estimation does not allow for these unobserved characteristics, it will generate an omitted variable bias to the predicted effect of regulatory compliances costs on investment. Therefore, using a continuous, time-varying (panel) dataset becomes important.

Finally, most literature uses cost-based measures of environmental standard stringency. Copeland and Taylor (2003) developed a model linking the firm's production and abatement cost. It suggests a particular specification for testing a firm's responsiveness to changes in environmental regulations, which raises the possibility of specification error.

In this chapter, we address a number of those limitations by adopting a five-year panel dataset for 30 provinces in China that includes three measures of environmental regulations that vary across time and province, and a significant number of control variables, including measures of agglomeration and factor abundance. We control for unobserved heterogeneity by using the feasible generalised least square estimator.

2.3 FDI, the Environment and Environmental Regulations in China

Section 2.3.1 firstly lays out the circumstances of foreign investment in China, including its development since 1978 and the characteristics of its uneven distribution. In the second part, it elucidates the environment problems that China faces at present, especially the industrial generated wastewater pollution, air pollution and solid wastes pollution. Following a brief description of environmental investment in China, the environmental regulatory framework, FDI related environmental regulations and the stringency of environmental regulations are expounded in detail.

2.3.1 Foreign Direct Investment in China

Since it launched economic reforms in 1978, China has received enormous FDI flows. In 2005, it received FDI in actually utilised value of $72.41 billion compared with $0.64 billion in 1983 (China Statistical Yearbook).[11] China has been the second-largest recipient of foreign capital ranking after the US.

2.3.1.1 Trends in Chinese FDI

General trends and the characteristics of FDI in China have been reviewed by many studies, e.g. Wu (1999), OECD (2000), Wei and Liu (2001), and Wei (2002). At the beginning of China's economic reforms, FDI inflows were not significant. FDI increased in the mid-1980s and reached a peak level in the early 1990s. Since the mid-1990s China has been a major host country for FDI. Table 2.3.1 shows the number of contracted projects, the

[11] Actually used FDI refers to the amount which has been actually used according to the agreements and contracts, i.e. the realised FDI.

amount of contracted and the amount of actually used FDI and the corresponding annual growth rate from 1979 to 2003. The development path of inward FDI is shown more clearly from Figure 2.3.1. Following the surveys of OECD (2000) and Wei (2002), the general trends can be distinguished by five phases: the experimental stage (1979-1983), the growth stage (1984-1991), the peak stage (1992-1994), the adjustment stage (1995-1999), and the renascent/recovered stage (2000 onwards).

During the first stage, the Chinese government established four Special Economic Zones (SEZs) in Guangdong and Fujian Provinces, and provided special incentive policies in these SEZs.[12] FDI inflows were mainly concentrated in these SEZs; however, the total amount was rather low, only $1.8 billion.

With the successful experiment in the first stage and a satisfactory economic situation nationwide, China formulated a series of laws and regulations to improve the business environment. In 1984, China established another SEZ – Hainan Island (which became a province in 1988) and opened fourteen coastal cities across ten provinces.[13] There was a steady and rapid growth of FDI flows during the second stage, with a growth rate of approximately 20 per cent.

[12] Guangdong and Fujian are both coastal provinces in the southeast of China. The four SEZs are Shenzhen, Zhuhai, Shantou in Guangdong, and Xiamen in Fujian.

[13] The fourteen cities include: Dalian (Liaoning Province), Qinhuangdao (Hebei Province), Tianjin (municipality), Yantai (Shandong Province), Qingdao (Shandong Province), Liangyungang (Jiangsu Province), Nantong (Jiangsu Province), Shanghai (municipality), Ningbo (Zhejiang Province), Wenzhou (Zhejiang Province), Fuzhou (Fujian Province), Guangzhou (Guangdong Province), Zhanjiang (Guangdong Province), and Beihai (Guangxi Province).

Table 2.3.1 FDI Inflows into China 1979-2004

USD billion (Current Price)

Year	# of Project	Growth Rate	Contracted Value	Growth Rate	Actually Used Value	Growth Rate
Total	**508465**		**1096.36**		**560.39**	
1979-1982	922	N/A	6.01	N/A	1.17	N/A
1983	470	N/A	1.73	N/A	0.64	N/A
1984	1856	294.89	2.65	53.18	1.26	96.88
1985	3073	65.57	5.93	123.77	1.66	31.75
1986	1498	-51.25	2.83	-52.28	1.87	12.65
1987	2233	49.07	3.71	31.10	2.31	23.53
1988	5945	166.23	5.30	42.86	3.19	38.10
1989	5779	-2.79	5.60	5.66	3.39	6.27
1990	7273	25.85	6.60	17.86	3.49	2.95
1991	12978	78.44	11.98	81.52	4.37	25.21
1992	48764	275.74	58.12	385.14	11.01	151.95
1993	83437	71.10	111.44	91.74	27.52	149.95
1994	47549	-43.01	82.68	-25.81	33.77	22.71
1995	37011	-22.16	91.28	10.40	37.52	11.10
1996	24556	-33.65	73.28	-19.72	41.73	11.22
1997	21001	-14.48	51.00	-30.40	45.26	8.46
1998	19799	-5.72	52.10	2.16	45.46	0.44
1999	16918	-14.55	41.22	-20.88	40.32	-11.31
2000	22347	32.09	62.38	51.33	40.72	0.99
2001	26140	16.97	69.20	10.93	46.88	15.13
2002	34171	30.72	82.77	19.61	52.74	12.50
2003	41081	20.22	115.07	39.02	53.51	1.46
2004	43664	6.29	153.48	33.38	60.63	13.31

Note: a) The number of project refers to the project numbers of the enterprises with foreign investment. The amount of contracted FDI refers to the amount of project investments supplied by the foreign businessmen in terms of approved or signed contracts. The amount of actually used FDI refers to the amount which has been actually used according to the agreements and contracts.

b) The values for 1979-1986 are different among the China Statistical Yearbooks for various years, possibly due to different measurements. The values presented in the table are collected from the corresponding year's Yearbook so that the total volumes are different from those in the latest Yearbook.

Source: China Statistical Yearbook, various years.

From 1992 to 1994, contracted and actually used FDI increased quickly and exceeded the corresponding figures for the previous years. In 1993, the contracted FDI value reached a peak level of $111.4 billion. This situation was closely associated with a number of events, including Deng Xiaoping's visit to the southern coastal areas and SEZs, nationwide implementation of opening up policies for FDI and the world wide rise in FDI flows.[14]

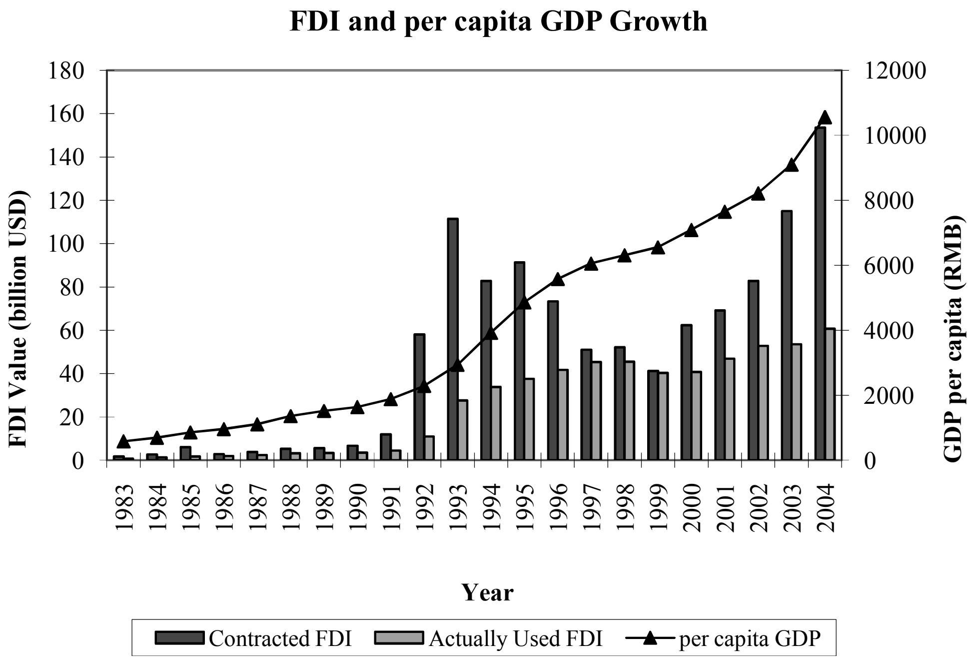
From 1994, the growth rate of actually used FDI slowed down and became negative in 1999. The number of projects and contracted FDI mostly kept falling during the period 1994 to 1999 and both arrived at their lowest point in 1999. This was mainly due to the impact of the Asian financial crisis and the rise of acquisition transactions in both OECD and non-OECD countries.

From 2000 onwards, inflows of FDI into China recovered quickly in terms of both contracted and actually used FDI. In 2003, it overtook the US as the biggest recipient of FDI in the world with contracted value of $115.07 billion and actually used value of $53.51 billion. National Bureau of Statistics of China reported that in 2004 the contracted value of FDI increased to $153.48 billion and the actually utilised amount rose to $60.63 billion, with the rank after US.

It should be noted that the growth of FDI is positively associated with the economic growth in China. It is also illustrated by Figure 2.3.1. FDI and economic growth interact with each other. GDP per capita increased quickly in the stage that FDI was booming, and slowly when FDI inflows decreased.

[14] Deng's visit in the spring of 1992, pushed China's overall economic reform process forward and emphasised China's commitment to the open door policy and market-oriented economic reform. It gave greater confidence to foreign investors in China. From then on, China adopted new approach, which pushed more nationwide implementation of open policies to encourage FDI inflows.

Figure 2.3.1 FDI Inflows into China 1979-2004



Source: China Statistical Yearbook, various years.

2.3.1.2 Unbalanced Distribution of FDI in China

Although the total amount of FDI inflows into China is extremely high, there are significant imbalances in FDI stocks across China in terms of its source, form, geographical and sectoral distribution.

1) Main Countries of Origin of Investment

According to the report from China's Ministry of Commerce (Tables 2.3.2 and 2.3.3), Asian countries contribute most of the FDI inflows into China, which takes up more than 70% of total actually used FDI into China between 1979 and 2003. It is followed by North

America and the EU, with 9.57% and 7.55% respectively. Among those countries with the highest investment in China, the majority of investors were ethnic Chinese, e.g. the share of FDI from Hong Kong, Taiwan and Macao was about 52.69% between 1979 and 2003.[15] Among developed countries, the US and Japan have been the most important investors in China, with about 8.79% and 8.25% respectively. Other developed countries invested lower amounts of FDI in China. In recent years the share of FDI from Hong Kong, Macao and Taiwan has decreased while that of the US and the EU has increased.

2) Forms of Investment

In terms of the form of FDI, the establishment of new enterprises like joint ventures and foreign invested companies seem to be the main types of FDI into China at the current time. From Table 2.3.4, it is clear that until 2003, equity joint ventures accounted for 41% of the inward actually used FDI and wholly owned foreign invested enterprises accounted for appropriately 40%. Cooperative operations have been the third important mode, which took 17.27% in terms of actually used FDI from 1979 to 2003. As mergers and acquisitions have become popular forms of global FDI, they may also have potential for further expansion in China. Additionally, the share of wholly owned foreign invested enterprises shows an increase in China in recent years (OECD 2000).

[15] For historical reasons, Hong Kong Dollar, New Taiwan Dollar and Macao Pataca had been called "foreign currencies", and the investment from Hong Kong, Taiwan and Macao has been counted as "foreign investment" since the 1980s, although Hong Kong, Taiwan and Macao are all part of China. Currently, some researchers have named the investment from these three regions as "non-RMB domestic investment". However, here we follow the traditional statistical classification, and treat all non-RMB investment as "foreign investment".

Table 2.3.2 FDI to China by Major Countries/Regions 1979 - 2003

USD billion

Country (Region)	**# of Project**	**%**	**Contracted Value**	**%**	**Actually Used Value**	**%**
Total	**465277**	**100**	**943.13**	**100**	**501.47**	**100**
Asia	**369789**	**79.48**	**654.14**	**69.36**	**357.41**	**71.27**
Hong Kong	224509	48.25	414.51	43.95	222.58	44.38
Indonesia	1079	0.23	2.58	0.27	1.27	0.25
Japan	28401	6.01	57.49	6.10	41.39	8.25
Macao	8407	1.81	12.09	1.28	5.19	1.03
Malaysia	2888	0.62	7.16	0.76	3.09	0.62
The Philippines	1945	0.42	3.74	0.40	1.65	0.33
Singapore	11871	2.55	43.57	4.62	23.53	4.69
Korea	27128	5.83	36.65	3.89	19.69	3.93
Thailand	3375	0.73	6.32	0.67	2.55	0.51
Taiwan	60186	12.94	70.03	7.43	36.49	7.28
EU	**16158**	**3.47**	**65.94**	**6.99**	**37.87**	**7.55**
Belgium	470	0.10	1.08	0.11	0.67	0.13
Denmark	267	0.06	1.41	0.15	0.52	0.10
UK	3856	0.83	20.84	2.21	11.44	2.28
Germany	3504	0.75	15.71	1.67	8.85	1.76
France	2302	0.49	7.92	0.84	6.15	1.23
Ireland	61	0.01	0.13	0.01	0.05	0.01
Italy	2137	0.46	3.81	0.40	2.55	0.51
Luxembourg	96	0.02	0.61	0.06	0.28	0.06
Netherlands	1254	0.27	9.93	1.05	5.06	1.01
Greece	47	0.01	0.11	0.01	0.03	0.01
Portugal	80	0.02	0.13	0.01	0.07	0.01
Spain	755	0.16	1.36	0.14	0.45	0.09
Austria	573	0.12	1.04	0.11	0.44	0.09
Finland	181	0.04	0.61	0.06	0.39	0.08
Sweden	575	0.12	1.27	0.13	0.93	0.19
North America	**48281**	**10.38**	**98.43**	**10.44**	**48.01**	**9.57**
Canada	6941	1.49	11.99	1.27	3.92	0.78
US	41340	8.89	86.44	9.17	44.09	8.79
Some Free Ports	**11665**	**2.51**	**81.05**	**8.59**	**38.14**	**7.61**
Cayman Islands	923	0.20	11.18	1.18	4.67	0.93
Virgin Islands	8877	1.91	62.01	6.58	30.17	6.02
Samoan	1865	0.40	7.86	0.83	3.30	0.66

Source: http://www.chinafdi.org.cn [Accessed 20/03/2005].

Table 2.3.3 Share of Major Source Countries/Regions of Actually Used FDI in China

Year	Hong Kong & Macao (%)	Taiwan (%)	US (%)	Japan (%)	EU (%)
1986	59.22		14.54	11.74	7.96
1987	69.08		11.36	9.50	2.28
1988	65.60		7.39	16.11	4.92
1989	61.24	4.56	8.38	10.50	5.53
1990	54.87	6.38	13.08	14.44	4.23
1991	59.96	10.68	7.40	12.20	5.63
1992	70.03	9.54	4.64	6.45	2.21
1993	64.91	11.41	7.50	4.81	2.44
1994	59.75	10.04	7.38	6.15	4.55
1995	54.64	8.43	8.22	8.28	5.68
1996	50.95	8.33	8.25	8.82	6.56
1997	46.46	7.27	7.16	9.56	9.22
1998	41.64	6.41	8.58	7.48	8.75
1999	41.35	6.45	10.46	7.37	11.11
2000	38.92	5.64	10.77	7.16	11.00
2001	36.35	6.36	9.46	9.28	8.92
2002	34.75	7.53	10.28	7.94	7.03
2003	33.86	7.35	7.85	9.45	7.35

Source: http://www.chinafdi.org.cn [Accessed 20/03/2005].

Table 2.3.4 FDI in China by Type up to 2003

USD billion

Type	# of Project	%	Contracted Value	%	Actually Used Value	%
Total	**465277**	**100**	**943.13**	**100**	**501.47**	**100**
Joint Ventures Enterprises	238367	51.23	351.84	37.31	206.03	41.08
Cooperative Operation Enterprises	54512	11.72	170.80	18.11	86.62	17.27
Foreign Invested Enterprises	172108	36.99	414.15	43.91	199.00	39.68
Foreign Invested Share Enterprises	67	0.01	1.46	0.15	1.55	0.31
Cooperative Development	191	0.04	4.74	0.50	7.40	1.48
Others	32	0.01	0.15	0.02	0.87	0.17

Source: China Statistical Yearbook, various years, and http://www.chinafdi.org.cn [Accessed 20/03/2005].

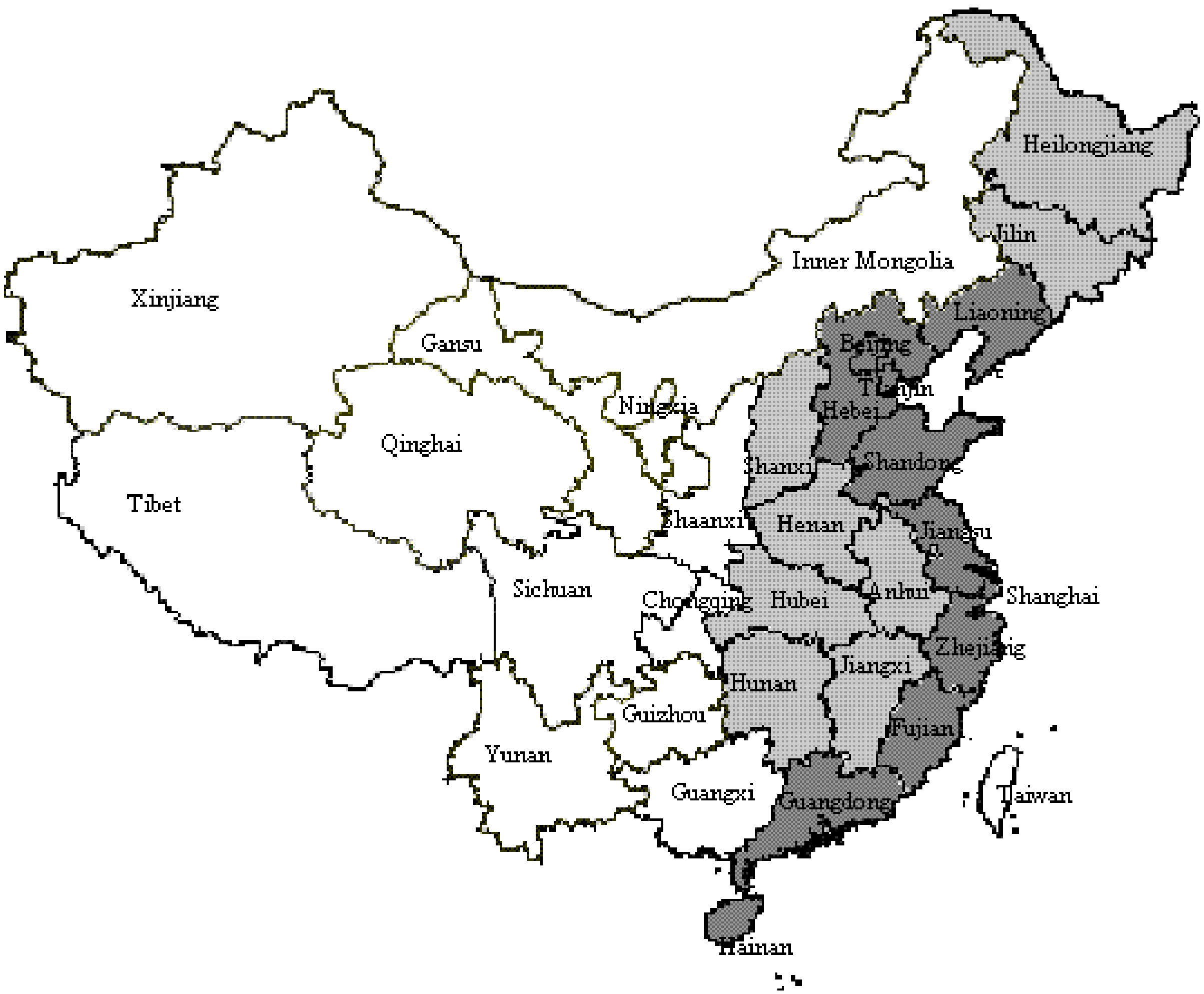
3) Geographical Distribution

The geographical distribution of FDI in China is very unbalanced. Figure 2.3.2 is a map of China with the names of administrative areas. It shows the traditional division of three regions in China. Eastern regions have received most of the FDI inflows. In addition to the natural and historical advantages of the eastern regions, the government's favourable policies towards FDI also offer a better business environment in this region than the others.[16] Although the central government began to place more attention on the development of central and western China in 2000 and "Western Development Programme" has been implemented, the economic development gap between coastal and inner regions is still large.

Table 2.3.5 demonstrates that 86.27% of cumulative FDI was located in the eastern region, 8.93% in the central region and only 4.80% in the western region between the years 1979 and 2003. Among the eastern region provinces, Guangdong has attracted more than a quarter of the total cumulative FDI (Figure 2.3.3). Jiangsu and Fujian, which have received 14.24% and 8.75% of the total FDI respectively, ranked second and third among thirty-one provinces in mainland China. Other eastern provinces, Shanghai, Shandong, Liaoning, Zhejiang, Beijing, Tianjin and Hebei also ranked in the top group. These eastern provinces are also the richest regions in China, in terms of both GDP and per capita GDP.

[16] China has a vast territory with coastal plains in the east and altiplano in the west. Eastern regions have an advantageous geographical position, which is favourable for international trade. The SEZs and fourteen opened coastal cities are the traditional industrial and commercial centres which offer better infrastructure than the inner areas of China. Numerous development zones have been established in eastern region, such as Yangtze River delta, the Pearl River delta, Bohai Sea Coastal Region and Pudong District of Shanghai.

Figure 2.3.2 Map of China



China administers 34 province-level divisions, including 4 municipalities (Beijing, Tianjin, Shanghai, and Chongqing), 23 provinces (Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Hainan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, and Taiwan) , 5 autonomous regions (AR) (Inner Mongolia AR, Guangxi Zhuang AR, Tibet AR, Ningxia Hui AR, and Xinjiang Uyghur AR) , and two special administrative regions (SARs) (Hong Kong and Macao). In this thesis, we only consider the 31 divisions in mainland China. Non-RMB domestic investment from Hong Kong, Taiwan and Macao are treated as "*foreign investment*" (see footnote 15).

- Eastern Regions
- Central Regions
- Western Regions

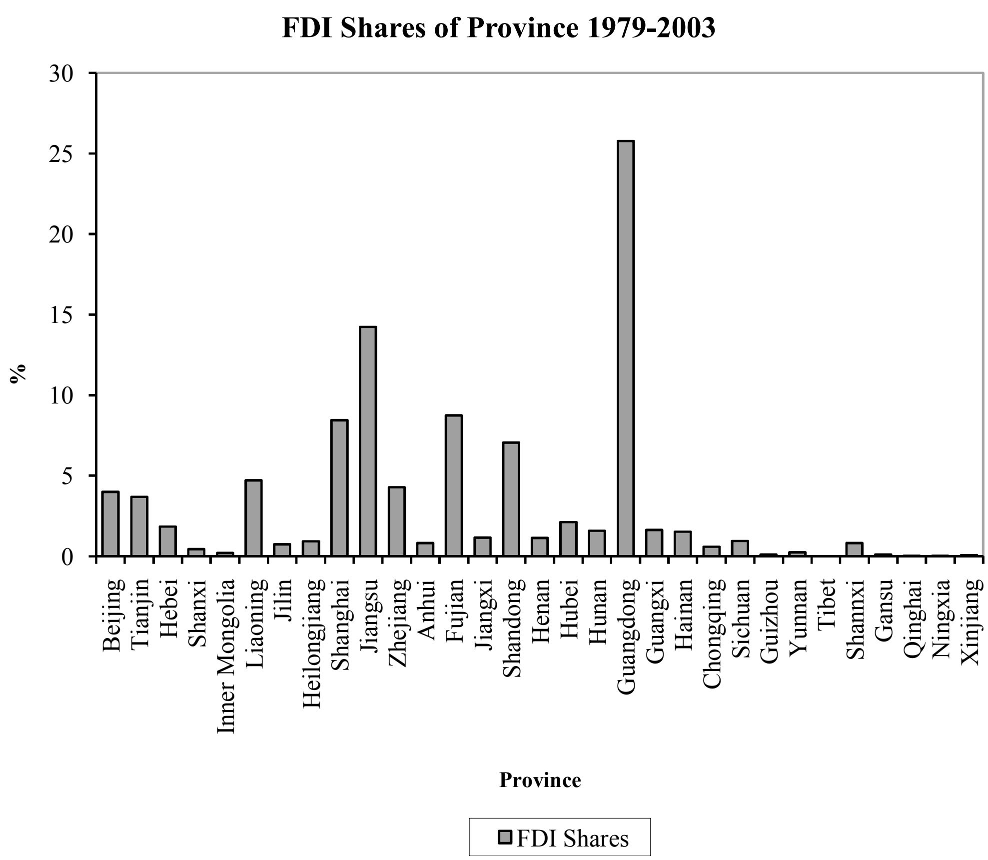
Table 2.3.5 FDI in Different Regions in China up to 2003

USD billion

Region	# of Project	%	Contracted Value	%	Actually Used Value	%
Total	**465277**	**100**	**943.13**	**100**	**501.47**	**100**
Eastern Region	381527	82.00	819.16	86.86	432.61	86.27
Central Region	52424	11.27	71.21	7.55	44.79	8.93
Western Region	31326	6.73	52.75	5.59	24.07	4.80

Source: http://www.chinafdi.org.cn [Accessed 20/03/2005].

Figure 2.3.3 FDI Shares of Provinces 1979-2003



Source: http://www.chinafdi.org.cn [Accessed 20/03/2005].

4) Sectoral Distribution

Chinese industry can be split into three main categories, primary industry, secondary industry and tertiary industry.[17] Thus far, the majority of FDI has flowed into the secondary industry.

Table 2.3.6 shows that among secondary industries, manufacturing has taken 63.66% of the total cumulative contracted FDI by 2003, with construction taking a significant proportion (2.57%). The tertiary industry comes second with the proportion of real estate (the leading sector) accounting for about 20%. The primary industry attracted less than 2% of the total FDI inflows.

According to the analysis of OECD (2002) and Wei (2002), much of FDI in the manufacturing sector was concentrated in labour-intensive sectors such as textiles, clothing and assembly lines of mechanical, electronic and electric products. However, there is a significant increase of FDI inflows into capital- and technology-intensive sectors.

In the future, especially with the accession to the WTO and further liberalisation, service trade, such as finance and insurance, telecommunications, wholesale and retail, are expected to increase. Further investment will also take place in traditional industries. Investment in agriculture depends on the extent of the opening up of the market for agricultural products and the industrialised process of production operations (OECD 2000).

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[17] Primary industry refers to extraction of natural resources, i.e. agriculture (including farming, forestry, animal husbandry and fishery). Secondary industry involves processing of primary products, i.e. industry (including mining and quarrying, manufacturing, production and supply of electricity power, gas and water) and construction. Tertiary industry refers to all other economic activities not included in primary and secondary industry.

Table 2.3.6 Cumulative FDI in the Three Industries 1979-2003

USD billion

Sector	**# of Project**	**%**	**Contracted Value**	**%**
Total	**465277**	**100**	**943.13**	**100**
Primary Industry	**13333**	**2.87**	**18.04**	**1.91**
Farming, Forestry, Animal Husbandry and Fishery	13333	2.87	18.04	1.91
Secondary Industry	**350170**	**75.26**	**632.01**	**67.01**
Mining and Quarrying	524	0.11	1.68	0.18
Manufacturing	338952	72.85	600.40	63.66
Electricity Power, Gas and Water Production and Supply	654	0.14	5.68	0.60
Construction	10040	2.16	24.25	2.57
Tertiary Industry	**101774**	**21.87**	**293.08**	**31.08**
Transport, Storage, Post and Telecommunication Services	5235	1.13	23.81	2.52
Wholesale & Retail Trade (& Catering Services)	23565	5.06	28.84	3.06
Finance and Insurance	48	0.01	0.87	0.09
Real Estate Management	40941	8.8	180.90	19.18
Renting and Business Services	15438	3.32	30.17	3.20
Scientific Research, Polytechnic Service & Geological Prospecting	3528	0.76	4.16	0.44
Household and other Services	10333	2.22	16.32	1.73
Education (Cultural & Arts, Radio, Film & Television)	1482	0.32	2.59	0.27
Health Care Sports and Social Welfare	1204	0.26	5.43	0.58

Source: http://www.chinafdi.org.cn [Accessed 20/03/2005].

2.3.2 Pollution in China

China has been a large polluting country with rapidly increasing industrial production, domestic and foreign trade and investment. Central and local governments and some industrial managers have recognised the problem and made an effort to reduce pollution and to encourage cleaner production. Environmental protection has been one of the "national fundamental policies" in China. However, economic growth is still the priority. The general public has little awareness of the threats of environmental degradation. Weak and uneven enforcement of environmental laws also discourage industries from reducing pollution and increasing efficiency. The disparity of economic growth and enforcement of environmental regulations has resulted in accumulated environmental problems especially in certain areas.

China's State Environmental Protection Administration (SEPA) reported that five of the ten most polluted cities worldwide are in China; acid rain is falling on one third of the country; half of the water in the seven largest rivers is "completely useless"; a quarter of China's citizens lack access to clean drinking water; one third of the urban population is breathing polluted air; and less than a fifth of the rubbish in cities is treated and processed in an environmentally sustainable way. SEPA officials reported in early August 2006, that China has become the world's top emitter of acid rain causing sulphur dioxide (SO_2), with discharges rising 27 per cent from 2000 to 2005, mostly from coal-burning power stations (Reuters, 16/08/2006).

Industrial pollution is a primary source of the environmental problems. SEPA reported that in 2004 industrial air pollution accounts for over 80% of the national total, including 83.9% of SO_2 emissions and 80.9% of flue dust. Although industrial water pollution has decreased year by year, it still accounts for about 45.8% of national total, including 38.1% of Chemical Oxygen Demand (COD) and 31.7% of Ammonia and Nitrogen.

Table 2.3.7 provides an insight into the discharge levels of industrial wastewater and industrial solid waste disposal from 1987 to 2004, and industrial waste gas emissions (including emissions of industrial SO_2, Soot and Dust) from 1991 to 2004. Figure 2.3.4 presents the emissions of carbon dioxide (CO_2) up to 2004.

These facts clearly show the pollution trend. Industrial wastewater pollution has been declining steadily; solid wastes disposal dropped quickly before the mid-1990s, and then fell slightly but has appeared to rise in recent years.

Air pollution is a serious problem. Waste gas emissions have increased rapidly since early 1990s. Among the air pollutants, industrial soot emission remains relatively stable, except an unexpected rise in 1998. Industrial dust stayed around 6 million tons from 1991 to 1997 and then jumped to over 10 million tons in 1998 and kept at this level until 2004. SO_2 and CO_2 emissions have generally maintained rapid growth and the emissions from the burning of solid fuels have contributed the most to CO_2 emissions.

Table 2.3.8 provides a regional perspective. Observe that the eastern region, which covers only 11.1% of the country's surface, has about 50% of the wastewater and waste gas emissions in 2004. However, in terms of solid wastes, the western region, which covers 70.1% of the country's surface, discharged over 50% of the total volume; while the eastern region only discharged about 5%.[18] Figures 2.3.5 -2.3.7 present a comparison of pollution in levels for 2004. The red coloured provinces have the highest emissions of pollutants in levels, while the yellowed provinces have the lowest emissions.

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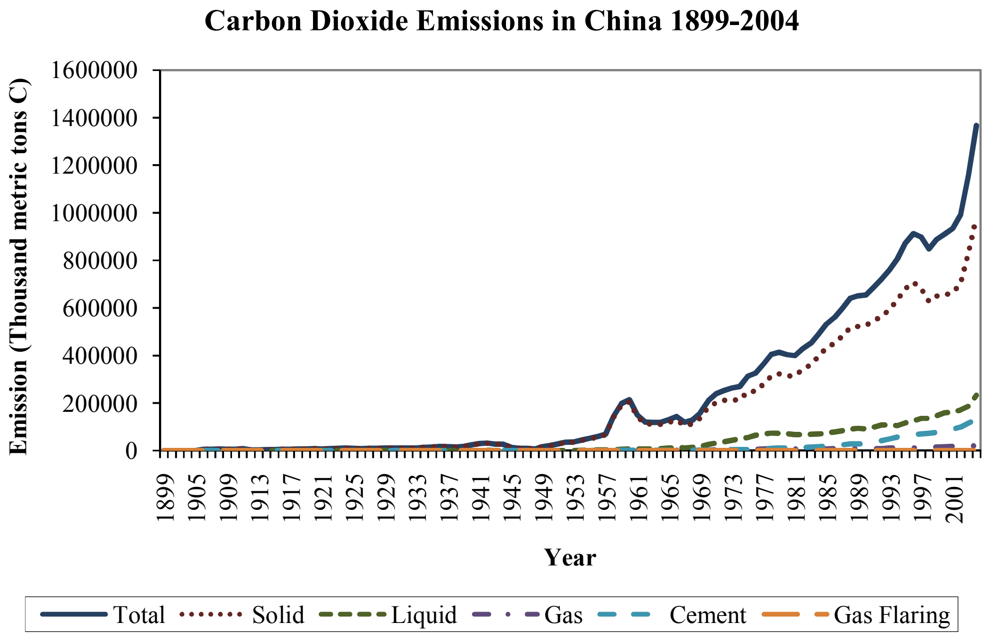
[18] Eastern regions have produced the 42.1% of the total volume of solid wastes. However, the utilise rate and treat rate of solid waste in eastern regions are much higher than the other two regions. Therefore, the discharged volume of solid wastes is low is eastern regions.

Table 2.3.7 Industrial Wastewater, Solid Wastes Discharges and Waste Gas Emissions up to 2004

Year	Wastewater (billion tons)	Solid Wastes (million tons)	Waste Gas (billion cu.m)	SO2 (million tons)	Soot (million tons)	Dust (million tons)
1987	26.38	87.19				
1988	26.84	85.45				
1989	25.27	52.65				
1990	24.87	47.67				
1991	23.57	33.76	8473.4	11.65	8.45	5.79
1992	23.39	25.87	8963.3	13.23	8.70	5.76
1993	21.95	21.52	9342.3	12.92	8.80	6.17
1994	21.55	19.32	9746.3	13.41	8.07	5.83
1995	22.19	22.42	10747.8	14.05	8.38	6.39
1996	20.59	16.90	11119.6	13.64	7.58	5.62
1997	18.83	15.49	11337.5	13.63	6.85	5.48
1998	20.06	18.21	12120.3	15.93	11.75	13.22
1999	19.73	11.54	12680.7	14.60	9.53	11.75
2000	19.42	10.40	13814.5	16.15	9.53	10.92
2001	20.26	28.94	16086.3	15.66	8.52	9.91
2002	20.72	26.35	17525.7	15.62	8.04	9.41
2003	21.24	19.41	19890.6	17.92	8.46	10.21
2004	22.11	17.62	23769.6	18.91	8.86	9.05

Source: China Statistical Yearbook and China Environment Yearbook, various years.

Figure 2.3.4 Carbon Dioxide Emissions in China 1899-2004



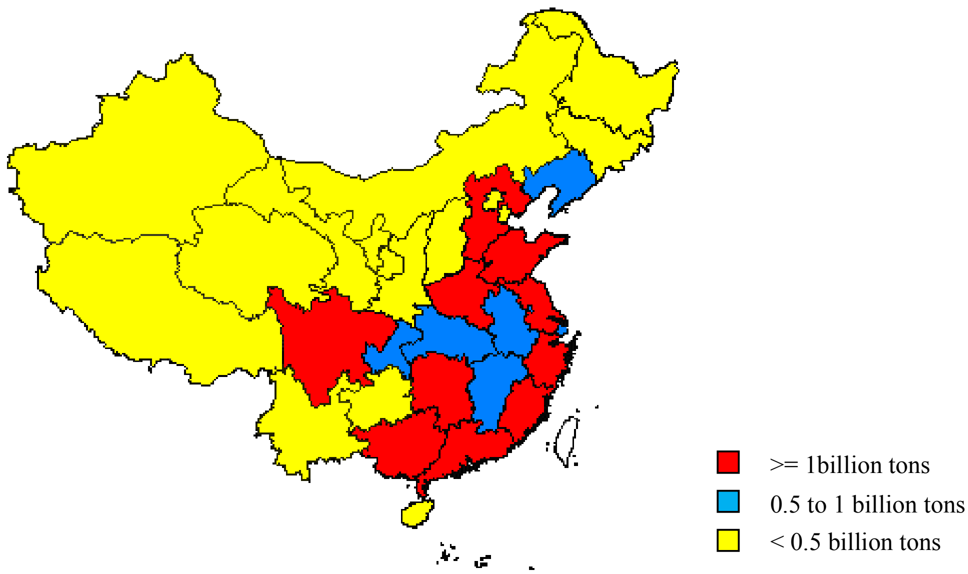
Source: Carbon Dioxide Information Analysis Centre, http://cdiac.esd.ornl.gov/trends/emis/prc.htm [Accessed 02/February/2008].

Table 2.3.8 Regional Comparison of Industrial Pollutions 2004 (proportions of total in brackets)

Region	Area (million km^2)	Wastewater (billion tons)	Waste Gas (trillion cu.m)	Solid Wastes (million tons)
Eastern Regions	1.07 (11.1%)	11.55 (52.2%)	11.79 (49.6%)	0.87 (4.9%)
Central Regions	1.68 (17.5%)	5.67 (25.6%)	6.00 (25.2%)	7.35 (41.7%)
Western Regions	6.73 (70.1%)	4.89 (22.1%)	5.98 (25.1%)	9.39 (53.3%)

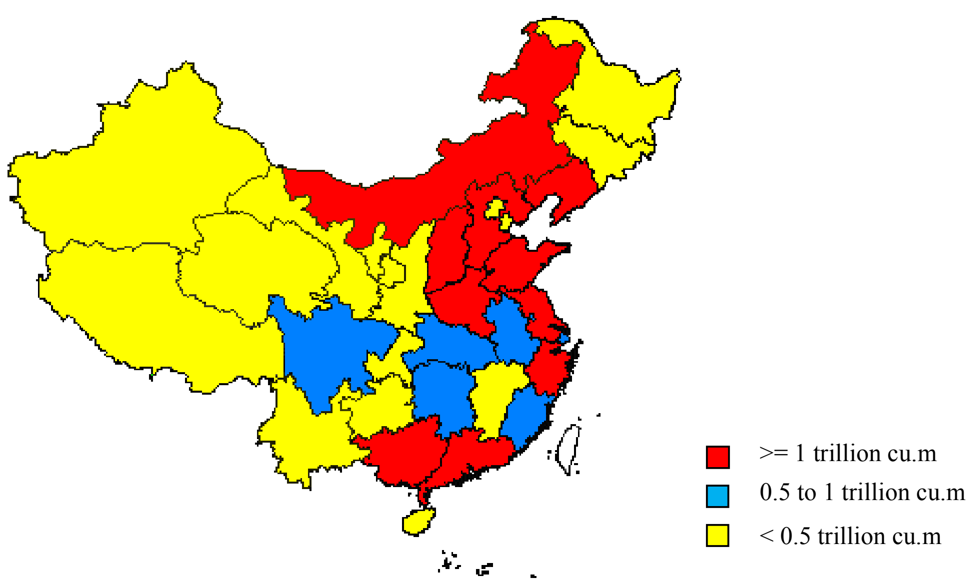
Source: China Environment Yearbook, 2004, and http://www.usacn.com/china/brief/population.htm [Accessed 23/March/2005].

Figure 2.3.5 Wastewater Discharges in Levels in 2004



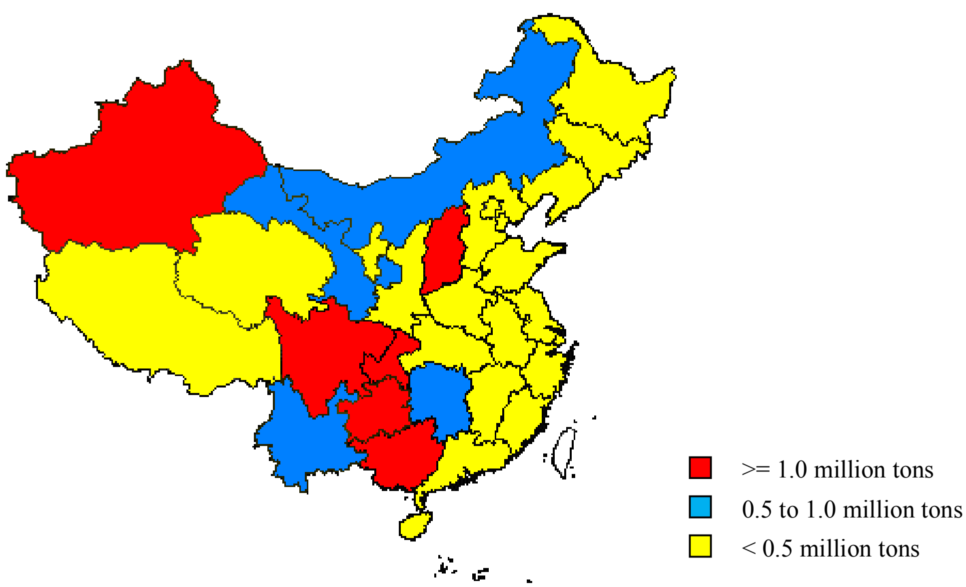
Source: China Environment Yearbook, 2005.

Figure 2.3.6 Waste Gas Emissions in Levels in 2004



Source: China Environment Yearbook, 2005.

Figure 2.3.7 Solid Wastes Disposals in Levels in 2004



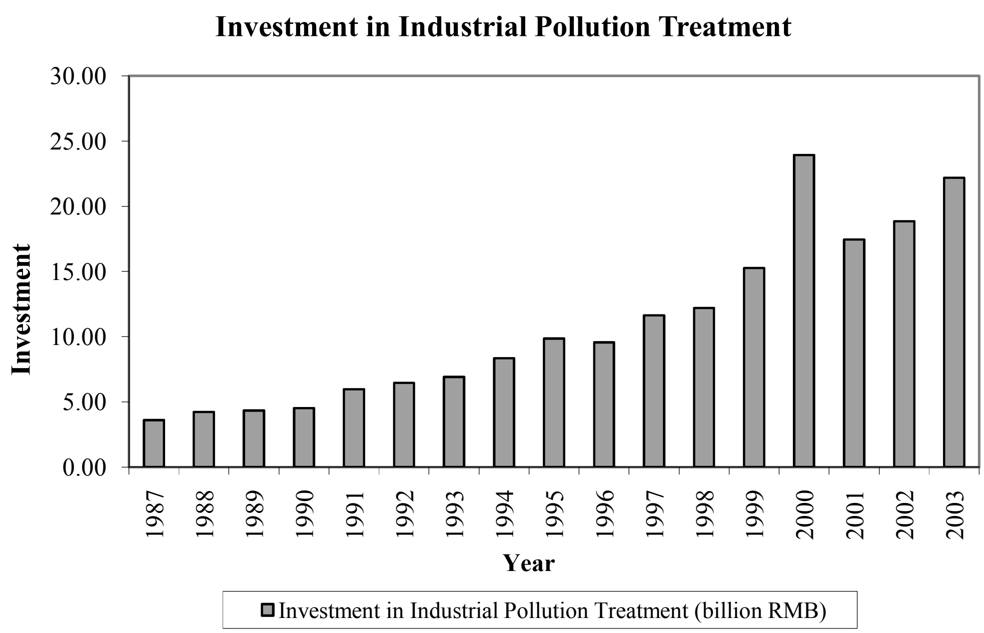
Source: China Environment Yearbook, 2005.

2.3.3 Environmental Investment

Facing such serious environmental problems, China's central and local governments, as well as some enterprises, have invested a great amount of money for environmental pollution treatment every year. In 2004 this investment amount increased to 190.98 billion RMB yuan (about $24.04 billion), which accounted for 1.40% of the country's GDP. Among this investment, 114.1 billion (59.8%) was used for city environmental infrastructural construction. Another 30.8 billion (16.1%) was provided for industrial pollution treatment. Figure 2.3.8 shows the rising trend of investments in industrial pollution treatment from 1987 to 2004. The investment in 2004 was more than eight times the 1987 value.

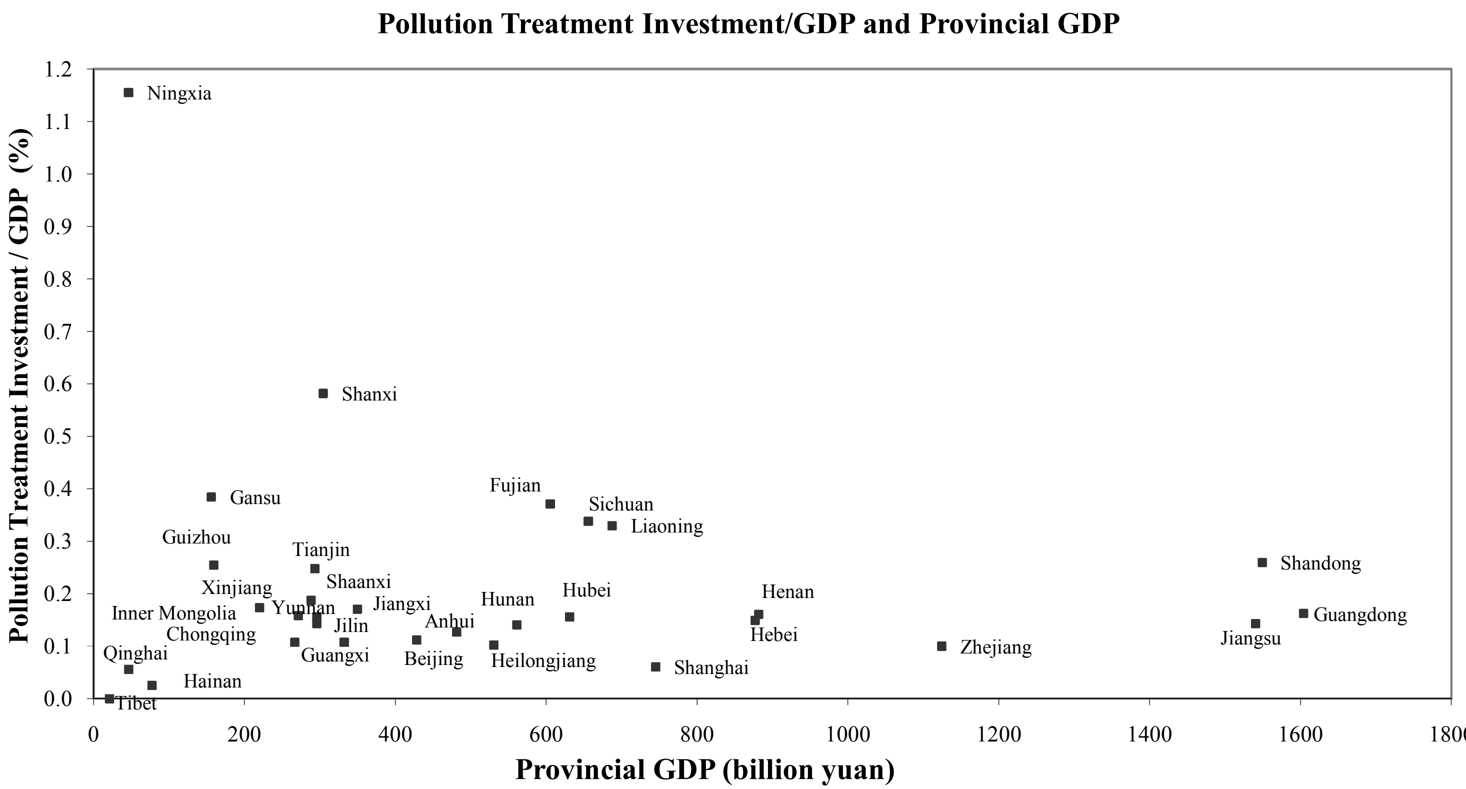
A disparity of investment in industrial pollution treatment also exists across provinces. Figure 2.3.9 shows that the provincial share of pollution treatment investment relative to GDP varies across province, an imbalance that is not consistent with GDP levels.

Figure 2.3.8 Investments in Industrial Pollution Treatment 1987-2004



Source: China Statistical Yearbook, various years.

Figure 2.3.9 Provincial Difference in Pollution Treatment Investment per unit of GDP and GDP in Levels 2004



Source: China Statistical Yearbook, 2005.

2.3.4 Environmental Regulations in China

2.3.4.1 Regulatory Framework

Environmental protection in China began to be the responsibility of the country in 1978 based on the *Constitution of the People's Republic of China*. China established the *Environment Protection Law* (EPL) in 1979 (provisional), and officially enacted it in September 1989. The EPL provides the basic principles governing the prevention of pollution and environmental protection and imposes criminal responsibility for serious environmental pollution. Based on EPL, China has had an established regulatory framework since 1979, with nine environmental protection laws, fifteen resource conservation laws and more than 50 pieces of environmental administrative regulation. Over 660 regulations have been issued by related ministries of central government and local governments. Environmental standards are another important component of this regulatory system. By the end of 2005, China has issued over 800 national environmental standards and more than 30 local environmental standards. All of these have formed a comprehensive and complex legal framework on environmental protection (China Environment Protection 1996-2005, SEPA).

The current environmental management system contains the following four important components:

- The environmental impact report system: every project that has possible negative effects on the environment should go through an environmental impact review process. It is only after the verification by national or local regulatory authorities, that the project can be legally established.

- Three synchronisations: Article 26 of EPL states that the pollution-preventing facility must be designed, constructed and operated simultaneously with the design, construction and operation of the main production line of the project. The environmental authorities are in charge of checking the project design in the review process and monitoring the construction. After inspection and approval of the environmental authorities, the project can start operation.
- The registration and licensing system for the discharge of pollutants (self-reporting system): Article 27 of EPL specifies that institutions and enterprises that emit pollutants must register and report to the environmental protection authorities. They should report six following categories: (1) basic economic information (sector, major products and raw materials); (2) production process diagrams; (3) volume of water use and wastewater discharge and pollutant concentrations in wastewater; (4) waste gas volume and air pollutant concentrations (before and after treatment); (5) noise pollution by source; and (6) discharge of solid wastes. It is an important tool in controlling pollution.
- Pollution levy system: any firm that discharges pollutants exceeding designated standards will be charged an excess effluent fee. Charges are levied for 29 water pollutants and 22 air pollutants, as well as solid wastes, radioactive wastes and noise. Among the pollutants, the major focus for monitoring and levy collection is on chemical oxygen demand and total suspended solids for water, and SO_2 and flue dust for air. Funds from the pollution levy have been used for pollution source control, damage remediation and development of environmental institutions. The lion's share of the levy has been used for pollution abatement. It should be noted that the charge paid for discharging does not legalise the pollution process. After paying the charge the enterprises should also face the costs of controlling and eliminating the pollution. To

encourage pollution reduction, levy charges increase with the duration of non-compliance. After two years of paying the levy, polluters are subject to an annual 5% increase in the charge rate. In the levy system, polluters have to report their emissions (including water and air pollutants, noise pollution, solid wastes, etc.) and the local environmental authorities check the reports and then decide the amount of levy to be collected. Penalties are imposed for false reporting and non-cooperation with the government. The levy design, verification and collection, and the development of levy system are fully described in Wang and Wheeler (2002).

2.3.4.2 Environmental Regulatory Framework towards Foreign Investment

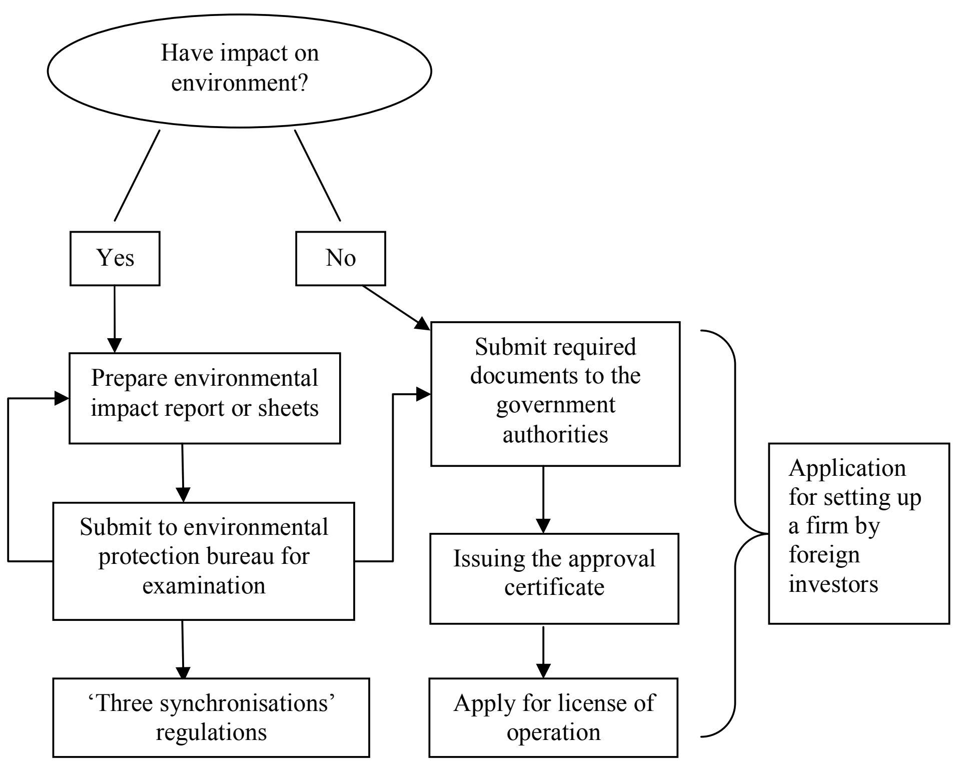
Generally, there are no separate environmental standards for foreign investment, but foreign investors' environmental behaviour must abide by Chinese environmental laws and regulations and meet the environmental standards. There are some specific policies and administrative procedures governing and monitoring of FDI with respect to environmental protection.

The *Provisions on Guiding Foreign Investment Direction* set out environmental protection requirements for foreign investment projects. It encourages investment in environmentally sound technologies and new technologies for controlling environmental pollution. It also limits the foreign investment in exploring rare and precious mineral resources and prohibits investment in those that pollute the environment, threaten human health or destroy natural resources.

Notice on Reinforcing Environmental Protection Management of Foreign Investment Projects, which was issued in 1992, states that foreign investors should abide by Chinese environment protection laws and regulations. They should prevent environmental pollution and ecological damage, and accept monitoring and supervision by environmental protection authorities. There are also other regulations such as Regulations of *Ocean Oil Exploring by Foreign Firms*, *Implementing Regulations on Joint Ventures*, *Project Construction and Operation in Part III of the Application Form for Establishing Foreign Invested Enterprises in China*, etc (Xian *et al.* 1999).

Xian *et al.* (1999) also provides the environmental aspect of approval procedures for FDI projects in China, shown by the following figure.

Figure 2.3.10 The Environmental Aspect of Approval Procedures for FDI Projects



Source: Xian et al., 1999.

2.3.4.3 Implementation of Environmental Regulations

Although the regulatory framework seems comprehensive, enforcement is weak. Ma (2007) points out that the limited power of environmental authorities is one reason for the failure to implement environmental law. SEPA has limited administrative power, and is not allowed to participate fully in national decision making. Local environmental authorities are subordinate to local government. They are reliant on the government for both funding and enforcement, making them hard act freely for local interest and protect the environment. Current legislation only allows the environmental authorities to make suggestions and issue fines. For example, local environmental authorities do not have the power to force a company to make changes within a certain time limit. In addition, the fines are usually small, thus it may cost more to obey the law than to break it.

Environmental policy is set by the government, overseen by the environmental authorities and implemented by various government departments. Such a principle is reasonable but the coordination between the environmental authorities and other departments is poor, mainly because the huge amount of overlap among departments. For example, water pollution is the responsibility of the environmental authorities, but water and groundwater are managed by the Ministry of Water Resource, sewage is dealt with by the Ministry of Construction, which also has the functions of directing the utilise and protection of groundwater in city. This problem has been solved in other countries, through greater departmental communication, but is failing in China due to the lack of legislative clarity of role, power and responsibilities of each department. Additionally, the public lacks awareness of environmental protection and participation in social supervision also to the detriment of enforcing the environmental regulations.

Furthermore, the environmental regulatory stringency varies among regions. The environmental standards are set jointly by local and national regulators. The levy rates are formally established by a national regulator but the actual levies are decided and collected by local regulators. Some local regulators protect the pollution companies for economic interests. Excessive pollution happens in some regions due to the failure of local government. The situation continues because of the lack of awareness of some local government officials about the environment, environmental laws and the rule of laws in general. Therefore, the local levies may vary for identical industries and pollutants. In addition, the discretion of local regulators' inspections varies as well. Some regions have better environmental management systems than others. As a result, regulatory strength varies across regions.

The weak environmental regulatory stringency in China provides an opportunity for some multinational firms to take advantage of weak environmental standards to transfer their out-of-date technologies and pollution-intensive production to China. Xian *et al.* (1999) find that about 30 per cent of the FDI in China was in pollution-intensive industries, of which 13 per cent was from highly-pollution-intensive industries. The recent report from Institute of Public and Environmental Affairs (IPE) in January 2008 also shows that over 300 MNCs have violated environmental regulations in China and only 8 of them passed the examination after controlling the pollution. The majority of these MNCs are from US, Japan and European countries. None of their subsidiaries are polluting firms in their home countries due to the strict environmental standards. The report also shows that a considerable number of these foreign polluting subsidiaries (about one third) are located in Shanghai, which have attracted over 15% of the national cumulative FDI inflows since 1979 (see Figure 2.3.3) and have relatively low environmental investment (see Figure 2.3.9).

It suggests that polluting firms would like to locate in the regions that have paid relatively less attention to the environment protection.

In sum, economic development, FDI inflows, levels of environmental deteriorations, and environmental regulations differ across regions in China. Correlations between these variables are useful if we wish to model the determinants of inter-province foreign plant location choice.

2.4. Methodology

We follow the methodology of previous studies on inter-state plant location choice and investigate the interaction between FDI flows and environmental regulations in China. This section firstly introduces the empirical models. It explains how we construct the explained and explanatory variables and how these variables capture provincial characteristics. Finally, a description of the data used in the empirical estimation is provided and some discussion of the selection of the estimators.

2.4.1 Estimating Models

Esty and Gentry (1997) and Aliyu (2005) outline four types of FDI – market seeking, production platform seeking, resource seeking and low cost seeking. A MNC will view and compare different locations to assess differences in, for example, production costs, market size, government regulations, infrastructure, agglomeration effects and so on. To examine whether FDI is attracted to provinces with relatively weaker environmental enforcement, we observe the location of FDI across 30 administrative areas (for simplicity we refer to these as regions/provinces).[19]

An empirical model that is adopted by some FDI researchers is given by

$$FDI = f(X, \eta, \gamma) \tag{2.4.1}$$

where X is a vector of regional characteristics that may affect the inflows of FDI; η is the unobserved provincial/regional effect; and γ is the unobserved time effect.

When considering the impact of environmental regulations on foreign plant location choice, a variable ***ER*** (the vector of level of environmental stringency) is included in the Equation 2.4.1 to give:

$$FDI = f(ER, X, \eta, \gamma) \tag{2.4.2}$$

where

FDI is the amount of FDI inflow into region i in time period t;

ER is the vector of measures to capture environmental stringency in region i in time period t;

X is the set of other regional characteristics that may affect FDI in region i in time period t;

η is time-invariant regional effects in region i;

γ is location-invariant time effects in time period t; and

ε is the idiosyncratic error term.

[19] Tibet is not included in our estimating sample due to the lack of data on FDI inflows.

FDI inflows are captured by the actually used value of FDI according to the agreements and contracts. It measures total amount of new foreign direct investment of the year, including the investment from Hong Kong, Taiwan and Macao, and the investment from foreign countries. The data are aggregated comprising of the investment in all the sectors in the economy. FDI inflows cannot be broken down by source country or by industrial sector as a result of the data unavailability.

Since the regions vary in size, we normalise the actually used FDI inflows by two measures of regional size, one of which is the value of FDI divided by regional GDP (*FDI/GDP*) and the other is FDI divided by regional population (*FDI/POP*). Scaling FDI by GDP or population does not affect the absolute value of FDI but allows FDI to be comparable across regions and time (see Appendix 2.1 for variable definitions and sources).

Factors that may influence provincial level FDI include environmental stringency, factor prices, infrastructure, and agglomeration effects.

The level of environmental stringency in different provinces is proxied by three variables:

- *EI1* – the share of investment in industrial pollution treatment projects in total innovation investment. Industrial pollution treatment investment is the total investment of enterprises in construction and installation projects, and purchasing of equipment and instruments required in the pollution harnessing projects for the treatments of wastewater, waste gas, solid wastes, noise pollution and other pollution. Industrial pollution treatment investment is accounted in innovation investment, which is one part of the total investment of fixed assets. Environmental regulations require that the pollution treatment facilities have to be designed, constructed and operated simultaneously with the design, construction and operation of the main production line of the projects. A region with more stringent environmental regulations is expected to have relatively more investment in pollution treatment projects. Therefore, investment pollution treatment project could be treated as environmental protection costs for any production project. We use the share of industrial pollution treatment investment in innovation investment to reflect the local government effort on environmental protection. Since a small fraction of the sources of industrial pollution treatment investment comes from state budgetary appropriations on capital construction investment, in our sensitivity analysis we separately normalise industrial pollution treatment investment by the sum of investment in innovation and capital construction (*EI2*) and by total investment in fixed assets (*EI3*). Details are in Appendix 2.2.

- *Punish* – the total number of administrative punishment cases filed by the environmental authorities in each region normalised by the number of enterprises in each region.[20] Administrative punishment cases are those cases that breach environmental protection laws and regulations. According to the Measures on Administrative Penalty for Environmental Offences, the types of administrative punishment includes: 1) warning; 2) fine; 3) confiscation of illegal gains; 4) compelling to stop producing or using; 5) revoking licence/permit or other permission certificates; and 6) other types of administrative punishments from Environmental Protection Law, laws and regulations. If the environmental illegal activity offends the criminal law and is suspected of a crime, the case should be transferred to judicial authority to investigate the criminal responsibility according to law. We normalise the number of cases by the number of enterprises. It is possible that the normalised punishment cases could capture the levels of firms violating the environmental regulations. However, given the

[20] The enterprises are all state-owned and non-state-owned enterprises above a designated size, which refers to enterprises with an annual sales income of over 5 million RMB yuan (about 0.60 million USD).

general weak environmental regulation stringency in China, we expect that the more enterprises are punished the more stringent of the environmental regulations exist in a region. *Punish* measures the prosecution cost of firms if they breach the laws and regulations and hence proxies the strength of enforcement of regional environmental legislation.

- *Charge* – a pollution emission charge normalised by the number of organisations that paid this charge. Pollution emission charge refers to the total amount of 1) pollutant emission charge exceeding the discharge standards; 2) sewage discharge levy; and 3) other four kinds of charges, including increasing levy standards, double charges, overdue charges and compensation fines. Pollutants include water and air pollution, solid wastes, noise and others. Although supervised by central government, the pollution charge is implemented by regional governments. *Charge* measures the penalty costs of firms if they emit pollutants more than the emission standards. Therefore it reflects the provincial differences in implementation of the pollution levy system.

These three measures are time varying, which improves upon the 0-3 type of measure of environmental stringency used in Smarzynska-Javorcik and Wei (2005). Since more stringent environmental regulations will generate higher pollution taxes or higher pollution abatement costs for the firm, the environmental regulation stringency variables should have a similar impact to factor prices on foreign investment location choice. It is expected that FDI is attracted to provinces with weaker regulations, i.e. with a lower share of investment in industrial pollution treatment investment, with a lower number of normalised administrative punishment cases related to environmental issues, and/or with a lower normalised pollution emission charge.

Since the pollution emission charge is more visible to enterprises than administrative punishment cases and environmental investment, we expect that *Charge* has the strongest impact on FDI location choice, followed by *Punish* and *EI1*, respectively.

Our control variables are as follows:

Manufacturing wage is included as a proxy for factor price differences across each region. The quality of labour force in a region is captured by two measures, labour productivity and the illiteracy rate. Population density is employed as a proxy for land prices and potential market size (assuming that labour mobility between provinces is low). The availability and quality of infrastructure also impacts the overall cost on doing business and hence is an attractive factor to FDI location. We include both railway density and road density to measure the quality of regional transportation network and thus to proxy the cost and availability of material inputs. Gross regional product (*GRP*) per capita is included to capture the average quality of the government, general infrastructure and the effect of market size differences across regions. We use regional gross industrial product (GIP) to capture the industrial agglomeration effect whereby firms locate where hubs of economic activity already exist (Bartik, 1988). GIP measures the concentration of the whole industrial sectors and also the regional availability of providing intermediate inputs.[21]

The regional fixed effects capture the effects specified to each region which do not change over time (including the unobserved preferential policies such as tax benefits and subsidies to foreign firms and exports). The year specific effects measure any effects that are common to all provinces but which change over time.

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[21] Gross industrial product is the total volume of final industrial products produced and industrial services provided during a given period. It measures the total achievement and overall scale of industrial production during a given period. Industrial enterprise is used as the basic accounting unit. Double counting does not exist within the same enterprise, but may exist between enterprises.

Following the literature, foreign investors are seeking a location with comparative advantages such as cheaper factors that they use in higher proportions. It is expected, that foreign investment will be attracted to provinces with relatively low labour costs, i.e. low manufacturing wages. However, wage has positive relationship with local income levels. Some recent empirical studies on intra-country FDI flows, such as Wei *et al.* (1999), Coughlin and Segev (2000), Cheng and Kwan (2000) and Fung *et al.* (2003), find significantly negative effects of wage on aggregate FDI flows in China. Conversely, wage is also found to be positive related with FDI flows (Gao, 2002). To specify the real impact of wage on FDI inflows, we add wage squared in our estimations and expect an inverted-U relationship between FDI and wage. When wage is below some benchmark, foreign investment are attracted to provinces with high wage level because labour cost is not the most important determinants compared with other factors, such as high regional income and good infrastructure. But when wage is beyond the benchmark, FDI is deterred by wage because it becomes more important in the standard profit function.

Since low labour cost is associated with low labour quality, foreign investment will be attracted by high illiteracy rate and/or low labour quality. However, some previous studies, such as Cheng and Kwan (2000), Gao (2002), and Fung *et al.* (2002), find that FDI prefers to locate into the regions that have high percentage of high education enrolment. Therefore, the impacts of illiteracy rate and productivity are ambiguous.

According to the previous work of Head and Ries (1996) and Dean *et al.* (2005), it is expected that FDI would flow into provinces with better industrial agglomeration and infrastructure. Therefore we expect a positive coefficient on *GIP* and transportation infrastructure variables. In addition, for foreign investors seeking a large local market they may be expected to invest in areas that have large consumption capability and potential which can be proxied by population density and per capita income. However, population density also proxies land price. In more densely populated areas, land price is usually higher than that in less densely populated areas. The sign of population density is therefore expected to be ambiguous.

Our five-year time period panel data help to control for unobserved heterogeneity. We presume that all the control variables are exogenous. However, environmental regulation stringency may be endogenous partly because the regions with relatively low FDI inflows may lower their environmental regulation standards in order to attract more FDI, and partly because FDI is an important engine of growth and hence helps to improve regional environment and environmental standards. Simultaneously, FDI could have an impact on other control variables, such as income, wage, population density and infrastructure quality. We therefore employ a one-year lag for all independent variables to minimise any possible causality links from FDI to the explanatory variables. Another reason to lag the independent variables is that the impact of these variables on FDI is unlikely to be immediate.

The estimating equation is therefore:

$$\begin{aligned}\ln(FDI_{it}) = \alpha &+ \beta_1 \ln(ER_{it-1}) + \beta_2 \ln(GRP\ per\ Capita_{it-1}) + \beta_3 \ln(Wage_{it-1}) \\ &+ \beta_4 (\ln(Wage_{it-1}))^2 + \beta_5 \ln(GIP_{it-1}) + \beta_6 \ln(Pop.\ Density_{it-1}) \\ &+ \beta_7 \ln(Rail\ Density_{it-1}) + \beta_8 \ln(Road\ Density_{it-1}) + \beta_9 \ln(Illiterate\ Rate_{it-1}) \\ &+ \beta_{10} \ln(Productivity_{it-1}) + \eta_i + \gamma_t + \varepsilon_{it}\end{aligned} \tag{2.4.3}$$

where *i* refers to province *t* refers to year.

We firstly regress the model only including the major explanatory variable *ER*, and then add the control variables one by one in accordance with the selection of control variables in previous studies on China's intra-country FDI location choice. Regional GDP per capita and wage rate are commonly used determinants of FDI and hence we introduce them into the model as control variables in the first place. GIP and population density are usually omitted in some studies. We thus add them in the next place in order to check if they have significant and stable impacts on FDI. Infrastructure variables and labour quality variables are also controlled in some previous studies and the selection usually depends on the emphasis of the papers. We therefore subsequently include these variables in the regressions. In addition, adding the independent variables incrementally is helpful to find whether *ERs* have stable and significant effects on FDI inflows.

We use the log transformation model which could help to correct the positive skewness of variables and make the error term close to homoskedestic (see Appendix 2.3 for the level model and results).[22]

If there is no effect of the stringency of environmental regulations on FDI across regions, we would expect β_1=0. If $\beta_1 < 0$, we cannot reject the hypothesis that FDI is attracted to provinces with lower regulatory stringency.

The expected signs of the coefficients are as follows:

Coefficients	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}
Expected Signs	-	+	+	-	+	-/+	+	+	-/+	-/+

[22] After taking logs, the positive skewness of all the variables is significantly reduced.

2.4.2 Data Description

A complete description of all variables definitions and sources is provided in Appendix 2.1. The China Statistical Yearbook (various years) was used to compile data on the manufacturing wage, illiteracy rate, infrastructure, agglomeration, market size and population data. The China Industrial Economy Statistical Yearbooks provide the labour productivity for all foreign funded enterprises. The raw data for the three environmental regulation standard variables are collected from China Environment Yearbook. Because one year lags are used for all independent variables in the estimation, all the independent variables of 30 regions are from 1998 to 2002. FDI data used for estimations are therefore from 1999 to 2003.

To gauge the consistency of the sample with what is known about the provincial distribution of foreign investment, Table 2.4.1 compares the provincial shares of total actually used FDI value in the sample. It illustrates, consistent with Figure 2.3.3, that most FDI inflows were located in eastern regions/provinces: Guangdong; Jiangsu; Shanghai; Fujian; Shandong; Liaoning; Zhejiang; and Beijing.

Table 2.4.2 shows the summary data for the provincial characteristics in 2002.[23] The maximum value of *EI1* is found in Ningxia with 910 RMB yuan per 10 000 RMB yuan innovation investment, while the lowest investment share is only 31.65 RMB yuan in Shanghai. For *Punish* the most stringent province is Heilongjiang with 5877 cases per 1000 enterprises, and the weakest province is Qinghai with 75. In terms of *Charge*, Shanghai becomes the most stringent province, where the charge is more than 32,793 RMB yuan per organisation, and Hainan is the lowest with a charge 2,775 RMB yuan per organisation. We

[23] Because all independent variable are one year lagged, the value of the two dependent variables, FDI_1 and FDI_2 are the values for 2003.

find that the values of our three environmental stringency variables vary widely across province, and a province could appear to be stringent using one measure of environmental regulations but not using the others. The correlation matrix (See Table 2.4.3) shows that these three environmental stringency variables do not have a strong correlation and we even find insignificant negative correlation between *Punish* and *Charge*.

The correlation matrix also shows that our FDI variables seem to have a negative correlation with *EI* and *Punish*, but a positive correlation with *Charge*. The correlations between the two FDI variables and other independent variables implies that FDI prefers to flow into provinces with better infrastructure, higher population density, higher income level, better agglomeration, higher quality of labour and higher labour costs.

The correlation matrix shows that per capita income is highly correlated with wage, population density and infrastructure variables, probably because per capita income could capture the similar things. Then the effect of income on FDI probably will be accompanied by strong side effects via these variables on FDI. Due to the importance of these variables and the availability of data, we cannot drop any of these variables or enlarge the sample size to remedy to this multicollinearity problem. However, mutlcollinearity does not actually bias the results but just produces large standard errors for income variable, i.e. may cause income becoming insignificant. And we estimate the model using generalised least square estimator, which will produce better results than ordinary least square estimator (see section 2.4.3).

The values of all the data are deflated by the GDP deflator, which is set to 100 for the year 1990.[24] All the FDI data, which are measured in US dollars, are converted to RMB yuan at the middle exchange rate of the year. Table 2.4.4 provides the descriptive statistics for each of our variables.

Table 2.4.1 FDI Distribution by Province, 1997-2003

Province	**FDI at 1990 Constant Price (USD 10 000)**	**FDI at 1990 Constant Price (RMB 10 000)**	**Shares of National FDI (%)**
Beijing	10611	58152	**4.07**
Tianjin	10425	56729	**3.97**
Hebei	5433	29560	2.07
Shanxi	1453	7937	0.56
Inner Mongolia	569	3139	0.22
Liaoning	13082	71982	**5.04**
Jilin	1814	9862	0.69
Heilongjiang	2370	12819	0.90
Shanghai	22473	123330	**8.63**
Jiangsu	41995	231648	**16.21**
Zhejiang	12695	70472	**4.93**
Anhui	1926	10536	0.74
Fujian	21328	116404	**8.15**
Jiangxi	3643	20225	1.42
Shandong	19362	107168	**7.50**
Henan	3089	16822	1.18
Hubei	6275	34616	2.42
Hunan	4687	25673	1.80
Guangdong	63197	345308	**24.17**
Guangxi	3397	18377	1.29
Hainan	3047	16568	1.16
Chongqing	1644	8921	0.62
Sichuan	2374	13100	0.92
Guizhou	222	1208	0.08
Yunnan	698	3789	0.27
Tibet	0	0	0.00
Shaanxi	2036	11064	0.77
Gansu	277	1523	0.11
Qinghai	91	514	0.04
Ningxia	122	671	0.05
Xinjiang	117	640	0.04
Sum	**260450**	**1428755**	**100**

[24] An alternative measure of inflation is consumer price index. However, GDP deflator is a better measure of overall inflation than the consumer price index because it is based on a broader market basket including every item in the GDP.

Table 2.4.2 Provincial Characteristics in 2002 (All values are at 1990 constant price)

Province	**FDI/GDP*** (yuan /10000 yuan)	**FDI/POP** (yuan)	**EI1** (yuan/ 10000 yuan)	**Punish** (case/1000 firms)	**Charge** (yuan/ organisation)	**GRP per capita** (yuan)
Beijing	495	657	315	229	18916	15312
Tianjin	519	663	611	256	8907	12045
Hebei	112	62	262	433	7266	4906
Shanxi	72	28	418	822	9010	3308
In. Mongolia	34	16	197	1165	4327	3897
Liaoning	389	293	280	4451	11147	6989
Jilin	63	31	305	524	5662	4485
Heilongjiang	60	37	703	5877	6836	5481
Shanghai	724	1395	32	176	32794	21876
Jiangsu	702	623	166	264	13918	7745
Zhejiang	439	465	294	268	3839	9062
Anhui	77	25	191	412	5395	3131
Fujian	411	325	326	267	7084	7264
Jiangxi	471	165	72	460	4041	3137
Shandong	400	288	484	267	14681	6267
Henan	63	24	313	512	9241	3464
Hubei	240	114	222	456	6090	4477
Hunan	182	67	202	660	6195	3533
Guangdong	475	429	210	195	5947	8089
Guangxi	127	38	151	411	6619	2744
Hainan	520	227	78	133	2775	4200
Chongqing	96	36	142	832	11117	3416
Sichuan	63	21	264	255	4628	3103
Guizhou	28	5	157	156	5269	1697
Yunnan	28	8	309	113	7200	2787
Shaanxi	115	39	226	955	5470	2973
Gansu	15	4	373	225	6630	2418
Qinghai	54	21	110	75	3827	3459
Ningxia	37	13	910	1389	9864	3124
Xinjiang	7	3	147	243	4455	4511

Table 2.4.2 continued

Province	Manu. Wage (yuan)	GIP (100 million yuan)	Pop. Density (persons per km^2)	Rail Density (km/10 000km^2)	Road Density (km/10 000km^2)	Illiterate Rate (%)	Productivity (yuan/ person)
Beijing	9497	1708	847	677	8547	5.4	66663
Tianjin	7663	1789	891	603	8581	6.7	61220
Hebei	4736	2311	354	241	3320	7.8	42067
Shanxi	4260	925	211	196	3821	6.4	47136
In. Mongolia	4388	535	22	56	661	13.5	51482
Liaoning	5657	2631	288	261	3298	5.2	44956
Jilin	5487	1169	144	190	2198	4.4	113101
Heilongjiang	4735	1339	81	117	1344	6.5	46886
Shanghai	11885	4166	2621	414	10139	8.2	66363
Jiangsu	6200	7463	719	131	5862	14.3	53099
Zhejiang	7157	5263	456	128	4484	13.5	32884
Anhui	4497	1143	456	160	4860	17.9	60328
Fujian	6133	1979	289	121	4513	13.7	37445
Jiangxi	4475	640	253	142	3643	10.8	26283
Shandong	4716	6188	594	187	4839	11.2	35999
Henan	4218	2316	576	215	4296	9.1	43656
Hubei	4793	1932	320	127	4594	15.1	63844
Hunan	5337	1130	316	131	4038	8.4	41774
Guangdong	7912	8815	423	113	5835	7.0	35459
Guangxi	5360	635	210	119	2448	9.5	47779
Hainan	5053	142	236	63	6140	8.9	42054
Chongqing	5497	661	379	88	3788	10.3	59041
Sichuan	5303	1473	178	60	2293	13.6	49243
Guizhou	5019	429	226	111	2601	18.7	9276
Yunnan	6343	711	110	60	4184	23.1	55359
Shaanxi	5058	810	179	141	2271	15.6	99224
Gansu	5427	557	58	52	894	21.1	39205
Qinghai	5821	112	7	15	333	24.8	81609
Ningxia	5142	145	87	119	1704	17.5	38201
Xinjiang	5590	494	12	17	518	8.2	34454

Table 2.4.3 Correlations of the Variables

	FDI/GDP	FDI/POP	EI1	Punish	Charge	GRP per capita	Wage	(Wage)^2	GIP	Pop. Density	Rail Density	Road Density	Illiterate Rate	Productivity
FDI/GDP	1.000													
FDI/POP	0.859	1.000												
EI1	-0.095	-0.120	1.000											
Punish	-0.108	-0.113	0.154	1.000										
Charge	0.294	0.601	0.060	-0.014	1.000									
GRP per capita	0.617	0.904	-0.084	-0.029	0.700	1.000								
Wage	0.511	0.781	-0.108	-0.062	0.568	0.862	1.000							
(Wage)^2	0.475	0.791	-0.134	-0.108	-0.162	-0.083	0.654	1.000						
GIP	0.544	0.553	0.019	-0.027	0.409	0.488	0.433	0.409	1.000					
Pop. Density	0.502	0.807	-0.143	-0.157	0.801	0.865	0.674	0.742	0.429	1.000				
Rail Density	0.393	0.616	-0.010	0.007	0.465	0.723	0.555	0.571	0.120	0.606	1.000			
Road Density	0.697	0.798	-0.098	-0.173	0.538	0.771	0.695	0.701	0.456	0.729	0.723	1.000		
Illiterate Rate	-0.321	-0.353	0.004	-0.229	-0.150	-0.421	-0.345	-0.322	-0.266	-0.279	-0.451	-0.430	1.000	
Productivity	0.007	0.148	-0.114	0.054	0.114	0.253	0.359	0.334	-0.002	0.181	0.251	0.159	-0.147	1.000

Table 2.4.4 Descriptive Statistics of the Variables

Variable	Obs.	Mean	Std. Dev.	Min	Medium	Max
FDI/GDP (FDI in RMB yuan per 10 000 RMB yuan GDP)	149	265.80	271.11	6.76	140.66	1140.13
FDI/POP (FDI in RMB yuan per capita)	149	188.62	276.04	3.19	42.89	1395.25
EI1 (yuan per 10 000 RMB yuan innovation investment)	150	342.20	216.12	31.65	289.32	1163.74
EI2 (yuan per 10 000 RMB yuan Inno.Inv.+ Capital Construction Inv.)	150	92.63	57.22	6.19	80.43	285.53
EI3 (yuan per 10 000 RMB yuan total investment in fixed assets)	150	55.04	35.78	4.46	44.71	185.08
Punish (Cases per 1000 enterprises)	148	452.34	701.53	29.18	267.30	5877.36
Charge (RMB yuan per organisation)	150	4319.00	2363.26	1467.24	3679.30	17649.92
GRP per capita (RMB yuan)	150	4765.65	3591.10	1255.09	3376.21	21876.21
Wage (RMB yuan at 1990 price)	150	4720.76	1549.53	2614.68	4399.02	11885.36
GIP (100 million RMB yuan at 1990 price)	150	1556.23	1713.53	79.41	912.00	8815.18
Pop. Density (persons per km^2)	150	376.11	460.55	6.99	251.56	2700.00
Rail Density (km/ 10 000 km^2)	150	151.39	145.08	8.38	109.65	690.83
Road Density (km/ 10 000 km^2)	150	3341.10	2110.37	204.76	3053.05	10138.71
Illiterate Rate (%)	150	13.13	6.46	4.36	12.11	42.92
Productivity (RMB yuan/person at 1990 price)	150	41039.37	18996.94	9276.10	35999.46	156645.80

2.4.3 Selection of Estimators

A problem faced when estimating the model is whether the unobserved individual-specific effects and time effects (η_i and γ_t) should be treated as random variables or as parameters to be estimated for each cross region observation *i* and time *t*. In this chapter we estimate both two-way fixed effects and random effects error component models. For our fixed effects models we initially use the within regression estimator which is a pooled OLS estimator based on time-demeaned variables, or uses the time variation in both dependent and independent variables within each cross-sectional observation (Wooldridge, 2000). For our random effects models we choose the generalised least square (GLS) estimator, which produces a matrix-weighted average of the between and within estimator results.[25]

Few assumptions are required to justify the fixed effects estimator. In the estimation, however, η_i and γ_t are not assumed to have a distribution, but are treated as fixed and estimable. The random effects estimator requires no correlation assumptions, that is η_i ~IID $(0,\sigma_\eta^2)$, γ_t ~IID $(0,\sigma_\gamma^2)$, and ε_{it} ~IID $(0,\sigma_\varepsilon^2)$ are independent of each other. In addition, all the independent variables (***ER*** and ***X*** in equation 2.4.2) are independent of η_i, γ_t, and ε_{it} for all *i* and *t*.

In order to calculate whether ε_{it} are uncorrelated with the independent variables, we use the Hausman specification test under the null hypothesis H_0: $E(\varepsilon_{it} | X_{it}) = 0$.[26] We compare the covariance matrix of the regressors in the fixed effects model with those in

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25 The between estimator is obtained by using OLS to estimate the models which use the time-averages for both dependent and independent variables and then runs a cross sectional regression (Wooldridge, 2000, Chapter 14, pp.442). GLS estimators produce more efficient results than between estimators because they use both the within and between information.

26 Here X_{it} proxies all the independent variables in the estimated model. Since we take one-year lag for all independent variables, the hypothesis is to test whether $E(\varepsilon_{it} | X_{it-1}) = 0$.

the random effects model in order to find out whether the random effects specification is powerful and parsimonious. The Hausman specification test results are reported in Appendix 2.4. The results of Hausman specification tests suggest that, in most cases, the individual effects and time effects could be adequately modelled by random effects models.

When using data on different provinces that have variation of scale, the variance for each of the panels will differ. The Breusch-Pagan test results reject the null hypothesis of homoskedasticity in our models. Both of the fixed effects and random effects estimators can solve the problem of heteroskedasticity across panels. However, neither controls for possible autocorrelation within the panels. In order to test whether or not the errors follow an autoregressive process of order one AR(1), we apply the following dynamic regression model:

$$\varepsilon_{it} = \rho\varepsilon_{it-1} + \nu_{it}, t = 2,\ldots,T. \tag{2.4.4}$$

where $|\rho| < 1$ and $\nu_{it} \sim \text{IID}(0,\ \sigma_\nu^2)$.

The null hypothesis is H_0: $\rho = 0$. Thus, ρ should be estimated from the regression of ε_{it} on ε_{it-1}, for all t = 2,…,T. The t statistics (see Table 2.4.5) for $\hat{\rho}$ show that we reject the null hypothesis for all log models. That is, there is AR(1) autocorrelation within panels in our log specifications.

One solution of AR(1) autocorrelation is to include the lagged dependent variables in the right-hand-side of Equation 2.4.3 and construct a dynamic model. In that case, an alternative estimation method is system Generalised Method of Moment (GMM) estimator by Blundell and Bond (1998) for AR(1) panel data models. System GMM estimator can tackle the problems of heteroskedasticity and autocorrelation as well as the endogeneity of variables. However, GMM estimator requires two or more lags of all the right-hand-side variables as instruments. Due to our relative short panel we cannot use GMM estimator.

Another solution is to use the feasible generalised least square (FGLS) estimator. In this study, we have a large number of panels (30 provinces) relative to time period (5 years). The FGLS estimator is appropriate for such a case.[27] FGLS models allow cross-sectional correlation and heteroskedasticity. It also allows models with heteroskedasticity and no cross-sectional correlation. In addition, it is possible to relax the assumption of autocorrelation within panels. FGLS is therefore more efficient than the other two estimators mentioned above.

Table 2.4.5 Autocorrelation Tests

	Levels					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
$\hat{\rho}$	0.064	-0.136	0.076	-0.129	0.067	-0.142
t Statistics	0.67	-1.38	0.79	-1.30	0.70	-1.44
p-value	0.504	0.169	0.430	0.197	0.488	0.153
	Logs					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
$\hat{\rho}$	**0.258**	**0.254**	**0.265**	**0.260**	**0.220**	**0.218**
t Statistics	**2.92**	**2.86**	**2.97**	**2.91**	**2.54**	**2.50**
p-value	**0.004**	**0.005**	**0.004**	**0.004**	**0.012**	**0.014**

Since the GLS estimator is less efficient than the FGLS estimator, the random effects results (in Appendix 2.4) are relatively weak even though GLS estimator is not rejected in

[27] David Greenberg, who is an expert in Stata in New York University, states on the Stata Listserver that FGLS is feasible when the number of panels is larger than time period. Clive Nicholas from Newcastle University agrees Greenberg's point of view and specifies that FGLS is efficient when the degree of freedom is larger than 25, which is the case in our model (see Greenberg, 26/January/2004; and Nicholas, 10/August/2004).

most specifications by Hausman specification tests. We therefore concentrate on the FGLS estimation results in the main text. Estimations are run using STATA 9.[28]

2.5 Empirical Results

In this section we only report the FGLS log results because of the advantages outlined above. We also include a series of sensitivity checks. For example, we normalise industrial pollution treatment investment by the sum of investment in innovation and capital construction (*EI2*), and by the total investment in fixed assets (*EI3*). The results are provided in Appendix 2.2. All levels estimations can be found in the Appendix 2.3. The random effects specification is not always efficient and hence are provided in Appendix 5. In this section, we also compare our main results with those in the Appendices as well as those of previous empirical studies.

2.5.1 FGLS Regression Results with Log Specification

Tables 2.5.1- 2.5.6 respectively present the FGLS regression results for the impact of different levels of environmental stringency on two measures of provincial level FDI inflows using data in logs for thirty provinces in China. Tables 2.5.1 and 2.5.2 are the results for *EI1*, Tables 2.5.3 and 2.5.4 for *Punish*, and Tables 2.5.5 and 2.5.6 for *Charge*.[29]

In Table 2.5.1, the dependent variable is the amount of FDI inflows divided by the regional GDP (*FDI/GDP*). The results show that the share of industrial pollution treatment

[28] The major syntaxes include *xtreg* with *fe* and *re*, and *xtgls*.

[29] Regional-specific effects and time effects are not reported in all the tables in the main text and appendices.

investment has a negative effect on FDI inflows into a province. The coefficients in each of the nine regressions are relatively stable and statistically significant. In column (10) the coefficient (-0.062) indicates that a 10 per cent increase in the share of environmental investment of a province leads to a 0.62 per cent decrease in the amount of FDI inflows to regional GDP. Therefore, stringent regional environmental regulations have detrimental effects on FDI inflows.

Turning to the other explanatory variables, as expected, per capita income generally has a positive and statistically significant coefficient, which means that the richer the province, the more foreign investment is attracted. Among all the independent variables, per capita income level has the strongest effect on FDI inflows. The coefficient could be treated as the income elasticity of FDI inflows. From column (10), a 10 per cent increase in provincial income level could lead to a more than 34 per cent increase in *FDI/GDP*.

The signs on the coefficients for manufacturing wage and wage square are consistent with our prior expectations, and reveal an inverted-U relationship between FDI and wages. Although they remain relatively stable in absolute values, they are not significantly different from zero in most regressions and only achieve marginal significance in the final two columns. For column (10), the turning point is 8.11, i.e. 3,336 RMB yuan ($698) in level.[30] From the descriptive statistics reported in Table 2.4.4, manufacturing wages in most Chinese provinces are higher than this level. Table 2.4.2 shows that in 2002, the provincial manufacturing wages are all above 4,000 RMB yuan (the lowest wage is found in Henan with 4,218 RMB yuan), that is, high wages currently deter FDI in China.

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[30] $\exp[6.49/(0.04\times2)] = 3{,}336$. RMB3,336 at 1990 price is equivalent to $698 at the 1990 middle exchange rate that $1=RMB4.78.

Table 2.5.1 FGLS Regression Results on FDI/GDP for Log Data with EI1

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1†	-0.071	-0.081	-0.083	-0.087	-0.11	-0.11	-0.063	-0.062	-0.063	-0.062
	-(2.30)**	(-2.92)***	(-2.93)***	(-2.69)***	(-3.20)***	(-3.16)***	(-2.00)**	(-2.09)**	(-1.94)*	(-2.03)**
GRP per capita		2.77	2.53	2.82	3.20	3.48	3.41	3.38	3.42	3.44
		(5.02)***	(4.10)***	(4.03)***	(4.32)***	(4.66)***	(4.98)***	(5.00)***	(4.78)***	(4.86)***
Wage			0.23	5.76	5.82	3.22	5.34	5.42	6.41	6.49
			(0.65)	(1.56)	(1.63)	(0.81)	(1.45)	(1.45)	(1.69)*	(1.68)*
Wage^2				-0.33	-0.33	-0.19	-0.32	-0.34	-0.38	-0.40
				(-1.48)	(-1.52)	(-0.78)	(-1.44)	(-1.49)	(-1.67)*	(-1.71)*
GIP					-0.51	-0.60	-0.25	-0.15	-0.23	-0.16
					(-1.76)*	(-2.00)**	(-0.80)	(-0.47)	(-0.70)	(-0.50)
Pop. Density						-1.14	-1.01	-1.07	-1.07	-1.13
						(-1.50)	(-1.49)	(-1.57)	(-1.60)	(-1.68)*
Rail Density							-0.21	-0.23	-0.22	-0.25
							(-1.98)**	(-2.20)**	(-2.08)**	(-2.32)**
Road Density							0.42	0.45	0.42	0.45
							(4.14)***	(5.03)***	(4.25)***	(5.30)***
Illiterate Rate								0.27		0.27
								(2.36)**		(2.34)**
Productivity									-0.17	-0.18
									(-1.37)	(-1.47)
Constant	6.82	-18.798	-18.56	-44.122	-44.69	-27.27	-40.74	-40.77	-43.42	-43.51
	(35.48)***	(-3.68)***	(-3.64)***	(-2.45)**	(-2.55)**	(-1.28)	(-2.11)**	(-2.08)**	(-2.23)**	(-2.20)**
Wald χ^2	4902.89	6449.04	6788.36	5384.91	5486.04	5717.34	7051.28	7398.75	6546.07	7071.95
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 2.5.2 FGLS Regression Results on FDI/POP for Log Data with EI1

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1†	-0.079	-0.080	-0.083	-0.094	-0.10	-0.10	-0.062	-0.063	-0.062	-0.062
	(-2.61)***	(-2.59)***	(-2.74)***	(-2.75)***	(-2.97)***	(-2.93)***	(-1.93)*	(-2.02)**	(-1.86)*	(-1.96)**
GRP per capita		3.38	3.04	3.43	3.71	3.99	4.04	3.97	3.98	3.98
		(6.13)***	(4.93)***	(4.93)***	(5.04)***	(5.42)***	(6.04)***	(6.03)***	(5.69)***	(5.74)***
Wage			0.37	7.95	7.87	5.53	7.48	7.52	8.52	8.54
			(0.99)	(2.24)**	(2.25)**	(1.41)	(2.03)**	(2.02)**	(2.25)**	(2.22)**
$Wage^2$				-0.46	-0.45	-0.32	-0.45	-0.46	-0.50	-0.52
				(-2.11)**	(-2.10)**	(-1.36)	(-2.01)**	(-2.04)**	(-2.21)**	(-2.24)**
GIP					-0.35	-0.42	-0.057	0.056	-0.036	0.045
					(-1.13)	(-1.31)	(-0.18)	(0.17)	(-0.11)	(0.13)
Pop. Density						-0.96	-0.88	-0.93	-0.86	-0.92
						(-1.25)	(-1.21)	(-1.28)	(-1.20)	(-1.28)
Rail Density							-0.16	-0.19	-0.17	-0.20
							(-1.43)	(-1.68)*	(-1.52)	(-1.78)*
Road Density							0.45	0.47	0.44	0.47
							(4.47)***	(5.17)***	(4.59)***	(5.47)***
Illiterate Rate								0.27		0.27
								(2.29)**		(2.23)**
Productivity									-0.16	-0.17
									(-1.25)	(-1.34)
Constant	6.79	-24.54	-24.50	-59.51	-59.41	-44.54	-58.28	-58.10	-61.11	-60.91
	(37.03)***	(-4.80)***	(-4.77)***	(-3.43)***	(-3.46)***	(-2.10)**	(-2.96)***	(-2.94)***	(-3.10)***	(-3.05)***
Wald χ^2	8255.26	9891.48	10168.32	8913.67	9078.33	9316.90	12471.36	13105.58	12174.31	13239.35
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 2.5.3 FGLS Regression Results on FDI/GDP for Log Data with Punish

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish†	-0.043	-0.043	-0.041	-0.051	-0.074	-0.078	-0.082	-0.076	-0.081	-0.076
	(-2.06)**	(-1.94)*	(-1.74)	(-2.13)**	(3.05)***	(-3.01)***	(-3.16)***	(-2.79)***	(-3.23)***	(-2.85)***
GRP per capita		2.90	2.92	3.13	3.50	3.79	3.84	3.93	3.70	3.85
		(5.02)***	(4.52)***	(4.51)***	(4.83)***	(5.13)***	(5.94)***	(6.01)***	(5.65)***	(5.75)***
Wage			-0.089	5.42	6.43	3.41	4.78	4.45	5.99	5.73
			(-0.21)	(1.35)	(-1.70)*	(-0.81)	(-1.24)	(-1.14)	(-1.51)	(-1.42)
Wage^2				-0.33	-0.39	-0.21	-0.30	-0.30	-0.36	-0.36
				(-1.36)	(-1.67)*	(-0.84)	(-1.28)	(-1.24)	(-1.50)	(-1.48)
GIP					-0.49	-0.62	-0.41	-0.36	-0.39	-0.36
					(-1.75)*	(-1.98)**	(-1.36)	(-1.19)	(-1.32)	(-1.17)
Pop. Density						-0.94	-0.98	-1.03	-0.97	-1.02
						(-1.26)	(-1.57)	(-1.61)	(-1.58)	(-1.63)
Rail Density							-0.30	-0.31	-0.30	-0.31
							(-2.87)***	(-2.89)***	(-2.86)***	(-2.90)***
Road Density							0.44	0.45	0.44	0.46
							(4.44)***	(5.05)***	(4.58)***	(5.28)***
Illiterate Rate								0.22		0.21
								(1.88)*		(1.83)*
Productivity									-0.14	-0.16
									(-1.16)	(-1.32)
Constant	6.62	-20.24	-19.67	-44.12	-48.62	-31.19	-39.87	-38.85	-43.17	-42.58
	(47.34)***	(-3.78)***	(-3.44)***	(-2.30)**	(-2.66)***	(-1.40)	(-2.00)**	(-1.93)*	(-2.16)**	(-2.10)**
Wald χ^2	5027.47	5287.33	5059.49	4945.25	6701.13	6263.02	8235.71	8374.58	8231.85	8466.13
Observations	147	147	147	147	147	147	147	147	147	147

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 2.5.4 FGLS Regression Results on FDI/POP for Log Data with Punish

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish†	-0.043	-0.047	-0.045	-0.054	-0.074	-0.074	-0.078	-0.071	-0.076	-0.070
	(-2.20)**	(-1.97)**	(-1.89)	(-2.26)**	(-2.78)***	(-2.57)**	(-2.62)***	(-2.33)**	(-2.66)***	(-2.38)**
GRP per capita		3.55	3.37	3.63	3.95	4.28	4.46	4.46	4.30	4.36
		(6.50)***	(5.45)***	(5.34)***	(5.40)***	(5.79)***	(6.99)***	(6.99)***	(6.52)***	(6.58)***
Wage			0.096	7.63	8.13	5.54	6.64	6.49	7.83	7.67
			(0.23)	(1.98)**	(2.17)**	(1.33)	(1.72)*	(1.67)*	(1.97)**	(1.91)*
$Wage^2$				-0.45	-0.48	-0.34	-0.41	-0.41	-0.47	-0.47
				(-1.92)*	(-2.08)**	(-1.33)	(-1.73)*	(-1.73)*	(-1.95)*	(-1.94)*
GIP					-0.42	-0.48	-0.20	-0.13	-0.18	-0.13
					(-1.34)	(-1.40)	(-0.63)	(-0.40)	(-0.55)	(-0.39)
Pop. Density						-0.69	-0.82	-0.83	-0.76	-0.77
						(-0.90)	(-1.18)	(-1.19)	(-1.11)	(-1.13)
Rail Density							-0.26	-0.26	-0.25	-0.26
							(-2.25)**	(-2.31)**	(-2.22)**	(-2.28)**
Road Density							0.46	0.47	0.46	0.48
							(4.72)***	(5.17)***	(4.90)***	(5.43)***
Illiterate Rate								0.21		0.20
								(1.77)*		(1.68)*
Productivity									-0.13	-0.14
									(-1.05)	(-1.14)
Constant	6.55	-26.34	-25.52	-58.88	-61.28	-47.77	-56.75	-56.29	-60.33	-59.97
	(49.65)***	(-5.19)***	(-4.72)***	(-3.19)***	(-3.40)***	(-2.16)**	(-2.80)***	(-2.76)***	(-2.97)***	(-2.92)***
Wald χ^2	7444.30	9495.49	9524.93	8280.40	8966.73	8852.64	13005.62	13285.83	13022.54	13589.33
Observations	147	147	147	147	147	147	147	147	147	147

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 2.5.5 FGLS Regression Results on FDI/GDP for Log Data with Charge

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge†	-0.054	-0.14	-0.15	-0.12	-0.098	-0.14	-0.22	-0.18	-0.21	-0.18
	(-0.49)	(-1.30)	(-1.40)	(-1.01)	(-0.84)	(-1.16)	(-2.00)**	(-1.66)*	(-1.86)*	(-1.54)
GRP per capita		2.94	2.73	2.89	3.11	3.47	3.50	3.47	3.47	3.47
		(4.87)***	(4.15)***	(3.95)***	(3.98)***	(4.42)***	(5.02)***	(5.01)***	(4.78)***	(4.80)***
Wage			0.14	3.87	4.38	0.49	1.99	2.37	2.89	3.26
			(0.34)	(0.94)	(1.07)	(0.11)	(0.49)	(0.58)	(0.69)	(0.77)
Wage^2				-0.23	-0.26	-0.039	-0.12	-0.15	-0.17	-0.20
				(-0.90)	(-1.03)	(-0.14)	(-0.48)	(-0.61)	(-0.66)	(-0.78)
GIP					-0.23	-0.31	0.13	0.15	0.13	0.14
					(-0.72)	(-0.94)	(0.39)	(0.46)	(0.38)	(0.42)
Pop. Density						-1.39	-1.54	-1.52	-1.63	-1.61
						(-1.67)*	(-2.27)**	(-2.22)**	(-2.40)**	(-2.34)**
Rail Density							-0.37	-0.36	-0.38	-0.37
							(-3.45)***	(-3.34)***	(-3.44)***	(-3.34)***
Road Density							0.42	0.44	0.42	0.44
							(3.92)***	(4.39)***	(3.93)***	(4.46)***
Illiterate Rate								0.22		0.22
								(1.69)*		(1.68)*
Productivity									-0.16	-0.16
									(-1.25)	(-1.32)
Constant	6.90	-19.58	-18.74	-35.64	-38.32	-14.44	-24.28	-26.01	-25.81	-27.59
	(-7.06)***	(-3.57)***	(-3.38)***	(-1.81)*	(-1.95)*	(-0.60)	(-1.15)	(-1.23)	(-1.22)	(-1.29)
Wald χ^2	4233.42	4850.38	5313.72	4558.54	4456.13	4891.34	7336.94	7180.77	6906.39	6817.20
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 2.5.6 FGLS Regression Results on FDI/POP for Log Data with Charge

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge†	-0.043 (-0.38)	-0.14 (-1.31)	-0.16 (-1.47)	-0.098 (-0.84)	-0.091 (-0.77)	-0.13 (-1.10)	-0.21 (-1.92)*	-0.18 (-1.65)*	-0.20 (-1.75)*	-0.17 (-1.50)
GRP per capita		3.65 (6.30)***	3.32 (5.18)***	3.57 (4.95)***	3.67 (4.78)***	3.99 (5.25)***	4.15 (6.27)***	4.06 (6.15)***	4.07 (5.85)***	4.02 (5.77)***
Wage			0.28 (0.68)	6.69 (1.67)*	6.82 (1.70)*	3.02 (0.67)	4.18 (1.02)	4.50 (1.09)	5.19 (1.23)	5.47 (1.29)
Wage^2				-0.39 (-1.59)	-0.40 (-1.63)	-0.19 (-0.68)	-0.25 (-0.99)	-0.28 (-1.10)	-0.31 (-1.18)	-0.33 (-1.28)
GIP					-0.097 (-0.29)	-0.15 (-0.45)	0.30 (0.89)	0.35 (1.02)	0.31 (0.88)	0.34 (0.97)
Pop. Density						-1.22 (-1.45)	-1.42 (-1.92)*	-1.37 (-1.87)*	-1.45 (-1.96)**	-1.41 (-1.92)*
Rail Density							-0.31 (-2.69)***	-0.30 (-2.65)***	-0.32 (-2.72)***	-0.31 (-2.68)***
Road Density							0.45 (4.20)***	0.47 (4.52)***	0.44 (4.19)***	0.46 (4.57)***
Illiterate Rate								0.21 (1.63)		0.21 (1.58)
Productivity									-0.15 (-1.19)	-0.16 (-1.25)
Constant	6.73 (6.81)***	-26.23 (-4.93)***	-25.48 (-4.65)***	-54.22 (-2.81)***	-54.99 (-2.85)***	-32.42 (-1.36)	-42.16 (-1.96)**	-43.47 (-2.02)**	-44.37 (-2.05)**	-45.52 (-2.09)**
Wald χ^2	6988.72	8136.79	8700.20	7749.89	7766.79	8301.63	12585.14	12298.18	12247.58	12082.78
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

GIP is intended to capture the degree of industrial agglomeration in a province and is expected to have a positive effect on FDI. However, none of the coefficients on *GIP* are positive and a statistically significant negative coefficient is found in regressions (5) and (6).[31] The coefficient on population density is found to be negative and only significant at 10% in the final column. It appears that FDI locates in less densely populated areas possibly due to the higher land prices.

We now consider our infrastructure variables. The railway density coefficient is contrary to our prior expectations. It has a significant negative effect on FDI inflows and is also found in all the other regression results in Tables 2.5.2 – 2.5.6 and most of the tables in Appendices 2.2, 2.3 and 2.5. A possible explanation is the relatively lower railway density in some coastal provinces with higher incomes and higher shares of FDI inflows. For example, Guangdong attracted the greatest FDI flows in China and its GDP accounts for about 10% of total. However, the railway length is 2,112.5 km with a density of 0.01 km/km^2, which ranks 11th from bottom and only slightly higher than the average level of the country.[32] The situation in other FDI preferred provinces, such as Hainan, Fujian, Zhejiang and Jiangsu, is similar to that of Guangdong. Although other eastern regions, such as Beijing, Tianjin, Shanghai, Liaoning, Hebei and Shandong, have very high railway densities, these six regions account for 28 per cent of national GDP and 36 per cent of FDI inflows compared with 31 per cent in GDP and 50 per cent in FDI inflows of the

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[31] We also estimate our regressions using the numbers of enterprises as a proxy of agglomeration. These enterprises include all state-owned and non-state-owned industrial enterprises with an annual sales income of over 5 million RMB yuan. Our main results are unaffected.

[32] The average railway density for a province in China is 0.0077 km/km^2 in 2003. The 10 provinces with the lowest railway density are Tibet, Qinghai, Xinjiang, Gansu, Inner Mongolia, Yunnan, Sichuan, Hainan, Chongqing, and Guizhou. These provinces all have geographical restrictions on building railways. Tibet and Qinghai are located on Qinghai-Tibet Plateau; Xinjiang and Gansu both have large areas of Gobi desert; Inner Mongolia has the largest grassland; Yunan, Sichuan, Chongqing and Guizhou are in the mountainous regions; and Hainan is an island province. Except Hainan, the other nine regions are all located in western China.

other five provinces with lower railway densities. In contrast, other measure of a region infrastructure, road density, has a positive and significant coefficient in all regressions in all the six tables. The value of the coefficient remains relatively stable.[33] The different results in railway density and road density are consistent with the real situation of transportation infrastructure in China. During the past 30 years, central and local governments have invested a great amount of money to improve the highway construction (at all classes) because road transportation network is regarded as an important sign for urbanisation and modernisation. "Building road is the fist step to become rich" has been a widely spread common saying since 1980s. Therefore, rich regions always have high road density but do not certainly have high railway density.

The rate of illiteracy in a province has a positive and significant coefficient as expected, indicating that FDI prefers to locate into regions with a high proportion of unskilled labour. Similarly, our measure of productivity has a consistent sign but it is not significant indicating that province level productivity does not appear to play an important role in investment location decision making.

Using the per capita FDI inflows (*FDI/POP*) as our dependent variable, the specifications of Table 2.5.2 are the same as those in Table 2.5.1. The coefficients for *EI1* in these two tables are very similar. Therefore, for both FDI measures, a 10 per cent increase of industrial pollution treatment investment in a province would lead to an approximate 0.62 per cent decrease of the amount of per capita FDI inflows into the province. The coefficients on other independent variables are robust across all regressions, except wage and squared wage which both become more significant. The turning point in the final

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[33] We also estimate our regressions including railway density and road density separately but the results were very similar. We also estimated the regressions respectively including numbers of ports in each province and dummy variable for coastal provinces. Both coefficients are positive but not significant.

regression is 8.21, i.e. 3,683 RMB yuan ($770) in level. It again indicates that wage has a negative effect on FDI inflows at current wage level in China.

Tables 2.5.3 and 2.5.4 show the FGLS regression results when we use *Punish* to measure the strictness of environmental regulations. The coefficients on punishment cases are negative and statistically significant in all regressions in Tables 2.5.3 and 2.5.4, and the absolute values are relatively stable. In column (10) of Table 2.5.3, the coefficient is -0.076, which means that a 10 per cent increase in environment litigiousness of the province leads to a 0.76 per cent decreases in the amount of *FDI/GDP*. As a result, the provinces with stricter environmental standards attract less FDI.

The effect of per capita income is still significantly positive. Similar to the *EI1* results, the coefficients on manufacturing wage does not have significant effect on *FDI/GDP* but have significant effect on *FDI/POP*; and the turning point is also below 4,000 RMB yuan (3,497 in regression (10) in Table 2.5.4). *GIP* and population density remain negative and insignificant. The results for railway and road density are similar to the *EI1* regressions. Their coefficients are robust for both signs and magnitude. The performances of rate of illiteracy and productivity are also similar to those in previous tables.

In terms of the results using normalised pollution emission charge, Tables 2.5.5 and 2.5.6 both indicate that foreign investors would like to locate in provinces with lower pollution emission charge standards, i.e. provinces with weaker implementation in environmental standards. However, the results are not as significant as *EI1* and *Punish*. And a 10 percent increase in pollution charge standard may lead to an approximately 1.8 per cent decrease in *FDI/GDP* or *FDI/POP* inflows. Compared to the industrial pollution treatment investment and administrative punishment cases, foreign investors are more sensitive to the pollution emission charge, possibly because it is more visible to the investors and has a more direct impact. The magnitudes of the coefficients on our three measures of environmental regulations are consistent with our expectation that *Charge* has the strongest elasticity, while *EI1* has the weakest. However, the impact of Charge is only significant at 10% level in regressions (7)-(9).

The results of per capita income and infrastructure variables are very similar to those in the previous four tables. However, wage and squared wage are now insignificant in the regressions on both measures of FDI. The *GIP* coefficient becomes positive in most regressions, although it still not different from zero. Population density becomes negatively significant, indicating that foreign investment prefers less populated provinces where land prices are lower. The coefficient on the illiterate rate is less significant but remains stable in magnitude. The results of productivity do not change.

We also apply some additional sensitivity checks to the labour quality and manufacturing wage. We include the percentage of enrolment in different levels of education to substitute for the rate of illiteracy. We find positive but insignificant results for primary school enrolment; positively significant results for junior high school enrolment; and negative but insignificant results for both senior high school and high education enrolments. These results support our premise that FDI is attracted to regions with relatively low education levels. We also include interaction terms for certain variables, for example, wage × income, wage × rate of illiteracy and wage × productivity. The results are remained broadly similar.

2.5.2 Comparison with Results in Appendices 2.2, 2.3 and 2.5

Appendix 2.2

Turning to the two alternative measures of the share of industrial pollution treatment investment, the results in Appendix 2.2 do not change our main results. The coefficients on *EI2* and *EI3* remain negative and stable in magnitude; however, they are not statistically different from zero in some regressions estimating on both measures of FDI inflows. The results of the other independent variables are very similar to those including *EI1*.

Appendix 2.3

Compared to the results using level equations in Appendix 2.3, the log specification results are more significant and robust. *EI1* is found to have significantly negative impacts on *FDI/GDP*. In terms of *FDI/POP*, the share of environmental investment is also found to have negative coefficient but only significant in a few regressions. *Punish* is generally negative but not significant. For *Charge*, we find positive coefficients in some specifications but none are statistically significant.

Per capita income has a significantly positive effect on *FDI/POP*. In the estimations on *FDI/GDP*, we find a positive and significant effect, as well as some negative results in some regressions. However, the negative coefficients are not statistically significant. The coefficients on manufacturing wage and its square when estimating *FDI/POP* including *EI1* and *Charge* (in Tables A2.3.2 and A2.3.6) are not statistically significant. In other estimations we only find a significant coefficient for wage squared in the estimations on *FDI/GDP*.

GIP is now positive in all tables and has significant effect on *FDI/POP*. Population density becomes positive and has relatively stable absolute values, but is only significant in some regressions for *FDI/POP*. The results on railway density and road density are not changed. We find inverse signs for the two measures of labour quality although neither is significant.

Appendix 2.5

Compared to the results using a random effects estimator provided in Appendix 2.5, the FGLS results are more robust. The log specifications of random effects results are roughly consistent with our main results, although they are relatively weak. A possible explanation is the disadvantage of GLS estimator in controlling for AR(1) autocorrelation for the log specifications.

2.5.3 Comparison with Previous Empirical Evidence

In contrast to the majority of existing studies of the PHH we do find consistent support for the existence pollution haven hypothesis within China. When we consider the effect of per capita income on aggregate FDI inflows to Chinese regions we find a strong and positive effect which is consistent with previous studies.

With respect to wage, we firstly include wage squared in the estimating equation and find an inverted-U relationship between FDI and wages. At the current wage level in China, our finding that wage deters FDI inflows are consistent with most empirical studies focusing China. We do not find a robust result for agglomeration effects, which is usually omitted in other studies. The measurement of agglomeration effects varies across empirical studies so in future research we will try alternative measures of agglomeration.

Growth of population density has been used in Wei *et al.* (1999) as a control variable to proxy the improvement in agglomeration effect and is found to be insignificant in all regressions for the realised FDI inflows, and has a negative sign when controlling for autocorrelation. In our case, population density is found to be significantly negative in our main results where a possible explanation is that it reflects regional land prices.

Infrastructure tends to be measured differently in other studies; however, most of them are measured by the characteristics of transportation (densities of highway, paved road, railway, waterway, etc.) and do not get constant significant results. Cheng and Kwan (2000) estimate the regression separately with all roads, paved roads and railways and also find the unexpected sign in the case of railways that is consistent with our findings. Gao (2002) combines the density of roads, railway and waterway together and finds the effects of transportation is not different from zero. A possible explanation for Gao's finding is that the strong negative effect of railway density, which is found in our results, may offset the positive effect of road density.

In terms of our labour quality variables, Coughlin and Segev (2000) employ similar measures and find that labour productivity is a positive determinant of FDI while rate of illiteracy is negative, which are opposite to our findings. Other studies have used the percentage of enrolment in different levels of education as the proxy of education or labour quality (Cheng and Kwan, 2000; Gao, 2002; Fung *et al.* 2002; and Fung *et al.* 2003), and the results are found to be better for junior and senior high schools and higher education than primary school education. Our sensitivity check results using the similar measures are also opposite to those in pervious studies. Cheng and Kwan (2000) argue that it is not surprising because at the beginning of China's open door policy, FDI was attracted not to areas with higher education attainment, but to South China due to preferential government policies and its geographical proximity to Hong Kong. Such a situation also exists during our sample period (1999-2003) even though China had been open for 20 years. This might be a possible explanation for our contrary results. The second reason is that illiteracy rate data is noisy because it measures the education level of household population, which may be affected by labour migration. Another explanation is that we use different normalisation of FDI inflows (*FDI*/*GDP*) and (*FDI*/*POP*) rather than FDI level data in USD at a constant price. Our normalisation does not reflect the absolute level of FDI but the relatively abundance of foreign investment. It may generate the different signs of some control variables.

2.6 Conclusions

This chapter uses provincial data for China to examine whether the foreign investment is more or less likely to be attracted to provinces with stringent environmental regulations.

We employ three proxies of the stringency of environmental regulations across provinces. They are the share of industrial pollution treatment investment in innovation investment in each province, the normalised administrative punishment cases and the normalised pollution emission charge. We also use two measures of FDI inflows, FDI divided by regional GDP and FDI divided by regional population. The regression results from FGLS estimator indicate that industrial pollution treatment investment and administrative punishment cases have significant negative effects on both measures of FDI inflows, while the impact of pollution emission charge is also negative although less significant. That is to say FDI prefers to locate into regions with weaker environmental regulations. Thus, to a certain extent we find evidence to support the existence of intra-country pollution havens within China. These results are robust for data in logs rather than in levels. The results for random effects estimators are somewhat weaker.

The results also find other independent variables are significant determinants of investment. Income level has a strong positive impact on the amount of FDI inflows. FDI is also found to be attracted to provinces with low manufacturing wages, good infrastructure, and a low educational level. FDI is found to prefer to locate into regions with low population density when we include pollution charge to proxy environmental regulations. It shows the importance of reliable infrastructure and factors of production in the investment location decision. Our results for income, wage and infrastructure are consistent with most previous studies; however, the results for population density and quality of labour force are different from others.

Our findings provide some policy implications. Three decades' of fast economic growth under the present growth mode has made China one of the largest pollution producers in the world, with, probably, the dirtiest air and increasingly polluted water resources. In this growth process, FDI has played an important role. It is regarded as an engine or catalyst for economic growth, a carrier of advanced technological and managerial knowledge that can drive the technological upgrading of the economy. Evidence from this chapter suggests that FDI is not always unalloyed blessing. Foreign investors may seek institutional voids in the developing countries and attempt to location in "pollution havens" where environmental regulation is not stringent. If a fast economic development is endurable, a sustainable development policy is needed that requires a rethinking about the location of population centres and types of investment, including the type and sector of foreign direct investment. Policies include encouraging more environmental friendly knowledge and human capital intensive FDI and controlling FDI in high energy consumption and high pollution sectors. The negative effect of environmental stringency on FDI can be offset by the improvement of some factors that are attractive to FDI, for example the quality of infrastructure.

One limitation in this chapter is that the data do not allow us to disaggregate FDI from different sources and/or into different industry sectors. Therefore, we cannot examine whether certain types of FDI from certain countries in certain industrial sectors would like to locate in regions with weak environmental regulations.

The second limitation is that we do not consider some other factors related to government characteristics which may have impact on FDI, such as the provincial difference in corruption. Corruption, as a detriment of FDI inflows, has recently been considered in cross national FDI location choice models. China has been widely recognised as a country with a serious corruption problem, but still attracts a large share of FDI inflows. The next question we wish to ask therefore is whether the difference in provincial level of corruption and governance quality encourage/deter FDI inflows in China.

Another limitation in this chapter is that we assume environmental stringency to be strictly exogenous, although we take one-year lag for all the explanatory variables to control for their endogeneity.

In this chapter we only consider the impact of environmental regulations on FDI inflows into China. However, the overall environmental impact of FDI is a mix of positive and negative effects. In some cases, FDI helps the improvement of China's environment. In other cases, FDI damages the environment and increases environmental risks.

Simultaneously, some other provincial differences, such as income level, also have impact on the environmental status and regulations.

To consider the impact of corruption and bureaucracy and the endogeneity of environmental regulations, therefore becomes our major work in Chapters three and four. And Chapter five investigates the overall environmental effects of economic development and FDI.

In sum, this chapter has addressed a number of limitations in PHH empirical studies. We provide the first study to examine the impacts of regional differences in environmental stringency on the amount of FDI inflows in China.

Appendix 2.1 Variables Definitions and Data Sources

Variable	Definition/Source
FDI/GDP	FDI divided by regional GDP (yuan per 10000 yuan). Source: China Statistical Yearbook.
FDI/POP	FDI divided by regional population (yuan per capita at 1990 price). Source: as above; GDP deflator data from Econ Stats, http://www.econstats.com
EI1	Investment in industrial pollution treatment project divided by total innovation investment (yuan per 10000 yuan). Source: China Environment Yearbook; Innovation investment data as FDI.
Punish	Total number of administrative punishment cases filed by the regional environmental authorities divided by the number of enterprises (cases per 1000 enterprises). Source: China Environment Yearbook; number of enterprises as FDI.
Charge	Pollution emission charge divided by the number of organisations paid the charge (yuan per enterprise, at 1990 price). Source: China Environment Yearbook.
GRP per capita	Gross regional product per capita (yuan at 1990 price). Source: as FDI.
Wage	Average wage of staff and workers in manufacturing (yuan at 1990). Source: as above.
GIP	Regional gross industrial output value (100 million yuan at 1990 price). Source: as above.
Pop. Density	Regional population density (persons per km^2). Source: as above; area data from http://www.usacn.com
Road Density	Regional highway density (km per 10000 km^2). Source: as above.
Rail Density	Regional railway density (km per 10000 km^2). Source: as above.
Illiterate Rate	Regional illiterate rate and semi-illiterate rate aged at 15 and above; values for 2000 are calculated as the average of the values in 1999 and 2001. Source: as FDI.
Productivity	Overall labour productivity for all foreign funded industrial enterprises (yuan per person per year, at 1990 price); values for 1998 are the average of those for 1997 and 1999. Source: China Industrial Economy Statistical Yearbooks.

Appendix 2.2 Normalisation of the Share of the Environmental Investment and the FGLS Regression Results for Log Data with *EI2* and *EI3*

A2.2.1 Alternative Normalisation Methods of *EI1*

The sources of industrial pollution treatment investment are state budgetary appropriations, special fund for environmental protection (which is mainly from the pollution emission charge), and other funds like domestic loans, foreign investment and enterprise fundraising.

The investment monies are spent on construction and installation projects, and purchasing of equipment and instruments required in the pollution harnessing projects for the treatments of wastewater, waste gas, solid wastes, noise pollution and other pollution.

All of these investment monies should be accounted to investment in innovation, which refers in general to the technological innovation of the original facilities (including renewal of fixed assets) by the enterprises and institutions as well as the corresponding supplementary projects for production or welfare facilities and the related activities. It includes the investment in all the projects, arranged both in the plan of innovation and in the plan of capital construction, of moving the whole factory to a new site so as to meet the requirements of urban environmental protection or safe production; and the projects in the state-owned units, listed neither in the plan of capital construction nor in the plan of innovation, of moving the whole factory to a new site so as to meet the requirements of urban environmental protection or safe production (China Statistical Yearbook).

Therefore, we normalise the industrial pollution treatment investment by the investment in innovation, i.e. the variable we used in the main text, *EI1*. But considering a small fraction of the industrial pollution treatment investment comes from state budget in capital construction, we also construct another two alternative variables for the share of environmental investment. *EI2* is normalised by the sum of investment in innovation and capital construction; and *EI3* is normalised by the total investment in fixed assets. Total investment in fixed assets is classified into four parts: investment in capital construction, investment in innovation, investment in real estates development and other investment in fixed assets.

Although the coefficients of *EI2* and *EI3* are less significant than that of *EI1*, the results reported in the following tables are roughly consistent with our main results.

A2.2.2 FGLS Regression Results for Log Data with EI2 and EI3

Table A2.2.1 FGLS Regression Results on FDI/GDP for Log Data with EI2

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2†	-0.062 (-1.77)*	-0.079 (-2.47)**	-0.078 (-2.39)**	-0.075 (-2.09)**	-0.098 (-2.64)***	-0.099 (-2.66)***	-0.051 (-1.50)	-0.057 (-1.80)*	-0.052 (-1.49)	-0.057 (-1.77)*
GRP per capita		2.67 (4.79)***	2.62 (4.13)***	2.87 (4.03)***	3.26 (4.30)***	3.56 (4.66)***	3.45 (5.00)***	3.39 (4.99)***	3.47 (4.81)***	3.47 (4.85)***
Wage			-0.021 (-0.06)	5.51 (1.45)	5.53 (1.50)	2.86 (0.71)	5.27 (1.41)	5.34 (1.41)	6.36 (1.65)*	6.43 (1.64)
Wage^2				-0.33 (-1.44)	-0.33 (-1.47)	-0.18 (-0.75)	-0.33 (-1.44)	-0.34 (-1.49)	-0.39 (-1.66)*	-0.40 (-1.71)*
GIP					-0.51 (-1.66)*	-0.61 (-1.92)*	-0.24 (-0.76)	-0.14 (-0.43)	-0.22 (-0.68)	-0.16 (-0.47)
Pop. Density						-1.16 (-1.53)	-1.03 (-1.54)	-1.08 (-1.62)	-1.09 (-1.65)*	-1.15 (-1.73)*
Rail Density							-0.22 (-2.12)**	-0.25 (-2.35)**	-0.23 (-2.18)**	-0.26 (-2.43)**
Road Density							0.42 (4.26)***	0.45 (5.17)***	0.42 (4.39)***	0.45 (5.47)***
Illiterate Rate								0.29 (2.55)**		0.29 (2.48)**
Productivity									-0.16 (-1.32)	-0.18 (-1.44)
Constant	6.70 (37.58)***	-17.91 (-3.47)***	-17.28 (-3.30)***	-42.54 (-2.32)**	-42.92 (-2.39)**	-25.16 (-1.17)	-40.18 (-2.06)**	-39.92 (-2.02)**	-43.18 (-2.20)**	-42.94 (-2.15)**
Wald χ^2	4929.07	6149.83	6106.43	4892.73	5063.15	5277.91	6985.84	7401.54	6478.25	7111.56
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.2.2 FGLS Regression Results on FDI/POP for Log Data with EI2

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2†	-0.077 (-2.21)**	-0.087 (-2.51)**	-0.085 (-2.49)**	-0.087 (-2.33)**	-0.098 (-2.58)***	-0.099 (-2.57)**	-0.053 (-1.51)	-0.059 (-1.78)*	-0.052 (-1.47)	-0.058 (-1.72)*
GRP per capita		3.31 (5.99)***	3.10 (5.00)***	3.48 (4.95)***	3.76 (5.04)***	4.03 (5.42)***	4.06 (6.08)***	3.97 (6.03)***	4.03 (5.72)***	3.99 (5.73)***
Wage			0.15 (0.39)	7.68 (2.12)**	7.57 (2.12)**	5.23 (1.31)	7.40 (1.99)**	7.46 (1.98)**	8.46 (2.21)**	8.48 (2.18)**
Wage^2				-0.45 (-2.06)**	-0.45 (-2.04)**	-0.32 (-1.32)	-0.45 (-1.99)**	-0.47 (-2.04)**	-0.51 (-2.20)**	-0.52 (-2.23)**
GIP					-0.35 (-1.09)	-0.42 (-1.28)	-0.050 (-0.15)	0.073 (0.22)	-0.031 (-0.09)	0.057 (0.17)
Pop. Density						-0.95 (-1.23)	-0.88 (-1.22)	-0.93 (-1.28)	-0.87 (-1.22)	-0.92 (-1.30)
Rail Density							-0.17 (-1.53)	-0.20 (-1.81)*	-0.17 (-1.58)	-0.21 (-1.87)*
Road Density							0.45 (4.58)***	0.47 (5.28)***	0.45 (4.72)***	0.48 (5.60)***
Illiterate Rate								0.29 (2.46)**		0.28 (2.35)**
Productivity									-0.15 (-1.21)	-0.16 (-1.30)
Constant	6.69 (38.85)***	-23.90 (-4.66)***	-23.29 (-4.49)***	-57.82 (-3.28)***	-57.60 (-3.29)***	-42.74 (-2.00)**	-57.81 (-2.92)***	-57.45 (-2.89)***	-60.92 (-3.07)***	-60.44 (-3.01)***
Wald χ^2	8253.71	9871.67	9920.83	8554.96	8743.28	8915.09	12553.26	13243.52	12242.10	13426.99
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.2.3 FGLS Regression Results on FDI/GDP for Log Data with EI3

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3†	-0.047	-0.071	-0.070	-0.066	-0.084	-0.087	-0.042	-0.048	-0.044	-0.049
	(-1.31)	(-2.12)**	(-2.06)**	(-1.76)*	(-2.19)**	(-2.27)**	(-1.22)	(-1.49)	(-1.22)	(-1.49)
GRP per capita		2.69	2.62	2.88	3.22	3.52	3.41	3.35	3.45	3.45
		(4.74)***	(4.08)***	(4.02)***	(4.21)***	(4.57)***	(4.93)***	(4.92)***	(4.76)***	(4.80)***
Wage			0.0027	5.89	6.06	3.25	5.59	5.64	6.65	6.70
			(0.01)	(1.52)	(1.61)	(0.79)	(1.48)	(1.47)	(1.72)*	(1.69)*
Wage^2				-0.35	-0.36	-0.20	-0.34	-0.36	-0.40	-0.42
				(-1.51)	(-1.57)	(-0.83)	(-1.50)	(-1.54)	(-1.72)*	(-1.75)*
GIP					-0.44	-0.54	-0.19	-0.091	-0.19	-0.12
					(-1.42)	(-1.71)*	(-0.62)	(-0.28)	(-0.57)	(-0.36)
Pop. Density						-1.20	-1.04	-1.10	-1.11	-1.17
						(-1.57)	(-1.58)	(-1.65)*	(-1.69)*	(-1.77)*
Rail Density							-0.23	-0.25	-0.23	-0.26
							(-2.17)**	(-2.38)**	(-2.20)**	(-2.43)**
Road Density							0.43	0.46	0.43	0.46
							(4.44)***	(5.35)***	(4.58)***	(5.67)***
Illiterate Rate								0.28		0.28
								(2.50)**		(2.45)**
Productivity									-0.16	-0.17
									(-1.30)	(-1.40)
Constant	6.59	-18.23	-17.62	-44.30	-45.39	-26.78	-41.62	-41.33	-44.67	-44.36
	(41.91)***	(-3.47)***	(-3.29)***	(-2.37)**	(-2.47)**	(-1.23)	(-2.13)**	(-2.09)**	(-2.28)**	(-2.22)**
Wald χ^2	4824.69	5696.37	5691.95	4709.51	4819.03	5111.18	7015.82	7375.20	6514.12	7123.89
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.2.4 FGLS Regression Results on FDI/POP for Log Data with EI3

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3†	-0.063	-0.076	-0.075	-0.076	-0.085	-0.086	-0.044	-0.050	-0.044	-0.050
	(-1.79)*	(-2.11)**	(-2.11)**	(-1.97)**	(-2.15)**	(-2.16)**	(-1.22)	(-1.46)	(-1.21)	(-1.44)
GRP per capita		3.35	3.12	3.48	3.71	3.99	4.03	3.94	4.01	3.97
		(5.96)***	(4.95)***	(4.93)***	(4.94)***	(5.31)***	(6.01)***	(5.95)***	(5.68)***	(5.68)***
Wage			0.16	8.14	8.10	5.61	7.71	7.76	8.74	8.74
			(0.43)	(2.20)**	(2.22)**	(1.38)	(2.05)**	(2.04)**	(2.26)**	(2.23)**
Wage^2				-0.48	-0.48	-0.34	-0.47	-0.48	-0.52	-0.54
				(-2.13)**	(-2.14)**	(-1.39)	(-2.05)**	(-2.09)**	(-2.24)**	(-2.26)**
GIP					-0.28	-0.36	-0.0027	0.12	0.0067	0.095
					(-0.89)	(-1.09)	(-0.01)	(0.36)	(0.02)	(0.27)
Pop. Density						-0.97	-0.89	-0.93	-0.88	-0.93
						(-1.25)	(-1.24)	(-1.30)	(-1.24)	(-1.31)
Rail Density							-0.17	-0.20	-0.18	-0.20
							(-1.57)	(-1.82)*	(-1.59)	(-1.86)*
Road Density							0.46	0.48	0.46	0.49
							(4.76)***	(5.43)***	(4.91)***	(5.77)***
Illiterate Rate								0.28		0.28
								(2.40)**		(2.30)**
Productivity									-0.15	-0.16
									(-1.18)	(-1.26)
Constant	6.58	-24.35	-23.74	-59.94	-60.04	-44.36	-59.38	-58.98	-62.45	-61.89
	(43.52)***	(-4.67)***	(-4.48)***	(-3.35)***	(-3.38)***	(-2.05)**	(-2.99)***	(-2.95)***	(-3.14)***	(-3.07)***
Wald χ^2	7957.08	9294.05	9373.60	8243.57	8391.45	8635.95	12577.41	13130.56	12305.90	13367.50
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Appendix 2.3 FGLS Regression Results for Level Data

Table A2.3.1 FGLS Regression Results on FDI/GDP for Level Data with EI1

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1	-0.041 (-2.20)**	-0.040 (-2.23)**	-0.038 (-1.99)**	-0.037 (-1.79)*	-0.033 (-1.59)	-0.034 (-1.72)*	-0.044 (-1.98)**	-0.045 (-2.04)**	-0.044 (-1.96)**	-0.045 (-2.03)**
GRP per capita		0.0078 (0.72)	0.0071 (0.59)	0.013 (0.87)	0.0020 (0.12)	-0.0031 (-0.19)	0.039 (1.85)*	0.042 (1.97)**	0.039 (1.83)*	0.043 (1.97)**
Wage			0.0018 (0.10)	0.044 (1.10)	0.043 (1.08)	0.045 (1.14)	0.078 (1.49)	0.079 (1.51)	0.079 (1.52)	0.081 (1.54)
$Wage^2$				-2.59e-06 (-0.95)	-2.11e-06 (-0.78)	-2.36e-06 (-0.86)	-8.10e-06 (-2.22)**	-8.30e-06 (-2.27)**	-8.15e-06 (-2.21)**	-8.39e-06 (-2.27)**
GIP					0.023 (1.08)	0.021 (0.98)	0.030 (1.49)	0.028 (1.34)	0.030 (1.48)	0.027 (1.32)
Pop. Density						0.22 (0.67)	0.20 (0.58)	0.18 (0.52)	0.19 (0.57)	0.18 (0.52)
Rail Density							-1.31 (-3.40)***	-1.29 (-3.32)***	-1.32 (-3.40)***	-1.29 (-3.30)***
Road Density							0.025 (2.63)***	0.025 (2.70)***	0.025 (2.62)***	0.025 (2.70)***
Illiterate Rate								-1.51 (-0.75)		-1.59 (-0.79)
Productivity									0.000039 (0.12)	0.000011 (0.03)
Constant	579.59 (13.28)***	484.84 (3.57)***	480.00 (3.17)***	260.99 (1.08)	345.01 (1.40)	231.09 (0.68)	526.58 (1.10)	493.89 (1.03)	522.12 (1.08)	483.67 (1.00)
Wald χ^2	1814.28	1776.79	1806.09	1746.66	1671.93	1802.93	2077.01	2077.02	2079.73	2079.84
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.2 FGLS Regression Results on FDI/POP for Level Data with EI1

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1	-0.020	-0.017	-0.018	-0.016	-0.0099	-0.0098	-0.013	-0.016	-0.012	-0.015
	(-1.36)	(-1.39)	(-1.44)	(-1.4)	(-0.87)	(-1.04)	(-1.69)*	(-2.00)**	(-1.50)	(-1.73)*
GRP per capita		0.045	0.042	0.039	0.021	0.012	0.026	0.027	0.025	0.026
		(4.47)***	(4.13)***	(3.87)***	(1.90)*	(1.21)	(1.97)**	(2.07)**	(1.90)*	(1.96)**
Wage			0.0098	-0.022	-0.023	-0.020	-0.011	-0.011	-0.012	-0.011
			(1.06)	(-0.93)	(-0.95)	(-0.84)	(-0.39)	(-0.38)	(-0.42)	(-0.39)
$Wage^2$				2.50e-06	3.01e-06	2.68e-06	8.44e-07	6.74e-07	1.02e-06	8.66e-07
				(1.38)	(1.68)*	(1.52)	(0.37)	(0.30)	(0.45)	(0.38)
GIP					0.047	0.047	0.058	0.056	0.058	0.057
					(3.34)***	(3.59)***	(4.79)***	(4.74)***	(4.84)***	(4.81)***
Pop. Density						0.40	0.43	0.42	0.42	0.42
						(1.66)*	(1.67)*	(1.67)*	(1.64)	(1.65)*
Rail Density							-0.64	-0.62	-0.66	-0.64
							(-2.93)***	(-2.79)***	(-2.99)***	(-2.87)***
Road Density							0.0095	0.011	0.095	0.010
							(1.83)*	(1.99)**	(1.83)*	(1.94)*
Illiterate Rate								-1.05		-0.85
								(-1.09)		(-0.85)
Productivity									0.00014	0.00013
									(0.93)	(0.91)
Constant	605.00	72.43	36.01	162.54	285.64	74.13	282.72	258.76	296.25	276.16
	(19.34)***	(0.56)	(0.27)	(1.05)	(1.81)*	(0.31)	(0.96)	(0.88)	(1.00)	(0.94)
Wald χ^2	1561.23	1935.00	2057.03	1935.39	2185.31	2565.05	2935.79	2964.59	2937.39	2965.54
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.3 FGLS Regression Results on FDI/GDP for Level Data with Punish

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish	-0.0014	-0.0017	-0.00075	-0.0016	0.00084	0.0017	-0.0076	-0.0079	-0.0078	-0.0082
	(-0.24)	(-0.29)	(-0.13)	(-0.27)	(0.14)	(0.29)	(-1.07)	(-1.11)	(-1.09)	(-1.14)
GRP per capita		0.0020	-0.0020	0.0069	-0.013	-0.024	0.042	0.047	0.044	0.049
		(0.17)	(-0.15)	(0.41)	(-0.60)	(-1.15)	(1.75)*	(1.88)*	(1.80)*	(1.96)**
Wage			0.013	0.058	0.053	0.056	0.085	0.083	0.096	0.091
			(0.64)	(1.31)	(1.21)	(1.26)	(1.51)	(1.46)	(1.74)*	(1.62)
Wage^2				-2.94e-06	-1.80e-06	-2.01e-06	-9.07e-06	-9.11e-06	-9.62e-06	-9.58e-06
				(-0.96)	(-0.58)	(-0.65)	(-2.26)**	(-2.27)**	(-2.40)**	(-2.39)**
GIP					0.035	0.035	0.033	0.030	0.032	0.028
					(1.48)	(1.49)	(1.62)	(1.42)	(1.56)	(1.34)
Pop. Density						0.36	0.20	0.18	0.19	0.17
						(1.07)	(0.57)	(0.51)	(0.55)	(0.49)
Rail Density							-1.37	-1.34	-1.39	-1.34
							(-3.41)***	(-3.30)***	(-3.45)***	(-3.29)***
Road Density							0.025	0.025	0.025	0.026
							(2.44)**	(2.51)**	(2.46)**	(2.54)**
Illiterate Rate								-1.81		-2.08
								(-0.82)		(-0.97)
Productivity									0.00013	0.000078
									(0.40)	(0.24)
Constant	568.72	543.63	502.00	243.06	405.60	246.81	500.82	479.03	446.96	428.34
	(13.74)***	(3.74)***	(3.17)***	(0.88)	(1.39)	(0.67)	(1.01)	(0.97)	(0.90)	(0.86)
Wald χ^2	1606.60	1579.33	1617.78	1626.47	1596.89	1685.29	2145.62	2146.11	2155.22	2156.02
Observations	147	147	147	147	147	147	147	147	147	147

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.4 FGLS Regression Results on FDI/POP for Level Data with Punish

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish	-0.00092 (-0.19)	-0.0049 (-1.03)	-0.0040 (-0.84)	-0.0037 (-0.75)	-0.00021 (-0.04)	-0.000037 (-0.01)	-0.0037 (-0.72)	-0.0040 (-0.78)	-0.0038 (-0.73)	-0.0040 (-0.77)
GRP per capita		0.044 (4.25)***	0.040 (3.83)***	0.036 (3.39)***	0.012 (0.98)	0.0052 (0.45)	0.032 (2.23)**	0.034 (2.35)**	0.033 (2.30)**	0.034 (2.39)**
Wage			0.0096 (1.04)	-0.014 (-0.58)	-0.019 (-0.76)	-0.017 (-0.68)	0.0055 (0.17)	0.0039 (0.12)	0.011 (0.36)	0.0083 (0.27)
Wage^2				1.90e-06 (0.98)	3.10e-06 (1.54)	2.84e-06 (1.51)	-4.35e-07 (-0.18)	-4.77e-07 (-0.19)	-6.77e-07 (-0.28)	-6.83e-07 (-0.28)
GIP					0.052 (3.57)***	0.050 (3.66)***	0.056 (4.59)***	0.053 (4.44)***	0.056 (4.58)***	0.054 (4.45)***
Pop. Density						0.45 (1.84)*	0.41 (1.54)	0.40 (1.51)	0.40 (1.51)	0.40 (1.51)
Rail Density							-0.56 (-2.51)**	-0.53 (-2.34)**	-0.58 (-2.58)***	-0.54 (-2.37)**
Road Density							0.012 (2.10)**	0.014 (2.25)**	0.013 (2.16)**	0.014 (2.31)**
Illiterate Rate								-1.15 (-1.08)		-1.12 (-1.06)
Productivity									0.00012 (0.81)	0.000086 (0.64)
Constant	599.07 (19.34)***	82.85 (0.62)	56.15 (0.41)	169.37 (1.05)	356.76 (2.03)**	88.89 (0.36)	100.22 (0.32)	77.00 (0.25)	73.52 (0.24)	54.51 (0.18)
Wald χ^2	1571.09	2058.29	2179.97	2046.20	2454.30	2897.49	2840.85	2865.64	2852.37	2875.18
Observations	147	147	147	147	147	147	147	147	147	147

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.5 FGLS Regression Results on FDI/GDP for Level Data with Charge

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge	0.0021 (0.46)	0.0016 (0.27)	0.00083 (0.14)	-0.00071 (-0.10)	-0.00054 (-0.08)	0.00027 (0.04)	-0.0031 (-0.43)	-0.0028 (-0.38)	-0.0033 (-0.45)	-0.0028 (-0.38)
GRP per capita		0.00080 (0.07)	0.00061 (0.05)	0.0066 (0.42)	-0.0045 (-0.26)	-0.0099 (-0.60)	0.033 (1.46)	0.036 (1.56)	0.034 (1.50)	0.038 (1.62)
Wage			0.0038 (0.22)	0.050 (1.23)	0.048 (1.17)	0.048 (1.18)	0.074 (1.35)	0.073 (1.33)	0.082 (1.52)	0.079 (1.47)
Wage^2				-2.61e-06 (-0.93)	-2.08e-06 (-0.74)	-2.37e-06 (-0.82)	-7.88e-06 (-2.07)**	-7.97e-06 (-2.09)**	-8.25e-06 (-2.16)**	-8.31e-06 (-2.18)**
GIP					0.028 (1.39)	0.027 (1.34)	0.037 (1.95)*	0.035 (1.77)*	0.037 (1.91)*	0.034 (1.71)*
Pop. Density						0.22 (0.67)	0.24 (0.70)	0.23 (0.65)	0.24 (0.68)	0.22 (0.62)
Rail Density							-1.32 (-3.33)***	-1.28 (-3.21)***	-1.33 (-3.37)***	-1.28 (-3.20)***
Road Density							0.025 (2.70)***	0.026 (2.76)***	0.025 (2.70)***	0.026 (2.78)***
Illiterate Rate								-1.49 (-0.69)		-1.75 (-0.83)
Productivity									0.00013 (0.41)	0.000094 (0.28)
Constant	553.59 (10.28)***	545.32 (4.12)***	526.71 (3.44)***	287.05 (1.14)	375.62 (1.46)	271.43 (0.77)	565.99 (1.16)	540.56 (1.11)	527.95 (1.08)	500.04 (1.02)
Wald χ^2	1791.45	1710.22	1722.41	1727.51	1716.63	1768.76	2258.26	2258.22	2265.39	2265.33
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.6 FGLS Regression Results on FDI/POP for Level Data with Charge

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge	0.0066	-0.00011	-0.00032	0.000098	-0.00040	0.0011	0.00014	0.00053	-0.00024	0.00025
	(1.43)	(-0.03)	(-0.08)	(0.03)	(-0.10)	(0.32)	(-0.04)	(0.15)	(-0.07)	(0.07)
GRP per capita		0.041	0.039	0.035	0.015	0.0069	0.026	0.028	0.027	0.028
		(4.00)***	(3.78)***	(3.38)***	(1.30)	(0.67)	(1.94)*	(2.04)**	(1.99)**	(2.06)**
Wage			0.0094	-0.016	-0.018	-0.021	-0.0025	-0.0040	0.0015	-0.00078
			(0.99)	(-0.66)	(-0.76)	(-0.88)	(-0.08)	(-0.13)	(0.05)	(-0.03)
Wage^2				2.08e-06	3.02e-06	2.92e-06	4.13e-07	4.08e-07	2.84e-07	3.03e-07
				(1.13)	(1.57)	(1.58)	(0.17)	(0.17)	(0.12)	(0.13)
GIP					0.052	0.052	0.060	0.057	0.060	0.058
					(4.05)***	(4.40)***	(5.39)***	(5.24)***	(5.39)***	(5.24)***
Pop. Density						0.41	0.39	0.38	0.39	0.38
						(1.73)*	(1.52)	(1.48)	(1.50)	(1.48)
Rail Density							-0.55	-0.51	-0.56	-0.52
							(-2.52)**	(-2.31)**	(-2.59)***	(-2.34)**
Road Density							0.012	0.013	0.012	0.013
							(2.16)**	(2.30)**	(2.18)**	(2.31)**
Illiterate Rate								-1.10		-1.07
								(-1.04)		(-1.01)
Productivity									0.00012	0.000093
									(0.81)	(0.66)
Constant	554.97	108.24	67.60	169.75	319.77	106.36	174.58	153.61	155.62	138.55
	(11.39)***	(0.85)	(0.50)	(1.09)	(1.94)*	(0.45)	(0.58)	(0.51)	(0.52)	(0.46)
Wald χ^2	1961.15	2221.08	2262.99	2219.06	2657.54	3130.58	3023.00	3054.15	3029.88	3058.95
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.7 FGLS Regression Results on FDI/GDP for Level Data with EI2

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2	-0.17	-0.16	-0.15	-0.15	-0.13	-0.13	-0.20	-0.20	-0.20	-0.20
	(-1.89)*	(-1.85)*	(-1.66)*	(-1.60)	(-1.44)	(-1.49)	(-2.02)**	(-2.00)**	(-1.99)**	(-1.98)**
GRP per capita		0.0093	0.0093	0.015	0.0046	-0.00053	0.043	0.046	0.043	0.046
		(0.85)	(0.76)	(1.03)	(0.28)	(-0.03)	(2.08)**	(2.18)**	(2.05)**	(2.16)**
Wage			-0.0011	0.044	0.043	0.045	0.080	0.079	0.079	0.079
			(-0.06)	(1.11)	(1.09)	(1.13)	(1.53)	(1.52)	(1.51)	(1.52)
Wage^2				-2.70e-06	-2.25e-06	-2.42e-06	-8.31e-06	-8.42e-06	-8.26e-06	-8.42e-06
				(-1.00)	(-0.85)	(-0.89)	(-2.29)**	(-2.31)**	(-2.24)**	(-2.28)**
GIP					0.023	0.021	0.028	0.026	0.028	0.026
					(1.07)	(1.00)	(1.38)	(1.26)	(1.39)	(1.25)
Pop. Density						0.19	0.17	0.15	0.16	0.15
						(0.59)	(0.49)	(0.44)	(0.48)	(0.43)
Rail Density							-1.34	-1.31	-1.34	-1.31
							(-3.50)***	(-3.39)***	(-3.49)***	(-3.37)***
Road Density							0.024	0.025	0.024	0.025
							(2.61)***	(2.68)***	(2.60)***	(2.67)***
Illiterate Rate								-1.43		-1.44
								(-0.72)		(-0.72)
Productivity									0.000032	5.69e-06
									(0.10)	(0.02)
Constant	583.05	469.73	476.84	244.21	325.50	230.06	523.13	495.67	529.32	495.40
	(13.09)***	(3.43)***	(3.13)***	(1.02)	(1.34)	(0.68)	(1.10)	(1.03)	(1.10)	(1.02)
Wald χ^2	1821.42	1768.21	1790.55	1763.69	1694.14	1820.48	2112.93	2112.16	2112.94	2112.51
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.8 FGLS Regression Results on FDI/GDP for Level Data with EI2

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2	-0.086 (-1.32)	-0.096 (-1.93)*	-0.097 (-1.96)**	-0.087 (-1.79)	-0.059 (-1.26)	-0.055 (-1.36)	-0.068 (-1.77)*	-0.075 (-1.90)*	-0.061 (-1.57)	-0.066 (-1.64)
GRP per capita		0.043 (4.61)***	0.041 (4.33)***	0.039 (4.20)***	0.023 (2.17)**	0.016 (1.67)*	0.027 (2.06)**	0.028 (2.18)**	0.026 (1.97)**	0.027 (2.04)**
Wage			0.0091 (1.07)	-0.023 (-1.03)	-0.025 (-1.08)	-0.021 (-0.95)	-0.0039 (-0.14)	-0.0015 (-0.06)	-0.0061 (-0.22)	-0.0032 (-0.12)
Wage^2				2.51e-06 (-1.51)	3.03e-06 (-1.80)*	2.66e-06 (-1.63)	2.44e-07 (0.11)	1.44e-08 (0.01)	5.29e-07 (0.24)	3.00e-07 (0.13)
GIP					0.046 (3.41)***	0.046 (3.67)***	0.058 (4.85)***	0.057 (4.80)***	0.059 (4.91)***	0.058 (4.88)***
Pop. Density						0.38 (1.55)	0.45 (1.77)*	0.45 (1.76)*	0.44 (1.74)*	0.44 (1.73)*
Rail Density							-0.63 (-2.87)***	-0.58 (-2.61)***	-0.64 (-2.94)***	-0.61 (-2.71)***
Road Density							0.010 (2.01)**	0.012 (2.17)**	0.010 (1.98)**	0.011 (2.08)**
Illiterate Rate								-0.91 (-0.98)		-0.66 (-0.69)
Productivity									0.00015 (1.01)	0.00013 (0.94)
Constant	606.85 (19.18)***	92.27 (0.75)	52.56 (0.41)	170.49 (1.19)	284.45 (1.91)*	67.30 (0.29)	215.57 (0.74)	167.54 (0.57)	240.50 (0.82)	197.09 (0.67)
Wald χ^2	1626.06	2007.55	2073.35	1994.59	2230.49	2655.82	2974.92	2967.06	2975.91	2966.74
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.9 FGLS Regression Results on FDI/GDP for Level Data with EI3

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3	-0.16 (-1.25)	-0.16 (-1.25)	-0.15 (-1.11)	-0.15 (-1.12)	-0.14 (-1.01)	-0.13 (-1.00)	-0.25 (-1.63)	-0.25 (-1.62)	-0.25 (-1.61)	-0.25 (-1.61)
GRP per capita		0.0081 (0.75)	0.0076 (0.62)	0.014 (0.95)	0.0027 (0.16)	-0.0032 (-0.20)	0.040 (1.90)*	0.043 (2.00)**	0.040 (1.90)*	0.044 (2.03)**
Wage			0.00025 (0.01)	0.044 (1.10)	0.041 (1.05)	0.044 (1.10)	0.078 (1.48)	0.078 (1.47)	0.083 (1.56)	0.082 (1.54)
Wage^2				-2.63e-06 (-0.97)	-2.10e-06 (-0.78)	-2.31e-06 (-0.84)	-8.32e-06 (-2.24)**	-8.41e-06 (-2.26)**	-8.53e-06 (-2.27)**	-8.64e-06 (-2.30)**
GIP					0.025 (1.19)	0.023 (1.12)	0.032 (1.62)	0.030 (1.49)	0.032 (1.59)	0.029 (1.44)
Pop. Density						0.20 (0.61)	0.18 (0.53)	0.17 (0.48)	0.18 (0.53)	0.16 (0.48)
Rail Density							-1.34 (-3.46)***	-1.31 (-3.36)***	-1.34 (-3.46)***	-1.30 (-3.34)***
Road Density							0.026 (2.71)***	0.026 (2.76)***	0.026 (2.71)***	0.026 (2.77)***
Illiterate Rate								-1.45 (-0.71)		-1.61 (-0.80)
Productivity									0.000046 (0.14)	0.000015 (0.04)
Constant	574.48 (12.95)***	475.67 (3.49)***	480.07 (3.15)***	251.34 (1.05)	342.83 (1.42)	244.67 (0.71)	532.64 (1.10)	507.74 (1.05)	512.11 (1.05)	482.008 (0.99)
Wald χ^2	1782.78	1739.80	1768.59	1742.83	1691.10	1800.75	2144.50	2144.69	2149.51	2149.79
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.3.10 FGLS Regression Results on FDI/GDP for Level Data with EI3

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3	-0.088 (-0.94)	-0.12 (-1.67)*	-0.12 (-1.67)*	-0.11 (-1.55)	-0.072 (-1.09)	-0.071 (-1.29)	-0.085 (-1.25)	-0.092 (-1.33)	-0.078 (-1.12)	-0.086 (-1.20)
GRP per capita		0.042 (4.48)***	0.040 (4.20)***	0.036 (3.98)***	0.020 (1.95)*	0.013 (1.45)	0.027 (2.05)**	0.029 (2.17)**	0.027 (2.06)**	0.028 (2.15)**
Wage			0.0094 (1.08)	-0.022 (-0.97)	-0.026 (-1.12)	-0.022 (-1.00)	-0.0013 (-0.05)	-0.00070 (-0.02)	0.0017 (0.06)	0.0018 (0.06)
$Wage^2$				2.45e-06 (1.44)	3.13e-06 (1.82)	2.72e-06 (1.64)	1.76e-07 (0.08)	4.97e-08 (0.02)	1.11e-07 (0.05)	-6.67e-09 (-0.00)
GIP					0.048 (3.61)***	0.048 (3.96)***	0.058 (4.91)***	0.056 (4.83)***	0.058 (4.93)***	0.057 (4.83)***
Pop. Density						0.38 (1.58)	0.44 (1.68)*	0.43 (1.66)*	0.43 (1.66)*	0.43 (1.65)*
Rail Density							-0.57 (-2.60)***	-0.53 (-2.36)**	-0.59 (-2.66)***	-0.54 (-2.40)**
Road Density							0.011 (2.06)**	0.012 (2.23)**	0.011 (2.07)**	0.012 (2.23)**
Illiterate Rate								-1.07 (-1.08)		-1.04 (-1.03)
Productivity									0.00011 (0.77)	0.000083 (0.60)
Constant	602.80 (19.04)***	107.48 (0.87)	68.73 (0.54)	188.38 (1.32)	314.97 (2.13)**	98.18 (0.42)	163.66 (0.55)	124.69 (0.42)	154.04 (0.51)	117.51 (0.39)
Wald χ^2	1599.17	2016.04	2089.63	1999.46	2296.55	2728.50	2865.43	2876.50	2872.31	2883.08
Observations	149	149	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Appendix 2.4 Hausman Specification Test

For random effects estimator (GLS estimator) we assume that the error (ε_{it}) is uncorrelated with the independent variables (X_{it}), i.e. $E(\varepsilon_{it}|X_{it})=0$. In the case $E(\varepsilon_{it}|X_{it})\neq 0$ the GLS estimator $\hat{\beta}_{GLS}$ becomes biased and inconsistent for β. However, the within estimator $\tilde{\beta}_{Within}$ is always unbiased and consistent for β because the within transformation wipes out the individual effects. So we undertake the Hausman specification test to find out whether $\hat{\beta}_{GLS}$ is BLUE (best linear unbiased estimator), consistent and asymptotically efficient under the null hypothesis H_0: $E(\varepsilon_{it}|X_{it})=0$.

The Hausman statistic is distributed as χ^2 and is computed as

$$H=(\tilde{\beta}_{Within}-\hat{\beta}_{GLS})'(V_{Within}-V_{GLS})^{-1}(\tilde{\beta}_{Within}-\hat{\beta}_{GLS})$$

where

$\tilde{\beta}_{Within}$ is the coefficient vector from the within estimator;

$\hat{\beta}_{GLS}$ is the coefficient vector from the GLS estimator;

V_{Within} is the covariance matrix of the coefficients from the within estimator; and

V_{GLS} is the covariance matrix of the coefficients for the GLS estimator.

If H_0 is not rejected, there is no systematic difference between these two estimators, hence GLS estimator $\hat{\beta}_{GLS}$ is efficient (Baltagi, 2005). We reject the GLS estimator only if the p-value is less than 0.05, which means in these cases, random effects specification is not appropriate. The results below show that GLS estimator produces efficient results in most specifications except 2 cases for level data. Therefore, we also estimate equation (2.4.5) using GLS estimator (see results in Appendix 2.5).

Table A2.4.1 Hausman Specification Test Results

	Levels									
	EI1		***Punish***		***Charge***		***EI2***		***EI3***	
	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP
χ^2 Statistics	5.71	10.30	**21.66**	10.53	13.56	**19.28**	16.05	14.00	7.99	14.62
p-value	0.839	0.415	**0.006**	0.395	0.094	**0.037**	0.098	0.233	0.630	0.201
	Logs									
	EI1		***Punish***		***Charge***		***EI2***		***EI3***	
	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP	FDI/ GDP	FDI/ POP
χ^2 Statistics	7.36	10.34	8.58	8.16	10.50	9.05	9.30	8.13	4.21	8.44
p-value	0.920	0.737	0.857	0.881	0.725	0.828	0.811	0.882	0.994	0.865

Appendix 2.5 Random Effects Regression Results

The results of random effects regressions are reported in Tables A2.5.1-A2.5.20. The results of log specifications are consistent with those of our fixed effects results. The level specification results are mixed. However, the significant coefficients are robust and none of the unstable coefficients are statistically significant.

The results of random effects models are comparatively weaker than FGLS estimator due to its failure in controlling for autocorrelation. It then leads us to just focus on the FGLS estimator results in the main text.

Table A2.5.1 Random Effects Estimation Results on FDI/GDP for Level Data with EI1

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1	-0.082 (-2.00)**	-0.072 (-1.64)*	-0.072 (-1.65)*	-0.080 (-1.87)*	-0.073 (-1.73)*	-0.072 (-1.73)*	-0.061 (-1.36)	-0.061 (-1.34)	-0.064 (-1.37)	-0.063 (-1.35)
GRP per capita		0.029 (3.99)***	0.025 (1.78)*	0.037 (2.27)**	0.031 (1.59)	0.027 (1.41)	0.059 (2.40)**	0.057 (2.22)**	0.060 (2.38)**	0.057 (2.21)**
Wage			0.012 (0.33)	0.19 (2.66)***	0.19 (2.72)***	0.19 (2.64)***	0.21 (3.37)***	0.21 (3.40)***	0.21 (3.37)***	0.21 (3.39)***
$Wage^2$				-0.000013 (-2.58)***	-0.000012 (-2.54)**	-0.000012 (-2.47)**	-0.000017 (-3.34)***	-0.000016 (-3.22)***	-0.000017 (-3.33)***	-0.000016 (-3.21)***
GIP					0.023 (0.87)	0.023 (0.84)	0.0069 (0.29)	0.0054 (0.22)	0.0062 (0.26)	0.0046 (0.19)
Pop. Density						0.032 (0.26)	-0.068 (-0.51)	-0.062 (-0.46)	-0.065 (-0.48)	-0.059 (-0.44)
Rail Density							-0.86 (-1.96)**	-0.91 (-2.12)**	-0.87 (-1.95)*	-0.92 (-2.11)**
Road Density							0.053 (1.74)*	0.051 (1.68)*	0.052 (1.70)*	0.050 (1.64)
Illiterate Rate								-4.40 (-1.65)*		-4.44 (-1.62)
Productivity									-0.00019 (-0.41)	-0.00021 (-0.47)
Constant	316.92 (5.06)***	196.42 (3.33)***	171.108 (1.85)	-364.54 (-1.97)**	-374.69 (-2.07)**	-368.31 (-1.98)**	-472.69 (-2.86)***	-373.17 (-2.17)**	-467.92 (-2.76)***	-366.71 (-2.09)**
R^2	0.015	0.41	0.41	0.50	0.56	0.55	0.67	0.67	0.67	0.67
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.2 Random Effects Estimation Results on FDI/POP for Level Data with EI1

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1	-0.085 (-2.70)***	-0.065 (-2.11)**	-0.064 (-2.12)**	-0.067 (-2.24)**	-0.062 (-2.14)**	-0.057 (-2.05)**	-0.052 (-1.70)*	-0.051 (-1.70)*	-0.054 (-1.77)*	-0.054 (-1.77)*
GRP per capita		0.066 (9.16)***	0.058 (6.69)***	0.061 (6.52)***	0.054 (4.64)***	0.041 (3.53)***	0.054 (3.34)***	0.053 (3.16)***	0.055 (3.34)***	0.054 (3.16)***
Wage			0.021 (1.04)	0.076 (1.51)	0.076 (1.55)	0.076 (1.54)	0.080 (1.75)*	0.078 (1.72)*	0.081 (1.75)*	0.079 (1.72)*
$Wage^2$				-3.91e-06 (-1.05)	-3.65e-06 (-0.97)	-3.18e-06 (-0.84)	-4.99e-06 (-1.36)	-4.74e-06 (-1.29)	-5.04e-06 (-1.37)	-4.78e-06 (-1.30)
GIP					0.023 (1.32)	0.023 (1.38)	0.013 (0.73)	0.012 (0.70)	0.012 (0.69)	0.012 (0.65)
Pop. Density						0.10 (1.36)	0.069 (0.76)	0.073 (0.79)	0.069 (0.77)	0.073 (0.79)
Rail Density							-0.41 (-1.36)	-0.43 (-1.44)	-0.41 (-1.34)	-0.43 (-1.42)
Road Density							0.027 (1.34)	0.026 (1.29)	0.027 (1.31)	0.026 (1.27)
Illiterate Rate								-1.35 (-0.82)		-1.39 (-0.83)
Productivity									-0.00023 (-0.82)	-0.00024 (-0.78)
Constant	200.71 (3.67)***	-69.18 (-2.00)**	-118.56 (-1.96)**	-272.52 (-2.12)**	-279.67 (-2.25)**	-271.59 (-2.15)**	-308.90 (-2.51)**	-277.08 (-2.19)**	-303.48 (-2.45)**	-270.32 (-2.12)**
R^2	0.017	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.88	0.88
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.3 Random Effects Estimation Results on FDI/GDP for Log Data with EI1

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1†	-0.072 (-0.79)	-0.064 (-0.73)	-0.064 (-0.71)	-0.076 (-0.84)	-0.075 (-0.83)	-0.077 (-0.90)	-0.061 (-0.71)	-0.060 (-0.70)	-0.058 (-0.67)	-0.057 (-0.66)
GRP per capita		1.50 (6.32)***	1.49 (4.46)***	1.57 (4.59)***	1.39 (3.05)***	1.29 (3.39)***	1.49 (4.12)***	1.52 (3.65)***	1.46 (3.97)***	1.50 (3.56)***
Wage			0.052 (0.06)	6.87 (1.18)	6.81 (1.18)	8.69 (1.39)	8.94 (1.50)	9.16 (1.51)	7.98 (1.30)	8.22 (1.31)
Wage^2				-0.41 (-1.20)	-0.40 (-1.19)	-0.53 (-1.45)	-0.57 (-1.62)	-0.58 (-1.62)	-0.51 (-1.42)	-0.53 (-1.42)
GIP					0.12 (0.54)	-0.16 (-0.99)	-0.16 (-1.15)	-0.16 (-1.13)	-0.16 (-1.10)	-0.16 (-1.08)
Pop. Density						0.46 (2.73)***	0.29 (1.17)	0.29 (1.16)	0.28 (1.15)	0.28 (1.14)
Rail Density							-0.31 (-2.60)***	-0.29 (-2.40)**	-0.31 (-2.55)**	-0.29 (-2.34)**
Road Density							0.51 (2.23)**	0.51 (2.22)**	0.53 (2.33)**	0.52 (2.32)**
Illiterate Rate								0.088 (0.33)		0.097 (0.37)
Productivity									0.15 (0.63)	0.15 (0.64)
Constant	5.488 (8.63)***	-6.78 (-3.05)***	-7.08 (-1.27)	-36.26 (-1.41)	-35.76 (-1.41)	-42.10 (-1.55)	-44.80 (-1.73)*	-46.24 (-1.75)*	-42.02 (-1.60)	-43.61 (-1.61)
R^2	0.011	0.49	0.49	0.50	0.51	0.66	0.72	0.72	0.72	0.72
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.4 Random Effects Estimation Results on FDI/POP for Log Data with EI1

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI1†	-0.070 (-0.76)	-0.060 (-0.68)	-0.060 (-0.67)	-0.076 (-0.84)	-0.075 (-0.84)	-0.077 (-0.89)	-0.061 (-0.72)	-0.061 (-0.71)	-0.059 (-0.68)	-0.058 (-0.67)
GRP per capita		2.43 (9.97)***	2.44 (7.29)***	2.55 (7.48)***	2.33 (5.20)***	2.25 (5.97)***	2.44 (6.75)***	2.48 (5.92)***	2.41 (6.57)***	2.45 (5.83)***
Wage			-0.020 (-0.02)	9.10 (1.62)	9.03 (1.62)	10.89 (1.81)*	11.16 (1.94)*	11.39 (1.95)*	10.10 (1.70)*	10.35 (1.70)*
$Wage^2$				-0.54 (-1.66)*	-0.53 (-1.65)*	-0.66 (-1.88)*	-0.70 (-2.07)**	-0.72 (-2.07)**	-0.64 (-1.83)*	-0.66 (-1.83)*
GIP					0.15 (0.66)	-0.13 (-0.79)	-0.13 (-0.89)	-0.13 (-0.87)	-0.13 (-0.84)	-0.12 (-0.82)
Pop. Density						0.44 (2.60)***	0.26 (1.06)	0.26 (1.05)	0.25 (1.03)	0.25 (1.02)
Rail Density							-0.29 (-2.41)**	-0.27 (-2.20)**	-0.28 (-2.35)**	-0.27 (-2.13)**
Road Density							0.51 (2.18)**	0.50 (2.17)**	0.52 (2.29)**	0.52 (2.28)**
Illiterate Rate								0.091 (0.34)		0.10 (0.39)
Productivity									0.16 (0.71)	0.17 (0.72)
Constant	4.46 (6.42)***	-15.37 (-6.79)***	-15.27 (-2.70)***	-54.29 (-2.19)**	-53.71 (-2.20)**	-60.05 (-2.30)**	-62.88 (-2.52)**	-64.37 (-2.53)**	-59.78 (-2.36)**	-61.42 (-2.35)**
R^2	0.0051	0.72	0.72	0.73	0.73	0.81	0.84	0.84	0.84	0.84
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.5 Random Effects Estimation Results on FDI/GDP for Level Data with Punish

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish	0.014 (0.95)	0.013 (0.91)	0.014 (0.98)	0.0083 (0.63)	0.010 (0.80)	0.011 (0.90)	0.013 (0.90)	0.012 (0.80)	0.012 (0.89)	0.012 (0.79)
GRP per capita		0.030 (4.11)***	0.024 (1.62)	0.036 (2.13)**	0.029 (1.42)	0.022 (1.07)	0.055 (2.10)**	0.053 (1.97)**	0.055 (2.06)**	0.053 (1.94)*
Wage			0.017 (0.46)	0.19 (2.64)***	0.19 (2.69)***	0.19 (2.60)***	0.21 (3.36)***	0.21 (3.38)***	0.21 (3.35)***	0.21 (3.36)***
$Wage^2$				-0.000012 (-2.51)**	-0.000012 (-2.46)**	-0.000012 (-2.34)**	-0.000016 (-3.22)***	-0.000016 (-3.10)***	-0.000016 (-3.19)***	-0.000016 (-3.08)***
GIP					0.025 (0.91)	0.025 (0.89)	0.0085 (0.35)	0.0070 (0.28)	0.0080 (0.33)	0.0065 (0.26)
Pop. Density						0.056 (0.44)	-0.050 (-0.37)	-0.046 (-0.33)	-0.046 (-0.33)	-0.042 (-0.30)
Rail Density							-0.87 (-1.94)*	-0.92 (-2.09)**	-0.88 (-1.94)*	-0.93 (-2.09)**
Road Density							0.054 (1.74)*	0.053 (1.68)*	0.054 (1.70)*	0.052 (1.64)
Illiterate Rate								-4.34 (-1.63)		-4.36 (-1.62)
Productivity									-0.000033 (-0.08)	-0.000062 (-0.14)
Constant	292.24 (4.88)***	170.45 (3.18)***	133.69 (1.42)	-388.48 (-2.07)**	-398.20 (-2.16)**	-387.64 (-2.04)**	-496.07 (-2.99)***	-396.56 (-2.31)**	-493.99 (-2.91)***	-393.05 (-2.25)**
R^2	0.0009	0.40	0.41	0.50	0.55	0.55	0.67	0.67	0.67	0.67
Observations	147	147	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.6 Random Effects Estimation Results on FDI/POP for Level Data with Punish

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish	0.0026 (0.24)	-0.00022 (-0.02)	0.0017 (0.17)	-0.00038 (-0.04)	0.0016 (0.19)	0.0045 (0.53)	0.0066 (0.71)	0.0063 (0.66)	0.0065 (0.70)	0.0062 (0.65)
GRP per capita		0.067 (9.41)***	0.058 (6.37)***	0.061 (6.25)***	0.054 (4.42)***	0.039 (3.11)***	0.052 (3.02)***	0.051 (2.87)***	0.052 (2.98)***	0.051 (2.84)***
Wage			0.023 (1.06)	0.075 (1.48)	0.075 (1.52)	0.074 (1.50)	0.080 (1.73)*	0.077 (1.69)*	0.080 (1.71)*	0.077 (1.68)*
Wage^2				-3.78e-06 (-1.01)	-3.46e-06 (-0.91)	-2.87e-06 (-0.75)	-4.77e-06 (-1.28)	-4.52e-06 (-1.21)	-4.77e-06 (-1.27)	-4.51e-06 (-1.20)
GIP					0.024 (1.36)	0.024 (1.41)	0.014 (0.77)	0.013 (0.74)	0.013 (0.75)	0.013 (0.71)
Pop. Density						0.116 (1.49)	0.080 (0.86)	0.083 (0.88)	0.082 (0.86)	0.085 (0.89)
Rail Density							-0.42 (-1.37)	-0.44 (-1.45)	-0.43 (-1.37)	-0.45 (-1.45)
Road Density							0.028 (1.35)	0.028 (1.31)	0.028 (1.33)	0.028 (1.28)
Illiterate Rate								-1.36 (-0.80)		-1.41 (-0.82)
Productivity									-0.00011 (-0.39)	-0.00012 (-0.39)
Constant	178.40 (3.38)***	-88.59 (-2.87)***	-140.89 (-2.33)**	-288.67 (-2.22)**	-294.20 (-2.34)**	-284.19 (-2.21)**	-323.65 (-2.61)***	-290.67 (-2.30)**	-320.01 (-2.56)**	-285.60 (-2.24)**
R^2	0.0024	0.83	0.83	0.84	0.86	0.86	0.88	0.88	0.88	0.88
Observations	147	147	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.7 Random Effects Estimation Results on FDI/GDP for Log Data with Punish

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish†	-0.083 (-1.21)	-0.070 (-1.05)	-0.070 (-1.04)	-0.066 (-0.98)	-0.066 (-0.97)	-0.061 (-0.92)	-0.058 (-0.87)	-0.056 (-0.83)	-0.053 (-0.80)	-0.050 (-0.76)
GRP per capita		1.50 (6.17)***	1.48 (4.34)***	1.55 (4.38)***	1.38 (2.96)***	1.28 (3.31)***	1.50 (4.10)***	1.52 (3.67)***	1.47 (3.97)***	1.50 (3.59)***
Wage			0.039 (0.05)	5.65 (0.90)	5.60 (0.90)	7.43 (1.13)	7.99 (1.27)	8.15 (1.28)	7.17 (1.13)	7.37 (1.14)
Wage^2				-0.33 (-0.92)	-0.32 (-0.91)	-0.46 (-1.18)	-0.52 (-1.40)	-0.52 (-1.41)	-0.47 (-1.26)	-0.48 (-1.27)
GIP					0.12 (0.54)	-0.16 (-0.95)	-0.16 (-1.16)	-0.16 (-1.14)	-0.16 (-1.11)	-0.16 (-1.10)
Pop. Density						0.46 (2.74)***	0.29 (1.18)	0.29 (1.17)	0.28 (1.16)	0.28 (1.15)
Rail Density							-0.32 (-2.66)***	-0.31 (-2.51)**	-0.32 (-2.61)***	-0.31 (-2.44)**
Road Density							0.52 (2.18)**	0.51 (2.17)**	0.53 (2.29)**	0.53 (2.28)**
Illiterate Rate								0.063 (0.23)		0.074 (0.28)
Productivity									0.14 (0.61)	0.14 (0.63)
Constant	5.54 (12.57)***	-6.70 (-3.20)***	-6.92 (-1.31)	-31.05 (-1.12)	-30.57 (-1.12)	-36.71 (-1.28)	-40.65 (-1.49)	-41.69 (-1.50)	-38.39 (-1.40)	-39.70 (-1.41)
R^2	0.023	0.49	0.49	0.49	0.50	0.65	0.72	0.72	0.72	0.72
Observations	147	147	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.8 Random Effects Estimation Results on FDI/POP for Log Data with Punish

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Punish†	-0.083 (-1.17)	-0.071 (-1.06)	-0.071 (-1.05)	-0.066 (-0.97)	-0.065 (-0.96)	-0.061 (-0.91)	-0.058 (-0.86)	-0.055 (-0.82)	-0.051 (-0.79)	-0.048 (-0.73)
GRP per capita		2.42 (9.78)***	2.44 (7.12)***	2.53 (7.20)***	2.32 (5.07)***	2.24 (5.86)***	2.45 (6.74)***	2.48 (5.99)***	2.42 (6.58)***	2.45 (5.91)***
Wage			-0.035 (-0.04)	7.91 (1.30)	7.85 (1.30)	9.67 (1.51)	10.26 (1.68)*	10.42 (1.69)*	9.34 (1.52)	9.54 (1.52)
Wage^2				-0.47 (-1.34)	-0.46 (-1.33)	-0.59 (-1.59)	-0.65 (-1.82)*	-0.66 (-1.83)*	-0.60 (-1.66)*	-0.61 (-1.66)
GIP					0.15 (0.66)	-0.13 (-0.77)	-0.13 (-0.91)	-0.13 (-0.89)	-0.13 (-0.87)	-0.12 (-0.84)
Pop. Density						0.44 (2.61)***	0.27 (1.06)	0.27 (1.05)	0.26 (1.04)	0.25 (1.03)
Rail Density							-0.30 (-2.49)**	-0.29 (-2.33)**	-0.30 (-2.43)**	-0.29 (-2.26)**
Road Density							0.51 (2.16)**	0.51 (2.14)**	0.53 (2.27)**	0.53 (2.26)**
Illiterate Rate								0.065 (0.24)		0.078 (0.30)
Productivity									0.15 (0.69)	0.16 (0.71)
Constant	4.52 (9.20)***	-15.25 (-7.14)***	-15.07 (-2.83)***	-49.21 (-1.83)*	-48.65 (-1.83)*	-54.81 (-1.97)**	-58.92 (-2.22)**	-59.98 (-2.23)**	-56.39 (-2.12)**	-57.74 (-2.12)**
R^2	0.019	0.72	0.72	0.73	0.73	0.81	0.84	0.84	0.84	0.84
Observations	147	147	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.9 Random Effects Estimation Results on FDI/GDP for Level Data with Charge

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge	0.011 (1.19)	-0.0076 (-0.63)	-0.0078 (-0.63)	0.0095 (0.63)	0.0088 (0.60)	0.0081 (0.54)	0.0070 (0.56)	0.0078 (0.60)	0.0072 (0.57)	0.0080 (0.61)
GRP per capita		0.036 (2.99)***	0.031 (2.02)**	0.034 (1.92)*	0.027 (1.39)	0.026 (1.34)	0.058 (2.30)**	0.054 (2.10)**	0.058 (2.27)**	0.055 (2.09)**
Wage			0.015 (0.40)	0.20 (2.71)***	0.21 (2.76)***	0.20 (2.67)***	0.22 (3.25)***	0.22 (3.31)***	0.22 (3.26)***	0.22 (3.31)***
Wage^2				-0.000013 (-2.48)**	-0.000013 (-2.42)**	-0.000013 (-2.38)**	-0.000018 (-3.13)***	-0.000017 (-3.07)***	-0.000018 (-3.13)***	-0.000017 (-3.07)***
GIP					0.025 (0.95)	0.026 (0.98)	0.0079 (0.34)	0.0064 (0.27)	0.0075 (0.32)	0.0060 (0.25)
Pop. Density						0.013 (0.11)	-0.084 (-0.65)	-0.080 (-0.62)	-0.081 (-0.62)	-0.078 (-0.60)
Rail Density							-0.86 (-1.96)**	-0.91 (-2.12)**	-0.87 (-1.96)**	-0.91 (-2.12)**
Road Density							0.054 (1.82)*	0.052 (1.76)*	0.054 (1.79)*	0.052 (1.73)*
Illiterate Rate								-4.55 (-1.71)*		-4.57 (-1.70)*
Productivity									-0.000067 (-0.16)	-0.000096 (-0.21)
Constant	250.55 (3.40)***	181.90 (3.26)***	150.03 (1.69)*	-439.78 (-2.12)**	-446.35 (-2.19)**	-441.15 (-2.10)**	-535.81 (-2.86)***	-438.58 (-2.37)**	-534.84 (-2.80)***	-436.22 (-2.32)**
R^2	0.077	0.43	0.44	0.49	0.54	0.54	0.67	0.67	0.66	0.67
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.10 Random Effects Estimation Results on FDI/POP for Level Data with Charge

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge	0.033 (2.39)**	0.00033 (0.03)	-0.00024 (-0.02)	0.0059 (0.55)	0.0052 (0.51)	0.00054 (0.05)	0.0023 (0.23)	0.0027 (0.26)	0.0024 (0.24)	0.0028 (0.27)
GRP per capita		0.066 (6.71)***	0.059 (5.66)***	0.058 (5.44)***	0.052 (4.22)***	0.040 (3.47)***	0.053 (3.24)***	0.052 (3.04)***	0.053 (3.23)***	0.052 (3.03)***
Wage			0.022 (1.05)	0.084 (1.74)*	0.083 (1.77)*	0.077 (1.63)	0.084 (1.87)*	0.082 (1.86)*	0.084 (1.88)*	0.083 (1.87)*
$Wage^2$				-4.48e-06 (-1.23)	-4.14e-06 (-1.11)	-3.18e-06 (-0.84)	-5.24e-06 (-1.40)	-5.04e-06 (-1.36)	-5.27e-06 (-1.41)	-5.06e-06 (-1.36)
GIP					0.024 (1.36)	0.024 (1.45)	0.013 (0.77)	0.013 (0.74)	0.013 (0.75)	0.013 (0.72)
Pop. Density						0.11 (1.31)	0.065 (0.70)	0.067 (0.71)	0.065 (0.69)	0.067 (0.71)
Rail Density							-0.41 (-1.37)	-0.43 (-1.45)	-0.41 (-1.36)	-0.43 (-1.44)
Road Density							0.028 (1.41)	0.028 (1.36)	0.028 (1.40)	0.027 (1.35)
Illiterate Rate								-1.38 (-0.80)		-1.40 (-0.82)
Productivity									-0.00013 (-0.45)	-0.00013 (-0.43)
Constant	40.41 (0.56)	-88.68 (-2.29)**	-139.11 (-2.31)**	-324.09 (-2.63)***	-325.69 (-2.73)***	-292.26 (-2.39)**	-339.11 (-2.86)***	-309.37 (-2.65)***	-336.96 (-2.81)***	-306.40 (-2.60)***
R^2	0.36	0.83	0.83	0.84	0.86	0.86	0.88	0.88	0.88	0.88
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.11 Random Effects Estimation Results on FDI/GDP for Log Data with Charge

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge†	0.020 (0.10)	-0.16 (-0.93)	-0.17 (-0.94)	-0.13 (-0.71)	-0.16 (-0.80)	-0.28 (-1.50)	-0.24 (-1.23)	-0.24 (-1.23)	-0.25 (-1.25)	-0.25 (-1.26)
GRP per capita		1.58 (6.28)***	1.53 (4.53)***	1.58 (4.54)***	1.37 (3.04)***	1.25 (3.51)***	1.48 (4.18)***	1.52 (3.76)***	1.45 (4.06)***	1.49 (3.68)***
Wage			0.14 (0.18)	5.09 (0.83)	4.84 (0.80)	5.98 (0.93)	6.40 (1.03)	6.65 (1.06)	5.29 (0.84)	5.56 (0.86)
Wage^2				-0.29 (-0.83)	-0.27 (-0.78)	-0.36 (-0.95)	-0.41 (-1.13)	-0.43 (-1.15)	-0.35 (-0.93)	-0.37 (-0.96)
GIP					0.15 (0.64)	-0.14 (-0.88)	-0.16 (-1.10)	-0.15 (-1.07)	-0.15 (-1.04)	-0.15 (-1.02)
Pop. Density						0.50 (3.15)***	0.36 (1.45)	0.36 (1.43)	0.36 (1.44)	0.35 (1.43)
Rail Density							-0.33 (-2.83)***	-0.31 (-2.61)***	-0.33 (-2.78)***	-0.31 (-2.54)**
Road Density							0.47 (1.98)**	0.47 (1.97)**	0.49 (2.09)**	0.49 (2.08)**
Illiterate Rate								0.097 (0.38)		0.11 (0.42)
Productivity									0.16 (0.76)	0.17 (0.77)
Constant	4.93 (2.75)***	-6.37 (-3.03)***	-7.14 (-1.41)	-28.53 (-1.05)	-27.05 (-1.02)	-29.17 (-1.04)	-32.82 (-1.21)	-34.45 (-1.25)	-29.46 (-1.07)	-31.22 (-1.11)
R^2	0.011	0.49	0.48	0.49	0.50	0.68	0.73	0.73	0.73	0.73
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.12 Random Effects Estimation Results on FDI/POP for Log Data with Charge

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Charge†	0.031 (0.13)	-0.18 (-1.00)	-0.18 (-0.99)	-0.13 (-0.67)	-0.16 (-0.79)	-0.28 (-1.46)	-0.24 (-1.19)	-0.24 (-1.19)	-0.25 (-1.21)	-0.25 (-1.22)
GRP per capita		2.51 (9.83)***	2.49 (7.36)***	2.56 (7.39)***	2.31 (5.22)***	2.22 (6.26)***	2.43 (6.91)***	2.47 (6.14)***	2.39 (6.76)***	2.44 (6.08)***
Wage			0.074 (0.09)	7.34 (1.23)	7.05 (1.21)	8.15 (1.32)	8.64 (1.43)	8.90 (1.46)	7.42 (1.21)	7.69 (1.23)
Wage^2				-0.43 (-1.25)	-0.41 (-1.20)	-0.49 (-1.36)	-0.55 (-1.54)	-0.56 (-1.57)	-0.48 (-1.31)	-0.49 (-1.33)
GIP					0.1 (0.75)	-0.11 (-0.69)	-0.12 (-0.85)	-0.12 (-0.82)	-0.12 (-0.80)	-0.11 (-0.77)
Pop. Density						0.48 (3.01)***	0.34 (1.33)	0.34 (1.32)	0.33 (1.32)	0.33 (1.30)
Rail Density							-0.31 (-2.65)***	-0.29 (-2.43)**	-0.31 (-2.60)***	-0.29 (-2.36)**
Road Density							0.47 (1.94)*	0.46 (1.93)*	0.49 (2.05)**	0.48 (2.04)**
Illiterate Rate								0.10 (0.39)		0.11 (0.44)
Productivity									0.18 (0.84)	0.19 (0.85)
Constant	3.83 (1.87)*	-14.86 (-7.00)***	-15.26 (-2.99)***	-46.68 (-1.76)*	-44.94 (-1.75)*	-47.22 (-1.74)*	-50.98 (-1.93)*	-52.66 (-1.96)**	-47.26 (-1.76)*	-49.09 (-1.79)*
R^2	0.011	0.72	0.72	0.72	0.73	0.82	0.85	0.85	0.85	0.85
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.13 Random Effects Estimation Results on FDI/GDP for Level Data with EI2

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2	-0.34 (-1.76)*	-0.31 (-1.50)	-0.30 (-1.49)	-0.35 (-1.80)*	-0.34 (-1.81)*	-0.34 (-1.81)*	-0.26 (-1.24)	-0.25 (-1.20)	-0.27 (-1.23)	-0.26 (-1.21)
GRP per capita		0.030 (4.06)***	0.027 (1.96)**	0.040 (2.43)**	0.033 (1.71)*	0.030 (1.64)*	0.060 (2.46)**	0.057 (2.27)**	0.060 (2.44)**	0.058 (2.27)**
Wage			0.0072 (0.20)	0.19 (2.64)***	0.19 (2.72)***	0.19 (2.66)***	0.21 (3.33)***	0.20 (3.36)***	0.21 (3.33)***	0.20 (3.35)***
Wage^2				-0.000013 (-2.60)***	-0.000013 (-2.56)**	-0.000012 (-2.52)**	-0.000017 (-3.33)***	-0.000016 (-3.21)***	-0.000017 (-3.32)***	-0.000016 (-3.20)***
GIP					0.026 (1.00)	0.025 (0.96)	0.0083 (0.35)	0.0067 (0.27)	0.0075 (0.31)	0.0058 (0.24)
Pop. Density						0.023 (0.19)	-0.068 (-0.51)	-0.061 (-0.46)	-0.066 (-0.49)	-0.059 (-0.44)
Rail Density							-0.84 (-1.89)*	-0.89 (-2.05)**	-0.85 (-1.88)*	-0.90 (-2.04)**
Road Density							0.052 (1.73)*	0.051 (1.67)*	0.052 (1.70)*	0.050 (1.63)
Illiterate Rate								-4.32 (-1.64)		-4.36 (-1.61)
Productivity									-0.00021 (-0.46)	-0.00023 (-0.51)
Constant	320.09 (4.97)***	198.44 (3.26)***	183.26 (1.92)*	-354.97 (1.94)*	-366.78 (-2.06)**	-361.95 (-1.98)**	-464.45 (-2.80)***	-367.22 (-2.12)**	-458.92 (-2.69)***	-360.04 (-2.03)**
R^2	0.0095	0.41	0.41	0.51	0.57	0.56	0.67	0.67	0.67	0.67
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.14 Random Effects Estimation Results on FDI/POP for Level Data with EI2

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2	-0.33	-0.26	-0.25	-0.27	-0.26	-0.25	-0.20	-0.20	-0.21	-0.21
	(-2.16)**	(-1.84)*	(-1.77)*	(-1.92)*	(-2.08)**	(-2.01)**	(-1.41)	(-1.41)	(-1.47)	(-1.46)
GRP per capita		0.066	0.060	0.062	0.055	0.043	0.055	0.054	0.055	0.054
		(9.32)***	(6.85)***	(6.59)***	(4.77)***	(3.73)***	(3.39)***	(3.21)***	(3.40)***	(3.22)***
Wage			0.018	0.073	0.074	0.073	0.078	0.076	0.078	0.076
			(0.85)	(1.45)	(1.52)	(1.51)	(1.70)*	(1.67)*	(1.70)*	(1.67)*
Wage^2				-3.97e-06	-3.74e-06	-3.28e-06	-4.97e-06	-4.73e-06	-5.02e-06	-4.77e-06
				(-1.06)	(-0.99)	(-0.87)	(-1.35)	(-1.28)	(-1.35)	(-1.29)
GIP					0.024	0.024	0.014	0.013	0.013	0.013
					(1.39)	(1.44)	(0.78)	(0.74)	(0.74)	(0.71)
Pop. Density						0.10	0.070	0.074	0.071	0.074
						(1.36)	(0.78)	(0.80)	(0.78)	(0.81)
Rail Density							-0.40	-0.42	-0.39	-0.41
							(-1.29)	(-1.37)	(-1.27)	(-1.35)
Road Density							0.027	0.026	0.026	0.026
							(1.31)	(1.27)	(1.29)	(1.24)
Illiterate Rate								-1.29		-1.33
								(-0.80)		(-0.81)
Productivity									-0.00024	-0.00024
									(-0.86)	(-0.82)
Constant	202.72	-68.55	-110.15	-265.76	-273.23	-265.88	-303.33	-272.94	-297.37	-265.72
	(3.58)***	(-1.96)**	(-1.76)*	(-2.06)**	(-2.20)**	(-2.11)**	(-2.44)**	(-2.14)**	(-2.38)**	(-2.06)**
R^2	0.0057	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.88	0.88
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.15 Random Effects Estimation Results on FDI/GDP for Log Data with EI2

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2†	-0.062 (-0.65)	-0.063 (-0.67)	-0.063 (-0.64)	-0.075 (-0.75)	-0.082 (-0.87)	-0.10 (-1.14)	-0.070 (-0.80)	-0.069 (-0.79)	-0.067 (-0.75)	-0.065 (-0.74)
GRP per capita		1.51 (6.49)***	1.50 (4.50)***	1.59 (4.59)***	1.38 (3.10)***	1.28 (3.49)***	1.47 (4.19)***	1.51 (3.70)***	1.45 (4.05)***	1.49 (3.61)***
Wage			0.016 (0.02)	6.79 (1.16)	6.82 (1.17)	8.96 (1.43)	8.97 (1.50)	9.16 (1.51)	8.032 (1.31)	8.23 (1.31)
Wage^2				-0.40 (-1.19)	-0.40 (-1.19)	-0.55 (-1.50)	-0.57 (-1.62)	-0.58 (-1.62)	-0.52 (-1.43)	-0.53 (-1.43)
GIP					0.14 (0.68)	-0.14 (-0.89)	-0.15 (-1.06)	-0.14 (-1.04)	-0.14 (-1.02)	-0.14 (-1.00)
Pop. Density						0.46 (2.83)***	0.29 (1.16)	0.29 (1.15)	0.28 (1.15)	0.28 (1.14)
Rail Density							-0.29 (-2.44)**	-0.28 (-2.23)**	-0.29 (-2.40)**	-0.28 (-2.18)**
Road Density							0.51 (2.22)**	0.50 (2.21)**	0.53 (2.32)**	0.52 (2.31)**
Illiterate Rate								0.085 (0.32)		0.094 (0.36)
Productivity									0.14 (0.62)	0.15 (0.64)
Constant	5.36 (9.82)***	-6.92 (-3.27)***	-7.01 (-1.25)	-36.01 (-1.40)	-35.78 (-1.40)	-43.13 (-1.58)	-44.97 (-1.73)*	-46.26 (-1.74)*	-42.23 (-1.61)	-43.65 (-1.61)
R^2	0.0069	0.49	0.49	0.50	0.51	0.67	0.72	0.72	0.72	0.72
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.16 Random Effects Estimation Results on FDI/POP for Log Data with EI2

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI2†	-0.063 (-0.65)	-0.059 (-0.62)	-0.059 (-0.60)	-0.075 (-0.76)	-0.084 (-0.89)	-0.10 (-1.16)	-0.074 (-0.84)	-0.072 (-0.82)	-0.070 (-0.79)	-0.068 (-0.77)
GRP per capita		2.44 (10.20)***	2.46 (7.31)***	2.57 (7.46)***	2.33 (5.30)***	2.25 (6.15)***	2.42 (6.90)***	2.46 (6.03)***	2.39 (6.72)***	2.43 (5.94)***
Wage			-0.055 (-0.06)	9.02 (1.59)	9.06 (1.62)	11.16 (1.86)*	11.22 (1.95)*	11.41 (1.95)*	10.17 (1.72)*	10.38 (1.71)*
$Wage^2$				-0.54 (-1.64)	-0.54 (-1.65)*	-0.68 (-1.94)*	-0.71 (-2.08)**	-0.72 (-2.08)**	-0.65 (-1.85)*	-0.66 (-1.83)*
GIP					0.17 (0.80)	-0.11 (-0.70)	-0.11 (-0.80)	-0.11 (-0.78)	-0.11 (-0.76)	-0.10 (-0.73)
Pop. Density						0.45 (2.69)***	0.26 (1.05)	0.26 (1.04)	0.25 (1.03)	0.25 (1.02)
Rail Density							-0.27 (-2.25)**	-0.26 (-2.03)**	-0.27 (-2.19)**	-0.26 (-1.98)**
Road Density							0.50 (2.17)**	0.50 (2.16)**	0.52 (2.28)**	0.52 (2.27)**
Illiterate Rate								0.088 (0.33)		0.098 (0.37)
Productivity									0.16 (0.70)	0.17 (0.72)
Constant	4.34 (7.22)***	-15.50 (-7.18)***	-15.20 (-2.69)***	-54.06 (-2.17)**	-53.82 (-2.19)**	-61.12 (-2.34)**	-63.12 (-2.52)**	-64.46 (-2.53)**	-60.06 (-2.37)**	-61.54 (-2.35)**
R^2	0.0012	0.72	0.72	0.73	0.74	0.82	0.85	0.85	0.85	0.85
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.17 Random Effects Estimation Results on FDI/GDP for Level Data with EI3

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3	-0.45	-0.40	-0.39	-0.52	-0.50	-0.49	-0.38	-0.37	-0.39	-0.39
	(-1.54)	(-1.26)	(-1.25)	(-1.73)*	(-1.73)*	(-1.72)*	(-1.26)	(-1.24)	(-1.25)	(-1.25)
GRP per capita		0.030	0.027	0.040	0.032	0.029	0.060	0.057	0.060	0.057
		(4.09)***	(1.96)**	(2.41)**	(1.67)*	(1.58)	(2.41)**	(2.24)**	(2.39)**	(2.23)**
Wage			0.0083	0.19	0.19	0.19	0.21	0.20	0.21	0.20
			(0.23)	(2.64)***	(2.70)***	(2.63)***	(3.31)***	(3.34)***	(3.31)***	(3.33)***
$Wage^2$				-0.000013	-0.000013	-0.000012	-0.000017	-0.000016	-0.000017	-0.000016
				(-2.59)***	(-2.54)**	(-2.49)**	(-3.31)***	(-3.19)***	(-3.29)***	(-3.18)***
GIP					0.025	0.025	0.0076	0.0061	0.0068	0.0053
					(0.95)	(0.92)	(0.32)	(0.25)	(0.28)	(0.22)
Pop. Density						0.025	-0.066	-0.061	-0.063	-0.059
						(0.21)	(-0.50)	(-0.45)	(-0.47)	(-0.43)
Rail Density							-0.85	-0.90	-0.86	-0.90
							(-1.90)*	(-2.05)**	(-1.89)*	(-2.04)**
Road Density							0.052	0.050	0.051	0.050
							(1.72)*	(1.66)*	(1.68)*	(1.62)
Illiterate Rate								-4.41		-4.45
								(-1.65)*		(-1.63)
Productivity									-0.00019	-0.00021
									(-0.41)	(0.47)
Constant	314.98	191.56	174.02	-359.16	-368.17	-363.08	-465.89	-366.31	-460.83	-359.50
	(5.07)***	(3.21)***	(1.84)*	(-1.95)*	(-2.04)**	(-1.97)**	(-2.78)***	(-2.09)**	(-2.67)***	(-2.01)**
R^2	0.028	0.42	0.42	0.51	0.57	0.57	0.67	0.67	0.67	0.67
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.18 Random Effects Estimation Results on FDI/POP for Level Data with EI3

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3	-0.43	-0.30	-0.27	-0.31	-0.29	-0.25	-0.18	-0.17	-0.19	-0.19
	(-1.78)*	(-1.32)	(-1.25)	(-1.44)	(-1.44)	(-1.30)	(-0.83)	(-0.83)	(-0.89)	(-0.89)
GRP per capita		0.066	0.059	0.062	0.055	0.042	0.054	0.053	0.054	0.054
		(9.28)***	(6.79)***	(6.59)***	(4.68)***	(3.55)***	(3.32)***	(3.13)***	(3.31)***	(3.13)***
Wage			0.020	0.074	0.074	0.074	0.078	0.076	0.079	0.077
			(0.95)	(1.47)	(1.50)	(1.49)	(1.71)*	(1.68)*	(1.70)*	(1.67)*
$Wage^2$				-3.93e-06	-3.64e-06	-3.15e-06	-4.93e-06	-4.68e-06	-4.96e-06	-4.70e-06
				(-1.05)	(-0.96)	(-0.83)	(-1.33)	(-1.27)	(-1.33)	(-1.27)
GIP					0.023	0.024	0.013	0.013	0.013	0.013
					(1.35)	(1.40)	(0.76)	(0.73)	(0.73)	(0.69)
Pop. Density						0.11	0.072	0.075	0.073	0.076
						(1.37)	(0.79)	(0.81)	(0.79)	(0.82)
Rail Density							-0.41	-0.43	-0.41	-0.43
							(-1.32)	(-1.39)	(-1.30)	(-1.38)
Road Density							0.027	0.027	0.027	0.026
							(1.32)	(1.28)	(1.30)	(1.26)
Illiterate Rate								-1.37		-1.41
								(-0.82)		(-0.84)
Productivity									-0.00019	-0.00019
									(-0.66)	(-0.63)
Constant	197.17	-74.24	-120.01	-272.53	-278.59	-270.87	-311.00	-278.60	-305.80	-272.39
	(3.58)***	(2.15)**	(1.97)**	(2.11)**	(2.22)**	(2.12)**	(2.49)**	(2.17)**	(2.43)**	(2.10)**
R^2	0.019	0.83	0.84	0.85	0.86	0.86	0.88	0.88	0.88	0.88
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.19 Random Effects Estimation Results on FDI/GDP for Log Data with EI3

FDI/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3†	-0.069 (-0.70)	-0.062 (-0.65)	-0.062 (-0.63)	-0.082 (-0.80)	-0.086 (-0.88)	-0.10 (-1.10)	-0.070 (-0.76)	-0.067 (-0.74)	-0.066 (-0.72)	-0.064 (-0.70)
GRP per capita		1.50 (6.45)***	1.49 (4.60)***	1.58 (4.70)***	1.38 (3.14)***	1.28 (3.49)***	1.47 (4.20)***	1.50 (3.71)***	1.44 (4.06)***	1.48 (3.62)***
Wage			0.014 (0.02)	7.30 (1.22)	7.31 (1.23)	9.43 (1.48)	9.29 (1.53)	9.45 (1.53)	8.32 (1.33)	8.50 (1.33)
Wage^2				-0.43 (-1.24)	-0.43 (-1.23)	-0.57 (-1.54)	-0.59 (-1.64)*	-0.60 (-1.64)	-0.53 (-1.44)	-0.55 (-1.43)
GIP					0.14 (0.65)	-0.15 (-0.94)	-0.15 (-1.09)	-0.15 (-1.07)	-0.15 (-1.04)	-0.14 (-1.02)
Pop. Density						0.46 (2.78)***	0.28 (1.12)	0.28 (1.11)	0.27 (1.10)	0.27 (1.09)
Rail Density							-0.29 (-2.37)**	-0.28 (-2.16)**	-0.29 (-2.32)**	-0.27 (-2.12)**
Road Density							0.51 (2.24)**	0.51 (2.22)**	0.53 (2.34)**	0.52 (2.33)**
Illiterate Rate								0.081 (0.31)		0.091 (0.35)
Productivity									0.15 (0.63)	0.15 (0.65)
Constant	5.35 (10.73)***	-6.85 (-3.25)***	-6.93 (-1.27)	-38.07 (-1.46)	-37.81 (-1.46)	-45.15 (-1.64)	-46.32 (-1.77)*	-47.50 (-1.77)*	-43.49 (-1.63)	-44.80 (-1.62)
R^2	0.021	0.49	0.49	0.50	0.52	0.67	0.72	0.72	0.72	0.72
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; **†** all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A2.5.20 Random Effects Estimation Results on FDI/POP for Log Data with EI3

FDI/POP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EI3†	-0.065 (-0.65)	-0.056 (-0.58)	-0.056 (-0.57)	-0.082 (-0.81)	-0.087 (-0.89)	-0.10 (-1.11)	-0.073 (-0.79)	-0.071 (-0.78)	-0.070 (-0.75)	-0.067 (-0.73)
GRP per capita		2.43 (10.17)***	2.44 (7.51)***	2.56 (7.65)***	2.32 (5.37)***	2.25 (6.15)***	2.42 (6.92)***	2.45 (6.06)***	2.39 (6.74)***	2.43 (5.96)***
Wage			-0.058 (-0.07)	9.54 (1.65)*	9.56 (1.67)*	11.64 (1.90)*	11.55 (1.97)**	11.72 (1.97)**	10.48 (1.73)*	10.66 (1.72)*
$Wage^2$				-0.57 (-1.69)*	-0.57 (-1.69)*	-0.71 (-1.97)**	-0.72 (-2.09)**	-0.74 (-2.08)**	-0.66 (-1.85)*	-0.68 (-1.83)*
GIP					0.16 (0.77)	-0.12 (-0.74)	-0.12 (-0.83)	-0.11 (-0.80)	-0.11 (-0.78)	-0.11 (-0.76)
Pop. Density						0.44 (2.65)***	0.25 (1.01)	0.25 (1.00)	0.24 (0.99)	0.24 (0.98)
Rail Density							-0.26 (-2.17)**	-0.25 (-1.96)**	-0.26 (-2.12)**	-0.25 (-1.91)*
Road Density							0.50 (2.19)**	0.50 (2.17)**	0.52 (2.30)**	0.52 (2.29)**
Illiterate Rate								0.084 (0.32)		0.095 (0.36)
Productivity									0.16 (0.71)	0.17 (0.72)
Constant	4.31 (7.74)***	-15.45 (-7.19)***	-15.14 (-2.74)***	-56.15 (-2.22)**	-55.88 (-2.24)**	-63.15 (-2.38)**	-64.56 (-2.55)**	-65.77 (-2.54)**	-61.40 (-2.38)**	-62.75 (-2.35)**
R^2	0.011	0.72	0.72	0.73	0.74	0.82	0.85	0.85	0.85	0.85
Observations	149	149	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

CHAPTER THREE

ENVIRONMENTAL REGULATIONS, CORRUPTION, GOVERNMENT EFFICIENCY AND FDI LOCATION IN CHINA: A PROVINCE-LEVEL ANALYSIS

3.1 Introduction

In Chapter two, we investigate whether there is an intra-country pollution haven effect in China using provincial data from 1999 to 2003. We employed three measures of environmental regulations and find that, *ceteris paribus*, FDI is attracted by relatively weak environmental standards, that is, a pollution haven effect exists within China.

The traditional determinants of FDI are all included, such as income level, labour costs, labour quality, infrastructure, and agglomeration effect. We find that income, labour cost, road density, and education level are important to foreign investors when making the location choice decision.

Corruption level and government quality may also play important roles in attracting the FDI inflows in China. These government characteristics are usually omitted in the majority of previous FDI literature, especially in intra-country FDI location choice studies, due to the unavailability of data. Therefore, in chapter two we treat these government characteristics as unobservable and use panel data estimation methods to control for the unobserved heterogeneities. Due to the lack of data, we construct two indices to measure the government effort in fighting against corruption and government quality using complicated methodologies and comprehensive available data. In this chapter, we extend the model in Chapter two and revisit the intra-country pollution haven hypothesis issue in China by allowing provincial government anti-corruption effort and governance quality to have impacts on FDI inflows.

From the 1990s, the disparity in international investment location leads some studies to examine the structural determinants of FDI inflows. Except the studies that explore the effect of environmental regulations, another line of research examines the impact of corruption on cross-country pattern of FDI, such as Wheeler and Mody (1992), Hines (1995) and Wei (2000). These studies employ cross-country perception based corruption index in FDI location decision models assuming that corruption has a negative effect on FDI into a country. Additionally, some researchers examine the role of governance in foreign capital flows, such as Globerman and Shapiro (2002, 2003) and Globerman *et al.* (2006), suggesting that investment in governance infrastructure helps to attract foreign investment.

A deficiency in empirical studies that examine the effect of environmental regulations is that government corruption and/or governance are rarely modelled. An exception is Smarzynska-Javorcik and Wei (2005), which take into account corruption in a host country as a possible deterrent of FDI when examining the inter-country pollution haven effects in 24 transition economies.

A deficiency in empirical studies focusing on corruption or governance is that most of them examine whether differences in corruption and/or governance across countries have an impact on FDI inflows, but few of them consider the difference in corruption within a country. A recent paper, Kao *et al.* (2005) investigate the relationship between inter-province governance efficiency and FDI in China and find that, after controlling other variables, FDI is attracted to provinces with more effective governments.

Within the existing literature, only Fredriksson *et al.* (2003) investigate the impacts of inter-state environmental regulations and corruption on inbound US FDI. They use the normalised number of convictions of public officials to measure bureaucratic corruption of each state in their empirical model. However, so far no study has considered whether the differences in inter-province environmental regulations, government corruption and/or governance have an impact on FDI location choice in China.

In this chapter, we include the impacts of provincial corruption and governance quality on FDI inflows. The lack of an obvious index of provincial government corruption meant we had to develop our own measure of corruption similar to that of Fredriksson *et al.* (2003). In China, the procuratorates only report the number of registered cases under their direct investigation which could be used to proxy provincial corruption. However, corruption is much more serious in China than in the US so that this measure, to a higher degree, is appropriate to proxy the extent to which provincial governments fight corruption. Therefore, we modify our objective to find out whether there are intra-country pollution havens in China by allowing provincial control for corruption and governance quality to influence FDI inflows.

We use the normalised number of registered cases related to corruption and dereliction of duty under the direct investigation of procuratorates to proxy the provincial control of corruption. Following the methodology in two papers, Tang and Tang (2004a and 2004b), we construct a government efficiency index to measure provincial governance quality.

Following Chapter two, we employ three measures of environmental stringency (*EI1, Punish* and *Charge*) and include all the other control variables to capture the provincial income level, labour costs and quality, infrastructure, agglomeration, and population density, which are known determinants of FDI inflows.

Consistent with the results in Chapter two, we find evidence to support the existence of an intra-country pollution haven effect in China. Additionally, the results suggest the foreign investment prefers to locate into regions where the government has made more effort to fight corruption. The results also indicate that foreign investment is attracted to provinces where the local government is more efficient.

In this chapter, section 3.2 presents the measurements of corruption and the previous literature on corruption/governance and FDI. Section 3.3 describes the corruption problem and anti-corruption performance in China. Section 3.4 provides the methodology and the construction processes of anti-corruption measurement and government efficiency index. Section 3.5 reports our main results and the final section concludes.

3.2 Literature on Corruption and Foreign Direct Investment

Modelling FDI is complicated because so many explanatory variables impact on it. Among these determinants, one factor that has recently attracted more attention by researchers is corruption in the host countries. Wei (2000) argues that the "popular press and policy circles seem to believe that corruption does reduce inward FDI, as suggested by the opening quote from James D. Wolfensohn", ninth president of the World Bank.[34]

> "We need to deal with the cancer of corruption… We can give advice, encouragement, and support to governments that wish to fight corruption – and *it is these governments that, over time, will attract the larger volume of investment*."(Emphasis added).
>
> James D. Wolfensohn[35]

[34] Wei (2000), pp.1.

[35] Wei (2000), pp.1, cited in Transition, 7(9-10), pp. 9, Sep. /Oct., 1996.

However, corruption does not always seem to deter FDI. Some countries, for example, China, Indonesia and Thailand, attract a large amount of FDI in spite of their perceived high levels of corruption and motivate empirical studies focusing on cross-country analysis. Studies in the 1990s have not found a consistent negative correlation between corruption and FDI (e.g. Wheeler and Mody, 1992; Hines, 1995). However, some recent analyses have reported a statistically significant negative impact of corruption on FDI (e.g. Wei, 2000; Smarzynska and Wei, 2000).

This section is organised as follows. It starts with a brief review of the definition of corruption and the measurement of corruption. It then describes the relationship between corruption and governance before laying out the empirical evidence on corruption/governance and FDI and evidence on the pollution haven hypothesis allowing for the impact of corruption on FDI inflows.

3.2.1 What Is Corruption?

Svensson (2005) adopts the common definition that corruption is "the *misuse* of public office for private gains". This is legalistic definition because misuse involves legal norms. Some other authors, however, for example, He (2000), employ the definition that corruption is "the *use* of public power and public resources for private interests". This is a strict definition as it includes all behaviour utilising public power for private benefits.

In this paper, we prefer the former definition, which captures bribes, sale of government property, embezzlement of government funds, abuse of public power, etc.

3.2.2 Measurements of Corruption

Picci (2005) defines three types of corruption assessment: judicial assessment, societal assessment and corruption indices. Since the extent to which corruption crimes are successfully prosecuted by the judiciary depends on many factors, judicial data are rarely used. Social assessment "may follow personal experience, hearsay or the observation of indirect effects of corruption. … Such a social assessment of corruption is facilitated by the presence of a free press, that processes and gives visibility to information that individual citizens would otherwise obtain with difficulty, particularly regarding grand corruption cases."[36] Corruption indices are the summary of some phenomena correlated with corruption, such as public honesty or measures of the quality of governance. Most corruption indices are subjective, being based on the perception of the phenomena. They are created through questionnaires, surveys, interviews, or data analysis.

Kaufmann *et al.* (2006) outline three broad ways to measure corruption:

1) By gathering the informed views of relevant stakeholders. These include surveys of firms, public officials and individuals, and views of outside observers in non-governmental organisations, multilateral donors, and the private sector. These are the only available data currently used for large scale cross-country comparisons and monitoring of corruption over time.
2) By tracking countries' institutional features. This provides information on opportunities and/or incentives for corruption, such as procurement practices and budget transparency. They do not measure actual corruption but indicate the

[36] Picci (2005), pp.3.

possibility of corruption. These are not developed for large scale countries and yet have no time dimension.

3) By careful audits of specific projects. These provide information about malfeasance in specific projects but not about country-wide corruption and tend to be one-off. They are not suitable for cross-country comparison or monitoring over time.

Survey-based corruption indices are therefore well developed and widely used in cross-country analyses. Well known indices include Transparency International's (TI) Corruption Perception Index, The World Bank's Control of Corruption Index, International Country Risk Guide's (ICRG) index of the Political Risk Services Inc., the corruption index in the World Competitiveness Yearbook of the Institute for Management Development (IMD), and the corruption index in the Global Competitiveness Report of the World Economic Forum. The TI and ICRG indices are the most widely applied in cross-country studies of FDI and corruption.

Golden and Picci (2005) discuss the weaknesses of these survey-based measures. The main concern is that the real degree of reliability of the survey information is unknown. For example, respondents involved in corrupt activity may underreport their involvement, while those not involved lack accurate information. TI attempts to solve this problem by aggregating information from multiple surveys, but such aggregation effort may be less successful.[37] There is also a concern that the reliability of a corruption index may deteriorate over time. There is a danger that the survey respondents report what they believe based on the highly publicised results of the most recent corruption index, rather

[37] Golden and Picci (2005) argue that for countries where the information from all surveys are available, the scoring is likely to be more reliable than the countries scored on the basis minimum number of available surveys. It also generates systematic biases in the dataset, making the index more reliable for developed countries than for less developed countries.

than the "real" corruption exists. The measures may well become endogenous to the index itself.

As a result of their concerns, Golden and Picci (2005) develop an objective measure of corruption for Italian regions for the mid-1990s which compared the difference between a measure of the total amount of investment in infrastructure over time and a measure of the physical quantity of public infrastructure, for example, km of roads and railways, the number and size of public buildings, etc. Regions with large differences between these two measures suggest that money has been siphoned off due to mismanagement, fraud, bribes, kickbacks, and embezzlement, and hence are perceived as having a higher corruption level. However, this measurement is based on the assumption that the regional corruption levels are unlikely to demonstrate much year-to-year variation. This is similar to Kaufmann *et al.* (2006) measurement of corruption by audit.

Within the limited intra-country corruption literature, Fridriksson *et al.* (2003) use the number of convictions of public officials per 1000 public employees as a measure of corruption for US states, known as "*judicial assessment*" in Picci (2005).

However, no measure of corruption can be 100% reliable. Kaufmann *et al.* (2006) argue that all efforts to measure corruption using any kind of data (subjective or objective) involve an irreducible element of uncertainty. There is always imprecision in specific measures and specific measures of corruption are imperfectly related to overall corruption.

3.2.3 Governance and Corruption

Corruption cannot be considered in isolation. The quality of government is strongly correlated with levels of corruption. The World Bank states: "bad governance is associated with corruption, distortion of government budgets, in equitable growth, social exclusion, lack of trust in authorities."[38]

Picci (2005) discusses the relationship between corruption, governance efficiency and effectiveness. Picci (2005) argues that corruption may cause inefficiency, because a corrupt official aims to extract a valuable rent, for example, from a project, and hence is interested in keeping this project running for a long period, resulting in the efficiency of the bureaucracy being reduced. This inefficiency may then lead to further corruption. In terms of the relationship between corruption and effectiveness, a corrupt official may be tempted to spend more on public projects which are easier to extract unlawful rents. Examples are "white elephant" projects.

However, Aidt (2003) analyses the existence of a category of corruption – efficient corruption, based on second-best reasoning. The notion is that given the unavoidable distortions created by various government procedures or policies, corruption can promote allocative efficiency by allowing agents to circumvent these procedures or polices. Corruption enhances allocative efficiency through two channels: 1) corruption speeds up bureaucratic procedures and 2) corruption causes competition for government resources which result in more efficient services. However, this argument is based on a number of problematic assumptions and the most fundamental weakness is the assumption that the government failure that corruption attempts to correct is exogenous when such failure in itself is unrelated and may well have been put in place and maintained by the corrupt official in the first place.

[38] World Bank, Corruption and Governance, Available online: - http://lnweb18.worldbank.org/eca/eca.nsf/Sectors/ECSPE/ E9AC26BAE82D37D685256A940073F4E9?OpenDocument [Accessed 15/August/2006].

Previous research (Globerman and Shapiro, 2002, and Globerman *et al.*, 2006) suggests "good" governance is characterised by economic freedom, secure property rights, a minimum cost of complying with regulations and restrictions on trade, honest government officials, efficient civil services, and a transparent legal system. Good governance promotes successful performance and hence encourages FDI by increasing the scope for profitable business activities (Globerman *et al.*, 2006).

The measures of governance vary across study but the typical measure is risk rankings provided by some international organisations. Some studies directly use corruption as the measure of governance. In Globerman and Shapiro (2002) and Globerman *et al.* (2006) a broad composite index is employed which includes measures of political instability, rule of law, graft, regulatory burden, voice and political freedom, and government effectiveness. This governance index is developed by Kaufmann *et al.* (1999a and 1999b) and recently updated by Kaufmann *et al.* (2003). Governance is therefore a broader measure of corruption than that employed in most empirical studies.

3.2.4 Empirical Evidence

3.2.4.1 Empirical Evidence on Corruption and FDI

There are many papers analysing the consequences and causes of corruption, but only a few of them look at the relationship between FDI and corruption. Wheeler and Mody (1992), Hines (1995), Wei (2000), Smarzynska and Wei (2000), and Habib and Zurawicki (2002) are the only papers we are aware of that examine the effects of corruption on FDI. These studies have failed to find a consistently negative relationship between corruption and FDI.

Wheeler and Mody (1992) develop and estimate a non-linear capital expenditure model for US multinationals. The model includes measures of agglomeration economies and RISK, which is a combined measure of risk extracted from Business International (BI, now a subsidiary of the Economist Intelligence Unit) that includes indicators of political stability, inequality, corruption, red tape, quality of the legal system, cultural compatibility, attitude toward foreign capital, and general expatriate comfort (including the risk of terrorism). They focus on US manufacturing investment and electronics investment in 42 countries in the 1980s and fail to find a significant correlation between the size of FDI and the host country's risk level. The results also suggest that agglomeration economies are the dominant influence on foreign investment and short-run incentives have a limited impact on location choice.

Hines (1995) analyses the US outward investment activities after the passage of Foreign Corrupt Practices Act (FCPA) of 1977, which prohibits American individuals and corporations from bribing foreign government officials. The FCPA may lead US multinational firms to avoid joint ventures in more corrupt countries. Hines (1995) investigates four indicators of US business activities in bribe-prone countries: FDI, capital/labour ratios, joint venture activity, and aircraft exports. The BI index is used to measure the country corruption levels. Controlling for the growth of the host country GDP, the results suggests that corruption negatively affected the growth of US-controlled FDI from 1977 to 1982, as well as other three indicators. However, considering the influence of FCPA on total FDI from US and non-US investors, Hines (1995) fails to find a significantly negative correlation between total inward FDI and the corruption level in the host countries.

Wei (2000) studies whether corruption has a negative effect on FDI and how big this effect is relative to the host countries' tax on foreign corporations. This paper uses a modified Tobit specification to estimate bilateral investment from 12 source countries and 45 host countries. It employs three measures of corruption, the BI index, the ICRG corruption rating and the TI index. It is found that either an increase in the corruption level in a host country or an increase in tax rate will reduce inward foreign investment. An increase in the corruption level from that of Singapore to that of Mexico would have the same effect on inward FDI as raising the tax rate by 18 to 50 per cent point depending on the specification. It is also found that American investors are averse to corruption in host countries, but not necessarily more so than other investors, despite of the FCPA of 1977.

Smarzynska and Wei (2000) is the first paper that uses firm-level data to estimate the impact of corruption in a host country on foreign investors' choice between a joint venture and full ownership. It presents a simple model of foreign investor's choice of entry mode that is affected by the extent of corruption in the host country. On one hand, having a local partner lowers the transaction cost of dealing with the local corrupt officials; on the other hand, sharing ownership may lead to technology leakage. The hypothesis is that conditional on foreign investment taking place, the foreign investor with sophisticated technology prefers a wholly-owned form, but holding the constant technological level, the higher the corruption (up to a limit), the more inclined the foreign investor will to be choose a joint venture. Two corruption indexes are adopted: the TI index and the WDR index (which is based on a survey undertaken in 1996 by the Word Bank in preparation of the Word Development Report 1997). The empirical tests suggest that host country corruption reduces inward FDI and shifts the ownership towards joint ventures. Technologically more advanced firms are found to be less likely to engage in joint ventures. Additionally, US firms are more averse to joint ventures in more corruption countries than others, which may due to the FCPA of 1977.

Habib and Zurawicki (2002) adopted a dual approach to examine the impact of corruption on FDI: the effect of corruption in the host country, and the effect of the absolute difference in corruption levels between the host and home country. This study employs the data of bilateral FDI flows from 7 home countries to 89 host countries for three years (1996-1998). The TI index is used to measure corruption. The empirical results provide support for the negative effects of corruption on FDI for both OLS and Probit model specifications. Foreign investors, as a whole, do not support corruption because it is difficult to manage, risky and costly, and can create operational inefficiencies.

3.2.4.2 Empirical Evidence on Governance and FDI

In terms of the relationship between FDI and governance quality, Globerman and his co-authors contribute greatly to the empirical literature. Their results generally suggest that good governance is particularly important for promoting FDI in developing countries. Globerman and Shapiro (2002) use their own composite index to examine the effects of governance infrastructure on both FDI inflows and outflows for a broad sample of developed and developing countries from 1995 to 1997. They also control for human capital and the environment regulations. The results indicate that governance infrastructure is an important determinant of both FDI inflows and outflows. Investment in governance infrastructure not only attracts capital but also creates the conditions under which domestic MNCs emerge and subsequently invest abroad. Investment in governance infrastructure is however subject to diminishing returns, so that FDI inflows are promoted most successfully for smaller and developing countries. In terms of environmental regulations, environmental protection and remediation encourage inward FDI. The results reject the "race-to-the-bottom" hypotheses and suggest that weakening environmental protection regimes are more likely to discourage FDI.

Globerman and Shapiro (2003) examine the importance of governance for US FDI using the same measure of governance. They adopt a two-stage estimation procedure. The first stage estimates the probability that a country is an FDI recipient and the results suggest that countries that fail to achieve a minimum threshold of effective governance are unlikely to receive any US FDI. The second stage focuses on the countries that receive US FDI inflows and the results indicate that governance infrastructure is an important determinant of the amount received.

Using the similar measure, Globerman *et al.* (2006) examine the role of governance infrastructure in determining inward and outward FDI for twenty emerging and transition economies in Europe between 1995 and 2001. The results again demonstrate that governance is an important determinant for both capital outflows and inflows for all countries.

The empirical studies mentioned above have made a great contribution to the literature about the impact of corruption/governance on FDI, although they have produced mixed results. What these studies have in common is the fact that they rely on perception-based measures of corruption/governance. However, reliable objective indices of corruption/governance are difficult to generate using hard data. Therefore, Kao *et al.* (2005) alternatively use objective data to construct a governance efficiency index based on the definitions of governance efficiency by IMD and the methodology in Tang and Tang

(2004b).[39] Kao *et al.* (2005) is the first paper to investigate the relationship between governance efficiency and FDI in China using a panel data for Chinese provinces from 2000 to 2004. They assume that the fewer bureaucratic practices of government officials, the more effective of the government. They find that more effective governments attract more FDI. In addition, other variables such as wage, infrastructure, level of free trade, income, etc. are also important determinants of FDI for Chinese provinces.

3.2.4.3 Empirical Evidence on Pollution Haven Hypothesis Including Corruption

One deficiency in the abovementioned studies is that the stringency of environmental regulations is rarely modelled, or equivalently, corruption is rarely modelled in the studies focusing on the pollution haven hypothesis issue. Smarzynska-Javorcik and Wei (2005), which is also mentioned in Chapter two, do include corruption as a possible deterrent to FDI in a pollution haven hypothesis model. They find that local corruption deters FDI and with this improvement they find some support for the pollution haven hypothesis but the overall evidence of pollution havens is relatively weak and not robust to sensitivity checks.

Few of the previous studies consider cross-state/province analysis. Fredriksson *et al.* (2003) address these two shortages by estimating the impacts of state-level bureaucratic corruption and environmental policy on inbound US FDI. They develop a theoretical model presuming that corruption affects FDI via two channels: the impact on the supply of public goods and the effect on environmental stringency. They use state-level panel data for four industry sectors from 1977 to 1987. The results suggest that environmental policy and corruption are both important for the spatial allocation of inbound US FDI, and the estimated effect of environmental policy is quite sensitive to the exogeneity assumption.

[39] The construction of the government efficiency variable is discussed later in Section 4.

Fredriksson *et al.* (2003) motivates us to re-examine the intra-country pollution haven effect in China controlling for the impact of provincial corruption and governance quality on FDI inflows.

3.3 Corruption, Anti-corruption and FDI in China

Corruption has been a significant social and political problem in China since 1978 when economic reforms started. It has been a "social pollution", contributing to problems such as environmental degradation, social and political stability, and decreased credibility of government officials. From the early 1990s, the Chinese government began to give priority to anti-corruption work and to enhance anti-corruption efforts. However, corruption remains socially widespread and results in large economic losses (Hu, 2001). Corruption is considered as the second greatest public concern behind unemployment (He, 2000).

This section summarises the four stages of corruption that China has experienced since the early 1980s, including the social and economic background and the characteristics of corruption. Section 3.3.2 describes the types of corruption in China and the corresponding economic losses. The development of anti-corruption activities in China is then expounded. Finally we discuss the relationship between corruption and FDI inflows.

3.3.1 The Extent of Corruption in China

Corruption in China increased gradually in the 1980s, but rose more sharply in the 1990s. After 1998, corruption became relatively stable. The extent of this stabilisation is demonstrated by the corruption perception index (CPI) provided by Transparency

International in Table 3.3.1. The score has decreased since 1980s and reached its lowest level in the mid-1990s. Due to increased anti-corruption effort, there was slight improvement but corruption is still widespread in China.

Table 3.3.1 Corruption Perception Index for China

Year	Rank	Score*	No. of Survey	No. of Countries Ranked
1980-1985	N/A	5.13	N/A	N/A
1988-1992	N/A	4.73	N/A	N/A
1995	40	2.16	4	41
1996	50	2.43	9	54
1997	41	2.88	6	52
1998	52	3.5	10	85
1999	58	3.4	11	99
2000	63	3.1	11	90
2001	57	3.5	10	91
2002	59	3.5	11	102
2003	66	3.4	13	133
2004	71	3.4	16	146
2005	78	3.2	14	159
2006	70	3.3	9	163

*Note: CPI Score relates to perceptions of the degree of corruption as seen by business people and country analysts and ranges between 10 (highly clean) and 0 (highly corrupt).

Source: Transparency International (http://ww1.transparency.org/ [Accessed 11/June/2006]).

Ni and Wang (2003) examine the changes in the number of corruption cases, the money involved, the number of people involved, and the number of committed officials above division director/county administrator level. They divide the extent of corruption into four stages.

The first stage is 1980-1988. When economic reform began around 1980, the distribution of income between different strata of the population was not significant. Corruption was rare. Along with the economic reform, the economies of coastal regions grew quickly.

However the earnings of government officials remained at a lower level. The income difference caused increasing individual corruption that peaked in 1986 and then decreased due to greater concern about corruption in society and government. The forms of corruption in this period are related to bribes to support smuggling, absorbing foreign investment and importing overseas advanced technology and equipment.

The second stage was after 1989 and was due to the co-existence of dual-track economic systems during the transition period which provided incentives and opportunities for corruption.[40] Some government officials abused their power and engaged in fraudulent buying and selling of resources. Such officials were called "*Guandao*" in Chinese, i.e. official/bureaucratic profiteers. The second peak of corruption was reached in 1989. After the 1989 Tiananmen Square Event, the government strengthened anti-corruption efforts so that corruption was contained.[41] This stage finished in 1992. The money involved in the first and second stages was still relatively small.

The third stage is from 1993 to 1998. In the 1990s economic reform extended to the factor market. Some new forms of corruption appeared in the fields of finance, security, and the transfer of property rights. The money involved in these kinds of corruption increased dramatically. Meanwhile, the loopholes and weakness of regulation and the lack of experience and technology in the anti-corruption agencies dealing with new forms of corruption made this stage the most serious period of corruption in China. Group and gang cases increased including many officials at different administrative levels. These corruption cases directly affected the people's daily life and made a bad impression on the

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[40] A dual-track economy involves the co-existence of central planning with a market mechanism for the allocation of the resources. Local officials play a critical role in coordinating production and exchange.

[41] From 1989, it is the era of the "third generation" political leaders. The new Chinese leaders gave priority to the anti-corruption works and hence corruption was controlled effectively around 1990s.

people. The peak occurred in 1997. After that the government paid more attention to the enforcement of regulations, rather than only investigating the large/key corruption cases.[42] This change led to a sharp decrease in corruption in 1998.

From 1999 corruption entered a fourth stage. In recent years, the growth rate of corruption has been slow. The anti-corruption activities have become more systematic and the regulatory framework has improved. There was a decrease in the total number of corruption cases. The number of large/key cases, involving money and number of officials above division director/county administrator, however, have significantly increased relative to previous stages. It illustrates that corruption involving a great amount of money, and high officials has become a serious problem.

3.3.2 Types of Corruption and the Economic Losses to Corruption

Referring to Hu (2001), the main types of corruption in China are tax evasion; rent-seeking behaviour, involvement in the underground economy, where the management of the goods is legal, but the income is illegal; involvement in the underground economy, where the management of the goods is illegal; and the abuse of public investment and public expenditure.

The economic loss to corruption published by the government is 49.13 billion RMB yuan (about $5.94 billion) from 1983 to 2002. [43] But this amount of money is based on the economic loss that has been investigated. Ni and Wang (2004) predict this investigation rate is only 10%, which means that the real corruption is ten times the amount the

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[42] Large case refers to the case involves a bribery of over 50,000 yuan, or a misappropriation of over 100,000 yuan, or other cases involving 500,000 yuan. Key case refers to a case committed by government officials with a ranking of division director or county administrator.

[43] Exchange rate in this chapter (if not specified) is the middle rate of RMB yuan against US Dollars in 2003: $1= RMB 8.277.

government published. Hence the real economic loss from 1983 to 2002 is 500 billion RMB yuan (about \$60 billion), in average 25 billion RMB yuan (about \$3 billion) a year.

However, this prediction is conservative according to other researchers. Hu (2001) predicts the annual economic loss in the late 1990s is about 987.5 -1257.0 billion RMB yuan (about \$119.3 – 151.9 billion), accounting for 13.2 – 16.8% of GDP. Tax evasion is the largest economic loss to corruption, which accounts for 7.6-9.1% of GDP. Illegal management of public investment monies and public expenditures has been the second largest loss to corruption, accounting for 3.4-4.5% of GDP. Rent-seeking behaviour leads to a loss of about 1.7-2.7% of GDP. Income from the underground economy in illegal goods (e.g. smuggling, drugs, and trafficking) is the fourth largest loss to corruption, accounting for 0.4-0.5% of GDP.

3.3.3 Anti-Corruption in China

In December 1978, the Communist Party of China (CPC) established the 1st CPC Central Commission for Discipline Inspection, which is in charge of rooting out corruption and malfeasance among CPC cadres. Since 1989 anti-corruption work has been placed high on the agenda of the Chinese government. On 15th August 1989, China's Supreme People's Court and China's Supreme People's Procuratorate (CSPP) together released a Circular, which declared the central government's determination to severely punish corrupt officials.[44] It set off an upsurge in the fight against corruption.

Following the example of the Independent Commission Against Corruption (ICAC) in Hong Kong, People's Procuratorate of Guangdong Province firstly established an

[44] The Circular announced that criminals related to corruption, bribe, fraudulent buying and selling etc. must surrender themselves to the police or judicial department within the fixed time.

anti-corruption bureau in 1989. In 1995 CSPP established an anti-corruption general bureau, and from then on anti-corruption units were established at four levels of the procuratorate throughout the country. Except the general bureau, anti-corruption offices are set up under the provincial people's procuratorates, municipal people's procuratorates, and county people's procuratorates. At present, there are more than 40,000 procurators from various procuratorates in China taking part in the fight against corruption. The anti-corruption offices are in charge of the investigation and preliminary hearing of the cases involving corruption, bribe, misappropriation, unstated sources of large properties, disguised overseas savings deposits, illegal possession of public funds, illegal possession of confiscated properties, etc.

During the first stage of corruption, ideological education was the major method for fighting corruption, which stressed the need to maintain the revolutionary tradition of CPC and maintain sharp vigilance of hedonism (i.e. pleasure-seeking). The corrupt officials were given disciplinary punishment within the Party. From the second stage, in addition to ideological education and disciplinary punishment, corrupt officials would be punished according to law. The people's procurator office, in accordance with laws and relevant facts, could decide arrest and approve the arrest of the suspect(s) of corruption cases that are proposed by the public security departments, state security departments or authority of prisons. Then the people's procurators office institutes proceedings to the people's court against the suspects.

The anti-corruption bureau has made a contribution towards the work of fighting corruption. CSPP reported that from 1998 to 2003, the anti-corruption offices had investigated 203,880 corruption cases involving 225,624 persons (including 13,854 government officials with a ranking of division director or county administrator) and helped to retrieve a great amount of economic loss for about 26.3 billion RMB yuan (about $3.18 billion). About half of these cases (123,295 cases involving 141,413 persons), were taken legal proceedings. In 2004, 43,757 government employees were probed by prosecutors for corruption and dereliction of duty, of which 30,788 were brought to court. About 4.56 billion RMB yuan ($0.55 billion) were retrieved. However, the rate of investigation is still low, according to the predictions of researchers on corruption. Moreover, the punishment/penalty of corruption is light. Hence the risks of engaging in corrupt activities are very low. Anti-corruption work seems to be a long-term fight.

3.3.5 Corruption and FDI

In the past ten years, the procurator's offices have investigated at least 500,000 corruption cases, and 64 per cent of them are related to international trade and foreign enterprises (Takung Pao, 19/09/2006). Bribes to the local officials given by foreign investors tended to increase in recent years. It has destroyed the fair competition in the markets and warped the resources allocation.

Some investors feel that the investment environment in China is different from that of their home country. They know corruption is a widespread social problem and consider that bribery is a "latent rule" in the Chinese economy. They take bribes to win the competition and to avoid some unfavourable regulations and polices.

China is still at the stage of transition to a market economy and the government has power to control the allocation of some resources. Multinational firms, sometimes, cannot gain the opportunity of market entrance just because of their advantages in capital, technology and management. In order to get higher profits, some multinational enterprises would like to pay the costs in giving bribes to the local officials.

Seeking high profits is therefore the intrinsic motivation of foreign investors to give bribes, and the weakness in anti-corruption (anti-bribe) and regulations also provides external condition for bribes.

However, corruption does not encourage foreign investment. Most foreign investors are worried, or fearful about the corruption of local government. Pei (2007) argues that "corruption endangers FDI because illicit behaviour by local officials could expose Western firms to potentially vast environmental, human rights and financial liabilities. Corruption creates serious obstacles for Western companies facing rivals who engage in illegal practices in order to win business in China. Corruption puts Western firms' intellectual property particularly at risk because unscrupulous local officials routinely protect Chinese counterfeiters in exchange for bribes."[45]

Although in short term they could get the market entrance or some other preferential policies by taking bribes, multinational firms would like to locate in place where the corruption level is low considering long-run benefits.

Figure 3.3.1 plots the relationship between Corruption Perception Index (CPI) score and FDI inflows from 1995 to 2004 (the correlation between this two indices is 0.60). FDI increased from 1995 to 1998 when the CPI score raised up, i.e. when the country became less corrupt; FDI dropped significantly in 1999 and stagnated in 2000 when China was perceived to be more corrupted. In recent years, the score remained relatively stable and FDI shows a relatively stable growth rate. It suggests that a clean government promotes foreign investment in current China.

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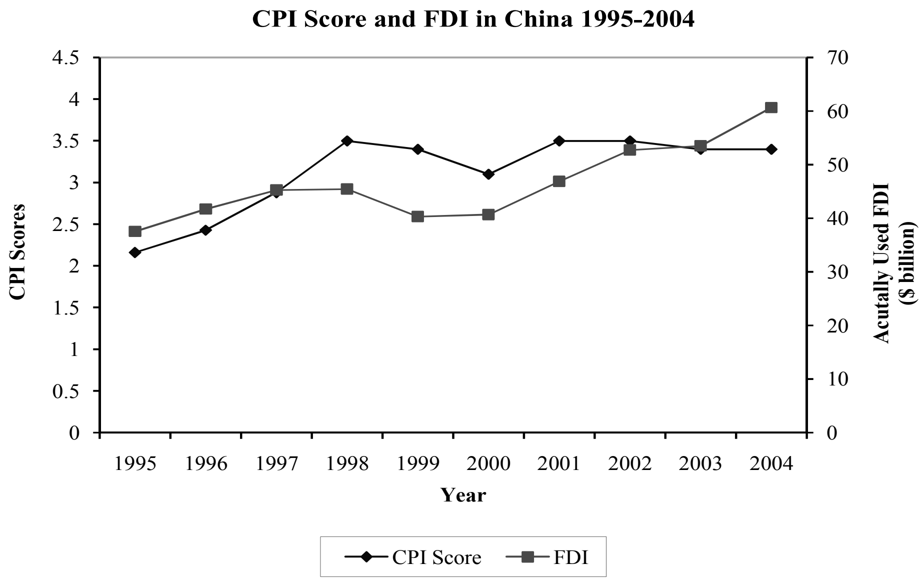
[45] Pei (2007), pp. 6.

Figure 3.3.1 CPI Score and Actually Used FDI in China 1995 -2004



Source: CPI from Transparency International; FDI from China Statistical Yearbook, various years.

Corruption has been openly recognised as an emerging challenge to China's economy and social reforms. Fighting corruption requires increasing transparency of government affairs and improving related laws and regulations. Some legal experts suggest revising the current Anti-Unfair Competition Law and drawing up Anti-Corruption Law and Anti-Commercial Bribery Law. Chinese President Hu Jintao has declared the fight against corruption a priority on the political agenda of the government. On 25th October, 2006, the International Association of Anti-Corruption Authorities (IAACA) was officially established in order to promote the United Nations (UN) Convention Against Corruption and Jia Chunwang, procurator-general of the CSPP, was elected as president. The new political leaders seem to have strengthened anti-corruption activities in recent years and, hopefully, the situation will improve.

3.4 Methodology

The methodology in this chapter follows that in Chapter two. We extend our estimation equation in Chapter two by adding control variables to capture provincial bureaucracy characteristics. We use the same estimators (FGLS) in this chapter and the similar dataset.

Since there is not any existing perception index for provincial bureaucracy characteristics across time, we use two objective variables to proxy the provincial difference in anti-corruption effort level and governance quality.

This section firstly lays out our planned empirical model and expectations. It then explains how we construct the variables to capture the provincial government characteristics. Simultaneously, it describes two new variables – anti-corruption effort and government efficiency index. It then expresses the modified empirical model and estimation techniques. Finally, it describes all variables.

3.4.1 Planned Empirical Model

Following the previous empirical literature, we supplement our previous empirical model, Equation 2.4.2, by adding another two variables to proxy provincial government corruption and governance quality.

$$FDI = f(ER, Corruption, Governance, X, \eta, \gamma) \tag{3.4.1}$$

where

FDI is the amount of FDI inflow into region *i* in time period *t*;

ER is the vector of measures to capture environmental stringency;

Corruption is the regional corruption level;

Governance is the regional governance quality;

X is the set of other regional characteristics that may affect FDI;

η is time-invariant regional effects; and

γ is location-invariant time effects.

The expectation of the coefficient on environmental regulation stringency remains negative indicating that FDI is attracted to provinces with lax regulatory stringency. Following previous studies, we expect that provinces that have more corruption will have reduced FDI inflows, and provinces that have better governance will attract more FDI.

However, a difficulty with our analysis is finding proxies for provincial corruption levels and provincial governance quality. There is not an organisation in China or elsewhere that have made a comprehensive survey of the perceived view of provincial corruption and/or governance quality from firms, government officials, individuals, etc. for any period of time. This leads us to find out whether or not there are any objective data which could help us construct such measures.

3.4.2 Provincial Anti-Corruption Effort Level and Government Efficiency in China

3.4.2.1 Provincial Anti-Corruption Effort

Fredriksson *et al.* (2003) use the number of convictions of public officials per 1000 public employees to measure bureaucratic corruption. The data is from a 1987 US Department of Justice report and has been used in Goel and Nelson (1998) and Fisman and Gatti (1999) to measure state-level corruption in the US.

Fredriksson *et al.* (2003) and Goel and Nelson (1998) have discussed the shortcomings of this measurement of corruption. "First, convictions are only recorded if the corrupt bureaucrats are caught and evidence of their guilt is obtained. Second, the data treat all corruption convictions homogeneously. […] Finally, the data of conviction provides no indication of when corrupt activity actually occurred. We attempt to circumvent this final problem by using the number of convictions in year t +1 to proxy for corruption in year t. Despite these caveats, it remains the best available measure of corruption."[46]

Since we lack a subjective state-level corruption index, such a measure of corruption seems to be the only feasible method. The Procuratorial Yearbook of China (various years) provides the annual reports of the Supreme People's Procuratorate and local people's procutatorates which include similar data. However, whilst all the procuratorates report the number of registered cases under their direct investigation, a number of provinces do not report the number of persons involved in these cases. When focusing on the provinces that provide the data including both cases and persons and the whole country, we find the correlation between the number of cases and number of persons is 0.99.[47] Therefore, we use registered cases under the direct investigation by procurator's offices to proxy the corruption level of each province.

Registered cases include those on corruption, bribery, misappropriation of public funds, collective illegal possession of public funds, unstated source of large property, abuse of power, dereliction of duty, fraudulent practices and others. Since those involved in these cases may not only include public officials but also the persons working in other sectors we normalise the number of cases by the provincial population.

[46] Fredriksson *et al.* (2003), footnote 12, pp.1416.

[47] One case is corresponding to at least one person.

Another issue to note is that corruption cases under investigation could be interpreted in two different ways, real corruption level or anti-corruption effort. However, China is very different from the US. According to the CPI score provided by TI, the average score of the US was above 7.5 in the past 10 years, while that of China was around 3.5. The corruption level in China is much higher than that in the US. Such high corruption level in China is compounded by the low investigation rate (at about 10% or less as discussed in Section 3.3.2). Therefore, the investigated corruption cases cannot reflect the real corruption level in Chinese provinces and hence to copy the method of Fredriksson *et al.* (2003) is not ideal. However, if we assume that inherent corruption levels are equal across provinces, which could be the case if individuals were equally susceptible to temptation, then investigated corruption cases scaled by population can be considered as a good proxy for the level of effort that a province expends fighting corruption. Given the high levels of corruption and the very public fight against it in China, we believe that it is more appropriate to think of the number of corruption cases under investigation as an indicator of how seriously a province takes the fight against corruption. The CSPP also treats these data as the anti-corruption achievement of supreme and local procuratorates of the year. In addition, the consistent positive coefficient on this variable in the results (see section 3.5) suggests that this measure should be interpreted as anti-corruption effort.

Since we consider the impact of tackling corruption on FDI inflows, we do not have the final problem of Fredriksson *et al.* (2003). The difference in provincial anti-corruption efforts is reported in Table 3.4.1.

Most provinces remain stable in terms of their number of normalised cases. We find some provinces have a significant increase during our investigation period, like Tianjin, Liaoning, and Jiangxi; some have a jump in specific years and return to previous level in the following years, such as Shandong and Ningxia; and few provinces have significant decrease in the value of normalised cases.

Compared with other provinces, the ranking shows that some provinces have always made more effort in tackling corruption, such as Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, and Shandong; and some provinces have made less effort such as Guangdong, Guangxi, Chongqing, Sichuan, and Gansu. We also find that the conditions of some provinces became worse, such as Shanghai, Hainan and Yunnan, and some provinces became better, such as Jiangsu, Jiangxi, Henan, and Guangxi.

Table 3.4.1 Provincial Anti-Corruption Efforts and Ranks

	Province	1998		1999		2000	
		Cases/ 100 000 persons	Rank	Cases/ 100 000 persons	Rank	Cases/ 100 000 persons	Rank
1.	Beijing	2.17	25	2.77	18	3.27	15
2.	Tianjin	3.21	12	4.26	3	6.15	1
3.	Hebei	3.60	5	4.06	5	4.30	6
4.	Shanxi*	3.76	4	4.05	6	4.98	5
5.	Inner Mongolia**	2.52	20	2.41	25	3.14	19
6.	Liaoning	3.28	10	4.14	4	5.43	3
7.	Jilin*	4.53	1	5.08	1	5.40	4
8.	Heilongjiang*	4.40	2	4.60	2	5.87	2
9.	Shanghai	3.39	8	3.11	12	3.03	24
10.	Jiangsu	2.33	22	2.57	23	3.26	16
11.	Zhejiang	2.76	16	3.06	14	3.11	20
12.	Anhui*	2.00	28	2.53	24	3.11	21
13.	Fujian	3.50	6	3.51	9	3.85	8
14.	Jiangxi*	2.59	19	3.27	10	3.31	14
15.	Shandong	3.42	7	3.58	8	2.47	27
16.	Henan*	2.33	23	3.04	16	3.90	7
17.	Hubei*	3.19	13	3.23	11	3.37	11
18.	Hunan*	2.52	21	2.75	20	3.03	23
19.	Guangdong	2.08	26	2.15	28	2.20	30
20.	Guangxi**	1.82	30	2.25	27	2.78	26
21.	Hainan	3.15	14	2.74	21	3.18	17
22.	Chongqing**	2.25	24	2.76	19	3.03	25
23.	Sichuan**	1.89	29	2.30	26	3.04	22
24.	Guizhou**	2.71	17	2.69	22	3.15	18
25.	Yunnan**	2.93	15	3.06	15	3.37	12
27.[a]	Shaanxi**	3.23	11	3.02	17	3.60	9
28.	Gansu**	2.04	27	2.12	29	2.33	28
29.	Qinghai**	3.32	9	3.10	13	3.38	10
30.	Ningxia**	2.70	18	2.03	30	2.28	29
31.	Xinjiang**	4.09	3	3.82	7	3.32	13

Table 3.4.1 Provincial Anti-Corruption Efforts and Ranks (Continued)

Province		2001		2002		2003	
		Cases/ 100 000 persons	Rank	Cases/ 100 000 persons	Rank	Cases/ 100 000 persons	Rank
1.	Beijing	2.95	22	3.08	21	2.30	25
2.	Tianjin	7.03	1	6.88	1	5.24	2
3.	Hebei	4.27	7	4.49	7	3.74	6
4.	Shanxi*	4.50	6	3.93	8	3.56	7
5.	Inner Mongolia**	2.92	24	3.25	16	2.94	17
6.	Liaoning	5.05	4	5.41	4	4.62	4
7.	Jilin*	5.12	3	4.72	6	4.25	5
8.	Heilongjiang*	5.65	2	5.92	3	6.10	1
9.	Shanghai	3.22	17	3.00	23	2.18	27
10.	Jiangsu	3.31	15	3.30	13	3.03	14
11.	Zhejiang	3.16	18	3.12	19	2.98	15
12.	Anhui*	3.03	19	3.61	11	2.38	23
13.	Fujian	3.67	11	3.28	15	3.42	8
14.	Jiangxi*	3.85	10	4.91	5	4.82	3
15.	Shandong	4.50	5	6.09	2	3.06	13
16.	Henan*	3.86	9	3.76	10	3.34	10
17.	Hubei*	3.49	13	3.29	14	2.81	18
18.	Hunan*	2.59	28	3.11	20	2.09	28
19.	Guangdong	2.28	29	2.32	29	1.99	29
20.	Guangxi**	3.02	20	2.83	24	2.80	19
21.	Hainan	2.88	25	2.76	25	2.33	24
22.	Chongqing**	2.72	26	2.56	28	2.42	21
23.	Sichuan**	2.67	27	2.61	27	2.42	22
24.	Guizhou**	2.97	21	3.05	22	2.95	16
25.	Yunnan**	3.66	12	2.76	26	2.29	26
27.[a]	Shaanxi**	3.35	14	3.19	18	3.17	12
28.	Gansu**	2.00	30	1.74	30	1.90	30
29.	Qinghai**	3.31	16	3.31	12	3.39	9
30.	Ningxia**	2.93	23	3.79	9	2.53	20
31.	Xinjiang**	4.03	8	3.21	17	3.33	11

Note: * indicates central provinces and ** western provinces. [a] No. 26 indicates Tibet.

3.4.2.2 The Measure of Provincial Government Efficiency

Tang and Tang (2004a and 2004b) create a system of indices to measure the provincial government efficiency of China following the methodology and analysis principles of IMD World Competitiveness Yearbook. The system contains 47 indices in four factors such as public services, public goods, government scale and national welfare. Then they calculated the standardised value (STD) of 37 indices with the help of Standard Derivation Method according to the data in 2001. Then the aggregated STD of each province is worked out using the weighted arithmetic mean method, and hence the rank of STD value. The STD is used to measure the efficiency of 31 provincial governments in 2002. This method is adopted in Kao *et al.* (2005) to create an index measuring the governance quality in each province. In this study, we follow this method and improve on Tang and Tang (2004b) and Kao *et al.* (2005) by adding more indices (from 37 to 40) and for a longer period of six years (1998-2003) across 30 provinces. We assume that a province with a higher level of government efficiency is an indicator that it has good local bureaucrats.

Table 3.4.2 lists the 47 indices in each of the four factors. The government services factor includes four sub-factors: 1) education, science and technology, culture, and public health services (11 indices), with a weight of 0.55 in the first factor; 2) public security services (8 indices) with a weight of 0.15; 3) meteorological services (2 indices) with a weight of 0.15; and 4) social security services (3 indices) with a weight of 0.15. Government public goods factor has two sub-factors, social infrastructure (6 indices) and city infrastructure (5 indices) with equal weights. Government scale factor has 5 indices and national welfare factor 7 indices in total. The weights of the four factors are 0.4, 0.3, 0.2, and 0.1 respectively, according to their importance. The indices in bold type are the seven indices that are not available.

Table 3.4.2 Government Efficiency Indices

Factors	Sub Factors	Indices
Government Public Services (24 indices) (weight = 0.4)	**Education, Science & Technology, Culture, and Public Health Services** (11 indices) (weight = 0.55)	1. Per Capita Government Budgetary Expenditures for Scientific and Technology Promotion (yuan) 2. Rate of Products with Excellent Quality (%) 3. Three Types of Patent (Inventions, Utility Models and Designs) Applications Granted (item/100 000 persons) 4.Per Capita Transaction value in Technical Market (yuan) *5. Student-Teacher Ratio of Primary Schools* *6. Student-Teacher Ratio of Secondary Schools* *7. Illiterate and Semi-illiterate Rate (%)* 8. The Share of Government Appropriation for Education in GDP (%) 9. Institutions for Culture and Art (unit/100 000 persons) 10. Beds in Health Institutions (unit/100 000 persons) 11. Employed Persons in Health Institutions (person/ 100 000 persons)
	Public Security Services (8 indices) (weight = 0.15)	*12. Three Accidents (Traffic Accidents, Fires and Pollution Accidents) (case/100000 persons)* *13. Losses in Three Accidents (yuan)* ***14. Legislations (New Legislations, Revised Old Legislations, Including Laws， Regulations, etc.)(case)*** ***15. First Trial Cases Accepted by Courts (case)*** ***16. First Trial Cases Settled by Courts (case)*** ***17. Arrests of Criminal Suspects by Procurator's Offices (person)*** ***18. Criminal Cases Cracked and/or Registered in Public Security Organs (case)*** ***19.Criminal Cases (case/ 100 000 persons)***
	Meteorological Services (2 indices) (weight = 0.15)	20. Agro-Meteorological Services Stations (unit/100 000 persons) 21. Earthquake Monitoring Stations (unit/100 000 persons)
	Social Security Services (3 indices) (weight = 0.15)	22. Number of Careers Service at the end of year (unit/100 000 persons) 23. Number of Urban Community Welfare Facilities (unit/100 000 persons) 24.Rural Social Security Network (unit/100 000 person)

Table 3.4.2 Government Efficiency Indices (Continued)

Factors	Sub Factors	Indices
Government Public Goods (11 indices) (weight = 0.3)	**Social Infrastructure** (6 indices) (weight = 0.5)	25. State Budgetary Appropriation in Capital Construction and Innovation (100 million yuan) 26. Local –Central Government Projects Ratio of Investment in Capital Construction and Innovation (%) 27. Ratio of Projects Completed and Put into Use in Capital Construction and Innovation (%) 28.Treatment Efficiency of Industrial Wastewater, Waste Gas and Solid Wastes **29. Reservoir Volume (100 million cubic metres/ 10 000 persons)** 30. Ratio of Area of Nature Reserves and Provincial Area (%)
	City Infrastructure (5 indices) (weight =0.5)	31. Rate of Access to Gas (%) 32. Numbers Public Transportation Vehicles per 10 000 persons in Cities (unit) 33. Per Capita Area of Paved Roads (sq.m) 34. Per Capita Green Area (sq.m) 35.Number of Public Toilet per 10 000 persons (unit)
Government Scale (5 indices) (weight = 0.2)		*36. Ratio of Staff and Workers in Government Agencies and Total Population (person/10 000 persons)* *37. Ratio of Staff and Workers in Government Agencies and Total Employed Persons (%)* *38. Ratio of Government Consumption and Final Consumption (%)* *39. Ratio of Government Expenditures and GDP (%)* *40. The Share of Penalty and Confiscatory Income and Income from Administrative Fees in Total Government Revenue*
National Welfare (7 indices) (weight = 0.1)		41. Per Capita Annual Net Income of Rural Households (yuan) 42. Per Capita Annual Disposable Income of Urban Households (yuan) *43. Engle Coefficient of Rural Households (%)* *44. Engle Coefficient of Urban Households (%)* *45. Consumer price index (preceding year = 100)* 46.GDP per capita (yuan) 47. Ratio of Expenditure on Policy-related Subsidies and Government Expenditure (%)

Note: The indices in italic are inverse criteria. The indices in bold type are unavailable.

The measure of provincial government efficiency is developed in five steps as follows:

1) *Construction of the primary measures for Chinese provinces.* The primary measures are constructed by the available data for a type of the provincial characteristics. For example, numbers of students and teachers in specialised and regularly secondary schools; total number and losses of traffic accidents, fire accidents and pollution accidents; central government and local government investments in capital construction and innovation, etc. Data are recorded in the form in which they are provided in China Statistical Yearbook and China Environment Yearbook.
2) *Normalisation of the primary measures.* In addition to the losses of three accidents, and the state budget investment in capital construction and innovation, each of the primary measures are either in the form of a ratio (e.g. student-teacher ratio, local-central government projects ratio of investment in capital construction and innovation, and Engle coefficients) or normalised either by present population or by the dimension (square kilometres) of the provincial area, depending on the features of the indices (but some data are already normalised in the yearbooks). The results are in the types as: per capita green area in the city, ratio of area of nature reserves and provincial area. Definitions of the 40 indices are reported in Appendix 3.1.
3) *Standardisation of the normalised measures.* The output of the normalisation is a set of indices that are presented in different units. They are not directly comparable. Each index is standardised using the following formula.

$$STD_{i,j} = (X_{i.j} - \overline{X}_j) / S_j \tag{3.4.2}$$

where

$STD_{i,j}$ is the standardised value of index *j* in region *i*;

$X_{i,j}$ is the original value of the index j in region i;

$\overline{X}$ is the mean value of X; and

S is standard error defined as $S_j = \sqrt{\sum_{i=1}^{n}(X_{i,j} - \overline{X}_j)^2 \frac{1}{n}}$.[48]

4) *Aggregation into the sub-factors*. The arithmetic mean is used to average the STD values for each region within each sub-factor. In most cases, a higher value is better, for example, per capita income; the province with the highest standardised value is ranked first while the one with the lowest is last. However, with some criteria (in italic in Table 3.4.2), the lowest value is the most efficient, for example, Engle coefficients. In these cases, a reverse ranking is used: the province with the highest standardised value is ranked last and the one with the lowest is first. According to the principles of IMD World Competitive Yearbook, in the aggregation of the statistics, all missing values are replaced with a STD value equal to zero. The resulting STD value for each sub-factor are then again averaged arithmetically, standardised and normalised.

5) *Aggregation of the sub factors and four factors*. The weighted mean is then used to aggregate these sub factors, and after that the four factors. The weight of each sub-factor and factor is following that in Tang and Tang (2004b). Finally we get the aggregated STD values and corresponding ranks of 30 provinces for 6 years. Results are provided in Table 3.4.3.

Table 3.4.3 shows that eight provinces, such as Beijing, Shanghai, Tianjin, Jiangsu, Jilin, Liaoning, Zhejiang and Heilongjiang, have relatively high STD values from 1998 to 2003. These provinces are located in eastern regions or regions on the border, where the

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48 n is number of provincial governments.

economy grows quickly and national welfare is high thanks to the geographical advantages and favourable policies. In contrary, some inland provinces, for example, Shanxi, Jiangxi, Henan, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Yunan and Gansu, remain relatively low or negative STD values indicating low government efficiencies. The difference in government efficiencies among Chinese provinces is consistent with the disparity of regional economic development.

Table 3.4.3 Government Efficiency STD Value Results and Ranks

Province		1998		1999		2000	
		STD Value	Rank	STD Value	Rank	STD Value	Rank
1.	Beijing	0.38	2	0.40	2	0.49	1
2.	Tianjin	0.37	3	0.24	5	0.25	5
3.	Hebei	0.01	12	0.09	10	-0.01	16
4.	Shanxi*	-0.12	21	-0.24	26	-0.21	26
5.	Inner Mongolia**	-0.04	16	0.00	16	0.07	10
6.	Liaoning	0.15	8	0.18	7	0.17	8
7.	Jilin*	0.33	4	0.32	4	0.25	4
8.	Heilongjiang*	0.15	9	0.22	6	0.20	6
9.	Shanghai	0.48	1	0.52	1	0.41	2
10.	Jiangsu	0.32	5	0.35	3	0.25	3
11.	Zhejiang	0.21	7	0.13	9	0.17	7
12.	Anhui*	-0.02	14	-0.05	18	-0.07	20
13.	Fujian	-0.07	19	-0.04	17	0.03	13
14.	Jiangxi*	-0.32	28	-0.36	29	-0.33	29
15.	Shandong	-0.06	17	0.02	15	0.07	12
16.	Henan*	-0.14	22	-0.22	24	-0.20	25
17.	Hubei*	0.10	11	0.07	13	0.08	9
18.	Hunan*	-0.33	29	-0.35	28	-0.31	28
19.	Guangdong	0.00	13	0.08	11	-0.03	18
20.	Guangxi**	-0.26	26	-0.24	25	-0.30	27
21.	Hainan	0.21	6	0.15	8	0.07	11
22.	Chongqing**	-0.28	27	-0.29	27	-0.09	21
23.	Sichuan**	-0.10	20	-0.12	21	-0.07	19
24.	Guizhou**	-0.43	30	-0.43	30	-0.40	30
25.	Yunnan**	-0.07	18	-0.11	20	-0.18	24
27.[a]	Shaanxi**	-0.25	25	-0.20	23	-0.14	22
28.	Gansu**	-0.14	23	-0.13	22	-0.16	23
29.	Qinghai**	-0.16	24	-0.10	19	0.02	14
30.	Ningxia**	-0.03	15	0.03	14	0.02	15
31.	Xinjiang**	0.10	10	0.08	12	-0.02	17

Table 3.4.3 Government Efficiency STD Value Results and Ranks (Continued)

Province		2001		2002		2003	
		STD Value	Rank	STD Value	Rank	STD Value	Rank
1.	Beijing	0.62	1	0.81	1	0.86	1
2.	Tianjin	0.26	4	0.29	3	0.34	4
3.	Hebei	0.09	9	0.15	10	0.02	12
4.	Shanxi*	-0.15	19	-0.09	19	-0.13	20
5.	Inner Mongolia**	0.08	11	0.24	5	0.28	6
6.	Liaoning	0.18	6	0.23	6	0.24	8
7.	Jilin*	0.12	8	0.16	9	0.19	9
8.	Heilongjiang*	0.15	7	0.22	7	0.36	3
9.	Shanghai	0.53	2	0.55	2	0.76	2
10.	Jiangsu	0.32	3	0.25	4	0.31	5
11.	Zhejiang	0.24	5	0.21	8	0.24	7
12.	Anhui*	-0.02	16	-0.06	17	-0.13	19
13.	Fujian	0.08	10	0.01	13	0.01	14
14.	Jiangxi*	-0.24	26	-0.29	27	-0.25	24
15.	Shandong	-0.03	17	-0.06	18	-0.11	18
16.	Henan*	-0.21	25	-0.23	24	-0.27	25
17.	Hubei*	0.02	15	-0.11	20	-0.11	16
18.	Hunan*	-0.27	28	-0.32	28	-0.41	28
19.	Guangdong	0.07	13	0.01	12	-0.14	21
20.	Guangxi**	-0.31	29	-0.35	29	-0.49	29
21.	Hainan	0.08	12	-0.06	16	-0.11	17
22.	Chongqing**	-0.21	24	-0.23	26	-0.31	26
23.	Sichuan**	-0.19	23	-0.22	23	-0.17	22
24.	Guizhou**	-0.49	30	-0.50	30	-0.64	30
25.	Yunnan**	-0.18	22	-0.20	22	-0.33	27
27.[a]	Shaanxi**	-0.04	18	-0.01	14	0.05	11
28.	Gansu**	-0.25	27	-0.18	21	-0.08	15
29.	Qinghai**	0.05	14	-0.02	15	0.01	13
30.	Ningxia**	-0.17	21	-0.23	25	-0.19	23
31.	Xinjiang**	-0.15	20	0.05	11	0.19	10

Note: * indicates central provinces and ** western provinces. [a] No. 26 indicates Tibet.

In terms of the trend over time, the ranks of the provinces, such as Beijing, Shanxi, Inner Mongolia, Heilongjiang, Shaanxi, Gansu, Qinghai and Xinjiang, have increased. The ranks of Shanghai and Liaoning remains relatively stable but the STD values have considerably increased. However, the situations for those provinces like Shandong, Jilin, Hubei, Guangdong, Hainan, Yunan and Ningxia are worsen from 1998 to 2003. The STD values and ranks of other provinces stay relatively stable. The trend of the ranks illustrates on one hand that some provinces in which their economic development is fast, for instance, Beijing, Shanghai, Jiangsu, Liaoning and Fujian, retain their advantages in government efficiency; and on the other hand that eastern regions generally have better governance than central and western regions.

Finally, the difference between the highest and the lowest scoring provinces has increased, for example, the difference between Beijing and Guizhou has increased from 0.81 in 1998 to 1.50 in 2003. This rise in the standard deviation means that provincial inequalities are widening which may further impact future growth and FDI prospects for these laggard provinces.

3.4.3 Modified Model and Estimation Equation

We now return to Equation 3.4.1 that we now write as:

$$FDI = f\left(ER, Anti\text{ - }Corruption, STD, X, \eta, \gamma\right) \tag{3.4.3}$$

where

FDI is the amount of FDI inflow into region *i* in time period *t*;

ER is the vector of measures to capture environmental stringency;

Anti-Corruption is the regional effort on tackling corruption;

STD is the index of regional government efficiency;

X is the set of other regional characteristics that may affect FDI;

η is time-invariant regional effects; and

γ is location-invariant time effects.

We now estimate whether or not the governments that fight corruption will attract the larger volume of investment over time. The expected sign of *Anti-Corruption* is positive. We also expect provinces that have good bureaucrats to attract more FDI so that the sign on *STD* is expected to be positive.

Similarly to Chapter two, we include two measurements of FDI inflows, i.e. FDI divided by regional GDP (*FDI/GDP*) and FDI divided by regional population (*FDI/POP*). We include our three variables of environmental regulation stringency, the share of regional anti-industrial pollution investment in innovation investment (*EI1*), the number of administrative punishment cases normalised by the number of enterprises (*Punish*), and the number of pollution emission charge normalised by the number of charged organisations (*Charge*). In terms of other control variables *X*, we use those from Chapter two to capture factor prices, income, infrastructure and agglomeration effects: per capita gross regional product (*GRP per capita*), manufacturing wage and wage squared, regional gross industrial product (*GIP*), population density, railway density, road density, rate of illiteracy and labour productivity.

The estimating equation in this chapter is as following:

$$\begin{aligned}\ln(FDI_{it}) = \alpha &+ \beta_1 \ln(ER_{it-1}) + \beta_2 \ln(GRP\ per\ Capita_{it-1}) + \beta_3 \ln(Wage_{it-1}) + \beta_4 (\ln(Wage_{it-1}))^2 \\ &+ \beta_5 \ln(GIP_{it-1}) + \beta_6 \ln(Pop.\ Density_{it-1}) + \beta_7 \ln(Rail\ Density_{it-1}) \\ &+ \beta_8 \ln(Road\ Density_{it-1}) + \beta_9 \ln(Illiterate\ Rate_{it-1}) + \beta_{10} \ln(Productivity_{it-1}) \\ &+ \beta_{11} \ln(Anti-Corruption_{it-1}) + \beta_{12} STD_{it-1} + \eta_i + \gamma_t + \varepsilon_{it}\end{aligned} \tag{3.4.4}$$

where *i* refers to province *t* refers to year.

Similar to Chapter two, we lag all independent variables to minimise the potential causality links from FDI to all the independent variables.

We do not take natural log to *STD* because it is an index with positive and negative values. The expected signs of the coefficients are:

Coefficients	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}
Expected Signs	-	+	+	-	+	-/+	+	+	-/+	-/+	+	+

Since pollution emission charge is more visible to polluters than the other two measures of environmental stringency, we expect that *Charge* has the strongest negative effect on FDI inflows rather than *Punish* and *EI1*.

We use fixed and random effects estimators. We apply a Hausman specification test to find out whether the random effects model is appropriate. The results (See Appendix 3.2) show that the random effects estimator is rejected in half of the cases. Therefore, we concentrate on the fixed effects results.

Since we use the similar dataset and the estimating equation based on that in Chapter two, the autocorrelation problem still exists. There is AR(1) autocorrelation within panels for log specification. The autocorrelation test results are reported in Appendix 3.3. Due to the existence of autocorrelation, neither the within estimator nor random effects estimator could produce efficient results. Therefore we continue to adopt the FGLS estimator, which can control for both autocorrelation and heteroskedasticity to specify unobserved regional effects and time effects.

3.4.4 Data Description

The Procuratorial Yearbook of China, the China Statistical Yearbook and the China Environment Yearbook provide the data for constructing the two government characteristic variables. Other data sources are as the same as those in Chapter two.

Table 3.4.4 provides the descriptive statistics table developed from Table 2.4.4 by adding the statistics of the two new variables, *Anti-Corruption* and *STD*. Similarly, Table 3.4.5 shows the correlations of all variables developed from Table 2.4.3. All the control variables are one-year lagged.

The correlation rank shows that FDI inflows are positively correlated with *STD* value, i.e. provinces that have high level of government efficiencies also have high FDI inflows. However, there is not significant correlation between FDI inflows and the anti-corruption effort. The correlation coefficient between anti-corruption effort and government efficiency is positive but the magnitude is small (0.263).

Table 3.4.4 Descriptive Statistics of the Variables

Variable	Obs.	Mean	Std. Dev.	Min	Medium	Max
FDI/GDP (FDI in RMB yuan per 10 000 RMB yuan GDP)	149	265.80	271.11	6.76	140.66	1140.13
FDI/POP (FDI in RMB yuan per capita)	149	188.62	276.04	3.19	42.89	1395.25
EI1 (yuan per 10 000 RMB yuan innovation investment)	150	342.20	216.12	31.65	289.32	1163.74
EI2 (yuan per 10 000 RMB yuan Inno.Inv.+Capital Construction Inv.)	150	92.63	57.22	6.19	80.43	285.53
EI3 (yuan per 10 000 RMB yuan total investment in fixed assets)	150	55.04	35.78	4.46	44.71	185.08
Punish (Cases per 1000 enterprises)	148	452.34	701.53	29.18	267.30	5877.36
Charge (RMB yuan per organisation)	150	4319.00	2363.26	1467.24	3679.30	17649.92
GRP per capita (RMB yuan)	150	4765.65	3591.10	1255.09	3376.21	21876.21
Wage (RMB yuan at 1990 price)	150	4720.76	1549.53	2614.68	4399.02	11885.36
GIP (100 million RMB yuan at 1990 price)	150	1556.23	1713.53	79.41	912.00	8815.18
Pop. Density (persons per km^2)	150	376.11	460.55	6.99	251.56	2700.00
Rail Density (km/ 10 000 km^2)	150	151.39	145.08	8.38	109.65	690.83
Road Density (km/ 10 000 km^2)	150	3341.10	2110.37	204.76	3053.05	10138.71
Illiterate Rate (%)	150	13.13	6.46	4.36	12.11	42.92
Productivity (RMB yuan/person at 1990 price)	150	41039.37	18996.94	9276.10	35999.46	156645.80
Anti-Corruption (Cases/100 000 persons)	150	3.37	1.01	1.74	3.18	7.03
STD	150	0.00	0.24	-0.50	-0.02	0.81

Table 3.4.5 Correlations of the Variables

	FDI/GDP	FDI/POP	EI1	Punish	Charge	GRP per capita	Wage	$(Wage)^2$	GIP	Pop. Density	Rail Density	Road Density	Illiterate Rate	Productivity	Anti-Corruption	STD
FDI/GDP	1.000															
FDI/POP	0.859	1.000														
EI1.	-0.095	-0.120	1.000													
Punish	-0.108	-0.113	0.154	1.000												
Charge	0.294	0.601	0.060	-0.014	1.000											
GRP per capita	0.617	0.904	-0.084	-0.029	0.700	1.000										
Wage	0.511	0.781	-0.108	-0.062	0.568	0.862	1.000									
$(Wage)^2$	0.475	0.791	-0.134	-0.108	-0.162	-0.083	0.654	1.000								
GIP	0.544	0.553	0.019	-0.027	0.409	0.488	0.433	0.409	1.000							
Pop. Density	0.502	0.807	-0.143	-0.157	0.801	0.865	0.674	0.742	0.429	1.000						
Rail Density	0.393	0.616	-0.010	0.007	0.465	0.723	0.555	0.571	0.120	0.606	1.000					
Road Density	0.697	0.798	-0.098	-0.173	0.538	0.771	0.695	0.701	0.456	0.729	0.723	1.000				
Illiterate Rate	-0.321	-0.353	0.004	-0.229	-0.150	-0.421	-0.345	-0.322	-0.266	-0.279	-0.451	-0.430	1.000			
Productivity	0.007	0.148	-0.114	0.054	0.114	0.253	0.359	0.334	-0.002	0.181	0.251	0.159	-0.147	1.000		
Anti-Corruption	0.035	0.081	0.152	0.357	-0.019	0.169	0.039	0.011	0.009	0.022	0.323	0.117	-0.410	0.209	1.000	
STD	0.520	0.662	0.039	0.093	0.407	0.766	0.565	0.571	0.375	0.528	0.595	0.492	-0.370	0.316	0.263	1.000

3.5 Empirical Results

As in Chapter two, we only report the FGLS estimation results for log specifications in our main text, and we compare our main results with level results (in Appendix 3.4) and random effects results (in Appendix 3.5).

3.5.1 Main Results

Tables 3.5.1-3.5.3 are the results of the impact of environmental regulations on provincial FDI inflows when we allow the control for corruption and government efficiency to influence FDI location choice. These tables provide the log specification results using FGLS estimators. Each table includes two parts, depending on the two measures of FDI inflows, *FDI/GDP* on the left-hand-side and *FDI/POP* on the other. We start the estimations from the final regression (column 10) in Chapter two, then respectively add *Anti-Corruption* and *STD* and finally include both of them.

Table 3.5.1 reports the results including the share of anti-industrial pollution investment to proxy environmental stringency. It shows that the negative effect of *EI1* on provincial FDI inflows remains significant, but its absolute value increases slightly from 0.062 to approximately 0.070 (for both measures of FDI inflows). FDI is therefore attracted to provinces with relatively low environmental investments, i.e. provinces with relatively low environmental protection efforts.

The coefficient on *Anti-Corruption* is positive and statistically significant, which means the province that has tackled more corruption would attract more FDI inflows. Column 13 on both sides of the table shows that the marginal effect of tackling corruption is 0.53. A 10 per cent increase of the control of corruption in a province would attract 5.3 per cent more FDI inflows.

The coefficient on the government efficiency measure *STD* is also positive and significant. The numerical effect in column 13 on the left-hand-side is that a 0.1 increase in the government efficiency level is associated with a 6.2 per cent increase in FDI inflows to regional GDP.[49] Regional government efficiency is therefore a significant determinant of foreign investment location choice.

The results of other explanatory variables are very similar to those in Chapter two. Income still has a strong positive effect on FDI inflows. Manufacturing wage and its square have the expected signs. They are less significant when estimating on *FDI/GDP* but are more significant when estimating on *FDI/POP*. From Colum 13 on the right-hand-side, we find the turning point is at approximately 2,228 RMB yuan (approximately $466) which is less than the minimum wage level (2614 RMB yuan) in our sample, indicating that FDI prefers to locate in regions with low wage levels.[50]

GIP, which proxies the regional agglomeration effects, remains insignificant and is not stable in signs. The population density coefficient is negative but not statistically different from zero. Turning to the two measures of infrastructure, railway density has a negative effect on FDI due to the relatively low railway densities in some significant FDI preferred provinces such as Guangdong, Jiangsu, Fujian and Zhejiang. The coefficient on road density shows that FDI prefers to locate in regions with good road transportation networks.

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[49] $[\exp(0.60\times0.1) - 1] \times 100\% = 6.18\%$.

[50] $\exp[8.48/(2\times0.55)] = 2228.52$. RMB2,228 is equivalent to $466 according to the middle exchange rate in 1990 that $1=RMB4.78.

The sign and significance of the illiteracy rate and labour quality are also very similar to those in Chapter two, indicating that FDI is attracted by relatively low education levels.

Table 3.5.1 also illustrates that the results of all explanatory variables are constant across all regressions no matter whether we normalise FDI inflows by regional GDP or by regional population.

Table 3.5.2 shows the results including normalised administrative punishment cases as the measure of environmental regulation standards. The coefficient on *Punish* remains negative and significant and is stable in magnitude. From regression 13 on *FDI/GDP*, we find a 10 per cent increase in environment litigiousness reduces the amount of *FDI/GDP* in a province by 0.82 per cent. FDI is demonstrated to be deterred by stringent environmental legislation. However, since the coefficient on *EI1* is enlarged a little by adding new control variables, the difference between the coefficients on *EI1* and *Punish* is not significant, especially when we regress on *FDI/POP*. The results of other control variables are very similar to those in Table 3.5.1.

Table 3.5.3 are the results of the effect of normalised pollution emission charge on FDI inflows. As expected, *Charge* has a negative effect on FDI inflows and the effect is greater than the other two measures of environmental regulation. From the last column estimating on *FDI/GDP*, the marginal effect of *Charge* on the share of FDI in GDP is 0.33, i.e. an increase of 10 per cent in the pollution emission charge will lead 3.3 per cent reduction in the share of FDI to GDP of a province. FDI is therefore reduced by stringent implementation of pollution levies.

The effects of *Anti-Corruption* and *STD* remain positive. From the regression on *FDI/GDP*, we find the marginal effect of tacking corruption is 0.60, which is slightly greater than the effects including *EI1* and *Punish*. The coefficient on *STD* is also greater than in the other two tables. The coefficient in column 13 on the left-hand-side is 0.66 and 0.72 on the other side, indicating the numerical effect that a 0.1 increase in the government efficiency level will increase 6.8 per cent amount of *FDI/GDP* or 7.5 per cent amount of *FDI/POP* .[51]

The results on manufacturing wage are constant in signs but are not significant any more. We find positive and but insignificant coefficient on agglomeration effects variable *GIP* that is consistent with our findings in Chapter two. However, the population density coefficient is no longer significant after we add *Anti-Corruption* and *STD* to the regressions.

The results of other control variable are constant across regressions and are similar to the other two tables.

[51] [exp (0.66×0.1) – 1]×100%= 6.82%, [exp (0.72×0.1) – 1]×100%= 7.47%.

Table 3.5.1 FGLS Regression Results for Log Data with EI1

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
EI1†	-0.062 (-2.03)**	-0.069 (-2.30)**	-0.078 (-2.44)**	-0.070 (-2.17)**	-0.062 (-1.96)**	-0.070 (-2.28)**	-0.081 (-2.47)**	-0.073 (-2.21)**
GRP per capita	3.44 (4.86)***	3.46 (5.08)***	3.34 (4.48)***	3.45 (4.54)***	3.98 (5.74)***	3.97 (5.94)***	3.74 (5.12)***	3.88 (5.18)***
Wage	6.49 (1.68)*	7.01 (1.81)*	7.75 (1.78)*	7.09 (1.59)	8.54 (2.22)**	8.75 (2.26)**	9.49 (2.17)**	8.48 (1.88)*
Wage²	-0.40 (-1.71)*	-0.44 (-1.89)*	-0.48 (-1.84)*	-0.48 (-1.77)*	-0.52 (-2.24)**	-0.54 (-2.29)**	-0.58 (-2.21)**	-0.55 (-2.02)**
GIP	-0.16 (-0.50)	-0.042 (-0.13)	-0.27 (-0.79)	-0.21 (-0.62)	0.045 (0.13)	0.17 (0.54)	-0.030 (-0.09)	0.0096 (0.03)
Pop. Density	-1.13 (-1.68)*	-0.91 (-1.33)	-0.61 (-0.93)	-0.31 (-0.47)	-0.92 (-1.28)	-0.73 (-1.01)	-0.33 (-0.46)	0.021 (0.03)
Rail Density	-0.25 (-2.32)**	-0.27 (-2.56)***	-0.23 (-2.12)**	-0.26 (-2.45)**	-0.20 (-1.78)**	-0.23 (-2.08)**	-0.19 (-1.66)*	-0.23 (-1.98)**
Road Density	0.45 (5.30)***	0.34 (3.59)***	0.46 (4.93)***	0.37 (4.04)***	0.47 (5.47)***	0.35 (3.64)***	0.48 (4.80)***	0.37 (3.77)***
Illiterate Rate	0.27 (2.34)**	0.32 (2.69)***	0.28 (2.38)**	0.36 (2.94)***	0.27 (2.23)**	0.31 (2.55)**	0.27 (2.21)**	0.33 (2.59)***
Productivity	-0.18 (-1.47)	-0.21 (-1.85)*	-0.16 (-1.29)	-0.17 (-1.36)	-0.17 (-1.34)	-0.20 (-1.77)*	-0.17 (-1.35)	-0.15 (-1.24)
Anti-Corruption		0.43 (3.36)***		0.53 (3.87)***		0.42 (3.21)***		0.53 (3.84)***
STD			0.47 (1.92)*	0.60 (2.59)***			0.54 (2.19)**	0.65 (2.74)***
Constant	-43.51 (-2.20)***	-46.22 (-2.36)**	-50.70 (-2.32)**	-48.44 (-2.21)**	-60.91 (-3.05)***	-62.13 (-3.14)***	-66.20 (-2.98)***	-63.07 (-2.82)***
Wald χ^2	7071.95	7950.17	6764.13	6977.84	13239.35	13662.04	11396.04	11187.17
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 3.5.2 FGLS Regression Results for Log Data with Punish

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Punish†	-0.076 (-2.85)***	-0.087 (-3.19)***	-0.079 (-2.68)***	-0.082 (-2.74)***	-0.070 (-2.38)**	-0.079 (-2.64)***	-0.070 (-2.26)**	-0.074 (-2.39)**
GRP per capita	3.85 (5.75)***	3.95 (6.00)***	3.74 (4.98)***	3.78 (5.01)***	4.36 (6.58)***	4.42 (6.79)***	4.02 (5.37)***	4.11 (5.46)***
Wage	5.73 (-1.42)	6.15 (1.51)	7.04 (1.59)	6.34 (1.40)	7.67 (1.91)*	7.92 (1.94)*	8.62 (1.93)*	7.78 (1.69)*
Wage²	-0.36 (-1.48)	-0.40 (-1.62)	-0.44 (-1.66)*	-0.42 (-1.53)	-0.47 (-1.94)*	-0.49 (-1.99)**	-0.53 (-1.98)**	-0.49 (-1.78)*
GIP	-0.36 (-1.17)	-0.33 (-1.07)	-0.40 (-1.23)	-0.36 (-1.06)	-0.13 (-0.39)	-0.057 (-0.17)	-0.14 (-0.43)	-0.099 (-0.29)
Pop. Density	-1.02 (-1.63)	-0.75 (-1.15)	-0.60 (-0.98)	-0.18 (-0.29)	-0.77 (-1.13)	-0.55 (-0.79)	-0.19 (-0.28)	0.23 (0.32)
Rail Density	-0.31 (-2.90)***	-0.34 (-3.11)***	-0.32 (-2.94)***	-0.33 (-3.02)***	-0.26 (-2.28)**	-0.29 (-2.56)**	-0.28 (-2.35)**	-0.29 (-2.46)**
Road Density	0.46 (5.28)***	0.37 (4.11)***	0.46 (4.39)***	0.38 (3.79)***	0.48 (5.43)***	0.39 (4.17)***	0.48 (4.30)***	0.38 (3.59)***
Illiterate Rate	0.21 (1.83)*	0.27 (2.21)**	0.24 (1.86)*	0.30 (2.28)**	0.20 (1.68)*	0.24 (1.96)**	0.23 (1.75)*	0.26 (1.94)*
Productivity	-0.16 (-1.32)	-0.19 (-1.61)	-0.16 (-1.27)	-0.20 (-1.57)	-0.14 (-1.14)	-0.17 (-1.45)	-0.15 (-1.15)	-0.16 (-1.28)
Anti-Corruption		0.40 (3.06)***		0.52 (3.60)***		0.39 (2.87)***		0.51 (3.48)***
STD			0.42 (1.73)*	0.56 (2.32)**			0.49 (1.98)**	0.62 (2.48)**
Constant	-42.58 (-2.10)**	-45.50 (-2.26)**	-49.48 (-2.23)**	-48.18 (-2.17)**	-59.97 (-2.92)***	-61.98 (-3.03)***	-64.51 (-2.85)***	-63.26 (-2.78)***
Wald χ^2	8466.13	8626.65	7454.09	7708.80	13589.33	14425.05	10759.08	11218.06
Observations	147	147	147	147	147	147	147	147

z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table 3.5.3 FGLS Regression Results for Log Data with Charge

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Charge†	-0.18	-0.24	-0.27	-0.33	-0.17	-0.25	-0.26	-0.34
	(-1.54)	(-2.23)**	(-2.31)**	(-2.78)***	(-1.50)	(-2.25)**	(-2.15)**	(-2.86)***
GRP per capita	3.47	3.39	3.12	3.16	4.02	3.88	3.54	3.57
	(4.80)***	(4.90)***	(4.02)***	(4.11)***	(5.77)***	(5.84)***	(4.65)***	(4.73)***
Wage	3.26	3.48	3.71	2.79	5.47	5.21	5.38	3.85
	(0.77)	(0.82)	(0.79)	(0.59)	(1.29)	(1.23)	(1.13)	(0.80)
Wage²	-0.20	-0.22	-0.23	-0.19	-0.33	-0.31	-0.32	-0.25
	(-0.78)	(-0.85)	(-0.79)	(-0.67)	(-1.28)	(-1.20)	(-1.12)	(-0.85)
GIP	0.14	0.38	0.065	0.18	0.34	0.60	0.28	0.41
	(0.42)	(1.16)	(0.18)	(0.50)	(0.97)	(1.78)*	(0.78)	(1.15)
Pop. Density	-1.61	-1.42	-1.15	-0.74	-1.41	-1.25	-0.91	-0.44
	(-2.34)**	(-2.08)**	(-1.63)	(-1.09)	(-1.92)*	(-1.72)*	(-1.17)	(-0.59)
Rail Density	-0.37	-0.42	-0.42	-0.46	-0.31	-0.37	-0.38	-0.43
	(-3.34)***	(-3.99)***	(-3.74)***	(-4.17)***	(-2.68)***	(-3.41)***	(-3.12)***	(-3.69)***
Road Density	0.44	0.33	0.45	0.33	0.46	0.34	0.45	0.31
	(4.46)***	(3.36)***	(3.62)***	(2.80)***	(4.57)***	(3.36)***	(3.53)***	(2.56)**
Illiterate Rate	0.22	0.27	0.18	0.22	0.21	0.26	0.19	0.20
	(1.68)*	(2.21)**	(1.23)	(1.49)	(1.58)	(2.09)**	(1.26)	(1.40)
Productivity	-0.16	-0.20	-0.18	-0.19	-0.16	-0.20	-0.19	-0.19
	(-1.32)	(-1.76)*	(-1.46)	(-1.58)	(-1.25)	(-1.72)*	(-1.49)	(-1.56)
Anti-Corruption		0.45		0.60		0.45		0.61
		(3.37)***		(4.19)***		(3.27)***		(4.26)***
STD			0.55	0.66			0.62	0.72
			(2.19)**	(2.81)***			(2.41)**	(3.03)***
Constant	-27.59	-28.47	-27.94	-25.02	-45.52	-44.21	-42.57	-37.42
	(-1.29)	(-1.35)	(-1.18)	(-1.06)	(-2.09)**	(-2.06)**	(-1.75)*	(-1.56)
Wald χ^2	6817.20	8440.52	7155.16	7966.66	12082.78	14087.79	11036.52	11985.42
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

3.5.3 Level Data Results and Random Effects Results

Appendix 3.4

The level data results are relatively weaker than log models. The signs on the three environmental regulation variables remain negative, although they are not statistically different from zero. Income and wage variables are neither significant nor stable in signs. We find positively significant coefficients on *GIP* and population density which are consistent with our initial expectations. Railway density and road density have the same signs to our main results and remain significant across regressions. Neither of illiterate rate and productivity is significant or constant in signs. *Anti-Corruption* and *STD* have significant positive effects on FDI inflows which are consistent with our main results.

The possible explanation of the weak level results is the positive skewness of variables and that the error term in level model is less homoskedestic than the log models.

Appendix 3.5

From the Hausman specification test results we find that most of the level data regressions are not efficient, therefore we only focus on the log specification results using GLS estimator. The log model results are roughly consistent with our main results but with less significance possibly because GLS estimator could not control for the autocorrelation within panels.

3.6 Conclusions

In this chapter, we use Chinese provincial data to re-examine whether FDI is attracted by lax environmental regulations by allowing government anti-corruption effort and government efficiency to have impacts on FDI location choice.

The methodology is very similar to that in Chapter two. We extend the estimating model by adding two variables to proxy the provincial government effort in fighting corruption and the provincial government efficiency. Other dependent and independent variables are the same as those in Chapter two. The log model results from FGLS estimator are consistent with our findings in Chapter two that environmental regulations have significant negative effect on FDI inflows. Additionally, we find that FDI is attracted to provinces that have tackled more corruption cases and that have higher grade of government efficiencies.

Therefore, this chapter provides a clear guidance for the local governments which aims to alleviate environmental problems and at the same time, attract more FDI and retain the rapid economic growth. Although the enforcement of environmental regulations has negative effects on the investment in pollution-intensive sectors and hence may decrease the total investment in a region, the improvement of governance will largely increase the total foreign investment inflows. Policies include the enhancement in anti-corruption effort, increase in the supply of public goods, public services, and the improvement in national welfare.

In this paper, we firstly construct data to proxy provincial government anti-corruption effort and update an index to measure cross-province government efficiency for six years.

We also firstly consider the impacts of provincial differences in environmental stringency and the government bureaucracy characteristics on the FDI inflows in China.

However, we still do not consider the endogeneity of environmental regulations. Government anti-corruption effort and efficiency may influence FDI inflows through their impacts on environmental regulation stringency. Treating environmental stringency as endogenous becomes our main task in the next chapter.

Appendix 3.1 Explanations of the Government Efficient Indices

1. Per Capita Government Budgetary Expenditures for Scientific and Technology Promotion: It refers to the expenses appropriated from the government budget for the scientific technological expenditure, including new products development expenditure, expenditure for intermediate trial and subsidies on important scientific researches.
2. Rate of Products with Excellent Quality: It reflects the quality of products. Sampling data is collected from 73 main industrial cities in different regions. There are missing values for some regions.
3. Three Types of Patent Applications Granted: Patent rights are granted for inventions, utility models and designs. This indicator reflects the achievements of science and technology and design with independent intellectual property.
4. Per Capita Transaction value in Technical Market: It indicates the regional ability of transfer of scientific and technological achievements.
5. Student-Teacher Ratio of Primary Schools: Student refers to the number of student enrolment and teacher refers to the number of teachers and staff in schools.
6. Student-Teacher Ratio of Secondary Schools: Secondary schools refer to regular junior secondary schools, regular senior secondary schools, specialised secondary schools, and vocational secondary schools.
7. Illiterate and Semi-illiterate Rate: Illiterate and semi-illiterate population refers to the population aged 15 and over, who are unable or very difficult to read. Data are obtained from the sample survey.
8. The Share of Government Appropriation for Education in GDP: Education expenses refer to the expenses appropriated from the government budget for the expenditures on salaries and operational expenditure of the causes of education.

9. Institutions for Culture and Art: The institutions include art performance troupes, art performance places, cultural centres, public libraries, and museums.
10. Beds in Health Institutions: Health institutions include hospital, health centre, clinic, centres for disease control (including epidemic prevention station), maternity and child care centre and other health institutions.
11. Employed Persons in Health Institutions: Employed persons refer to all medical technical personnel (including doctors, assistant nurses, pharmacists, and laboratory technicians) and other employed persons working in health institutions.
12. Three Accidents: These refer to the number of traffic accidents, fire accidents and pollution and destruction accidents.
13. Losses in Three Accidents: These refer to the direct economic losses of three accidents converted into cash.
20. Agro-Meteorological Services Stations: The stations include agro-meteorological observation stations, agro-meteorological stations, and agro-meteorological information services stations.
21. Earthquake Monitoring Stations: The earthquake stations include fiducial stations, basic stations, provincial stations, city and county stations, and enterprises managing stations.
22. Number of Careers Service.
23. Number of Urban Community Welfare Facilities: The number of places, buildings and equipment used for urban community activities and services.
24. Rural Social Security Network: The number of established rural social security network.
25. State Budgetary Appropriation in Capital Construction and Innovation: Investment in capital construction and innovation from state budget consists of budgetary appropriations and loans from state budget.

26. Local – Central Government Projects Ratio of Investment in Capital Construction and Innovation: It reflects the administrative relationship of the fund sources in capital construction and innovation. Capital construction refers to the new construction projects or extension projects and related activities of the enterprises, institutions, or administrative units mainly for the purpose of expanding production capacity, covering only projects each with a total investment of 500,000 RMB yuan (about $60,459) and over. Innovation refers to the technological innovation of original facilities by the enterprises and institutions as well as the corresponding supplementary projects for production or welfare facilities and the related activities, covering only projects each with a total investment of 500,000 RMB yuan and over.

27. Ratio of Projects Completed and Put into Use in Capital Construction and Innovation: It refers to the ratio of the number of projects completed and put into use in certain period of time to the number of projects under construction in the same period.

28. Treatment Efficiency of Industrial Wastewater, Waste Gas and Solid Wastes: The average ratio of treated pollutants to the discharged pollutants. Industrial wastewater treatment efficiency refers to the ratio of the volume of industrial wastewater up to the discharged standards to the total volume of discharged wastewater. Waste gas treatment efficiency refers to the ratio of the volume of removed waste gas to the volume of waste gas emissions: for 1998-2000, it equals to the ratio of the removed soot and dust plus waste gas purified to the total waste gas emission; and for 2001-2003, it equals to the removed SO_2 to the total SO_2 emission. Solid wastes treatment efficiency refers to the ratio of the volume of industrial solid wastes utilised in a comprehensive way to the total solid wastes produced.

30. Ratio of Area of Nature Reserves and Provincial Area: Nature reserves refer to certain areas of land, waters or sea that are representative in natural ecological systems, or are

natural habitats for rare or endangered wild animals or plants, or water conservation zones, or the location of important natural or historic relics, which are demarked by law and put under special protection and management. Nature reserves are designated by the formal approval of governments at and above county level.

31. Rate of Access to Gas: It refers to the ratio of the urban population with access to gas to the total urban population at the end of reference period.
32. Numbers Public Transportation Vehicles per 10 000 persons in Cities: Public transportation vehicles include bus, trolley, vehicles with tracks (metro, light railway, tram, ropeway and cable car), taxi, and public ferry. The standardised set = $\sum$ sets of each type of vehicle × corresponding coefficient.
33. Per Capita Area of Paved Roads: paved road refers to paved roads with a width of 3.5 meters and over (including roads in open-ended factory compounds and residential quarters) and paved surface including square bridges and tunnels connected with roads.
34. Per Capita Green Area: Green area refers to those to the public such as municipal, community and neighbourhood parks and roadside parks, including waters within parks. Neighbourhood parks should occupy an area larger than 10,000 square meters, and the roadside parks should occupy an area larger than 400 square meters, with a width of more than 8 meters.
35. Number of Public Toilet per 10 000 persons.
36. Ratio of Staff and Workers in Government Agencies and Total Population: It refers to the ratio of the number of persons working in government agencies, party agencies, public management and social organisations to the number of total population.
37. Ratio of Staff and Workers in Government Agencies and Total Employed Persons.
38. Ratio of Government Consumption and Final Consumption: Government consumption refers to the expenditure on the consumption of the public services

provided by the government to the whole society and the net expenditure on the goods and services provided by the government to the households free of charge or at low prices. Final consumption refers to the total expenditure of resident units of purchases of goods and services from domestic economic territory and abroad to meet the requirements of materials, cultural and spiritual life. The final consumption consists of household consumption and government consumption.

39. Ratio of Government Expenditures and GDP.
40. The Share of Penalty and Confiscatory Income and Income from Administrative Fees in Total Government Revenue: Penalty and confiscatory income refers to the fines and converted income of confiscated properties collected by the government agencies, institutions and social organisations which have the rights to impose fines and confiscate delegated in accordance with laws, rules and regulations. Administrative fees refers to the fund not covered by the regular government budgetary management, which is collected by government agencies, institutions and social organisations while performing duties delegated to them or on behalf of the government in accordance with laws, rules and regulations.
41. Per Capita Annual Net Income of Rural Households: It reflects the average income level of rural households in a given area. Net income refers to the total income of rural households from all sources minus all corresponding expenses, including household operation expenses, taxes and fees, depreciation of fixed assets for production, subsidy for participating in household survey, and gifts to non-rural relatives. Net income is mainly used as input for reproduction and as consumption expenditure of the year, and also used for savings and non-compulsory expenses of various forms.
42. Per Capita Annual Disposable Income of Urban Households: Disposable income refers to the actual income at the disposal of members of the households which can be

used for final consumption, other non-compulsory expenditure and savings. It equals to total income minus income tax, personal contribution to social security and sample household subsidy for keeping diaries.

43. Engle Coefficient of Rural Households: Engle coefficient refers to the percentage of expenditure on food in the total consumption expenditure.
44. Engle Coefficient of Urban Households.
45. Consumer price index: it reflects the trend and degree of changes in prices of consumer goods and services purchased by urban and rural residents, and is composite indices derived from the urban consumer price indices and the rural consumer price indices.
46. GDP per capita.
47. Ratio of Expenditure on Policy-related Subsidies and Government Expenditure: expenditure on policy-related subsidy refers to the expenditure appropriated, with the approval of the government, from the state budget for price subsidies on such products as grain, cotton and edible oil.

Appendix 3.2 Hausman Specification Test

We undertake the Hausman specification test to find out whether GLS estimator is BLUE, consistent and asymptotically efficient under the null hypothesis H_0: $E(\varepsilon_{it}|X_{it}) = 0$.The results below show that GLS estimator does not always produce efficient results especially for level data. Therefore we focus on fixed effect models but we also estimate equation (3.4.5) using GLS estimator for sensitivity check.

Table A3.2.1 Hausman Specification Test Results

	Levels					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
χ^2 Statistics	12.74	**26.57**	**19.97**	**38.44**	17.05	**27.98**
p-value	0.311	**0.005**	**0.046**	**0.000**	0.106	**0.003**
	Logs					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
χ^2 Statistics	**2.58**	6.39	4.03	5.20	**51.66**	1.32
p-value	**0.011**	0.983	0.999	0.995	**0.000**	1.000

Appendix 3.3 Autocorrelation Test

We apply the dynamic model, $\varepsilon_{it} = \rho\varepsilon_{it-1} + \nu_{it}, t = 2,\ldots,T$ to the final regression equation (column 13 in results tables). The null hypothesis is H_0: $\rho = 0$. The *t* statistics show that we reject the null hypothesis for all log specifications. Therefore AR(1) autocorrelation exists within panels in our log specifications.

Table A3.3.1 Autocorrelation Test Results

	Levels					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
$\hat{\rho}$	0.039	-0.143	0.058	-0.123	0.061	-0.135
t Statistics	0.42	-1.46	0.63	-1.24	0.66	-1.37
p-value	0.678	0.147	0.532	0.217	0.513	0.174
	Logs					
	EI1		***Punish***		***Charge***	
	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP	FDI/GDP	FDI/POP
$\hat{\rho}$	**0.228**	**0.223**	**0.240**	**0.236**	**0.173**	**0.171**
t Statistics	**2.58**	**2.52**	**2.73**	**2.67**	**2.01**	**1.98**
p-value	**0.011**	**0.013**	**0.007**	**0.009**	**0.046**	**0.050**

Appendix 3.4 FGLS Regression Results for Level Data

Table A3.4.1 FGLS Regression Results for Level Data with EI1

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
EI1	-0.045	-0.053	-0.037	-0.041	-0.015	-0.019	-0.013	-0.015
	(-2.03)**	(-2.01)**	(-1.70)*	(-1.80)*	(-1.73)*	(-1.35)	(-1.26)	(-1.15)
GRP per capita	0.043	0.025	0.032	-0.015	0.026	0.029	0.026	0.018
	(1.97)**	(0.93)	(1.50)	(-0.52)	(1.96)**	(1.87)*	(1.91)*	(1.13)
Wage	0.081	0.076	0.10	0.087	-0.011	0.00062	-0.0031	-0.0050
	(1.54)	(1.30)	(2.06)**	(1.51)	(-0.39)	(0.02)	(-0.11)	(-0.15)
Wage²	-8.39e-06	-6.94e-06	-9.01e-06	-5.04e-06	8.66e-07	9.42e-08	4.68e-07	9.12e-07
	(-2.27)**	(-1.69)*	(-2.44)**	(-1.19)	(0.38)	(0.04)	(0.20)	(0.34)
GIP	0.027	0.035	0.025	0.050	0.057	0.048	0.055	0.050
	(1.32)	(1.55)	(1.22)	(2.29)**	(4.81)***	(3.65)***	(4.43)***	(3.94)***
Pop. Density	0.18	0.30	0.23	0.45	0.42	0.49	0.43	0.55
	(0.52)	(0.90)	(0.66)	(1.27)	(1.65)*	(1.89)*	(1.65)*	(2.06)**
Rail Density	-1.29	-1.29	-1.29	-1.48	-0.64	-0.57	-0.54	-0.68
	(-3.30)***	(-2.95)***	(-3.46)***	(-3.41)***	(-2.87)***	(-2.34)**	(-2.30)**	(-2.77)***
Road Density	0.025	0.018	0.029	0.014	0.010	0.012	0.012	0.013
	(2.70)***	(1.76)*	(3.12)***	(1.38)	(1.94)*	(2.00)**	(2.15)**	(2.10)**
Illiterate Rate	-1.59	-1.50	-0.90	0.54	-0.85	-1.16	-1.23	-0.77
	(-0.79)	(-0.64)	(-0.48)	(0.26)	(-0.85)	(-0.94)	(-1.23)	(-0.66)
Productivity	0.000011	-0.00012	-0.000075	-0.000025	0.00013	-0.000034	0.000091	-0.000037
	(0.03)	(-0.33)	(-0.25)	(-0.08)	(0.91)	(-0.19)	(0.68)	(-0.23)
Anti-Corruption		13.40		33.94		7.95		12.61
		(1.38)		(3.71)***		(1.62)		(2.65)***
STD			117.83	174.85			4.47	68.95
			(2.49)**	(3.01)***			(0.19)	(2.21)**
Constant	483.67	575.46	340.59	713.77	276.16	85.37	155.17	169.99
	(1.00)	(1.15)	(0.71)	(1.38)	(0.94)	(0.26)	(0.49)	(0.51)
Wald χ^2	1814.28	1702.59	2424.43	1916.29	2965.54	2849.85	2865.97	2963.13
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.4.2 FGLS Regression Results for Level Data with Punish

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Punish	-0.0082	-0.0042	-0.0064	-0.0049	-0.0040	-0.0023	-0.0032	-0.0020
	(-1.14)	(-0.55)	(-0.93)	(-0.66)	(-0.77)	(-0.42)	(-0.65)	(-0.39)
GRP per capita	0.049	0.025	0.032	-0.025	0.034	0.026	0.028	0.0094
	(1.96)**	(0.86)	(1.22)	(-0.81)	(2.39)**	(1.65)*	(1.91)*	(0.57)
Wage	0.091	0.081	0.11	0.081	0.0083	0.0062	0.0080	-0.0053
	(1.62)	(1.35)	(2.00)**	(1.38)	(0.27)	(0.18)	(0.26)	(-0.16)
Wage²	-9.58e-06	-7.64e-06	-9.59e-06	-4.73e-06	-6.83e-07	-1.83e-07	-4.31e-07	1.23e-06
	(-2.39)**	(-1.76)*	(2.38)**	(-1.07)	(-0.28)	(-0.07)	(-0.17)	(0.45)
GIP	0.028	0.039	0.031	0.058	0.054	0.051	0.055	0.055
	(1.34)	(1.75)*	(1.46)	(2.63)***	(4.45)***	(3.90)***	(4.48)***	(4.36)***
Pop. Density	0.17	0.30	0.26	0.52	0.40	0.52	0.44	0.61
	(0.49)	(0.87)	(0.71)	(1.39)	(1.51)	(1.95)*	(1.64)	(2.26)**
Rail Density	-1.34	-1.27	-1.39	-1.54	-0.54	-0.56	-0.56	-0.68
	(-3.29)***	(-2.84)***	(-3.49)***	(-3.45)***	(-2.37)**	(-2.32)**	(-2.39)**	(-2.82)***
Road Density	0.026	0.020	0.030	0.017	0.014	0.012	0.015	0.013
	(2.54)**	(1.83)*	(3.01)***	(1.55)	(2.31)**	(1.83)*	(2.33)**	(1.91)*
Illiterate Rate	-2.08	-2.19	-0.98	0.066	-1.12	-1.08	-1.07	-0.66
	(-0.97)	(-0.91)	(-0.50)	(0.03)	(-1.06)	(-0.88)	(-1.09)	(-0.59)
Productivity	0.000078	-0.000029	-2.13e-06	2.10e-06	0.000086	0.000033	0.00010	0.000022
	(0.24)	(-0.08)	(-0.01)	(0.01)	(0.64)	(0.20)	(0.83)	(0.16)
Anti-Corruption		7.31		30.85		7.06		13.37
		(0.67)		(3.09)***		(1.37)		(2.74)***
STD			143.11	226.58			18.78	85.41
			(2.73)***	(3.83)***			(0.81)	(2.68)***
Constant	428.34	539.94	364.80	786.02	54.51	52.00	84.01	190.56
	(0.86)	(1.06)	(0.73)	(1.49)	(0.18)	(0.16)	(0.26)	(0.57)
Wald χ^2	2156.02	1750.57	2504.41	1988.63	2875.18	2895.56	2923.34	3097.32
Observations	147	147	147	147	147	147	147	147

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.4.3 FGLS Regression Results for Level Data with Charge

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Charge	-0.0028	-0.00047	-0.0073	-0.0053	0.00025	-0.00022	-0.00020	-0.0021
	(-0.38)	(-0.06)	(-1.03)	(-0.75)	(0.07)	(-0.06)	(-0.06)	(-0.56)
GRP per capita	0.038	0.021	0.027	-0.023	0.028	0.024	0.023	0.011
	(1.62)	(0.79)	(1.14)	(-0.82)	(2.06)**	(1.55)	(1.65)*	(0.67)
Wage	0.079	0.078	0.096	0.077	-0.00078	0.0038	-0.0016	-0.0059
	(1.47)	(1.32)	(1.82)*	(1.34)	(-0.03)	(0.12)	(-0.05)	(-0.18)
Wage^2	-8.31e-06	-7.41e-06	-8.20e-06	-4.35e-06	3.03e-07	1.14e-07	5.51e-07	1.35e-06
	(-2.18)**	(-1.76)*	(2.15)**	(-1.01)	(0.13)	(0.04)	(0.23)	(0.51)
GIP	0.034	0.042	0.036	0.061	0.058	0.053	0.059	0.056
	(1.71)*	(1.95)*	(1.81)*	(2.87)***	(5.24)***	(4.28)***	(5.20)***	(4.75)***
Pop. Density	0.22	0.31	0.28	0.51	0.38	0.50	0.42	0.58
	(0.62)	(0.90)	(0.77)	(1.40)	(1.48)	(1.90)*	(1.60)	(2.17)**
Rail Density	-1.28	-1.27	-1.41	-1.57	-0.52	-0.56	-0.56	-0.71
	(-3.20)***	(-2.89)***	(-3.52)***	(-3.49)***	(-2.34)**	(-2.29)**	(-2.41)**	(-2.83)***
Road Density	0.026	0.021	0.030	0.018	0.013	0.012	0.014	0.013
	(2.78)***	(2.04)**	(3.17)***	(1.72)*	(2.31)**	(2.01)**	(2.39)**	(2.12)**
Illiterate Rate	-1.75	-1.98	-0.64	0.30	-1.07	-0.99	-1.02	-0.50
	(-0.83)	(-0.83)	(-0.33)	(0.14)	(-1.01)	(-0.81)	(-1.01)	(-0.44)
Productivity	0.000094	-0.000028	0.000015	0.000018	0.000093	0.000024	0.000090	0.000018
	(0.28)	(-0.08)	(0.05)	(0.06)	(0.66)	(0.14)	(0.68)	(0.12)
Anti-corruption		6.55		28.83		6.65		12.69
		(0.62)		(2.89)***		(1.32)		(2.64)***
STD			146.87	226.74			24.39	84.25
			(2.80)***	(3.80)***			(1.02)	(2.61)***
Constant	500.04	578.31	460.62	814.96	138.55	91.03	172.41	219.20
	(1.02)	(1.14)	(0.93)	(1.55)	(0.46)	(0.29)	(0.55)	(0.67)
Wald χ^2	2265.33	1813.27	2559.56	1989.22	3058.95	3015.52	3051.61	3182.84
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Appendix 3.5 Random Effects Results

Table A3.5.1 Random Effects Results for Level Data with EI1

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
EI1	-0.063 (-1.35)	-0.068 (-1.49)	-0.060 (-1.35)	-0.066 (-1.51)	-0.054 (-1.77)*	-0.056 (2.00)**	-0.054 (-1.78)*	-0.056 (1.99)**
GRP per capita	0.057 (2.21)**	0.052 (2.15)**	0.040 (1.26)	0.032 (1.08)	0.054 (3.16)***	0.051 (3.32)***	0.054 (2.66)***	0.051 (2.83)***
Wage	0.21 (3.39)***	0.212 (3.36)***	0.20 (3.26)***	0.21 (3.26)***	0.079 (1.72)*	0.081 (1.74)*	0.078 (1.69)*	0.080 (1.70)*
Wage²	-0.000016 (-3.21)***	-0.000016 (-3.15)***	-0.000015 (-2.92)***	-0.000015 (-2.81)***	-4.78e-06 (-1.30)	-4.56e-06 (-1.23)	-4.76e-06 (-1.26)	-4.51e-06 (-1.19)
GIP	0.0046 (0.19)	0.0038 (0.15)	0.0042 (0.17)	0.0036 (0.1)	0.012 (0.65)	0.012 (0.65)	0.012 (0.64)	0.012 (0.64)
Pop. Density	-0.059 (-0.44)	-0.031 (-0.24)	-0.0088 (-0.06)	0.035 (0.22)	0.073 (0.79)	0.089 (0.97)	0.075 (0.72)	0.093 (0.90)
Rail Density	-0.92 (-2.11)**	-0.96 (-2.04)**	-0.95 (-2.20)**	-1.01 (-2.15)**	-0.43 (-1.42)	-0.45 (-1.39)	-0.44 (-1.44)	-0.46 (-1.42)
Road Density	0.050 (1.64)	0.047 (1.60)	0.053 (1.86)*	0.049 (1.77)*	0.026 (1.27)	0.025 (1.25)	0.026 (1.29)	0.025 (1.26)
Illiterate Rate	-4.44 (-1.62)	-4.47 (-1.59)	-3.80 (-1.44)	-3.74 (-1.36)	-1.39 (-0.83)	-1.48 (-0.87)	-1.45 (-0.87)	-1.52 (-0.88)
Productivity	-0.00021 (-0.47)	-0.00022 (-0.47)	-0.00038 (-0.78)	-0.00039 (-0.80)	-0.00024 (-0.78)	-0.00024 (-0.78)	-0.00023 (-0.73)	-0.00024 (-0.76)
Anti-Corruption		10.23 (0.41)		15.30 (0.62)		5.89 (0.36)		6.08 (0.37)
STD			165.86 (1.46)	180.44 (1.64)			-4.74 (-0.07)	1.49 (0.02)
Constant	-366.71 (-2.09)**	-394.572 (-1.81)*	-330.00 (-1.76)*	-369.64 (-1.65)*	-270.32 (-2.12)**	-283.17 (-1.88)*	-268.00 (-2.00)**	-279.20 (-1.80)*
R^2	0.67	0.65	0.67	0.65	0.88	0.88	0.88	0.88
Observations	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.5.2 Random Effects Results for Log Data with EI1

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
EI1†	-0.057	-0.063	-0.062	-0.070	-0.058	-0.064	-0.063	-0.071
	(-0.66)	(-0.69)	(-0.76)	(-0.81)	(-0.67)	(-0.70)	(-0.77)	(-0.83)
GRP per capita	1.50	1.43	1.13	1.03	2.45	2.38	2.06	1.95
	(3.56)***	(3.61)***	(2.43)**	(2.31)**	(5.83)***	(5.99)***	(4.46)***	(4.40)***
Wage	8.22	7.85	9.36	8.75	10.35	9.94	11.52	10.88
	(1.31)	(1.25)	(1.45)	(1.34)	(1.70)*	(1.64)	(1.83)*	(1.71)*
$Wage^2$	-0.53	-0.50	-0.60	-0.55	-0.66	-0.63	-0.73	-0.68
	(-1.42)	(-1.36)	(-1.56)	(-1.44)	(-1.83)*	(-1.75)*	(-1.94)*	(-1.82)*
GIP	-0.16	-0.16	-0.16	-0.14	-0.12	-0.12	-0.11	-0.11
	(-1.08)	(-1.13)	(-1.03)	(-1.06)	(-0.82)	(-0.86)	(-0.76)	(-0.78)
Pop. Density	0.28	0.31	0.30	0.33	0.25	0.28	0.27	0.31
	(1.14)	(1.25)	(1.25)	(1.40)	(1.02)	(1.15)	(1.13)	(1.29)
Rail Density	-0.29	-0.32	-0.34	-0.37	-0.27	-0.29	-0.32	-0.35
	(-2.34)**	(-2.52)**	(-2.73)***	(-2.86)***	(-2.13)**	(-2.33)**	(-2.52)**	(-2.66)***
Road Density	0.52	0.52	0.60	0.59	0.52	0.52	0.60	0.58
	(2.32)**	(2.29)**	(2.72)***	(2.63)***	(2.28)**	(2.24)**	(2.71)***	(2.62)***
Illiterate Rate	0.097	0.12	0.11	0.13	0.10	0.12	0.11	0.14
	(0.37)	(0.43)	(0.43)	(0.50)	(0.39)	(0.45)	(0.45)	(0.53)
Productivity	0.15	0.14	0.078	0.058	0.17	0.15	0.093	0.073
	(0.64)	(0.58)	(0.34)	(0.25)	(0.72)	(0.65)	(0.40)	(0.31)
Anti-Corruption		0.24		0.30		0.25		0.31
		(0.90)		(1.13)		(0.92)		(1.15)
STD			0.97	0.99			1.01	1.04
			(2.48)**	(2.61)***			(2.56)**	(2.70)***
Constant	-43.61	-41.92	-45.09	-42.28	-61.42	-59.61	-62.93	-59.98
	(-1.61)	(-1.54)	(-1.63)	(-1.51)	(-2.35)**	(-2.27)**	(-2.34)**	(-2.20)**
R^2	0.72	0.71	0.72	0.71	0.84	0.84	0.84	0.84
Observations	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.5.3 Random Effect Results for Level Data with Punish

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Punish	0.012	0.011	0.011	0.0095	0.0062	0.0058	0.0062	0.0058
	(0.79)	(0.72)	(0.76)	(0.64)	(0.65)	(0.60)	(0.64)	(0.59)
GRP per capita	0.053	0.051	0.036	0.031	0.051	0.050	0.051	0.050
	(1.94)*	(1.97)**	(1.08)	(0.98)	(2.84)***	(3.06)***	(2.39)**	(2.62)***
Wage	0.21	0.21	0.20	0.21	0.077	0.077	0.077	0.076
	(3.36)***	(3.29)***	(3.21)***	(3.18)***	(1.68)*	(1.66)*	(1.64)	(1.62)
Wage^2	-0.000016	-0.000016	-0.000015	-0.000015	-4.51e-06	-4.39e-06	-4.48e-06	-4.32e-06
	(-3.08)***	(-3.04)***	(-2.78)***	(-2.70)***	(-1.20)	(-1.16)	(-1.17)	(-1.12)
GIP	0.0065	0.0059	0.0062	0.00657	0.013	0.013	0.013	0.013
	(0.26)	(0.23)	(0.24)	(0.22)	(0.71)	(0.71)	(0.70)	(0.70)
Pop. Density	-0.042	-0.024	0.010	0.044	0.085	0.095	0.088	0.10
	(-0.30)	(-0.18)	(-0.06)	(-0.27)	(0.89)	(1.00)	(0.81)	(0.93)
Rail Density	-0.93	-0.96	-0.96	-1.01	-0.45	-0.47	-0.45	-0.48
	(-2.09)**	(2.00)**	(2.19)**	(2.10)**	(-1.45)	(-1.40)	(-1.47)	(-1.42)
Road Density	0.052	0.049	0.055	0.052	0.028	0.027	0.027	0.027
	(1.64)	(1.65)*	(1.86)*	(1.81)*	(1.28)	(1.30)	(1.32)	(1.32)
Illiterate Rate	-4.36	-4.38	-3.70	-3.66	-1.41	-1.49	-1.45	-1.53
	(-1.62)	(-1.60)	(-1.42)	(-1.36)	(-0.82)	(-0.86)	(-0.85)	(-0.87)
Productivity	-0.000062	-0.000059	-0.00024	-0.00024	-0.00012	-0.00011	-0.00011	-0.00012
	(-0.14)	(-0.13)	(-0.51)	(-0.51)	(-0.39)	(-0.37)	(-0.37)	(-0.37)
Anti-Corruption		5.65		11.00		2.44		2.65
		(0.22)		(0.43)		(0.14)		(0.15)
STD			171.34	182.63			0.26	3.79
			(1.50)	(1.66)*			(0.00)	(0.06)
Constant	-393.05	-406.79	-352.34	-379.27	-285.60	-287.04	-282.25	-282.68
	(-2.25)**	(-1.87)*	(-1.87)*	(-1.68)*	(-2.24)**	(-1.91)*	(2.10)**	(-1.81)*
R^2	0.67	0.66	0.67	0.65	0.88	0.87	0.88	0.87
Observations	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.5.4 Random Effects Results for Log Data with Punish

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Punish†	-0.050	-0.054	-0.047	-0.053	-0.048	-0.053	-0.046	-0.052
	(-0.76)	(-0.82)	(-0.72)	(-0.81)	(-0.73)	(-0.81)	(-0.70)	(-0.80)
GRP per capita	1.50	1.42	1.14	1.026	2.45	2.37	2.07	1.96
	(3.59)***	(3.52)***	(2.48)**	(2.27)**	(5.91)***	(5.89)***	(4.54)***	(4.35)***
Wage	7.37	6.68	8.45	7.55	9.54	8.83	10.65	9.73
	(1.14)	(1.02)	(1.27)	(1.11)	(1.52)	(1.39)	(1.63)	(1.46)
Wage^2	-0.48	-0.43	-0.55	-0.49	-0.61	-0.56	-0.68	-0.62
	(-1.27)	(-1.13)	(-1.39)	(-1.21)	(-1.66)	(-1.51)	(-1.77)*	(-1.57)
GIP	-0.16	-0.16	-0.15	-0.15	-0.12	-0.12	-0.11	-0.11
	(-1.10)	(-1.10)	(-1.06)	(-1.05)	(-0.84)	(-0.85)	(-0.79)	(-0.77)
Pop. Density	0.28	0.32	0.30	0.34	0.25	0.29	0.27	0.32
	(1.15)	(1.27)	(1.27)	(1.42)	(1.03)	(1.15)	(1.14)	(1.30)
Rail Density	-0.31	-0.33	-0.36	-0.38	-0.29	-0.31	-0.34	-0.36
	(-2.44)**	(-2.56)**	(-2.85)***	(-2.89)***	(-2.26)**	(-2.38)**	(-2.65)***	(-2.70)***
Road Density	0.53	0.51	0.60	0.58	0.53	0.51	0.61	0.58
	(2.28)**	(2.18)**	(2.65)***	(2.51)**	(2.26)**	(2.16)**	(2.66)***	(2.52)**
Illiterate Rate	0.074	0.096	0.087	0.11	0.078	0.10	0.091	0.12
	(0.28)	(0.35)	(0.34)	(0.43)	(0.30)	(0.37)	(0.35)	(0.45)
Productivity	0.14	0.13	0.069	0.051	0.16	0.14	0.084	0.066
	(0.63)	(0.56)	(0.31)	(0.22)	(0.71)	(0.64)	(0.38)	(0.29)
Anti-Corruption		0.26		0.31		0.26		0.31
		(0.96)		(1.16)		(0.96)		(1.18)
STD			0.96	0.99			1.00	1.03
			(2.47)**	(2.60)***			(2.54)**	(2.67)***
Constant	-39.70	-36.70	-41.01	-36.99	-57.74	-54.64	-59.06	-54.92
	(-1.41)	(-1.29)	(-1.43)	(-1.25)	(-2.12)**	(-1.97)**	(-2.10)**	(-1.90)*
R^2	0.72	0.71	0.71	0.70	0.84	0.84	0.84	0.83
Observations	147	147	147	147	147	147	147	147

Robust z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.5.5 Random Effect Results for Level Data with Charge

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Charge	0.0080	0.0082	0.0060	0.0059	0.0028	0.0030	0.0029	0.0031
	(0.61)	(0.61)	(0.46)	(0.43)	(0.27)	(0.28)	(0.29)	(0.29)
GRP per capita	0.055	0.052	0.039	0.032	0.052	0.051	0.053	0.051
	(2.09)**	(2.10)**	(1.19)	(1.06)	(3.03)***	(3.27)***	(2.55)**	(2.79)***
Wage	0.22	0.22	0.21	0.22	0.083	0.084	0.083	0.083
	(3.31)***	(3.33)***	(3.17)***	(3.18)***	(1.87)*	(1.92)*	(1.85)*	(1.89)*
$Wage^2$	-0.000017	-0.000017	-0.000016	-0.000016	-5.06e-06	-4.94e-06	-5.08e-06	-4.93e-06
	(-3.07)***	(-3.01)***	(-2.77)***	(-2.66)***	(-1.36)	(-1.30)	(-1.34)	(-1.27)
GIP	0.0060	0.0058	0.0057	0.0055	0.013	0.013	0.013	0.013
	(0.25)	(0.23)	(0.24)	(0.22)	(0.72)	(0.72)	(0.71)	(0.71)
Pop. Density	-0.078	-0.058	-0.022	0.015	0.067	0.077	0.067	0.079
	(-0.60)	(-0.46)	(-0.14)	(-0.10)	(0.71)	(0.81)	(0.63)	(0.73)
Rail Density	-0.91	-0.94	-0.945	-0.99	-0.43	-0.45	-0.43	-0.45
	(-2.12)**	(-2.02)**	(-2.22)**	(-2.12)**	(-1.44)	(-1.39)	(-1.46)	(-1.40)
Road Density	0.052	0.049	0.055	0.051	0.027	0.027	0.027	0.026
	(1.73)*	(1.73)*	(1.93)*	(1.87)*	(1.35)	(1.36)	(1.38)	(1.37)
Illiterate Rate	-4.57	-4.58	-3.91	-3.84	-1.40	-1.48	-1.46	-1.52
	(-1.70)*	(-1.67)*	(-1.50)	(-1.41)	(-0.82)	(-0.84)	(-0.85)	(-0.86)
Productivity	-0.000096	-0.000094	-0.00026	-0.00026	-0.00013	-0.00013	-0.00013	-0.00013
	(-0.21)	(-0.21)	(-0.55)	(-0.55)	(-0.43)	(-0.43)	(-0.40)	(-0.40)
Anti-corruption		6.71		11.80		3.29		3.34
		(0.26)		(0.47)		(0.19)		(0.20)
STD			162.87	175.20			-5.35	-1.48
			(1.47)	(1.64)			(-0.08)	(-0.02)
Constant	-436.22	-455.90	-386.22	-416.68	-306.40	-313.40	-306.28	-311.59
	(-2.32)**	(-2.10)**	(-1.93)*	(-1.85)*	(-2.60)***	(-2.38)**	(-2.48)**	(-2.27)**
R^2	0.67	0.66	0.66	0.65	0.88	0.88	0.88	0.87
Observations	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A3.5.6 Random Effects Results for Log Data with Charge

	FDI/GDP				FDI/POP			
	(10)	(11)	(12)	(13)	(10)	(11)	(12)	(13)
Charge†	-0.25	-0.27	-0.31	-0.33	-0.25	-0.27	-0.31	-0.33
	(-1.26)	(-1.38)	(-1.57)	(-1.70)	(-1.22)	(-1.34)	(-1.54)	(-1.67)
GRP per capita	1.49	1.41	1.09	0.97	2.44	2.36	2.01	1.90
	(3.68)***	(3.68)***	(2.43)**	(2.24)**	(6.08)***	(6.17)***	(4.56)***	(4.42)***
Wage	5.56	4.86	6.27	5.30	7.69	6.98	8.42	7.43
	(0.86)	(0.74)	(0.97)	(0.80)	(1.23)	(1.10)	(1.33)	(1.14)
Wage^2	-0.37	-0.32	-0.41	-0.34	-0.49	-0.45	-0.54	-0.47
	(-0.96)	(-0.82)	(-1.06)	(-0.87)	(-1.33)	(-1.19)	(-1.43)	(-1.22)
GIP	-0.15	-0.15	-0.13	-0.13	-0.11	-0.11	-0.097	-0.096
	(-1.02)	(-1.06)	(-0.96)	(-0.98)	(-0.77)	(-0.80)	(-0.68)	(-0.70)
Pop. Density	0.35	0.39	0.39	0.44	0.33	0.36	0.36	0.41
	(1.43)	(1.57)	(1.64)	(1.82)	(1.30)	(1.46)	(1.52)	(1.71)
Rail Density	-0.31	-0.33	-0.37	-0.40	-0.29	-0.31	-0.35	-0.38
	(-2.54)**	(-2.68)***	(-3.00)***	(-3.06)***	(-2.36)**	(-2.51)**	(-2.81)***	(-2.89)***
Road Density	0.49	0.47	0.56	0.53	0.48	0.47	0.55	0.53
	(2.08)**	(2.01)**	(2.47)**	(2.34)**	(2.04)**	(1.97)**	(2.46)**	(2.32)**
Illiterate Rate	0.11	0.13	0.12	0.15	0.11	0.14	0.12	0.15
	(0.42)	(0.51)	(0.49)	(0.59)	(0.44)	(0.52)	(0.51)	(0.61)
Productivity	0.17	0.16	0.094	0.075	0.19	0.17	0.11	0.090
	(0.77)	(0.71)	(0.43)	(0.34)	(0.85)	(0.78)	(0.51)	(0.41)
Anti-Corruption		0.25		0.32		0.26		0.32
		(0.95)		(1.19)		(0.96)		(1.21)
STD			1.06	1.09			1.10	1.13
			(2.84)***	(2.96)***			(2.92)***	(3.05)***
Constant	-31.22	-28.09	-30.25	-25.86	-49.09	-45.90	-48.02	-43.54
	(-1.11)	(-0.98)	(-1.07)	(-0.89)	(-1.79)*	(-1.65)*	(-1.75)*	(-1.54)
R^2	0.73	0.72	0.72	0.72	0.85	0.85	0.85	0.84
Observations	149	149	149	149	149	149	149	149

Robust z-statistics in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

CHAPTER FOUR

ENDOGENOUS ENVIRONMENTAL REGULATIONS

4.1 Introduction

In previous chapters, we find the evidence for the existence of pollution haven behaviour of FDI within China, i.e. FDI is attracted to regions with weak environmental regulations. However, environmental policy may be influenced by local government behaviour. Local authorities sometimes tolerate environmental violations, driven by the need to boost economic growth. For example, in 2006 the two serious pollution incidents in Gansu and Hunan Provinces were both caused by negligence and malpractice of the local government and environmental departments, which ignored people's health in favour of economic growth.[52] The relationship between polluting industries and local officials may therefore weaken the level of environmental enforcement. Governments' failure to fulfil their environmental responsibilities and interference in environmental law enforcement are the main reasons for some of China's persistent environmental problems. Therefore, it is possible that local government may reduce the environmental regulations in low FDI regions in order to attract more investment. Hence, government behaviour may impact on FDI inflows through their impact on environmental regulations.

In this chapter, we use the same dataset that we use in Chapters two and three to revisit the pollution haven debate but this time we treat our three measures of environmental

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52 Huixian County Non-Ferrous Metal Smelter Co Ltd, which produced about 5,000 tons of lead a year, had never operated anti-pollution equipment, despite being upgraded in 2004, and was guilty of illegal waste discharges ever since it began operations in 1996. The factory continued to operate secretly after being told to stop production in early 2006. The lead poisoning resulted in the hospitalisation of 250 children under age 14 and left hundreds of others with excessive amounts of lead in the blood, at Huixian County in Gansu Province. The chairman of the polluting smelter, and other 19 officials (mostly county-level officials and city environmental authorities) received various punishments for their roles in the lead contamination scandal. The other serious pollution incident was caused by two factories in Yueyang County in Hunan Province that released wastewater with high concentrations of an arsenic compound into the Xinqiang River, affecting the water supply for 80,000 residents in the lower reaches. The head and a deputy head of the local environmental protection bureau were fired and other five officials were given warning and other penalties. The two plants were closed and the managers of the two companies have been arrested, facing criminal charges and prosecution (China View, 2006a, 2006b and 2007).

regulations as endogenous. First, we examine whether environmental regulations have a negative effect on FDI inflows across Chinese provinces, and second, we examine the role of government characteristics (anti-corruption effort and government efficiency) play in the determination of environmental stringency.

Brunnermeier and Levinson (2004) summarise two issues that complicate empirical tests of the pollution haven hypothesis: unobserved heterogeneity and endogeneity. The first issue has been addressed in previous chapters by using panel data and incorporating regional fixed effects. The second issue is that both environmental regulations and FDI may be endogenous. On one hand, Henderson and Millimet (2007) argue that regulatory stringency may be related to bureaucratic corruption (Fredriksson *et al.* 2003), political climate, or the presence of industry subsidies used to offset the costs of pollution abatement (Eliste and Fredriksson, 2002). On the other hand, there are causal relationships between FDI and environmental regulations running in both directions, i.e. environmental regulations could be a function of FDI (Brunnermeier and Levinson, 2004).[53] The solution of the second issue is to employ an instrumental variable approach to account for the endogeneity of environmental stringency.

Within the pollution haven literature some studies focusing on trade and environmental regulations have found more robust evidence of a moderate pollution haven effect, for instance, Ederington and Minier (2003) and Levinson and Taylor (2008). They find that pollution abatement costs and expenditures (PACE) have no impact on US exports when the PACE are treated as exogenous, but have significant impact when PACE are treated as endogenous.

[53] For example, if higher FDI leads to higher income, and higher income leads to greater demand for environmental quality, then environmental regulations could be a function of FDI (Brunnermeier and Levinson, 2004).

Evidence is also provided by empirical studies focusing on FDI and environmental stringency. Xing and Kolstad (2002) is the first study to take into account the endogeneity of environmental regulations. Due to a lack of regulation data, the stringency of environmental regulations is expressed as an inverse function of pollution emissions (SO_2), i.e. environmental stringency is determined by SO_2 emissions and other variables. Then they substitute this function for environmental regulations in the FDI model. They employ instruments for SO_2 emissions and investigate outbound US FDI to 22 countries in six manufacturing sectors. The cross-section estimation suggests positive significant coefficients on SO_2 emissions for the two most pollution intensive industries, chemicals and primary metals only, i.e. FDI is an increasing function of lax environmental regulations for these two sectors. In general, the results indicate that lax environmental policy in a foreign host country tends to attract more FDI from the US for pollution intensive industries.

Another paper that considers the endogeniety of environmental policy is Fredriksson *et al.* (2003) when examining the intra-country pollution haven effects of US inbound FDI. In this paper, they also allow for the impact of differences in regional corruption levels. In a model of international capital flows, capital flows have a positive relationship with the pollution emission levels, i.e. capital flows are reduced by stringent environmental standards. When considering the effect of corruption, the model suggests that corruption influences capital flows through two channels. First, corruption influences the level of capital stock through its effect on environmental policy, and this effect is positive (negative) if an increase in corruption results in greater capital inflows (outflows). Second, corruption influences capital flows through its impact on public goods, and this effect is negative because the theft of public funds reduces the expenditure on productivity enhancing public goods and thus lowers the productivity of capital. Therefore, conditional on environmental regulation and public goods, corruption has no measurable effect on FDI inflows.

Fredriksson *et al.* (2003) use state-level panel data from 1977 to 1987 to test the predictions of their model. The first stage results confirm their theory that corruption has a significant effect on environmental stringency and the supply of public goods. From the second stage results, they find public expenditure and environmental stringency to have an impact upon FDI in some sectors; while conditional on environmental policy and supply of public goods, they do not find a remaining influence of corruption on FDI inflows. Additionally, the effects of environmental stringency are found to be sensitive to the exogeneity assumption, which explains the significant effect of environmental regulations compared with the previous literature.

The majority of previous theoretical and empirical papers in this area investigate the effects of differences in the stringency of environmental regulations on FDI. The influence of FDI on environmental policy is ignored. Cole *el al.* (2006) firstly address this weakness and develop a political economy model of local environmental policymaking. The model assumes an imperfectly competitive local goods market containing both local and foreign firms, which jointly lobby the local government for a favourable pollution tax. The impact of FDI on environmental stringency is conditional on the government's degree of corruptibility. If the degree of corruptibility is low (high), FDI leads to more (less) stringent environmental policy. Using panel data containing 33 developed and developing countries from 1982 to 1992, the empirical results are consistent with their predictions of the model. The results also suggest that the overall effect of corruption on environmental stringency is negative at the mean level of FDI stock, however, positive at the mean level of FDI flows.

In this chapter, we control for the endogeneity of environmental regulations to investigate whether or not intra-country pollution haven effects exist within China. The results show that two of our measures of environmental stringency, *Punish* and *Charge*, are exogenous in our estimation, i.e. only *EI1* is endogenous. After controlling for endogeneity, we find *EI1* has a negative effect on FDI inflows and the magnitude of this effect is much larger than that in Chapter three, indicating that the previous estimation involving *EI1* is biased downwards. Such an effect is generally robust using different measures of FDI and a fixed-effects estimator; however, it is not robust using different instrumental variables and random-effects estimator.

The organisation of this chapter is as follows. Section 4.2 describes the empirical model and the variables. Section 4.3 reports the results and Section 4.4 concludes.

4.2 Empirical Model and Variables

To consider the endogeneity of environmental regulations, the model of Fredriksson *et al.* (2003) suggests that corruption plays an important role in the determination of environmental regulations, but has no remaining effect on FDI conditional on environmental policy and the supply of public goods. Therefore, corruption is excluded in their main model and included as a determinant of FDI for the robustness checks.

However, in the case of China, we cannot find any reliable index to measure the regional government corruption level. Following Chapter three, we examine the impact of government anti-corruption effort and government efficiency on environmental regulations. In addition, we have illustrated that government anti-corruption effort and government efficiency do have effects on inter-province FDI location choice in China. Therefore, these two government characteristic variables are also included in our main model.

The following empirical model is the same as that in Chapter three.

$$FDI_{it} = \alpha + \beta_1 ER_{it-1} + \beta_2 X_{it-1} + \beta_3 Anti-Corruption_{it-1} + \beta_4 STD_{it-1} + \eta_i + \gamma_t + \varepsilon_{it} \tag{4.2.1}$$

where

FDI is the amount of FDI inflow into region *i* in time period *t*;

ER is the vector of measures to capture environmental stringency;

X is the set of other regional characteristics that may affect FDI;

Anti-Corruption is the regional effort on tackling corruption;

STD is the index of regional government efficiency;

η is a time-invariant regional effect;

γ is a location-invariant time fixed effect; and

ε is the idiosyncratic error term.

As before, we focus on the log specification. We retain the same two continuous measurements of FDI (*FDI/GDP* and *FDI/POP*), and the same set of explanatory and control variables on the right-hand-side of the equation, i.e. environmental stringency (*ER*), government bureaucracy characteristics (*Anti-Corruption* and *STD*) and *X*. *ER* is captured by three different measures, *EI1*, *Punish* and *Charge*. *X* includes all the control variables used in previous chapters: income, manufacturing wage, agglomeration effects, population density, infrastructure, education level and labour productivity. As in previous chapters, we expect negative β_1 and positive β_3 and β_4.

We still take one year lags of all the explanatory variables partly because the impact of these variables on FDI is unlikely to be immediate; and partly because taking lags help to minimise any potential causality links from FDI to all the control variables. In this case, we only consider the impact of the control variables and others on the environmental regulations. Taking lags for all the independent variables including the endogenous variables has been used in previous empirical studies, such as Cole *et al.*, 2006.

To allow for the potential endogeneity of environmental regulations, we apply an instrumental variable approach. The main econometric problem is to find appropriate instruments for environmental regulations (*ER*). To be suitable for use as an instrument, the variable must be correlated with the stringency of environmental regulations, yet have no correlation with FDI inflows. We employ instruments similar to those employed by Fredriksson *et al.* (2003). One is the share of government expenditure on public security agencies, the procuratorial agency and court of justice in regional GDP (labelled as *Legalsh*). The expenditure on the legal system "may explain the differential enforcement of environmental legislation across states by affecting the resources devoted to enforcing regulations (or, conversely, protecting firms from enforcement)".[54] By similar reasoning, we also include regional government employment (*Gov.Employment*) and the interaction term between *Gov.Employment* and *Legalsh* as instruments.

For a sensitivity check, we employ another set of instrumental variables. Xing and Kolstad (2002) choose two external exogenous variables as instruments, infant mortality rate and population density. They argue that the infant mortality rate indicates "a general level of social consciousness …, which is likely to accompany strict environmental regulations"; and "population density is an indicator of congestion and the ability of pollutants to

[54] Fredriksson *et al.* (2003), pp. 1416.

naturally disperse away from population centres".[55] Thus, as a second set of instruments, we include the rate of surviving children to the live births (*Mortality*) and population density (*Pop.Density*).[56] Population density has been used as a control variable in the main estimation equation in the previous chapters. However, it does not have a constant and significant affect on FDI inflows. For a sensitivity check, we thus drop population density from the main estimating equation and use it as one of the excluded instrumental variables.

Finally, other exogenous variables in Equation 4.2.1 are also used to instrument environmental regulations.[57] Since these variables are lagged in the second-stage regression, they also enter the first-stage regressions in lagged form. Data that were used to construct *Legalsh*, *Gov.Employment*, and *Mortality* are collected from the China Statistical Yearbook (various years). Appendix 4.1 provides a table of the descriptive statistics of these instruments.

We report estimates based on instrumental variables estimations with fixed effects. To be consistent with previous chapters, we apply the FGLS estimator (IV-FGLS) to the two-stage estimations. Since the model treating environmental stringency endogenously is over-identified, we provide results of a Sargan test of the over-identifying restrictions to assess the validity of our instruments. We also present Davidson-MacKinnon test results to examine whether our three measures of environmental regulations can be treated as exogenous.

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[55] Xing and Kolstad (2002), pp. 11.

[56] Live births refer to the births when babies had shown any vital phenomena regardless of the length of pregnancy.

[57] We test the endogeneity of lagged *Anti-Corruption* and *STD*. The results do not reject the exogeneity hypothesis of these two variables.

We employ the two-stage estimations manually. Hence the estimated standard errors in the second-stage regressions need to be modified. To find the true standard errors, we multiply the estimated standard errors by a correction factor. The formula of the correction factor is given in Appendix 4.2. We also employ a fixed-effects estimator (IV-Within) and random-effects estimator (IV-RE) for comparison (see results tables in Appendix 4.3).

4.3 Results

4.3.1 Results for EI1

Table 4.3.1 reports our main FGLS results based on both measures of FDI (*FDI/GDP* and *FDI/POP*) when using *EI1* to proxy environmental stringency. Models (1) and (4) report the results that we have reported in Chapter three, Models (2) and (5) report estimates using the first set of instrumental variables, and Models (3) and (6) reports the estimates using the alternative instruments for sensitivity checks.

For all the models that employed instrumental variables, the Davidson-MacKinnon (DM in tables) test rejects the hypothesis that *EI1* can be treated as exogenous, so that the results reported in Chapter three (Models 1 and 4 in Table 4.3.1) are inconsistent. A Sargan test of over-identification restrictions shows that the exogeneity of the instruments is not rejected, i.e. the instruments are uncorrelated with the error term, and the excluded instruments are correctly excluded from the estimated equation (in short, the instruments are valid).

The first-stage results (See Table A4.4.1 in Appendix 4.4) show that *EI1* is only significantly affected by a few variables. An increase in government size will reduce the pollution treatment investment. The impacts of industrial agglomeration (*GIP*) and road density on *EI1* are also negative. Neither of our government bureaucracy variables has significant effect on environmental regulations. This result is inconsistent with the model and findings in Fredriksson *et al.* (2003). One reason may be that the Chinese government only began to pay more attention to the fight against the government-backed environmental violations in recent years. The central government has announced that environmental protection would be an important index for assessing local governments' performance starting from 2007. Therefore, few corruption and malpractice cases relating to the environment have been investigated by the procuratorates. Moreover government protection is not included when calculating the government efficiency index.[58] This could be a possible explanation for the insignificant results on *Ant-Corruption* and *STD*. However, each specification in the first stage is significant at the 1% (*P*=0.000) level indicating that our estimations have significant explanatory power.[59]

In terms of the results using the first set of instrumental variables in Table 4.3.1, we find *EI1* has a significant negative effect on FDI inflows in Models (2) and (5), which is consistent with the pollution haven hypothesis that FDI is attracted by lax environmental regulations. In Model (2), when using FGLS estimator in the two-stage estimation, we find that the marginal effect of *EI1* is -0.72, indicating that a 10% increase in local industrial pollution treatment investment will reduce the share of FDI to GDP in this region by 7.2%.

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[58] STD index considers the treatment efficiency of industrial wastewater, waste gas and solid waste, which relate to environment. But the weight of the efficiency is only 0.03 (=0.2×0.5×0.3).

[59] *EI1* in Table A4.2.1 is lagged for one year as well as all the control variables and instrumental variables. However, the impact of the explanatory variables on *EI1* is unlikely to be immediate. It is a possible explanation for the less significant first-stage results.

This impact is approximately ten times that in Model (1) without the control for endogeneity. It suggests that the estimation in Model (1) is biased downwards. Similar results are also found when we use the alternative normalisation of FDI in Models (4) and (5). These results suggest the stringent environmental regulations decrease the inflows of FDI in all regions in China.

With regard to our government bureaucratic variables, we find positive coefficients on *Anti-Corruption*. The magnitude of the effect is broadly consistent across specifications. FDI is therefore attracted to regions that have put more effort on fighting against corruption. In terms of *STD*, we fail to find significant results when controlling for the endogeneity of *EI1*.

Turning to other control variables, only income (*GRP per capita*) always yields a significant positive relationship with FDI inflows. In Models (2), we find negative agglomeration effects (*GIP*) on *FDI/GDP* at 10% significant level, but the impact is not constantly significant across models.

We do not find constant and significant results for our other control variables when we instrument *EI1* using *Legalsh*, *Gov.Empoyment* and the product of them. Models (2) and (5) in Table 4.3.1 show broadly similar results for different measures of FDI.

Table 4.3.1 FGLS Regression Results for Log Data with EI1

	(1) FDI/GDP	(2) FDI/GDP IV	(3) FDI/GDP Alt. IV	(4) FDI/POP	(5) FDI/POP IV	(6) FDI/POP Alt. IV
EI1†	-0.070	-0.72	0.55	-0.073	-0.68	0.93
	(-2.17)**	(-2.92)***	(0.93)	(-2.21)**	(-2.97)***	(1.08)
GRP per capita	3.45	3.28	2.59	3.88	3.83	2.69
	(4.54)***	(2.46)**	(1.90)*	(5.18)***	(3.05)***	(1.26)
Wage	7.09	5.33	9.21	8.48	6.70	11.79
	(1.59)	(0.74)	(1.32)	(1.88)*	(0.99)	(1.07)
Wage^2	-0.48	-0.36	-0.58	-0.55	-0.45	-0.72
	(-1.77)*	(-0.85)	(-1.39)	(-2.02)**	(-1.12)	(-1.08)
GIP	-0.21	-1.47	0.94	0.0096	-1.19	1.82
	(-0.62)	(-1.82)*	(0.80)	(0.03)	(-1.56)	(1.03)
Pop. Density	-0.31	-0.031		0.021	0.37	
	(-0.47)	(-0.027)		(0.03)	(0.31)	
Rail Density	-0.26	-0.29	-0.32	-0.23	-0.24	-0.31
	(-2.45)**	(-1.59)	(-1.83)*	(-1.98)**	(-1.27)	(-1.18)
Road Density	0.37	0.0095	0.63	0.37	0.040	0.78
	(4.04)***	(0.048)	(2.21)**	(3.77)***	(0.21)	(1.74)*
Illiterate Rate	0.36	0.17	0.42	0.33	0.17	0.41
	(2.94)***	(0.78)	(1.82)*	(2.59)***	(0.76)	(1.06)
Productivity	-0.17	-0.020	-0.25	-0.15	0.017	-0.27
	(-1.36)	(-0.083)	(-1.18)	(-1.24)	(0.072)	(-0.77)
Anti-Corruption	0.53	0.58	0.52	0.53	0.61	0.45
	(3.87)***	(2.41)**	(2.32)**	(3.84)***	(2.64)***	(1.23)
STD	0.60	0.48	0.59	0.65	0.49	0.64
	(2.59)***	(1.16)	(1.53)	(2.74)***	(1.21)	(1.00)
Constant	-48.44	-27.35	-65.34	-63.07	-43.60	-87.82
	(-2.21)**	(-0.72)	(-1.90)*	(-2.82)***	(-1.21)	(-1.63)
Wald χ^2	6977.84	7553.28	6528.47	11187.17	13281.53	11780.47
Observations	149	149	149	149	149	149
Sargan test		P=0.659	P=0.771		P=0.654	P=0.885
DM test		P=0.000	P=0.001		P=0.000	P=0.001

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

4.3.2 Sensitivity Analysis

Table 4.3.1 also reports the results employing an alternative set of instrumental variables (mortality and population density) in the first stage estimations. Model (3) scales FDI by GDP while Model (6) scales FDI by population. The Davidson-MacKinnon test and Sargan test results suggest that *EI1* is endogenous and the instrumental variables are valid. However, we no longer find a negative significant effect of *EI1* on FDI inflows. *EI1* has a positive coefficient although it is not statistically different from zero.

For other variables in Model (3), we find that income, road density, rate of illiteracy and anti-corruption effort have positive and significant effects on FDI inflows, whilst the impact of railway density is negative and significant. These results are broadly consistent with those in Model (1). In Model (6), only road density is found to have a significant coefficient at 10% level, although other variables coefficients are similar to those in Model (3) in sign and magnitude.

As another check on the robustness of our results, we use the within estimator and random-effects estimator. Results are reported in Appendix 4.3. The within estimator results are broadly similar to those in Table 4.3.1.[60] When we use the first set of instruments (Models 2 and 5), we find significant negative coefficient on *EI1*, and the marginal effect of *EI1* is even larger (almost double that in Table 4.3.1). Government efficiency is found to have a significant influence on FDI inflows. We also find a positive effect of income and a non-linear relationship between manufacturing wage and FDI in

[60] FGLS and within estimator both consider the fixed effects.

Models (2) and (5).[61] The results using alternative IVs are similar to those using the FGLS estimator.

Hausman specification test results (in Table A4.3.2) suggest that the random-effect estimator is always efficient when controlling for the endogeneity of environmental stringency variable *EI1*. However, for the random-effects results we no longer find any evidence to support the negative effect of environmental regulations on FDI inflows. Moreover, we find insignificant negative coefficient on *Anti-Corruption* which is contrary to all the fixed-effects regression results. The coefficient of government efficiency (*STD*) is positive but not statistically different from zero. The results for other control variables are roughly similar to those using within estimator.

4.3.3 Results for Punish and Charge

In terms of the other two measures of environmental regulations *Punish* and *Charge*, the Davidson-MacKinnon test suggests that they both can be treated as exogenous in all models. Therefore, the results in the previous chapters are consistent. Nevertheless, we include the results controlling for the endogeneity of *Punish* and *Charge* in Appendix 3.4. The Sargan test suggests the instrumental variables are valid. The effect of these two measures of environmental regulations remains negative but insignificant. The results of the other control variables are broadly similar to those in Table 4.3.1.

We do not report the sensitivity check results when we using *Punish* and *Charge* to proxy environmental regulation stringency, because the Davidson-MacKinnon test still suggest

[61] The turning points in Models (2) and (5) in Table A4.3.1 are both around RMB 4140 (about $ 866). In our sample, 60% of the observations are located on the down sloping part of the inverted-U curve. And all the provinces have passed the turning point at the wage level in 2002.

that they both can be treated as exogenous when we adopt the alternative set of instrumental variables. They both remain negative and insignificant.

4.4 Conclusions

In this chapter, we address the endogeneity issue of environmental regulations to re-examine the intra-country pollution havens within China. We apply an instrumental variable approach to our base models in Chapters two and three. We find that the first measure of our environmental regulations, *EI1*, is endogenous, while the other two measures, *Punish* and *Charge,* can be treated as exogenous. After controlling for endogeneity, *EI1* still has a significant and negative effect on FDI. It confirms that there are inter-province pollution haven effects of FDI inflows in China. We also find that such an impact is larger than those found in Chapter three, suggesting that the impact of *EI1* is biased downwards in Chapter three. However, the effect of environmental regulations on FDI does not pass all of the sensitivity checks when we use a different set of instrumental variables and random-effects estimator.

We do not find any measurable effects of government bureaucratic characteristics on environmental regulations during our investigation period. However, we find significant and positive effects of anti-corruption effort on FDI inflows.

One deficiency of this chapter is that the selected instrumental variables are relatively weak, which leads to weak results in the first-stage estimation. However, the difficulty in searching for the valid instrumental variables makes them be the best available choice.

Appendix 4.1 Descriptive Statistics of the Instruments

Variable	Obs.	Mean	Std. Dev.	Min	Medium	Max
Legalsh. (%)	149	0.87	0.30	0.33	0.83	1.99
Gov. Employment (10 000 persons)	149	36.54	19.43	6.10	34.78	82.64
Mortality (%)	150	2.08	3.28	0.44	1.27	34.50

Appendix 4.2 Correction Factor

We construct the correction factor using the method introduced in Gujarati (1995). For simplicity, suppose we estimate the following regression:

$$\boldsymbol{Y_t} = \beta_0 + \beta_1 \boldsymbol{X_t} + \varepsilon_t \qquad \text{(A4.2.1)}$$

where X_t is endogenous.

In stage 1, we regress X_t on all instrumental variables $\boldsymbol{Z_t}$.

$$\boldsymbol{X_t} = \hat{\Pi}_0 + \hat{\Pi}_1 \boldsymbol{Z_t} + \hat{\mu}_t \qquad \text{(A4.2.2)}$$

Then, we obtain

$$\boldsymbol{\hat{X}_t} = \hat{\Pi}_0 + \hat{\Pi}_1 \boldsymbol{Z_t} \qquad \text{(A4.2.3)}$$

where $\boldsymbol{\hat{X}_t}$ is an estimated mean value of X conditional on the fixed $\boldsymbol{Z}$'s. Then Equation (A4.2.2) can be expressed as

$$\boldsymbol{X_t} = \boldsymbol{\hat{X}_t} + \hat{\mu}_t \qquad \text{(A4.2.4)}$$

Then Equation (A4.2.1) in stage 2 can now be written as

$$\begin{aligned} \boldsymbol{Y_t} &= \beta_0 + \beta_1 \boldsymbol{X_t} + \varepsilon_t \\ &= \beta_0 + \beta_1 (\boldsymbol{\hat{X}_t} + \hat{\mu}_t) + \varepsilon_t \\ &= \beta_0 + \beta_1 \boldsymbol{\hat{X}_t} + (\varepsilon_t + \beta_1 \hat{\mu}_t) \\ &= \beta_0 + \beta_1 \boldsymbol{\hat{X}_t} + \varepsilon_t^* \end{aligned} \qquad \text{(A4.2.5)}$$

where $\varepsilon_t^* = \varepsilon_t + \beta_1 \hat{\mu}_t$.

When we run regression (A4.2.5), the standard error of, say, $\hat{\beta}_1$ is obtained from the following equation:

$$\text{var}(\hat{\beta}_1) = \frac{\hat{\sigma}_{\varepsilon*}^2}{\sum \hat{\boldsymbol{x}}_t^2} \qquad \text{(A4.2.6)}$$

where

$$\hat{\sigma}_{\varepsilon*}^2 = \frac{\sum (\hat{\varepsilon}_t^*)^2}{\boldsymbol{n} - 2} = \frac{\sum (\boldsymbol{Y}_t - \hat{\beta}_0 - \hat{\beta}_1 \hat{\boldsymbol{X}}_t)^2}{\boldsymbol{n} - 2} \qquad \text{(A4.2.7)}$$

However, $\hat{\sigma}_{\varepsilon*}^2$ is not the same as $\hat{\sigma}_{\varepsilon}^2$ (the unbiased estimate of true variance of ε_t, To obtain the true $\hat{\sigma}_{\varepsilon}^2$, we get

$$\hat{\varepsilon}_t = \boldsymbol{Y}_t - \hat{\beta}_0 - \hat{\beta}_1 \boldsymbol{X}_t \qquad \text{(A4.2.8)}$$

Hence,

$$\hat{\sigma}_{\varepsilon}^2 = \frac{\sum (Y_t - \hat{\beta}_0 - \hat{\beta}_1 X_t)^2}{n - 2} \qquad \text{(A4.2.9)}$$

Note that the difference between (A4.2.7) and (A4.2.9) is that in the latter equation we use the actual X rather than the estimated X from the first-stage regression.

Finally, we get the correction factor $\theta = \hat{\sigma}_{\varepsilon}^2 / \hat{\sigma}_{\varepsilon*}^2$

Then correct standard errors are obtained by multiplying θ to the standard errors of coefficients estimated in the second-stage regression; and hence the correct t-statistics are obtained using the coefficients divided by the correct standard errors.

Appendix 4.3 Fixed and Random Effects Results for Log Data with EI1

Table A4.3.1 Fixed Effects (Within-estimator) Regression Results for Log Data with EI1

	(1) FDI/GDP	(2) FDI/GDP IV	(3) FDI/GDP Alt. IV	(4) FDI/POP	(5) FDI/POP IV	(6) FDI/POP Alt. IV
EI1†	-0.072	-1.36	0.94	-0.071	-1.34	1.06
	(-0.82)	(-2.43)**	(1.08)	(-0.82)	(-2.39)**	(1.18)
GRP per capita	2.65	3.85	1.62	3.16	4.34	2.06
	(-1.80)*	(2.40)**	(1.06)	(2.20)**	(2.76)***	(1.38)
Wage	7.21	14.33	2.53	9.26	16.32	3.44
	(0.89)	(1.87)*	(0.33)	(1.16)	(2.13)**	(0.45)
Wage^2	-0.44	-0.86	-0.16	-0.56	-0.98	-0.22
	(-0.96)	(-1.98)**	(-0.35)	(-1.24)	(-2.25)**	(-0.48)
GIP	-0.053	-1.84	1.35	0.10	-1.67	1.68
	(-0.07)	(-1.73)*	(1.44)	(0.13)	(-1.54)	(1.74)*
Pop. Density	-0.86	-1.28		-0.62	-1.04	
	(-0.63)	(-0.94)		(-0.45)	(-0.75)	
Rail Density	-0.33	0.043	-0.61	-0.27	0.092	-0.60
	(-1.59)	(0.17)	(-2.50)**	(-1.30)	(0.36)	(-2.39)**
Road Density	0.40	-0.041	0.75	0.41	-0.032	0.80
	(1.61)	(-0.13)	(2.26)**	(1.65)	(-0.10)	(2.41)**
Illiterate Rate	0.23	0.011	0.40	0.21	-0.0022	0.40
	(0.77)	(0.032)	(1.30)	(0.71)	(0.007)	(1.29)
Productivity	0.055	0.070	0.045	0.078	0.093	0.066
	(0.16)	(0.21)	(0.14)	(0.23)	(0.28)	(0.20)
Anti-Corruption	0.40	0.71	0.18	0.43	0.73	0.16
	(1.28)	(2.20)**	(0.50)	(1.36)	(2.26)**	(0.46)
STD	1.04	1.10	1.01	1.11	1.17	1.06
	(2.14)**	(2.34)**	(2.14)**	(2.26)**	(2.47)**	(2.25)**
Constant	-43.90	-60.78	-36.74	-60.48	-77.20	-48.57
	(-1.03)	(-1.51)	(-0.99)	(-1.43)	(-1.92)*	(-1.33)
R^2	0.24	0.27	0.26	0.25	0.28	0.27
Observations	149	149	149	149	149	149
Sargan Test		P=0.894	P=0.804		P=0.881	P=0.969
DM test		P=0.015	P=0.036		P=0.016	P=0.021

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A4.3.2 Random Effects Regression Results for Log Data with EI1

	(1) FDI/GDP	(2) FDI/GDP IV	(3) FDI/GDP Alt. IV	(4) FDI/POP	(5) FDI/POP IV	(6) FDI/POP Alt. IV
EI1†	-0.070 (-0.81)	0.37 (0.49)	0.62 (0.99)	-0.071 (-0.83)	0.42 (0.54)	0.69 (1.09)
GRP per capita	1.03 (2.31)**	1.36 (3.48)***	1.26 (2.85)***	1.95 (4.40)***	2.33 (5.78)***	2.27 (5.04)***
Wage	8.75 (1.34)	7.23 (0.56)	2.74 (0.24)	10.88 (1.71)*	8.74 (0.66)	4.42 (0.37)
$Wage^2$	-0.55 (-1.44)	-0.48 (-0.62)	-0.20 (-0.29)	-0.68 (-1.82)*	-0.57 (-0.73)	-0.31 (-0.43)
GIP	-0.14 (-1.06)	-0.23 (-1.38)	-0.14 (-1.03)	-0.11 (-0.78)	-0.22 (-1.24)	-0.13 (-0.97)
Pop. Density	0.33 (1.40)	0.30 (1.07)		0.31 (1.29)	0.30 (1.06)	
Rail Density	-0.37 (-2.86)***	-0.47 (-1.86)*	-0.38 (-2.01)**	-0.35 (-2.66)***	-0.48 (-1.86)*	-0.40 (-2.06)**
Road Density	0.59 (2.63)***	0.76 (3.12)***	1.01 (5.52)***	0.58 (2.62)***	0.74 (3.00)***	1.01 (5.45)***
Illiterate Rate	0.13 (0.50)	0.010 (0.05)	0.071 (0.29)	0.14 (0.53)	0.027 (0.12)	0.069 (0.28)
Productivity	0.058 (0.25)	0.12 (0.57)	0.17 (0.80)	0.073 (0.31)	0.14 (0.62)	0.20 (0.87)
Anti-Corruption	0.30 (1.13)	-0.016 (-0.06)	-0.054 (-0.18)	0.31 (1.15)	-0.0026 (-0.01)	-0.079 (-0.25)
STD	0.99 (2.61)***	0.49 (0.85)	0.49 (0.84)	1.04 (2.70)***	0.52 (0.88)	0.44 (0.71)
Constant	-42.28 (-1.51)	-39.91 (-0.79)	-24.53 (-0.54)	-59.98 (-2.20)**	-55.32 (-1.07)	-41.00 (-0.87)
R^2	0.71	0.70	0.63	0.84	0.83	0.79
Observations	149	149	149	149	149	149
Hausman (*p-value*)	0.011	0.986	0.906	0.983	0.989	0.943

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Appendix 4.4 First Stage Regression Results: EI1

Table A4.4.1 First-stage Regression Results: EI1

	(2) and (5) FGLS	(3) and (6) FGLS	(2) and (5) Within	(3) and (6) Within	(2) and (5) RE	(3) and (6) RE
Legalsh†	1.87		0.88		0.58	
	(1.51)		(0.49)		(0.53)	
Gov.	-2.57		-1.22		-0.32	
Employment	(-3.10)***		(-0.79)		(-1.16)	
(Legalsh×Gov.	-0.52		-0.27		-0.22	
Employment)	(-1.58)		(-0.54)		(-0.72)	
Mortality		-0.10		-0.15		-0.14
		(-1.82)*		(-1.83)*		(-1.63)
GRP	0.82	1.03	1.07	1.19	-0.51	-0.23
per capita	(0.86)	(1.07)	(0.63)	(0.70)	(-1.21)	(-0.64)
Wage	3.90	-2.22	8.00	5.82	13.14	13.00
	(0.58)	(-0.34)	(0.68)	(0.48)	(1.83)*	(1.89)*
$Wage^2$	-0.24	0.12	-0.46	-0.34	-0.78	-0.80
	(-0.61)	(0.30)	(-0.66)	(-0.47)	(-1.83)*	(-1.90)*
GIP	-1.78	-1.79	-1.33	-1.48	0.37	0.14
	(-3.22)***	(-3.23)***	(-1.40)	(-1.63)	(1.60)	(1.16)
Pop.	0.76	-0.26	-0.63	-0.67	-0.40	-0.19
Density	(0.52)	(-0.18)	(-0.33)	(-0.34)	(-1.82)*	(-0.96)
Rail	0.16	0.0031	0.34	0.22	0.31	0.16
Density	(0.63)	(-0.01)	(0.95)	(0.63)	(2.02)**	(0.99)
Road	-0.45	-0.38	-0.30	-0.30	0.20	0.066
Density	(-1.75)*	(-1.48)	(-0.91)	(-0.91)	(0.95)	(0.31)
Illiterate	-0.21	-0.12	-0.21	-0.20	-0.098	0.025
Rate	(-0.83)	(-0.48)	(-0.58)	(-0.55)	(-0.45)	(0.13)
Productivity	0.057	0.10	-0.034	-0.013	-0.19	-0.17
	(0.37)	(0.66)	(-0.17)	(-0.07)	(-1.18)	(-1.05)
Anti-	0.11	0.051	0.18	0.22	0.031	0.14
Corruption	(0.53)	(0.26)	(0.55)	(0.67)	(0.01)	(0.58)
STD	-0.41	0.0028	-0.093	0.064	0.33	0.30
	(-0.94)	(-0.01)	(-0.14)	(0.10)	(0.73)	(0.66)
Constant	1.21	23.22	-19.92	-13.52	-46.04	-46.77
	(0.03)	(0.65)	(-0.34)	(-0.23)	(-1.49)	(-1.59)
Wald χ^2	888.29	721.50			85	82
R^2			0.43	0.43		
Observations	149	149	149	149	149	149
Province and Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Model Significance	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Appendix 4.5 Regression Results: Punish and Charge

Table A4.5.1 Regression Results for Log Data with Punish

	(1) FDI/GDP FGLS	(2) FDI/GDP IV-FGLS	(4) FDI/POP FGLS	(5) FDI/POP IV-FGLS
Punish†	-0.082 (-2.74)***	-0.18 (-0.73)	-0.074 (-2.39)**	-0.26 (-0.99)
GRP per capita	3.78 (5.01)***	3.62 (4.20)***	4.11 (5.46)***	4.08 (4.61)***
Wage	6.34 (1.40)	5.00 (0.89)	7.78 (1.69)*	4.83 (0.81)
$Wage^2$	-0.42 (-1.53)	-0.33 (-0.93)	-0.49 (-1.78)*	-0.30 (-0.80)
GIP	-0.36 (-1.06)	-0.26 (-0.45)	-0.099 (-0.29)	-0.14 (-0.23)
Pop. Density	-0.18 (-0.29)	-0.37 (-0.55)	0.23 (0.32)	0.035 (0.05)
Rail Density	-0.33 (-3.02)***	-0.36 (-2.87)***	-0.29 (-2.46)**	-0.35 (-2.54)**
Road Density	0.38 (3.79)***	0.35 (3.35)***	0.38 (3.59)***	0.33 (2.85)***
Illiterate Rate	0.30 (2.28)**	0.29 (1.78)*	0.26 (1.94)*	0.22 (1.25)
Productivity	-0.20 (-1.57)	-0.22 (-1.47)	-0.16 (-1.28)	-0.24 (-1.45)
Anti-Corruption	0.52 (3.60)***	0.51 (3.55)***	0.51 (3.48)***	0.50 (3.30)***
STD	0.56 (2.32)**	0.57 (2.23)**	0.62 (2.48)**	0.63 (2.30)**
Constant	-48.18 (-2.17)**	-27.35 (-1.52)	-63.26 (-2.78)***	-47.64 (-1.66)*
Wald χ^2	7708.80	6869.78	11218.06	11256.36
Observations	147	149	147	149
Sargan test		P=0.386		P=0.355
DM test		P=0.317		P=0.211

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A4.5.2 Regression Results for Log Data with Charge

	(1) FDI/GDP FGLS	(2) FDI/GDP IV-FGLS	(4) FDI/POP FGLS	(5) FDI/POP IV-FGLS
Charge†	-0.33 (-2.78)***	-0.87 (-1.47)	-0.34 (-2.86)***	-0.98 (-1.55)
GRP per capita	3.16 (4.11)***	3.76 (4.53)***	3.57 (4.73)***	4.22 (4.91)***
Wage	2.79 (0.59)	-0.87 (-0.12)	3.85 (0.80)	-0.63 (-0.08)
Wage^2	-0.19 (-0.67)	0.0066 (0.02)	-0.25 (-0.85)	-0.0025 (0.00)
GIP	0.18 (0.50)	0.18 (0.46)	0.41 (1.15)	0.44 (1.08)
Pop. Density	-0.74 (-1.09)	-1.18 (-1.37)	-0.44 (-0.59)	-0.92 (-0.96)
Rail Density	-0.46 (-4.17)***	-0.60 (-2.48)**	-0.43 (-3.69)***	-0.60 (-2.33)**
Road Density	0.33 (2.80)***	0.35 (3.57)***	0.31 (2.56)**	0.35 (3.14)***
Illiterate Rate	0.22 (1.49)	0.29 (2.15)**	0.20 (1.40)	0.25 (1.75)*
Productivity	-0.19 (-1.58)	-0.12 (-0.88)	-0.19 (-1.56)	-0.088 (-0.63)
Anti-Corruption	0.60 (4.19)***	0.53 (3.46)***	0.61 (4.26)***	0.54 (3.37)***
STD	0.66 (2.81)***	0.67 (2.33)**	0.72 (3.03)***	0.73 (2.44)**
Constant	-25.02 (-1.06)	-6.53 (-0.17)	-37.42 (-1.56)	-15.01 (-0.37)
Wald χ^2	7966.66	6969.60	11985.42	11041.23
Observations	149	149	149	149
Sargan test		P=0.210		P=0.258
DM test		P=0.191		P=0.167

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

Table A4.5.3 First-stage Regression Results: Punish and Charge

	Punish	***Charge***
	Models (2) and (5) FGLS	Models (2) and (5) FGLS
Legalsh†	2.92 (3.09)***	-0.45 (-1.01)
Gov. Employment	0.23 (0.40)	-0.34 (-1.49)
(Legalsh×Gov. Employment)	-0.84 (-2.93)***	0.061 (0.55)
GRP per capita	0.99 (0.84)	0.29 (0.81)
Wage	-10.42 (-2.00)**	-9.15 (-4.22)***
Wage^2	0.73 (2.44)**	0.55 (4.24)***
GIP	-1.56 (-2.87)***	0.23 (1.42)
Pop. Density	0.95 (1.04)	-0.92 (-3.31)***
Rail Density	-0.13 (-0.83)	-0.34 (-6.29)***
Road Density	-0.20 (-1.42)	-0.030 (-0.38)
Illiterate Rate	-0.38 (-2.03)**	-0.042 (-0.54)
Productivity	-0.35 (-2.14)**	0.022 (0.42)
Anti-Corruption	-0.040 (-0.28)	0.039 (0.59)
STD	-0.017 (-0.05)	0.18 (1.47)
Constant	41.42 (1.43)	51.62 (4.72)
Wald χ^2	1339.18	3404.53
Observations	147	149
Province and Time Effects	Yes	Yes
Model Significance	P=0.000	P=0.000

t-statistics (for within estimator) and z-statistics (for FGLS estimator) in parentheses; † all the independent variables are in logs except STD; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Province and time dummies are included.

CHAPTER FIVE

ECONOMIC GROWTH, FOREIGN INVESTMENT AND THE ENVIRONMENT: EVIDENCE FROM CHINESE CITIES

5.1 Introduction

In this chapter, we investigate the environmental effects of economic growth and foreign investment using Chinese city-level data.

The relationship between economic growth and the environment was first observed by Grossman and Krueger (1991) in their investigation of the environmental impacts of a North American Free Trade Agreement. They find the relationship between economic growth and environmental quality "may change sign from positive to negative when a country reaches a level of income at which people demand and afford more efficient infrastructure and a cleaner environment".[62] Such an inverted-U relationship between environmental degradation and economic growth is known as the Environmental Kuznets Curve (EKC), analogous to the income-inequality relationship hypothesised by Kuznets (1955).

Since 1992, a considerable amount of empirical and theoretical research has examined the relationship between economic growth and various indicators of environmental degradation, with mixed results. Generally there are two different schools of thought in the EKC literature: optimists, who support the EKC implication that economic growth is ultimately good for the environment (e.g. Beckerman, 1992; Shafik and Bandyopadhyay, 1992, Grossman and Krueger, 1995; Lomborg, 2001); and critics, who point out a number of methodological flaws in deriving the EKC or advocate caution in interpreting its causes and implications (e.g. Arrow *et al.*, 1995; Stern *et al.*, 1996; Ekins, 1997; Stern, 1998; Suri and Chapman, 1998; Rothman, 1998; Stern and Comman, 2001; and Cole, 2003 and 2004).

62 Panayotou (2003), pp. 2.

One of the most damaging criticisms is related to the occurrence of foreign direct investment and international trade. "The argument asserts that the downturn in emissions at higher levels of PCI (per capita income) can be explained, at least to some extent, by the relocation of 'dirty' industries from developed to developing countries, and the tendency among developed countries to import pollution-intensive goods from developing countries rather than produce them at home."[63]

The past approach of empirical work on trade/FDI patterns and the EKC is to test the pollution haven hypothesis (Tobey, 1990; Birdsall and Wheeler, 1993; Jaffe *et al.*, 1995; Rothman, 1998; Antweiler *et al.*, 2001; Levinson, 1996a and 1996b; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; and Smarzynska-Javorcik and Wei, 2005). These studies find little evidence that environmental stringency impacts on trade/investment flows. However, it does not mean that trade and FDI flows do not explain the environmental Kuznets curve.

Grossman and Krueger (1991) describe three possible sources of environmental impact from a greater openness to trade and foreign investment: a scale effect, a technique effect and a composition effect. Such points of view are usually used in the following studies on FDI and the environment.

The scale effect relates to the impact on the environment as a result of an increase in economic output due to the expansion of investment. The composition effect refers to investment that will change the industrial structure of an economy. The technique effect states that investment on one hand drives a more rapid rate of technology development, diffusion and transfer, and on the other hand increases income and hence the demand for a

[63] Nahman and Antrobus (2005), pp.112

cleaner environment. All these changes can influence the pollution level in different directions. In general, the scale effect is expected to be negative, and technique effect is expected to be positive, while composition effect is ambiguous. Therefore, the real relationship between FDI and the environment cannot be explained simply as positive or negative. Previous studies (e.g. Jha, 1999; and Zarsky, 1999) show that the effects of FDI on host counties' environment can be positive, negative, or neutral.

Although many empirical studies have been devoted to the impact of environmental stringency on FDI inflows, studies on the "net effect" of FDI on the environment are rather scarce. One reason for the scarcity is that it is difficult to clearly separate the environmental effects of domestic economic activity from the effects from activities of foreign affiliates.

In this chapter, we investigate the relationship between economic growth and industrial pollution emissions in China using data for 112 major cities from 2001 to 2004. We also compare the environmental effects of domestic firms with those of foreign firms. Foreign firms are split into two groups: affiliates from Hong Kong, Macao and Taiwan, and affiliates from other foreign economies. We choose four industrial water pollution indicators (wastewater, chemical oxygen demand, hexavalent chromium compounds, and petroleum-like matter) and four industrial air pollution indicators (waste gas, sulphur dioxide, soot and dust).

Our random-effects results suggest that most air and water pollution emissions rise with the increase of economic growth at the current income levels. Domestic firms have a strong and positive impact on all pollution emissions. The impact of firms from Hong Kong, Macao and Taiwan is positive for all pollution emissions but only significant for the first three industrial water pollution emissions; while the impact of firms from other foreign economies is only positive and significant for petroleum-like matter, and neutral for other pollutants.

This chapter is organised as follows. Section two describes the theoretical and empirical research on the EKC and FDI-environment relationship. Section three introduces the related background information. Section four provides the model specification and data description. Section five describes the empirical results and section six draws the conclusions and policy implications.

5.2 Literature Review

This section commences with the theoretical and empirical studies on economic growth and the environment, then introduces the literature on the environmental effects of FDI, and finally provides a brief summary including the contributions of the present study.

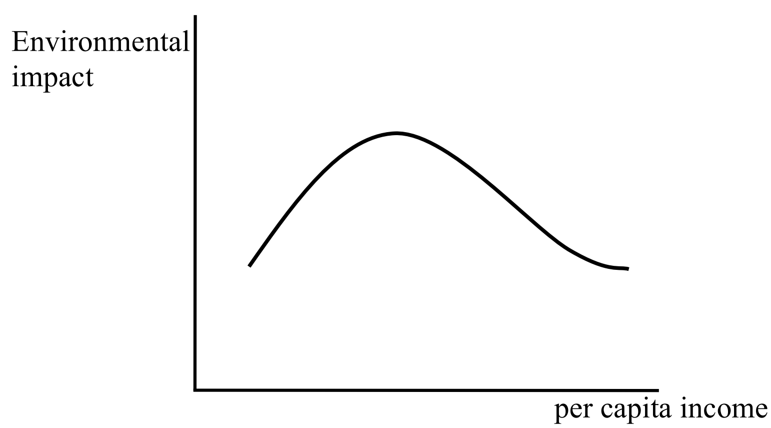
5.2.1 Economic Growth and the Environment

5.2.1.1 Theoretical Principles

The basic Environmental Kuznets Curve is the hypothesis that as an economy's per capita income increases, the total amount of environmental impact of economic activities initially grows, reaches a maximum and then falls. The hypothesis is illustrated in Figure 5.2.1.

Grossman and Krueger (1991) explain that the improvement in environmental quality at higher levels of per capita income due to factors such as changes in the composition of output, the introduction of cleaner production technology, and the greater demand for improved environmental quality, leading to more stringent environmental regulations. Grossman and Krueger (1995) add another possible explanation for the downward sloping part of the EKC: as countries develop, they stop producing the pollution-intensive goods and instead import them from developing countries with weaker environmental standards. However, they argue that it does not mean the differences in environmental stringency are an important determinant of the pattern of international trade, because "the volume of such trade is probably too small to account for the reduced pollution that has been observed to accompany episodes of economic growth".[64]

Figure 5.2.1 Environmental Kuznets Curve



Numerous theoretical and empirical papers have considered the relationship between economic growth and environmental quality. Theoretical studies have concentrated on deriving the path of environmental quality and development under alternative assumptions

[64] Grossman and Krueger (1995), pp. 372.

about social welfare functions, pollution damage, the cost of abatement, and the productivity of capital (Dasgupta *et al.* 2002).

Lopez (1994) uses a model to show that if producers pay the social marginal cost of pollution, the relationship between pollution and income depends on the properties of both technology and preferences. If the preferences are homothetic, pollution levels will increase with economic growth. If the preferences are non-homothetic, the relationship between income and pollution depends on the elasticity of substitution between pollution and other inputs and on the marginal utility of income. The higher the elasticity of substitution and marginal utility, the less pollution will increase with income. Then the inverted-U relationship between pollution and income is obtained.

Selden and Song (1995) use the neoclassical environmental growth model of Forster (1973) to derive an inverted-U curve for optimal pollution, assuming the optimal abatement is zero until a critical level of development but increases at an increasing rate thereafter.

McConnell (1997) focuses on the role of preferences and, in particular, the income elasticity of demand for environmental quality using a simple static model. He finds that higher income elasticity results in slower increases or faster declines in pollution, and there is no special role of income elasticity equal to one. Pollution can decline even with zero or negative income elasticity when pollution causes a reduction in output (for example forestry reduction and material damage due to acid rain and health effects to labour force due to air and water pollution). He also provides microeconomic evidence to support a major role for the income responsiveness of preferences in the EKC models.

Lopez and Mitra (2000) suggest that corruption may not preclude the existence of an inverted-U shaped EKC. The results show that for any level of per capita income the pollution levels corresponding to corruption behaviour are always above the social optimal level. In addition, the turning point of the EKC takes place at income and pollution levels above those corresponding to the social optimum.

5.2.1.2 Empirical Studies

A great number of empirical studies have been devoted to the relationship between economic growth and the environment. The empirical models are usually the reduced form single-equation specifications relating an environmental quality indicator to a measure of income per capita. The indicators of environmental quality include certain water and air pollutants (e.g. oxygen, heavy metals, SO_2, CO_2 and particulates), deforestation rate, energy consumption, solid wastes, traffic volume, and environmental R&D. Recent analysis considers a far wider range of environmental problems, for example, hazardous wastes, greenhouse gas emissions and biodiversity loss. Water and air pollutants are widely used in empirical studies, in the forms of emissions per capita and concentration of pollutants as recorded by monitoring stations.

The common dependant variable is income per capita, but some studies use income data converted into purchasing power parity (PPP), while others use incomes at market exchange rates. Different studies use different control variables, such as openness to trade, population density, income distribution, geographical variables and political freedom. The functional specification is usually quadratic, log quadratic or cubic in income. They are estimated econometrically using cross-section or panel data. Some test for country and time-fixed-effects and some test for random-effects.

The first set of empirical studies appeared independently in three working papers: Grossman and Krueger (1991); Shafik and Bandyopadhya (1992); and Panayotou (1993).

They find turning points for several pollutants (the concentrations of SO_2, NO_x and suspended particulate matter (SPM)) in a similar income range of \$3,000 – \$5,000 per capita. The results of some studies before mid-1990s also confirm the basic EKC pattern for certain pollutants (e.g. Selden and Song, 1994; and Grossman and Krueger, 1995). However, the turning points for the emissions of SO_2, NO_x, SPM, and CO in Selden and Song (1994) are much higher than those found by Grossman and Krueger (1993). The difference is explained as the reduction of emissions lagging behind the reduction in ambient concentrations. Additionally, the results from Shafik (1994) are ambiguous, suggesting that the EKC does not hold at all times and for all pollutants (e.g. the linear downward relationship between income and some pollution indicators such as lack of safe water, dissolved oxygen in water, municipal waste, and carbon emission.).

Since the mid-1990s, the EKC has been attacked on both empirical and methodological grounds, a trend that has continued in recent years, and the results have been far more ambiguous (Nahman and Antrobus, 2005).

Cole *et al.* (1997) estimate the EKC for many environmental indicators, including total energy use, transport emissions of SO_2, SPM and NO_2, nitrates in water, traffic volumes, chlorofluorocarbons emissions and methane. They find a meaningful EKC exits only for local air pollutants whereas indicators with a more global, more indirect, environmental impact either increase monotonically with income or else have turning points at high income levels with large standard errors. They also confirm that the concentration of local pollutants peak at a lower income level than total emissions per capita. Hilton and Levinson (1998) find the EKC for automotive lead emissions, but the peak of the curve is sensitive to both the functional form estimated and the time period considered. Kaufmann *et al.* (1998) find a U-relationship between income and atmospheric concentration of SO_2

and an inverted-U relationship between the spatial intensity of economic activity (GDP/Area) and SO_2 concentration. The trade-off between the effects of income gains and the spatial intensity of economic activity on the concentration of SO_2 is consistent with the notion that some environmental problems can be improved by slowing population growth and increasing income levels.

Hettige *et al.* (2000) reject the EKC hypothesis for industrial water pollution: i.e. industrial water pollution rises rapidly through middle-income status and remains roughly constant thereafter. Stern and Common (2001) estimate the EKC for sulphur emissions using a larger and more globally sample than previous studies. They find the emissions-income relationship is monotonic for the global sample because the estimated turning point is far above all countries' income levels; whilst the relation is an inverted-U shape for the sample of high-income countries. The model estimated in first differences suggests the income-emissions relation is monotonically increasing in income in both high-income and global samples. They conclude that reductions in emissions are time-related rather than income-related. Harbaugh *et al.* (2002) use the updated and revised panel data on ambient air pollution in cities worldwide to re-examine the robustness of the evidence for the existence of the EKC studied by Grossman and Krueger (1995). They test the sensitivity of the pollution-income relationship to function forms and econometric specification used, including additional covariates and changes in the nations, cities and years sampled. They conclude that there is little evidence to support an inverted-U shaped relationship between several important air pollutants and national income in these data.

There have been some studies that attempt to decompose the EKC relationship into its constituent scale, composition and abatement effects. Such studies include Panayotou (1997) and De Bruyn *et al.* (1998).

Panayotou (1997) argues that the determinants of environmental quality include: 1) the scale of economic activity (scale effects); 2) the composition of economic activity (composition effects); and 3) the effect of income on the demand and supply of pollution abatement efforts (pure income effects). The scale effect is expected to be a monotonically increasing function of income while the income effect is monotonically decreasing function of income, all else equal. The composition effect is likely to be a non-monotonic (inverted-U) function of income. Panayotou (1997) specified a cubic function form for all decomposition effects, and other variables including population density, the rate of economic growth and the quality of institutions. The results on ambient SO_2 levels confirm the expectation of the three effects, and also suggest that policies and institutions can help flatten the EKC and reduce the environmental price of economic growth.

De Bruyn *et al.* (1998) adopt a dynamic model and estimate for three types of emissions (CO_2, NO_x and SO_2) in four separate developed countries (Netherlands, UK, US and Western Germany). It is found that these emissions correlate positively with economic growth and that emissions may decline over time probably due to structural and technological changes.

There are a few studies focusing on individual countries. For example, Vincent *et al. (*1997) find that SPM and chemical oxygen demand (COD) are increasing with income, while biochemical oxygen demand (BOD) is decreasing with income in Malaysia; Carson *et al.* (1997) find all major air pollutants decline with increasing levels of income across 50 US states.

In terms of the empirical studies on China, Shen (2006) uses a simultaneous equations model to examine the existence of the EKC relationship between per capita income and per capita pollution emissions. Shen (2006) tests two air pollutants (SO_2 and Dust Fall) and three water pollutants (COD, Arsenic and Cadmium) from 1993 to 2002 in 31 Chinese provinces and municipalities. The results suggest an EKC relationship for all water pollutants. Meanwhile, SO_2 shows a U-shaped relationship with income levels and Dust Fall has no significant relationship with income levels. In addition, government expenditure on pollution abatement has a significant and negative effect on pollution; and the net effects of the secondary industry share on pollution emissions are all positive and significant. Therefore, environmental policy and industrial structure both play important roles in determining the water and air pollution levels in China.

5.2.1.3 Critiques of the EKC

Nahman and Antrobus (2005) summarise that "in some cases the data does give rise to an EKC-type relationship, in other cases it does not, whilst in many cases the emergence of an EKC-type relationship depends on the variables included in and the functional form attached to the statistical model, or on the type of model used".[65] Therefore, there has been decline in theoretical explanations of the EKC patterns and a rise in empirical explanations, especially in studies that criticise previous empirical studies. Cole (2003) divides these critiques of the EKC into two categories: the EKC methodology and the interpretation of the EKC results.

In terms of the EKC methodology, there are following five kinds of critiques. First, EKC is no more than a methodology artefact due to the omission of certain important variables, such as the price of energy, the distribution of income and the demand for and supply of environmental quality, or education (e.g. Chapman and Agras, 1999; Magnani, 2000;

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65 Nahman and Antrobus (2005), pp. 110.

Heerink *et al.*, 2001; Lekakis and Koukis, 2001; and Hill and Magnani, 2002). In addition, some argue that the basic EKC is determined by changing trade and investment patterns rather than growth-induced pollution abatement, and these trade/investment patterns have been omitted in the EKC studies. EKC might arise by the relocation of "dirty" industries from developed countries to developing countries to take the advantages of less stringent environmental regulations (e.g. Stern *et al.* 1996; Stern, 1998; Suri and Chapman, 1998; Rothman, 1998; and Cole, 2003 and 2004). This argument led to a research on the well-known pollution haven hypothesis related to international trade and foreign direct investment, with mixed and relatively weak results.[66] However, weak evidence in support of the pollution haven hypothesis does not imply that trade/investment flows do not explain the environmental Kuznets curve. Pollution-intensive industries might relocate to developing countries for reasons other than weaker environmental regulations. For example, the strong incentive of access to the source of raw materials leads many traditionally energy- and pollution-intensive activities to migrate to developing countries (Rothman, 1998).

Second, the EKC assumes unidirectional causality from income to emissions and does not allow environmental degradation to have an impact on income levels. Therefore, "least square estimation in the presence of such simultaneity will provide biased and inconsistent estimates".[67]

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[66] The pollution haven hypothesis studies related to trade include Tobey, 1990; Birdsall and Wheeler, 1993; Jaffe *et al.*, 1995; Rothman, 1998; Antweiler *et al.*, 2001; Ederington and Miner (2003) and Levinson and Taylor (2008); and to foreign direct investment include Levinson, 1996a and 1996b; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; Fredriksson *et al.* (2003); and Smarzynska-Javorcik and Wei, 2005. Some studies avoid the issues of environmental regulations, for example, Cole (2004) examines the pollution-intensity of trade inflows between developed and developing counties. Some other studies began to examine the relationship between consumption, rather than production, of pollution-intensive goods and economic growth.

[67] Cole (2003), pp. 561.

Third, Stern and Common (2001) and Perman and Stern (1999) provides two econometric issues that 1) the estimated turning points using data for the world are at higher income levels than using only OECD data because the developing countries are experiencing increasing emissions of local air pollutants such as SO_2; and 2) the non-stationarity of income and emissions are usually neglected by the EKC studies.

Next, there are some other econometric issues, for example, Stern *et al.* (1996) concern that many EKC studies ignore the issue of heteroskedasticity that may be present in cross-section data; cubic relationship between income and pollution should be considered in case emissions begin to increase again at high income levels; the pattern of the EKC depends on the datasets, particular function form used or covariates included in the model (e.g. Ekins, 1997; List and Gallet, 1999; Spangenberg, 2001; Harbaugh *et al.*, 2002; Perman and Stern, 2003; and Millimet, *et al.*, 2003).

Finally, Stern (1998) argues that "EKC regressions that allow levels of pollution to become zero or negative as being incompatible with the laws of thermodynamics, since all resource use inevitably produces wastes".[68]

Regarding the interpretation of the EKC results, first, the EKC relationship may not exist for all environmental indicators (Arrow *et al.* 1995). Second, EKCs do not indicate that economic growth automatically solves environmental problems without any attention to the environment. Emissions could be reduced through investment and regulations, neither of which are automatic consequences of economic growth. Finally, "although many EKC estimate turning points around the current world mean per capita income level, this does not mean that, globally, emissions are about to decline. Global income distribution is

[68] op. cit.

skewed with far more people below the mean than above it".[69] Therefore, median income levels are worth to be considered rather than mean income levels.

In this chapter we address many of these criticisms (see details in section 5.4).

5.2.2 Effects of FDI on the Environment

5.2.2.1 Theoretical Analysis

Grossman and Krueger (1991) distinguish three separate mechanisms by which a change in trade and foreign investment policy can affect the level of pollution and the depletion rate of scare environmental resources. The three mechanisms are scale effects, composition effects and technique effects. It has been the standard approach to analyse the FDI-environment nexus.

Scale Effect

The scale effect refers to the expansion of economic activity as a result of an increase in foreign investment. If the nature of the economic activity remains unchanged, the total amount of pollution generated must increase, as well as the use of natural resources. "Even if the foreign firms are relatively less polluting across all emissions and/or more concerned about sustainable resource harvesting, the overall quantity of pollution and level of resource degradation increases with a greater level of investment. In addition to pollution, a larger increase in the scale of investment without a larger 'sustainable development' land and resource use planning framework is likely to undermine biodiversity and degrade

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[69] op. cit. pp. 562

common access resources such as river and coastlines."[70] *Ceteris paribus*, the scale effect on the environmental quality is expected to be negative.

Composition Effect

The composition effect (or structural effect) means that FDI may have an impact on the environment by changing the industrial structure. Traditional trade theory suggests that countries will specialise in those sectors in which they have competitive advantage. Foreign investment, to a greater extent, is attracted by such competitive advantage. "If competitive advantage derives largely from differences in environmental regulation, then the composition effect […] will be damaging to the environment. […] On the other hand, if the sources of international comparative advantage are more traditional ones, namely cross-country differences in factor abundance and technology, then the implications of the composition effect for the state of environment are ambiguous. […] The net effect of this on the level of pollution in each location will depend upon whether pollution-intensive activities expand or contract in the country that on average has the more stringent pollution controls."[71]

However, some research (e.g. OECD, 2002) believes that structural effects are expected to be positive because trade and investment liberalisation promote allocative efficiency among economies. A report from UNCTAD in 1999 shows that FDI destined to primary sectors has declined from 8.6 per cent to 4.5 per cent between 1988 and 1997 in developed and developing countries, while the services sector has a corresponding increase in both categories of countries in the same period. Some analysis suggests that this structural shift

[70] Zarsky, (1999), pp.3.

[71] Grossman and Krueger (1991), pp.4.

toward service FDI generally has a positive effect on the environment (Gentry, 1998; UNCTAD, 1999; and OECD, 2001).

Technique Effect

Grossman and Krueger (1991) provide two reasons that pollution per unit of output might fall, especially in developing countries. First, foreign investors may bring newer and better technologies and such technologies tend to be less polluting and use fewer resources. In addition to the technology transfer, FDI may also create other positive technological spillovers to national firms through imitation, employment turnover, and supply chain requirements (OECD, 2002). Second, FDI may increase resident's income and then people may have more demand for environmental quality. Thus, there will be more pressure on the government to implement more stringent environmental regulations and stricter enforcement of exiting laws. Some researchers decompose the second point from technique effect and call it an income effect (e.g. Zarsky, 1999).

However, the technology effect may be negative in some cases (OECD, 2002). Multinationals may apply relatively more damaging technologies in regions with weak environmental regulations. In addition, some evidence suggests that overseas multinational R&D is concentrated in only a few developed countries (Freeman and Hagedoorn, 1994; and UNCTAD, 1999).

5.2.2.2 Empirical Studies

From an analytical perspective, research on the net outcome of these three effects is relevant. However, identifying the "net effects" of FDI on the environment is complex. OECD (2002) presents two limitations that might explain the difficulties in addressing the net environmental effects of FDI flows. First, it is difficult to separate clearly the environmental effects of domestic economic activity from the effects of activities of foreign affiliates. Second, FDI does not occur in a vacuum so that the environmental effects cannot be analysed in isolation from other related factors, for example, trade influences the potential market opportunities in a country.

These limitations lead to some pragmatic studies on foreign investment and the environment, for example, the reports from UNCATD/CBS (Copenhagen Business School) projects on 'Cross Border Environmental Management in Transnational Corporations' which includes case studies on China (Xian *et al.*, 1999), India (Jha, 1999) and Malaysia (Rasiah, 1999). These reports provide many examples of positive and negative environmental effects of transnational corporations.

Wheeler (2001) provides a simple statistical test of the race-to-the-bottom model using data on FDI and urban air quality (measured by concentrations of fine particulate matter less than 10 microns in diameter, PM_{10}, or SPM) in three developing countries, China, Brazil and Mexico. The race-to-the-bottom model indicates that after decades of increasing capital and economic liberalisation, pollution should increase everywhere: pollution increases in poor countries because they are pollution havens, and in rich countries because they are relaxing environmental standards to remain cost-competitive. These three developing countries received 60 per cent of the total FDI for developing countries in 1998. If the race-to-the-bottom model is correct, then air pollution should increase in all three countries. At the same time, the air quality in US cities should decline because US industrial imports from these three countries have been expanding for decades. However, the figures show that the urban air qualities in these four countries have all improved. The result strongly contradicts the race-to-the-bottom model.

There has been scarce empirical evidence on the cross-country study of the environmental effects from foreign investment in 1990s. Recently, some studies have begun to investigate the extent to which different forms of environmental degradation within less developed countries are a function of transnational organisation of production (e.g. Grimes and Kentor, 2003; Jorgenson, 2006, 2007a, 2007b, 2007c; Kentor and Grimes, 2006). These studies are based on the context of foreign investment dependence theory.[72]

Grimes and Kentor (2003) observe the impact of foreign investment dependence on carbon dioxide emissions between 1980 and 1996 using a cross-country panel data for 66 less developed countries. They find that foreign capital penetration in 1980 has a significant positive effect on the growth of CO_2 emissions between 1980 and 1996.

Jorgenson (2007c) investigates the extent to which the transnational organisation of production affects the environment in 37 less developed countries from 1975 to 2000. It tests the hypotheses that foreign investment dependence in the manufacturing sector is, respectively, positively associated with carbon dioxide emissions and organic water pollutants (BOD) in less developed countries. In addition to the key determinant variable, the secondary sector FDI stock as percentage of total GDP, other control variables include population size, level of economic development (GDP per capita), domestic investment, relative size of manufacturing sector, urbanisation, and export intensity. The findings from fixed effect estimations confirm the hypotheses and provide support for the theory of foreign investment dependence. The other studies of Jorgenson use a similar methodology

72 "In general, the theory of foreign investment dependence asserts that the accumulated stocks of foreign investment make a less developed country more vulnerable to different global political-economic conditions, often leading to negative consequences for domestic populations within investment-dependent nations. These structural process and outcome are partly maintained and reproduced by the stratified interstate system" (Jorgenson, 2007c, pp. 138).

and get the consistent results that foreign investment increases pollution emissions in less developed countries.

5.2.2.3 Empirical Studies Related to China

Two papers have examined the environmental impact of FDI in China. A working paper Liang (2006) uses city level data (more than 260 cities) in the late 1990s to examine the relationship between local SO_2 emissions and the scale of foreign direct investment, industry composition and income. This paper tests two hypotheses: 1) that the pollution level in China's cities increases with per capita income, but decreases with the square of per capita GDP (i.e. pollution-income nexus is of an EKC-type); and 2) everything else being equal, the pollution intensity in China's cities decreases with the scale of foreign direct investment. The scale of FDI is measured by net assets or employment by foreign firms in each city, and is instrumented by geographic location, trade policy and local population. The major conclusion is that there is a negative correlation between FDI and SO_2 emissions, indicating that the overall effect of FDI is beneficial to the environment. The results also support the EKC hypothesis. A turning point of around $1,200 is found, suggesting that 30% or more cities have passed this level in 2000 and the proportion increases by about 4% each year. This interpretation is optimistic and much lower than the official prediction of the SEPA in April 2006 ($3,000).

He (2006) constructs a five-equation simultaneous system to study the FDI-emission nexus and gets different results from Liang (2006). The system includes the FDI location decision with respect to host country's environmental regulation stringency and the impact of FDI on pollution through the scale, composition and technique effects. The simultaneous system is estimated on a dynamic panel of 29 Chinese provinces' SO_2 emissions during the period from 1994 to 2001. A Generalised Method of Moment (GMM) estimator is used to correct potential first-order serial correlation and heteroskedasticity. The results show that the total impact of FDI on industrial SO_2 emissions is very small. A 1 per cent increase in FDI capital stock contributes a 0.098 per cent increase in industrial SO_2 emission, indicating that the emission increase caused by the impact of FDI on economic growth and composition transformation cancels out the emission reduction resulting from the impact of FDI on reinforcing environmental regulations. Furthermore, the FDI entry decision equation (that depends on the previous period's economic growth and environmental regulation stringency) in the simultaneous system provides convincing evidence for the pollution haven hypothesis. Although the overall effect of FDI on industrial SO_2 emission is relatively weak and the foreign funded enterprises in China generally produce with higher efficiency, the increase in environmental stringency does have a modest deterrent effect on FDI inflows.

5.2.3 Summary

There have been numerous theoretical and empirical studies that examine the relationship between economic growth and the environment based on the theory of the environmental Kuznets curve since it was found in early 1990s. The results of empirical evidence are mixed and show that the EKC does not hold at all the time or for all pollutants. Among the empirical studies, only a few employ a cross-region analysis for an individual country. There are several critiques of the EKC, focusing on the methodology issues and interpretation of the results. In this chapter, we address many of these critiques in section 5.4.

To consider the impact of FDI on environment, most analytical studies are pragmatic and empirical evidence is rather limited. The most recent cross-country studies on the FDI-environment nexus are all focusing on less developed countries and based on the foreign investment dependence theory. Of those empirical studies on the cross-region FDI-environment relationship for China, Liang (2006) and He (2006) both look at the impact of FDI on SO_2 industrial emissions but get different results.

The lack of cross-regional evidence for the EKC for an individual country and the contradictory empirical results in the FDI-environment nexus in China provided the motivation to examine the net environmental effects of income as well as foreign investment in China. We believe that this is the first study to examine these issues using Chinese city level data for a range of environmental indicators, in order to check the robustness of these two effects. This chapter also represents the first attempt to examine the differences between the behaviour of firms from Hong Kong, Taiwan and Macao, and other foreign firms.

5.3 Economic Growth, FDI and the Environment in Chinese Cities

In this section we first outline the economic development, FDI inflows and pollution levels in a large number of Chinese cities. We also provide information about the environmental indicators that are considered in this chapter.

5.3.1 Economic Development and FDI

Cities are classified into three levels in China according to the administrative divisions: county-level cities, prefecture-level cities (including sub-provincial cities) and municipalities.

County-level cities are usually governed by prefecture level divisions, but a few are governed directly by province-level divisions.[73] Prefecture-level cities are completely ruled by their provinces; sub-provincial cities are ruled by their provinces but are administered independently in regard to economy and law, and the mayor of a sub-provincial city is equal in status to a vice-governor of a province; and municipalities are independent and equivalent to province. City, here, is not a "city in the strict sense", but an administrative unit, including both urban core and surrounding rural areas.

Since 1978, China has upgraded and reclassified many counties into cities, and many towns into counties. The total number of cities increased from 191 in 1978 to 661 in 2004, including 374 county-level cities, 283 prefecture-level cities (including 15 sub-provincial cities) and 4 central municipalities.

Similar to the development across provinces, the development is quite uneven across cities. Table 5.3.1 compares the population, income and FDI in some key cities in China in 2004. Cities in coastal provinces generally have higher income levels than inland cities (15 of the 17 cities with per capita income above $3,000 are located in eastern regions), especially in some southeast coastal provinces, for example, Zhuhai, Shenzhen and Guangzhou in Guangdong province; Xiamen in Fujian province; and Ningbo and Hangzhou in Zhejiang province. In terms of the per capita GDP growth, some inland cities have higher rates than

[73] Most county-level cities are created in the 1980s and 1990s, by replacing counties. This process was halted in 1997.

the eastern cities, possibly thanks to the recent Western Development Programme. However, the gap between east and west is still large.[74]

Table 5.3.1 Population, Income and FDI for Some Cities in China, 2004

City	Population (million)	GDP per capita ($)	GDP per capita growth rate (2003-2004) (%)	FDI (million $)	FDI/GDP (%)
Zhuhai	0.86	7848	3.32	510	7.73
Shenzhen	1.65	7161	1.62	3612	8.73
Guangzhou	7.38	6799	8.82	2401	4.83
Shanghai	13.52	6682	11.21	6541	7.27
Xiamen	1.47	4850	5.60	570	5.34
Ningbo	5.53	4733	12.84	2103	8.07
Hangzhou	6.52	4695	11.10	1410	4.64
Beijing	11.63	4477	8.64	3084	5.96
Dalian	5.62	4226	12.72	2203	9.30
Nanjing	5.84	3993	11.73	2566	11.12
Tianjin	9.33	3812	11.86	2472	6.98
Qingdao	7.31	3401	12.66	3799	14.53
Jinan	5.90	3336	10.09	483	2.47
Shenyang	6.94	3321	10.72	2423	10.55
Huhhot*	2.15	3180	18.12	239	3.87
Yantai	6.47	3043	16.37	1857	9.42
Wuhan*	7.86	3016	10.01	1520	6.43
Fuzhou	6.09	2832	7.25	1360	7.27
Urumuchi*	1.86	2757	8.81	15	0.26
Changchun*	7.24	2572	7.03	902	4.86
Zhengzhou*	6.71	2565	15.79	242	1.45
Chengdu*	10.60	2510	8.28	332	1.26
Wenzhou	7.46	2277	6.99	209	1.23
Taiyuan*	3.32	2272	15.20	143	1.84
Kunming*	5.03	2268	8.65	62	0.55
Changsha*	6.10	2179	13.11	501	3.66
Haikou	1.43	2166	1.15	320	10.47

[74] For example, the poorest city, Xining (in Table 5.3.1), would have to spend 24 years to catch up to the income level of the richest city, Zhuhai, if both of them remain at their current income growth paths (ln(7848/1025)/ln[(100+12.37)/(100+3.32)]= 24).

Shijiazhuang	9.18	2159	10.63	352	1.78
Yinchuan*	1.38	2135	9.42	64	2.79
Harbin*	9.70	2110	9.87	405	1.99
Nanchang*	4.61	2083	10.58	730	7.85
Qinhuangdao	2.76	1995	9.17	202	3.68
Lanzhou*	3.08	1991	6.53	-	-
Nantong	7.74	1910	15.10	1104	7.46
Xi'an *	7.25	1701	8.18	276	2.08
Hefei*	4.45	1616	17.42	316	4.43
Guiyang*	3.48	1532	8.60	78	1.46
Shantou	4.88	1501	7.11	78	1.07
Beihai*	1.48	1328	7.83	20	1.01
Zhanjiang	7.16	1176	9.48	71	0.97
Chongqing*	31.44	1161	10.88	405	1.26
Nanning*	6.49	1103	4.40	78	1.09
Lianyungang	4.69	1074	13.29	247	4.90
Xining*	2.07	1025	12.37	9	0.44

Note: Cities reported in this table include:

1) 4 municipalities: Beijing, Tianjin, Shanghai, and Chongqing;
2) 26 province capital cities: Shijiazhuang, Taiyuan, Huhhot, Shenyang, Changchun, Harbin, Nanjing, Hangzhou, Hefei, Fuzhou, Nanchang, Jinan, Zhengzhou, Wuhan, Changsha, Guangzhou, Nanning, Haikou, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, and Urumuchi (Lasa is not included due to lack of data)
3) 15 sub-provincial cities: Shenyang, Dalian, Changchun, Harbin, Nanjing, Hangzhou, Ningbo, Xiamen, Jinan, Qingdao, Wuhan, Guangzhou, Shenzhen, Chengdu, and Xi'an;
4) 5 special economic zones: Shenzhen, Zhuhai, Shantou, Xiamen, Hainan; and
5) 14 coastal open cities: Tianjin, Shanghai, Dalian, Qinhuangdao, Yantai, Qingdao, Lianyungang, Nantong, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang, and Beihai.

Some cities appear in several categories, for example, Guangzhou, the capital of Guangdong province, is also a sub-provincial city and a coastal open city. * indicates cities in inland provinces.

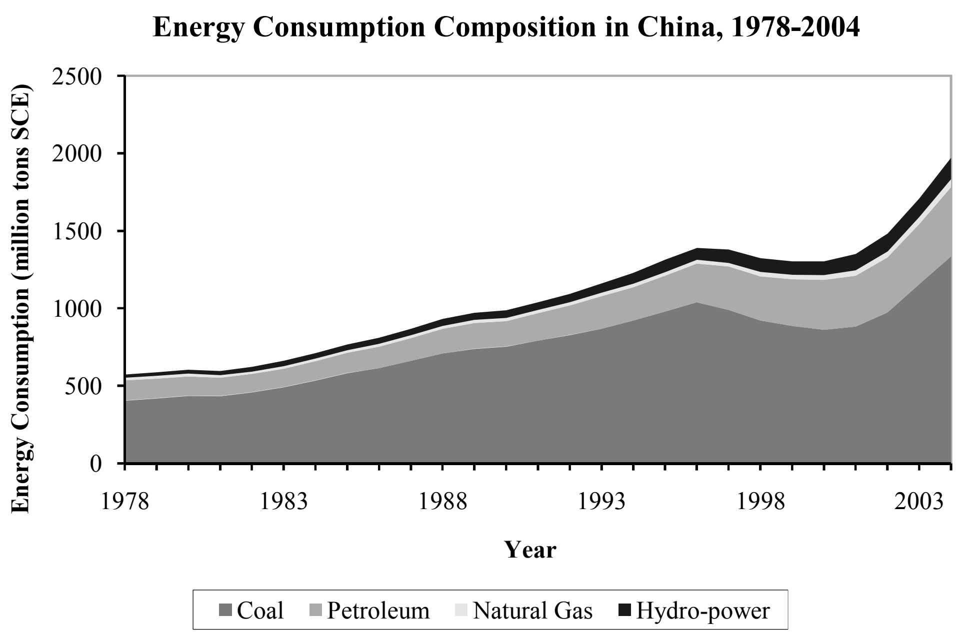
Source: China City Statistical Yearbook, 2004, 2005.

The geographical distribution of FDI is also unbalanced. In terms of the total amount of FDI inflows, Shanghai, Qingdao, Shenzhen and Beijing are the four largest magnates for foreign capital. These four cities together attracted more than 28 per cent of FDI inflows in China in 2004. Among the cities with the total FDI inflows above $1,000 million, only Wuhan, the capital of Hubei province, is located in central China; others are all eastern cities. Similarly, among the cities with the share of FDI over GDP above 5 per cent, the majority are located in eastern regions, except Wuhan and Nanchang (the capital of Jiangxi province).

5.3.2 Environmental Quality in Chinese Cities

The World Bank reported that 20 of the world's 30 most polluted cities are located in China, largely due to high coal use and motorization. As shown in Figure 5.3.1, of the total energy consumption in China in 2004, around 67.7% was coal, 22.7% was oil, 2.6% was natural gas and 7.0% was hydro-power. Although the percentages of consumption of oil and hydro-power increased to some extent, coal is still widely used as the major source of energy.

Figure 5.3.1 Energy Consumption Composition in China, 1978-2004



Note: the coefficient for conversion of electric power into SCE (standard coal equivalent) is calculated on the basic of the data on the average coal consumption in generating electric power in the same year.

Source: China Compendium of Statistics, 1949-2004.

The combustion of coal generates several air pollutants, such as SO_2, NO_x and dust, which are harmful to human health, especially to the respiratory system. The World Bank report estimates that 300,000 people a year die prematurely from respiratory diseases in China. The main reason is that around 70% of China's energy needs are supplied by coal-fired power stations. Additionally, China has the world's highest emission of sulphur dioxide and one third of the country endures acid rain. The World Bank announced that pollution is costing China an annual 8-12% of GDP (about $110-170 billion) in direct damage, such as the impact on crops by acid rain, medical bills, lost work from illness, money spent on disaster relief following floods and the implied costs of resource depletion (The Economist, 21/08/2004).

To monitor the environmental quality, since 1980 China has established 2389 environmental monitoring stations, including 1 general station, 41 provincial central stations, 401 prefecture-level stations, 1914 county-level stations and 32 nuclear monitoring stations. The environmental monitoring stations are responsible for monitoring the conditions of water, air, ecology, aquatic bios, soil, noise, sea, and radiation. In this chapter we focus on water and air quality.

5.3.2.1 Water Pollution

Table 5.3.2 provides general information about city drinking water quality, the groundwater quality and groundwater level in recent years. In terms of the number reaching drinking water quality standard, the proportion reaching 80% and above has decreased from 83% (55%+28%) in 2002 to 70% (53%+17%) in 2004, while correspondingly, the proportion in the less than 60% group increased from 2% to 23%, illustrating the deterioration of drinking water quality. Turning to the groundwater level, the number of cities in the

"Drop" group decreased significantly. However, the groundwater quality is becoming worse in more than half of the monitored cities in 2004. SEPA reported that the groundwater quality was mainly affected by human activities. The major pollutants in the groundwater are nitrate, nitrite, nitrogen-ammonia, and chloride.

Table 5.3.2 Drinking Water Quality, Groundwater Level and Quality in Cities

	Rate of Reaching Drinking Water Quality Standard				
	100%	99.9% ~ 80%	79.9% ~ 60%	59.9% ~ 0	Total
2002	26 (55%)	13 (28%)	7 (15%)	1 (2%)	47
2003	22 (47%)	9 (19%)	8 (17%)	8 (17%)	47
2004	25 (53%)	8 (17%)	3 (6%)	11 (23%)	47

	Groundwater Level			
	Raise	Stable	Drop	Total
2001	63 (34%)	8 (4%)	115 (62%)	186
2002	75 (34%)	34 (16%)	109 (50%)	218
2003	61 (31%)	73 (38%)	60 (31%)	194
2004	53 (28%)	78 (41%)	61 (32%)	192

	Groundwater Quality			
	Improve	Stable	Worsen	Total
2004	39 (21%)	52 (28%)	96 (51%)	187

Note: # of cities reported in the table; and proportion in brackets.

Source：*China Environment Yearbook, 2002-2005.*

Domestic sewage is the major source of water pollution. SEPA reported industrial sectors discharged 44.9% of the total wastewater in 2004, and the shares of the pollutants, for example, COD and nitrogen-ammonia, are respectively 35.8% and 32.7%.

5.3.2.2 Air Pollution

Monitoring stations observe the concentrations of SO_2, NO_2 and PM_{10} every day in a number of key cities. Tables 5.3.3 – 5.3.6 present 20 the most polluted cities and 20 the cleanest cities, respectively, according to the annual average concentrations of SO_2, NO_2, PM_{10} and the air pollution comprehensive index in 2004.[75] In terms of SO_2 and PM_{10}, the most polluted cities are mostly located in northern and central regions, for example, Linfen, Yangquan, Datong, Changzhi, and Taiyuan in Shanxi province; Jiaozuo, Kaifeng, Anyang, Luoyang, Sanmenxia and Pingdingshan in Henan province; Chifeng and Baotou in Inner Mongolia; Zhuzhou and Xiangtan in Hunan province; and Yibin, Panzhihua, and Zigong in Sichuan province. The major industry sectors in these cities are mining and washing of coal, mining and procession of ores, processing of coking, and smelting of ferrous and non-ferrous metals, etc. These cities are mostly reported in Table 5.3.6 because their SO_2 and PM_{10} pollutions contribute a great weight to the comprehensive index. However, in terms of NO_2, some eastern cities enter the most polluted group, such as Beijing, Guangzhou, Shenzhen, Shanghai, Wenzhou and Ningbo. However, the overall level of NO_2 pollution is lower than SO_2 and PM_{10}, therefore does not significantly affect the comprehensive index.

Table 5.3.6 shows the cleanest cities in China are generally coastal cities, for example Beihai, Haikou, Rizhao, Zhanjiang, Zhuhai, Xiamen, Fuzhou, Shantou and Lianyungang; or those inland cities without heavy polluting industries such as Lasa, Guilin, Yuxi, Qiqiharr and Karamay.

However, it is worth noting that such indices reflect the ambient concentrations of pollutants in *urban* area of a city, but cannot reflect the total industrial pollution emissions of the city.

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[75] The index is calculated from $P=\sum_{i=1}^{n}P_i=\sum_{i=1}^{n}\frac{C_i}{C_{io}}$ where C_i is the concentration of pollutant *i*, and C_{io} is the limit value of C_i. The limit value is the annual average concentration level according to the national ambient air quality standard II. The annual average limit values for SO_2, NO_2 and PM_{10} are respectively 0.06, 0.08 and 0.10 (mg/m^3).

Table 5.3.3 Annual Average SO_2 Concentration in Some Cities in China, 2004

The Most Polluted Cities	SO_2 Concentration (mg/m^3)	The Cleanest Cities	SO_2 Concentration (mg/m^3)
Yangquan	0.231	Lasa	0.003
Linfen	0.224	Beihai	0.005
Jinchang	0.198	Haikou	0.007
Yibin	0.155	Karamay	0.007
Datong	0.149	Fuzhou	0.010
Zunyi	0.135	Zhanjiang	0.012
Sanmenxia	0.132	Changchun	0.013
Jiaozuo	0.127	Hefei	0.013
Zhuzhou	0.123	Wuhu	0.017
Handan	0.121	Qiqiharr	0.019
Yichang	0.120	Maanshan	0.019
Chongqing	0.113	Shenzhen	0.023
Liuzhou	0.109	Zhuhai	0.024
Urumuchi	0.102	Changzhou	0.024
Chifeng	0.099	Xining	0.024
Anyang	0.094	Rizhao	0.024
Guiyang	0.094	Quanzhou	0.025
Changzhi	0.093	Xiamen	0.025
Luoyang	0.093	Huzhou	0.026
Shizuishan	0.090	Mudanjiang	0.027

Source: China Environment Yearbook, 2005.

Table 5.3.4 Annual Average NO_2 Concentration in Some Cities in China, 2004

The Most Polluted Cities	NO_2 Concentration (mg/m^3)	The Cleanest Cities	NO_2 Concentration (mg/m^3)
Guangzhou	0.073	Beihai	0.007
Shenzhen	0.072	Yuxi	0.011
Beijing	0.071	Zhanjiang	0.012
Chongqing	0.067	Haikou	0.013
Shanghai	0.062	Hefei	0.017
Wenzhou	0.062	Quanzhou	0.018
Ningbo	0.060	Lasa	0.020
Harbin	0.060	Jinchang	0.020
Urumuchi	0.058	Lianyungang	0.020
Jiaozhuo	0.056	Taiyuan	0.022
Changzhi	0.056	Qinhuangdao	0.023
Yangquan	0.055	Qujing	0.023
Linfen	0.055	Deyang	0.023
Nanjing	0.055	Changde	0.023
Hangzhou	0.055	Guiyang	0.024
Huzhou	0.054	Zhangjiajie	0.024
Wuhan	0.054	Maanshan	0.024
Tianjin	0.052	Qingdao	0.024
Suzhou	0.051	Mianyang	0.025
Datong	0.050	Luzhou	0.025

Source: China Environment Yearbook, 2005.

Table 5.3.5 Annual Average PM_{10} Concentration in Some Cities in China, 2004

The Most Polluted Cities	PM_{10} Concentration (mg/m^3)	The Cleanest Cities	PM_{10} Concentration (mg/m^3)
Panzhihua	0.256	Haikou	0.033
Linfen	0.219	Beihai	0.043
Kaifeng	0.198	Guilin	0.046
Baotou	0.186	Zhuhai	0.046
Datong	0.180	Zhanjiang	0.050
Weinan	0.175	Lasa	0.052
Taiyuan	0.175	Rizhao	0.058
Pingdingshan	0.174	Karamay	0.059
Changzhi	0.173	Shantou	0.059
Lanzhou	0.172	Xiamen	0.063
Zhuzhou	0.171	Wenzhou	0.068
Luoyang	0.165	Yantai	0.068
Yangquan	0.162	Shaoxing	0.072
Fushun	0.162	Fuzhou	0.074
Xuzhou	0.158	Mianyang	0.075
Xiangtan	0.153	Shenzhen	0.076
Zigong	0.151	Qinhuangdao	0.076
Tongchuan	0.151	Nanning	0.078
Beijing	0.149	Ningbo	0.079
Jinan	0.149	Huhhot	0.080

Source: China Environment Yearbook, 2005.

Table 5.3.6 Air Pollution Comprehensive Index in Some Cities in China, 2004

The Most Polluted Cities	Index	The Cleanest Cities	Index
Linfen	6.61	Beihai	0.60
Yangquan	6.16	Haikou	0.61
Datong	4.91	Zhanjiang	0.85
Jinchang	4.61	Karamay	1.03
Yibin	4.49	Zhuhai	1.29
Zhuzhou	4.20	Rizhao	1.31
Chongqing	4.14	Guilin	1.38
Jiaozuo	4.13	Fuzhou	1.42
Changzhi	3.98	Quanzhou	1.45
Panzhihua	3.91	Changchun	1.50
Yichang	3.88	Xiameng	1.52
Sanmenxia	3.85	Yuxi	1.52
Kaifeng	3.81	Hefei	1.53
Zunyi	3.73	Wuhu	1.54
Luoyang	3.66	Maanshan	1.55
Baotou	3.65	Qiqiharr	1.61
Weinan	3.64	Shantou	1.63
Anyang	3.61	Lasa	1.64
Urumuchi	3.56	Lianyungang	1.90
Pingdingshan	3.51	Changzhou	1.92

Source: China Environment Yearbook, 2005.

SEPA also reported that 132 of 342 monitored cities (38.6% of total) arrived at the national ambient air quality standard II (living standard), 141 (41.2%) at standard III and 69 (20.2%) lower than standard III. Additionally, air quality in large cities is worse than that in middle and small cities. 66.1% of citizens were living in the cities under the air quality standard II.

Industrial waste gas is the major source of the serious air pollution. For instance, in 2004, industrial SO_2 and soot accounted for 86.7% and 81.4% of the total emissions in cities.

Acid rain is another serious problem. Table 5.3.7 compares the frequency and the pH value of city acid rain in recent years. We find that the proportion of cities without acid rain decreased from 49.7% in 2002 to 43.5% in 2004, i.e. the number of cities suffered from acid rain increased. The proportion of cities with frequency of acid rain more than 40% moved up as well, from 24.0 % to 30.1%. Of those cities suffering the acid rain, the proportion with rainwater pH value less than 5.6 increased from 36.9% in 2001 to 41.4% in 2004.

Table 5.3.7 City Acid Rain pH Value and Frequency

	Frequency of Acid Rain						
	0	0 ~ 20	20 ~ 40	40 ~ 60	60 ~ 80	80 ~ 100	Sub total > 40
2001	41.2	23.7	10.9	8.0	9.1	6.9	24.0
2002	49.7	18.6	10.5	5.8	7.7	7.7	21.2
2003	45.6	18.7	7.4	6.8	11.1	10.5	28.4
2004	43.5	18.2	8.2	8.5	9.5	12.1	30.1

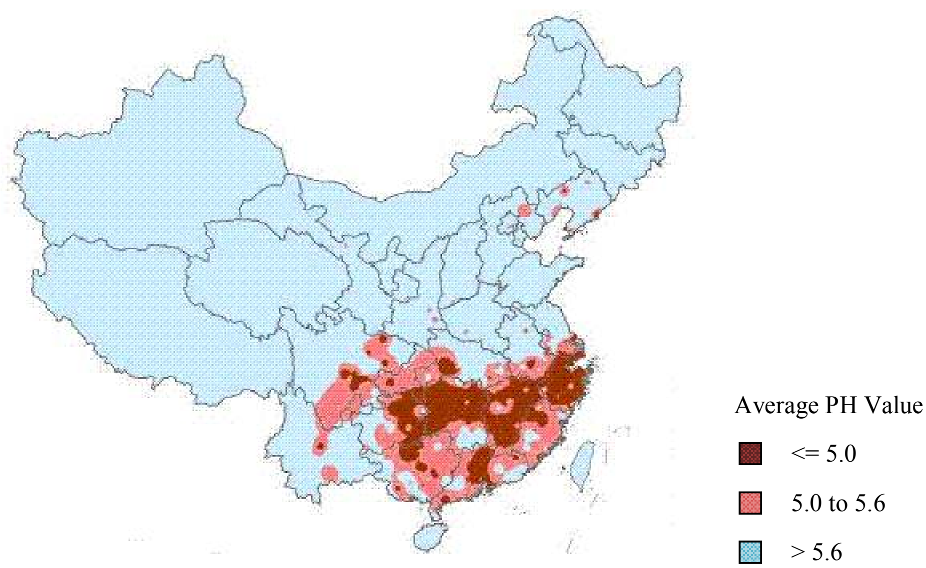
	Average pH Value of Acid Rain					
	≤ 4.5	4.5 ~ 5.0	5.0 ~ 5.6	5.6 ~ 7.0	> 7.0	Sub total < 5.6
2001	3.3	18.3	15.3	63.1	-	36.9
2002	6.0	12.4	14.2	50.5	16.9	32.6
2003	8.8	15.6	12.9	48.9	13.8	37.3
2004	10.8	17.5	13.1	44.2	14.4	41.4

Note: proportion of cities reported in the table.

Sauce: China Environment Yearbook, 2002-2005.

Figure 5.3.2 provides the distribution of acid rains in China in 2004. South China suffers the most from serious acid rain due to the presence of low hills, abundant rainfall and wet climate, mixed with increasing waste gas emissions. Some northern cities in Liaoning, Hebei, and Shaanxi provinces also suffered from acid rain because of the heavy industrial air pollution.

Figure 5.3.2 Acid Rain Distribution in 2004



Source: China Environment Bulletin, 2004.

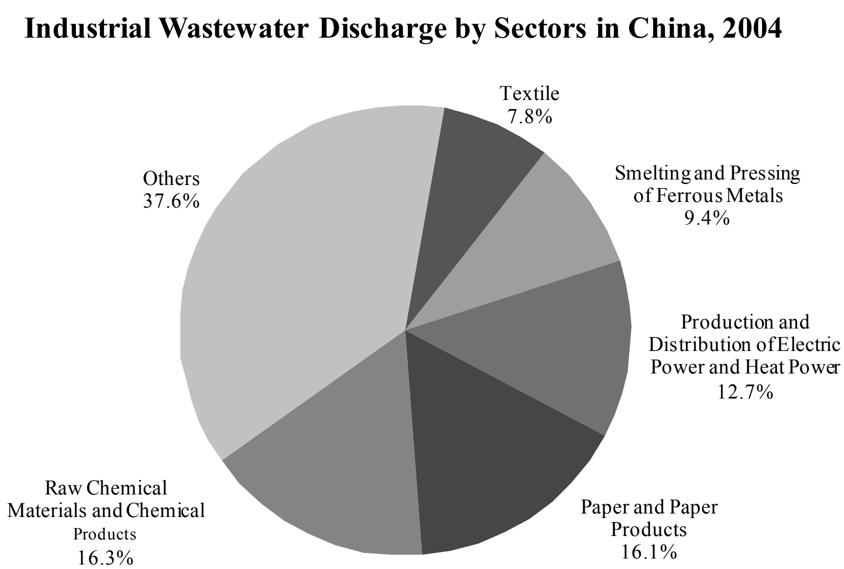
Although to some extent a geographical unbalance exists in the distribution of income and FDI among regions in China, we do not find a consistent geographical imbalance for all pollutants. For example the regional concentration of the most polluted cities in terms of SO_2 is different from that in terms of NO_2. Therefore, we infer that the relationship between income and the environment, as well as FDI and the environment, might depend on the pollutants we choose.

5.3.3 Industrial Water and Air Pollution

In this chapter, we focus on industrial water and air pollution. For industrial water pollution, we examine discharges of total wastewater, and specific water pollutants, including chemical oxygen demand (COD), hexavalent chromium compounds (CrVI), and petroleum-like matter. For industrial air pollution, we observe the emissions of total waste gas, and specific air pollutants, including sulphur dioxide (SO_2), soot and dust.

Wastewater refers to all the industrial wastewater discharged to the outside of the industrial factory, including wastewater from production process, direct cooling water, mine groundwater that is in excess of the discharge standard, and the domestic sewage mixed within the industrial wastewater (indirect cooling water not included).

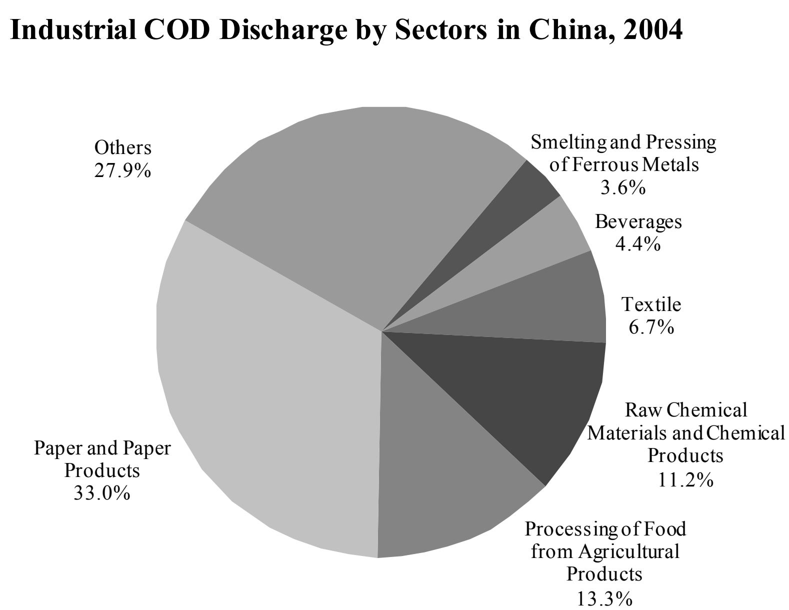
Figure 5.3.3 Industrial Wastewater Discharge by Sectors in China, 2004



Source: China Environment Yearbook, 2005.

Figure 5.3.3 shows the sectoral distribution of wastewater discharges in 2004 for 70,462 investigated firms in China. The heavy wastewater polluting sectors are located in chemical products, paper products, electric and heat power supply, smelting and pressing of ferrous metals, and textiles. Within the electric and heat power supply sector, coal-fired power station is the major source of wastewater.

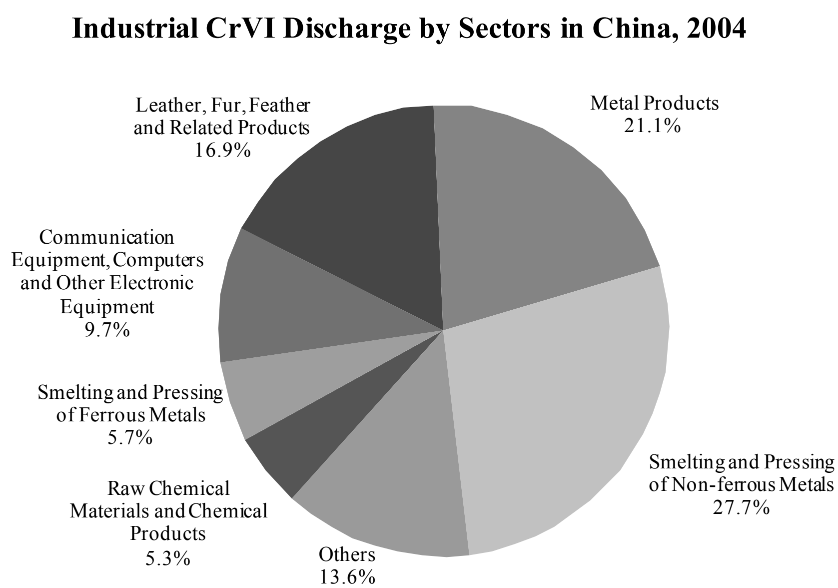
Figure 5.3.4 Industrial COD Discharge by Sectors in China, 2004



Source: China EnvironmentYearbook, 2005.

The specific pollutants in wastewater refer to the net weights of the pollutants, which is equal to the average concentration of the pollutants multiplied by the total weight of wastewater in the reported period. The COD test is commonly used to indirectly measure the amount of organic compounds in water. It is a useful wastewater quality indicator. The COD test determines whether or not wastewater will have significant adverse effect upon fish or upon aquatic plant life. Figure 5.3.4 illustrates that COD is high in the wastewater discharged from the factories of paper products, food products, chemical products, and textiles.

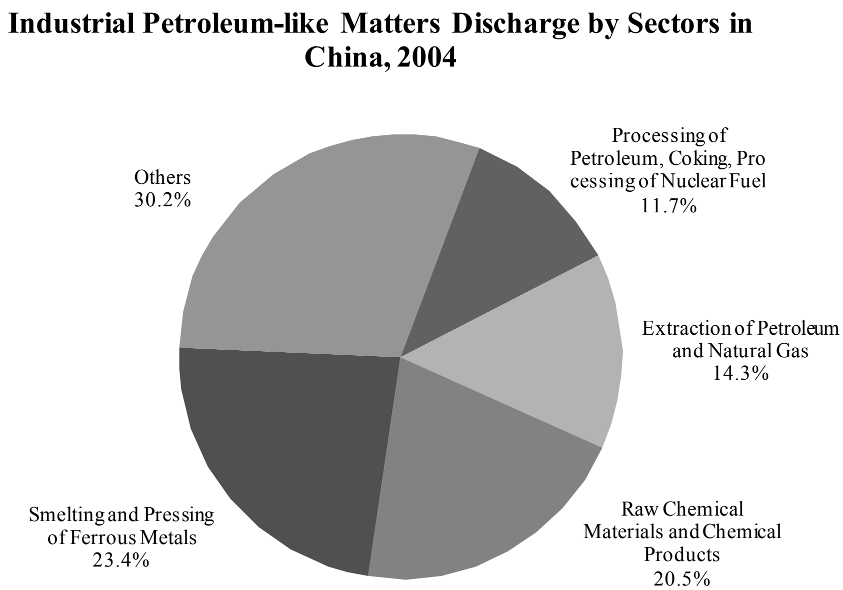
Figure 5.3.5 Industrial CrVI Discharge by Sectors in China, 2004



Source: China Environment Yearbook 2005.

The second specific pollutant is CrVI compounds, which are toxic if ingested or inhaled. CrVI is an established human carcinogen. Chronic exposure to CrVI compounds may cause permanent eye injury and can increase risk of lung cancer. CrVI compounds are widely used as pigments for photography, and in pyrotechnics, dyes, paints inks and plastics. They can also be used for stainless steel production, textile dyes, wood preservation, leather tanning, and as anti-corrosion and conversion coatings. Figure 5.3.5 shows the major sources of CrVI: smelting and pressing of non-ferrous metals, metal products, leather products, electronic equipment, smelting and pressing of ferrous metals and chemical products.

Figure 5.3.6 Industrial Petroleum-like Matter Discharge by Sectors in China, 2004

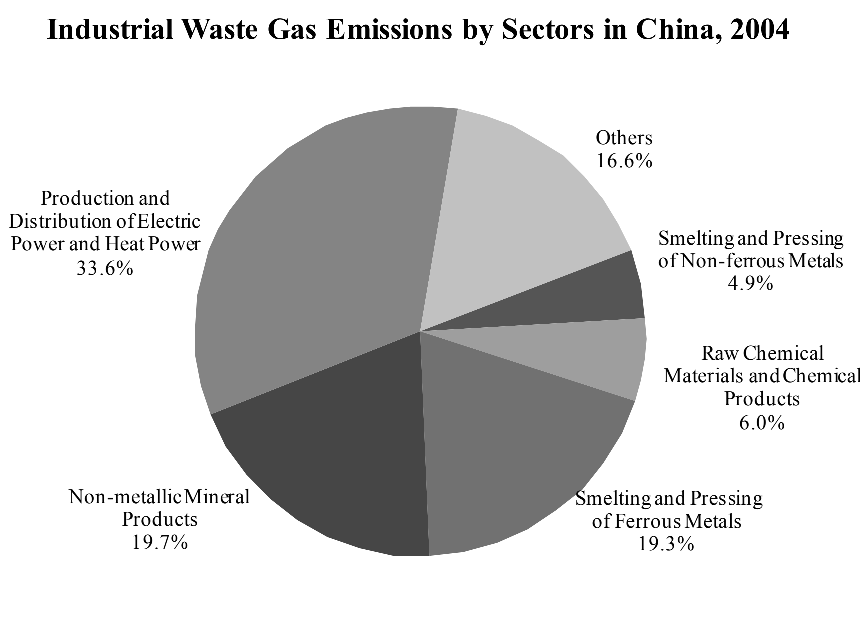


Source: China Environment Yearbook, 2005.

Petroleum-like matter refers to various kinds of hydrocarbon compounds. They float on the surface of the water and prevent gas exchange, thus lead to the deterioration of water quality. They can cause the death of fish and aquatic plants and hence affect the life of aquatic birds, and have a negative effect on the aquatic products industry. Figure 5.3.6 shows that about 70% petroleum-like matter come from four sectors, smelting and pressing of ferrous metals, chemical products, extraction of petroleum and the processing of petroleum.

Industrial waste gas is the main source of air pollution. It refers to the volume of total emitted gas comprising of pollutants caused through fuel combustion and industrial production processes such as smelting and processing of metals, chemical materials production, and paper production. The volume of waste gas is worked out under the standard conditions for temperature and pressure, i.e. 273 K (0 °C) and 101.325 kPa (1 atmosphere of absolute pressure). Figure 5.3.7 shows that the most waste-gas-pollution-intensive industrial sectors are production and distribution of electric power and heat power, non-metallic mineral products, and smelting and processing of ferrous metals. It is noticeable that within the power supply sector and non-metallic mineral products sector, coal-fired power stations and cement manufacture respectively contribute 91% and 81% of the waste gas emissions from each sector.

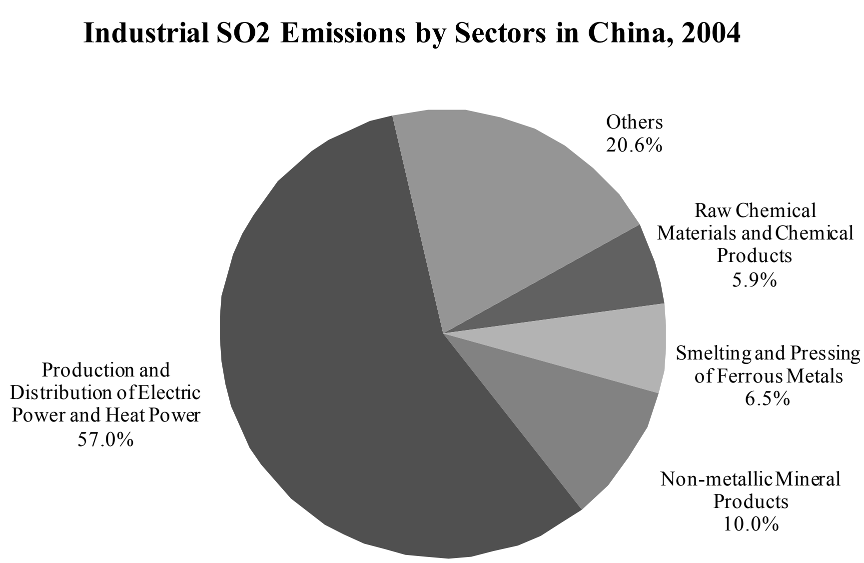
Figure 5.3.7 Industrial Waste Gas Emissions by Sectors in China, 2004



Source: China Environment Yearbook, 2005.

Sulphur dioxide measures the weight of SO_2 generated through fuel combustion, especially the burning of coal and oil; and production processes like smelting of non-ferrous ores. According to the annual reports of SEPA, in recent years 85% of SO_2 comes from fuel combustion, and 15% from industrial processes. China's SO_2 emissions have been the highest in the world, and half of them are attributed to burning of coal. Sulphur dioxide is widely employed in previous research as an important indicator of air pollution. Excess SO_2 emissions will cause severe damage to human health, especially to the respiratory system. Excess SO_2 emissions can also result in acid rain. Figure 5.3.8 illustrates that the majority of industrial SO_2 emissions are from the production and distribution of electric power and heat power. SEPA also reported that of the 57.0% emissions of SO_2, 93.4% are emitted from coal-fired power stations. Other sources of SO_2 emissions include manufacture of non-metallic mineral products, smelting and processing of ferrous metals, and chemical products.

Figure 5.3.8 Industrial SO_2 Emissions by Sectors in China, 2004



Source: China Environment Yearbook, 2005.

The level of SO_2 pollution in China is recorded in two ways: ambient concentration (ug/m^3) and mass emissions (tons). SO_2 ambient concentration, as mentioned in Table 5.3.3, is widely used as an air quality indicator. However, it combines all emissions of SO_2 from industrial, domestic and natural resources, and can be influenced significantly by climate factor such as wind-force and wind direction. Mass sulphur dioxide emissions are directly collected from factories and estimated by SEPA. The local bureaus of SEPA calculate mass emissions from the factories by combining factory self-reported data on fuel consumption and industrial process and periodic boiler stack testing data. Although the mass emission data is as robust as ambient data, it is more accurate for estimating industrial pollution (Liang, 2006).

Industrial soot and dust are two kinds of suspended particulate matter. Soot refers to the weight of suspended particulates in the smoke caused from fuel combustion, especially the component of smoke caused by the incomplete burning of carbon-rich organic fuels; while dust are those from industrial production processes, for example, refractory dust from iron and steel firms, screen dust from coking firms, sintering machine dust, lime kiln dust, and cement dust of constrution materials.[76] The emissions of dust are caluclated using the following equation.

Industrial dust emissions = Volume of gas from dust exhaust system × Average dust concentration of gas at the discharge point of the precipitator × Uptime of dust exhaust system

A similar equation applies to soot.

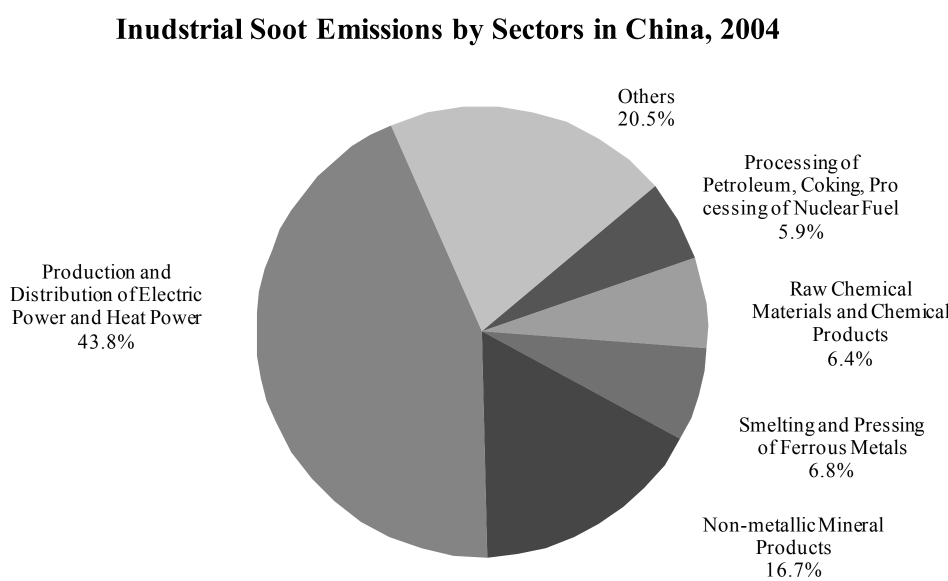
These two types of suspended particulates are considered as dangeous owing to both their particulate size and the chemical compounds present. They can stain clothing and can

[76] The particulates discharged from the power station are counted in industrial soot.

possibly cause illness if inhaled. They are hazardous to the lungs and general health when the particles are less than 5 micrometres in diameter, as such particles are not filtered out by the upper respiratory tract.

Similar to SO_2 emissions, the major sources of industrial soot pollution are the electric and heat supply sector, non-metallic mineral products, smelting and processing of ferrous metals, chemical products, and processing and coking of fuels (Figure 5.3.9).

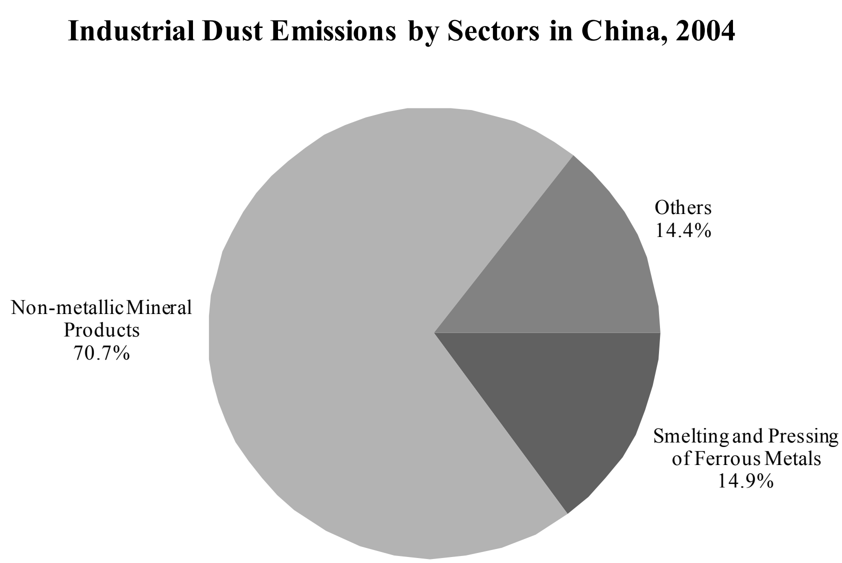
Figure 5.3.9 Industrial Soot Emissions by Sectors in China, 2004



Source: China Environment Yearbook, 2005.

In terms of dust, the non-metallic mineral products sector accounts for more than 70% of total emissions. Meanwhile, smelting and processing of ferrous metals is also a major source of dust (Figure 5.3.10).

Figure 5.3.10 Industrial Dust Emissions by Sectors in China, 2004



Source: China Environment Yearbook, 2005.

China Environment Yearbook has reported several other pollutants in wastewater, such as lead, arsenic, nitrogen-ammonia, volatile phenol, and others. These pollutants are not considered in this study because a number of cities did not report these data. Therefore, in this chapter, we focus on the total volumes of industrial wastewater and waste gas, plus the emissions of three specific water pollutants and three specific air pollutants.

5.4 Methodology

In this chapter, we employ a panel data of 112 main cities in China to estimate the relationship between income and eight environmental indicators. Then we examine the differences in environmental impact between domestic and foreign firms. We split foreign firms into two groups, i.e. firms funded from Hong Kong, Taiwan and Macao, and firms funded by other foreign economies.

In this section, we firstly introduce our model specification and then describe our data and discuss the methodology issues.

5.4.1 Model Specifications

In the light of previous literature on economic growth and environment we start by estimating the following reduced-form equation for the emissions of industrial pollutants.

$$Epc_{it} = \alpha + \gamma_i + \theta_t + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + \beta_4 (GIP / GDP)_{it} + \varepsilon_{it} \qquad (5.4.1)$$

where *Epc* denotes per capita emissions, γ is city-specific intercepts, θ is time-specific intercepts, Y represents per capita income, *GIP/GDP* refers to the gross industrial product (GIP) normalised by city GDP, and ε is the error term. Subscripts i and t represent city and year, respectively.

Equation 5.4.1 is estimated for a mixture of the abovementioned eight industrial water and air pollution indicators (*Wastewater*, *COD*, *CrVI*, *Petroluem*, *Waste Gas*, SO_2, *Soot* and *Dust*) over the period 2001-2004 for a sample of 112 major cities in China (See Appendix 5.1 for data definitions and sources, and Appendix 5.2 for the selected cities in the sample).

Per capita income indicates the direct scale and technique effects of economic growth. Some studies use GDP per km^2 to measure scale effects and per capita GDP to capture technique effects. "However, this is only appropriate when estimating *concentrations* of pollution. [In this chapter] pollution data are in the form of … emissions per capita and hence there seems no obvious way to separate scale and technique effects" (Cole, 2003).

The share of industrial output in GDP is used to capture the extent to which structural change within the economy has affected pollution, i.e. the composition effects of growth. The year specific effects are included to pick up any effects that are common to all cities but which change over time; and the city specific effects pick up the effects specific to each city which do not change over time.

In order to examine the environmental impacts of foreign affiliates and separate the activities of foreign affiliates from those of domestic firms, we decompose *GIP* into three components: industrial output for domestic firms (*GIPd*), the industrial output for the firms from Hong Kong, Taiwan and Macao (*GIPh*) (i.e. Chinese-sourced firms), and the industrial output for the firms funded by foreign countries (*GIPf*) (i.e. non-Chinese sourced firms). Thus Equation 5.4.1 becomes:

$$\begin{aligned} Epc_{it} &= \alpha + \gamma_i + \theta_t + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 \\ &\quad + \beta_4 (GIPd/GDP)_{it} + \beta_5 (GIPh/GDP)_{it} + \beta_6 (GIPf/GDP)_{it} + \varepsilon_{it} \end{aligned} \quad . \qquad (5.4.2)$$

In practice, we include per capita income (Y), and then add its quadratic term (Y^2) and finally the cubic term (Y^3). If a linear regression is considered, we expect a positive relationship between income and pollution at current economic development levels in China. If a quadratic function is estimated, we expect a standard EKC relationship (inverted-U) between income and pollution, i.e. $\beta_1>0$ and $\beta_2<0$. Following Grossman and Krueger (1995), we expect negative β_1 and β_3 and a positive β_2 in the cubic functions.

We expect that the greater the industrial output, the higher the industrial pollution emissions, i.e. a positive coefficient on *GIP/GDP* in Equation 5.4.1. There is a common view that domestic firms are usually less efficient than foreign affiliates, and hence induce more pollution. Thus we expect a positive sign on *GIPd/GDP* in Equation 5.4.2.

The previous literature suggests that the "net effects" of foreign investment may be positive and negative. Therefore, the signs on *GIPh/GDP* and *GIPf/GDP* are ambiguous. Furthermore, the signs may also depend on the sectors on which foreign capital have concentrated. It is not possible to get data on either foreign industrial output or FDI inflows/stocks by sectors; however, the China Industrial Economy Statistical Yearbook provides the paid-in capital into detailed industrial sectors. Table 5.4.1 presents the distribution of paid-in capital for all industrial sectors sorted by the share of domestic paid-in capital. Chinese-sourced capital is relatively high in sectors such as leather, fur, feather and related products; textile wearing apparel, footwear and caps; articles for cultural, education and sport activity; furniture; plastics; metal products; textiles; chemical fibres; and printing, reproduction of recoding media. Non-Chinese-sourced capital is high in various kinds of machinery and equipment; foods; metal products; rubber; paper and paper products; beverages; processing of food from agricultural products; medicines; and raw chemical and chemical products. Since the pollution intensity of these sectors varies according to pollution indicators, the environmental effect of Chinese-sourced and non-Chinese sourced firms may differ and depend on the pollution emissions estimated.

Table 5.4.1 Paid-In Capital of Industrial Sectors in China, 2003

Sector	Domestic (%)	H.T.M (%)	Foreign (%)	Total Capital
Leather, Fur, Feather and Related Products	4.86	60.91	34.23	21.05
Recycling and Disposal of Waste	6.11	8.78	85.11	0.26
Textile Wearing Apparel, Footware, and Caps	6.83	52.58	40.59	32.74
Articles for Culture, Education and Sport Activity	7.90	62.98	29.13	17.17
Artwork and Other Manufacturing	8.67	53.58	37.75	13.86
Furniture	12.26	53.40	34.34	10.39
Plastics	12.89	49.86	37.24	52.97
Communication Equipment, Computers & Other Electronic Equipment	17.01	24.62	58.38	190.26
Foods	19.54	25.06	55.40	38.50
Metal Products	19.71	38.83	41.46	44.47
Electrical Machinery and Equipment	22.44	24.99	52.58	85.03
Measuring Instruments and Machinery for Cultural Activity and Office Work	25.41	29.34	45.25	26.47
Rubber	26.37	18.39	55.24	21.80
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products	31.03	34.11	34.86	13.12
Textile	32.06	40.44	27.50	87.47
Paper and Paper Products	33.34	21.80	44.86	46.62
Beverages	35.73	23.51	40.76	53.87
Chemical Fibers	41.12	34.50	24.38	23.63
Processing of Food from Agricultural Products	41.57	18.82	39.61	43.42
General Purpose Machinery	43.71	11.33	44.96	76.90
Printing, Reproduction of Recording Media	48.03	35.93	16.04	25.06
Non-metallic Mineral Products	48.34	21.80	29.85	90.28
Medicines	49.99	13.28	36.74	44.74
Raw Chemical Materials and Chemical Products	54.57	12.93	32.50	146.88
Transport Equipment	57.62	9.64	32.74	149.45
Special Purpose Machinery	62.91	13.94	23.15	52.51
Smelting and Pressing of Non-ferrous Metals	77.67	9.55	12.78	53.96
Processing of Petroleum, Coking, Processing of Nuclear Fuel	81.17	9.07	9.76	47.86
Production and Distribution of Electric Power and Heat Power	87.00	5.66	7.35	330.13
Production and Distribution of Gas	88.06	3.38	8.56	22.34
Smelting and Pressing of Ferrous Metals	88.54	5.64	5.81	165.08
Extraction of Petroleum and Natural Gas	90.64	8.96	0.41	81.39
Mining and Processing of Nonmetal Ores	93.18	3.01	3.82	12.74
Production and Distribution of Water	96.23	1.25	2.52	60.10
Mining & Processing of Non-Ferrous Metal Ores	97.06	1.71	1.24	7.68
Mining and Processing of Ferrous Metal Ores	98.90	0.74	0.36	11.38
Mining of Other Ores	99.11	0.89	0.00	0.56
Tobacco	99.18	0.42	0.39	34.34
Mining and Washing of Coal	99.70	0.09	0.21	126.14

Note: H.T.M. indicates the paid-in capital from Hong Kong, Taiwan and Macao. Total capital is in billion yuan.

Source: China Industry Economy Statistical Yearbook, 2004.

In addition, Dean *et al.* (2005) suppose that FDI from Chinese sources enters China for the purpose of producing for export and is expected to be concentrated in relatively more unskilled labour-intensive industries; whilst FDI from non-Chinese sources produces for the internal Chinese market and is expected to be concentrated in relatively more skilled labour-intensive industries. They find Chinese-sourced FDI is significantly attracted by low environmental levies, but non-Chinese-sourced FDI is not. These findings give indirect evidence that non-Chinese firms use cleaner technology. This conclusion is supported by the survey of Brandt and Zhu (2005) that during 1983-1992, of the cumulative value of technology import contracts between foreign firms and Shanghai firms, 23.9 per cent was from Japan, 20.5 percent from Germany and 15.4 per cent from the United States. And as reported by the firms, the origin of imported equipment is mainly from these three technologically advanced countries as well. For these reasons, we assume firms funded by foreign countries are the cleanest and domestic firms the dirtiest. Additionally, if the signs on *GIPh/GDP* and *GIPf/GDP* are both positive, we expect that *GIPd/GDP* will have the largest effect on pollution emissions, followed by *GIPh/GDP* and *GIPf/GDP*.

In sum, the estimating results may differ by pollutant. Table 5.4.3 provides the expected signs of all the explanatory variables in Equations 5.4.1 and 5.4.2.

Table 5.4.2 Expected Signs for the Estimated Coefficient in Equations 5.4.1 and 5.4.2

Explanatory Variables	Signs
Y: per capita GDP	$+^a$, $+^b$, $-^c$
Y^2: (per capita GDP)^2	$-^b$, $+^c$
Y^3: (per capita GDP)^3	$-^c$
GIP/ GDP	+
GIPd/GDP: GIP/GDP for domestic firms	+
GIPh/GDP: GIP/GDP for firms invested by Hong Kong etc.	-/+
GIPf/GDP: GIP/GDP for firms invested by foreign courtiers	-/+

Note: a, b, and c indicate the linear function, quadratic function and cubic function.

5.4.2 Data Description

5.4.2.1 Pollution Emissions

The data of pollution emissions are collected from China Environment Yearbook.

The eight measurements of environmental quality are described in Section 5.3.3. We use the per capita emissions rather than concentrations. Previous evidence has illustrated that the relationship between income and pollution can vary depending on whether the pollutants are measured in terms of concentration or emissions.[77]

Cole and Elliott (2003) argue that concentrations and emissions data provide different information. City-level concentrations provide more information regarding the human

[77] For example, Selden and Song (1994) find that the turning points for city-level concentrations is at lower income levels than for national emissions because the reduction of concentration within a city is reasonably easy to achieve.

health impact of a particular pollutant. In contrast, emissions provide more information on wider environmental issues and may have a weak relationship with concentrations. For instance, if the government plans to tackle the detrimental health impact from air pollution, they could execute a policy of heightening the factory chimneys or encouraging firms to locate outside the city. These policies would reduce the city-level concentrations but would not reduce national emissions. Cole and Elliott (2003) also point out that concentrations data tend to be "noisier" than emissions data and require the inclusion of some dummy variables to capture site-specific effects, for example, variables to control for the nature of the observation site, the measuring equipment, the average temperature, and the level of rainfall.

Comparing the advantages and disadvantages associated with concentrations and emissions data, and regarding to our aim to examine the impact of economic growth and foreign affiliates on industrial pollutions, we decide to use industrial pollution emissions data to represent the environmental quality.

We choose the pollution indicators following the criteria claimed in Antweiler *et al.* (2001) that useful pollutants should: 1) be a by-product of goods production; 2) be emitted in greater intensity in some industries than others; 3) have strong local effects; 4) be subject to regulations because of its adverse effects on the population; 5) have well-known abatement technologies; 6) have data available from a wide mix of countries.

As shown in section 5.3.3, the selected eight pollution emissions are all generated from industrial production; are emitted in greater quantities in some industries than others; have strong local effects; subject to regulations at different degrees; and have available data for a wide mix of cities in China.

The China Environment Yearbook reports industrial pollution emissions for a number of key enterprises investigated by local environmental protection bureaus. The number of selected enterprises and the proportion of enterprises vary across cities. Such data cannot provide the information of total industrial pollution emissions at city level. Additionally, the data are not comparable. We have to convert the available pollution emissions of selected enterprises to the emissions of all the enterprises in the city. In addition to pollution emissions and treatments, other data reported in the China Environment Yearbook only include the number of selected enterprises and their industrial output. The number of enterprises is not appropriate to covert the industrial pollution emissions because of the difference in firm sizes. In this case, we use the industrial output to adjust the total industrial pollution emissions using the following equation.

$$E = e \times correction\ ratio = e \times \left(\frac{GIP}{gip} \right) \tag{5.4.3}$$

where e and gip are respectively the pollution emissions and gross industrial output from the investigated firms; and E and GIP are those for the city. Equation 5.4.3 implies that the total industrial emissions equal to the emissions of selected enterprises divided by the share of the selected firm's output to the total industrial output in the city. In this equation, we assume that the emissions per industrial product are the same within a city. Although some limitations exist for this assumption, it is the only available method to get the total industrial pollution emissions in a city.

5.4.2.2 Explanatory Variables

Data for the explanatory variables are all collected from China City Statistical Yearbook. All the values (per capita GDP, capital, and industrial output) are adjusted to 1990 prices using GDP deflator.

Tables 5.4.3 and 5.4.4 respectively provide the descriptive statistics of all variables and their correlations. The correlations matrix generally supports the sign expectations in Table 5.4.2.

Table 5.4.3 Descriptive Statistics of Variables

Variable	Obs.	Mean	Std. Dev.	Min	Medium	Max
Wastewater (tons per person)	424	38.49	32.34	2.03	27.92	168.96
COD (tons per 10000 persons)	432	81.80	70.72	0.67	62.58	340.88
CrVI (kg per 10000 persons)	384	1.62	2.46	0.0021	0.50	13.83
Petroleum (tons per 1000000 persons)	424	46.33	51.17	0.026	25.46	236.16
Waste Gas (m^3 per person)	439	4.70	4.19	0.13	3.34	21.39
SO_2 (tons per 10000 persons)	428	325.39	252.65	4.38	260.84	1355.84
Soot (tons per 10000 persons)	436	138.54	103.47	0.74	107.83	693.93
Dust (tons per 10000 persons)	424	118.09	122.58	0.020	71.17	649.65
Y (1000 yuan)	428	8.55	6.37	1.94	6.56	48.04
GIP/ GDP (100 yuan per yuan)	427	96.44	42.10	11.89	87.73	277.76
GIPd/GDP (100 yuan per yuan)	424	75.94	32.14	9.82	72.87	179.99
GIPh/GDP (100 yuan per yuan)	422	9.00	16.14	0	3.86	119.13
GIPf/GDP (100 yuan per yuan)	422	11.60	16.86	0	4.80	120.61

Note: extreme outliers have been removed for all dependent variables' statistics; the descriptive statistics of the independent variables are those in the sample for SO_2 without extreme outliers.

Table 5.4.4 Correlations of the Variables

	Waste-water	*COD*	*CrVI*	*Petro-leum*	*Waste Gas*	SO_2	*Soot*	*Dust*	Y	Y^2	Y^3	*GIP/ GDP*	*GIPd/ GDP*	*GIPh/ GDP*	*GIPf/ GDP*
Y	0.470	0.111	0.430	0.226	0.551	0.537	0.128	-0.043	1.000						
Y^2	0.377	0.076	0.390	0.155	0.502	0.469	0.088	-0.095	0.933	1.000					
Y^3	0.288	0.049	0.341	0.098	0.451	0.379	0.060	-0.116	0.789	0.951	1.000				
GIP/ GDP	0.531	0.222	0.421	0.295	0.622	0.645	0.196	0.123	0.679	0.577	0.439	1.000			
GIPd/GDP	0.406	0.188	0.203	0.322	0.561	0.515	0.301	0.329	0.309	0.265	0.234	0.721	1.000		
GIPh/GDP	0.249	0.147	0.409	-0.052	0.214	0.355	-0.056	-0.155	0.507	0.434	0.300	0.553	-0.081	1.000	
GIPf/GDP	0.248	0.032	0.268	0.177	0.271	0.291	-0.021	-0.139	0.630	0.527	0.367	0.598	-0.031	0.579	1.000

Note: extreme outliers are removed for the correlations between all dependent variables and independent variables; correlations between independent variables are those in the sample for SO_2 without extreme outliers.

5.4.3 Methodological Issues

Equations 5.4.1 and 5.4.2 are estimated using two alternative functional forms in levels and in logs. However, Cole *et al.* (1997) argue that the quadratic logs function seems to provide a more realistic income-environment relationship than the quadratic levels function because of the symmetrical nature of the latter. The symmetry of quadratic levels function implies, first, that pollution levels will fall at the same rate as they increased and, second, that these pollution levels will become negative, probably in a short space of time. In contrast, a quadratic log function falls away gradually once it passes the turning point, because the curve asymptotically approaches zero. In addition, the distribution of the variables in both equations with positive skewness can be easily corrected by taking logs.[78] Therefore, log functions are reported in the main text.

The second methodological issue concerns the exogeneity of per capita income, in response to the claim that the EKC may suffer from simultaneity bias due to causality moving from environmental degradation to income. A Davidson-MacKinnon test is employed to test the null of exogeneity of current income in fixed-effects regressions for Equations 5.4.1 and 5.4.2. Lagged income is used as an instrumental variable. The null hypothesis of exogeneity is accepted in the majority cases suggesting that simultaneity bias is not present. Per capita income shows to be endogenous in logged models when using waste gas and industrial soot as dependent variables; and in level models when using CrVI and industrial dust as dependent variables. Therefore, instrumental variable (IV) regression is used with lagged income as an instrumental variable when income shows to be endogenous.

[78] After taking logs, the positive skewness of all the dependent and independent variables is significantly reduced.

Third, we test for heteroskedasticity and autocorrelation. We employ a Breusch-Pagan test for heteroskedasticity. The results reject the null hypothesis of homoskedasticity in all cases. We also estimate the following dynamic model for the residuals to test whether or not there is first order autocorrelation.

$$\varepsilon_{it} = \rho\varepsilon_{it-1} + v_{it}, t = 2, \ldots, T \tag{5.4.4}$$

where $|\rho| < 1$ and $v_{it} \sim \text{IID}(0,\ \sigma_v^2)$.

The results show that the estimated $\hat{\rho}$'s are significant for a few cases, indicating that there is first-order autocorrelations within the panel. $\hat{\rho}$'s are not statistically different from zero in other regressions. Thus, heteroskedasticity and autocorrelation need to be corrected for if they are present.[79]

The next concern is the non-stationary of the income and emissions data, which has been tested in some papers, such as Stern and Common (2001) and Cole (2003). However, all the samples in our dataset are extremely short, with only four observations for each city. Thus the test of stationary is largely meaningless. It is impossible to take individual Augmented Dick-Fuller tests or panel unit root tests with only four time series observations.

The fifth issue is to find the appropriate estimator. Grossman and Krueger (1991and 1995) point out that the random-effects estimator is more appropriate than fixed-effects

[79] For random-effects models, AR(1) presents in CrVI logged models; while for fixed-effects models, AR(1) presents in Wastewater level models, SO_2 logged models and Soot logged models. We use the Stata command *xtreg* with the *robust* option to remove the heteroskedasticity and the Stata command *xtregar* to correct the autocorrelation. However, *xtregar* does not allow a *robust* option to be applied. Therefore, we employ a heteroskedasticity test for the *xtregar* results. For example, we plot the squared residuals and the fitted values of logged CrVI, and do not find significant relationship between them for our random-effects models, suggesting homoskedasticity in the residuals.

estimator for studies that use unit-specific data. In the model with fixed-effects, all unit-specific characteristics that are constant over time are absorbed in the constant term, *a*. Thus, we cannot discriminate between the effects of some variables, such as the province dummies of the city, which may influence pollution. If we add these variables as additional regressors, these individual-specific effects cannot be estimated in the fixed-effects model due to perfect collinearity. To account for this, we estimate Equations 5.4.1 and 5.4.2 by Generalised Least Square (GLS). In this case, the error term is the sum of two components, the random component and an idiosyncratic error component. In order to check the efficiency of random-effects estimator, a Hausman specification test is employed to examine whether or not there is some correlation between the explanatory variables and the error terms (the strictly exogeniety assumption of the random-effects model). The results generally indicate that the random-effects specification is consistent and efficient (only 1 rejects the null for logged models). Therefore, random-effects specification results are reported in the main text. We add province level dummy variables to capture province-specific characteristics which are assumed to be constant over time, such as, geographical location, climate, resource endowments, corruptibility of government.

Finally, according to the current development level in China, we expect that economic development will increase environmental pollution levels. We therefore expect most Chinese cities to be on the upsloping part of the curve. Therefore, we begin with a simple linear model and then move on to quadratic models. A cubic income term is also included in order to examine the possibility that pollution will increase again at high income levels. However, every cubic relationship necessarily extends to plus or minus infinity, which is not realistic. In addition, the cubic term is generally not statistically significant at the 90% confidence level. Although the cubic term is found to be significant for some pollutants, such as *Petroleum* and SO_2, the turning point is not found (i.e. the curve is monotonically increasing). Therefore, linear and quadratic equations are reported in the main text.

In sum, linear and quadratic log specifications with random-effects are reported in the main text of this chapter.

5.5 Empirical Results

5.5.1 Main Results

Tables 5.5.1 - 5.5.4 provide our main results for each of the pollution indicators. Other results are presented in Appendices (Cubic log results with random-effects can be found in Appendix 5.3, log results with fixed-effects in Appendix 5.4, and all level results in Appendix 5.5).

Wastewater

Table 5.5.1 starts the results with industrial wastewater and chemical oxygen demand. Models 1 and 2 are the linear and quadratic specifications from Equation 5.4.1, while Models 3 and 4 are those from Equation 5.4.2. The Davidson-MacKinnon test results of exogeneity are provided, suggesting the exogeniety of current income. Hausman specification test results indicate that there is no correlation between the explanatory variables and the error terms, i.e. random-effects estimator is appropriate. Nevertheless, the autocorrelation test also suggests no such correlation within panels.

Model 1 for industrial wastewater shows a statistically significant and positive relationship between income and the emissions of industrial wastewater. The income elasticity is approximately 0.43, indicating a 10 per cent increase in per capita income will increase per capita emissions of industrial water by 4.3 per cent. When a quadratic specification is considered, we find a statistically significant inverted-U-shaped relationship between per capita income and per capita emissions. The estimated turning point is around RMB 35,235 at 1990 price (about $7,371).[80] In our sample, only Karamay city passed this income level in 2003 and 2004, demonstrating that most of Chinese cities are on the left side of the EKC curve, i.e. economic growth has positive effects on the industrial wastewater pollution emissions. The estimated income elasticity in Model 2 is around 0.46 at the mean of per capita income and is similar to that for the linear Model 1. The table also reports the estimated turning points from the fixed-effects results to enable comparison with the random-effects turning points. We find that they are broadly similar.

Referring to the effects of industrial output, we find that it has a constant significant and positive impact on wastewater emissions. Thus, the structural changes within the economy are responsible for the pollution levels. The structural changes from traditional agricultural economy to current dualistic economy (modern and traditional sectors) have increased the pollution emissions. Further structural changes within the modern sectors (from manufacturing to service sectors), at higher income levels, may improve the environmental quality.

Models 3 and 4 decompose industrial output according to the ownership of enterprises. The results of per capita income are similar to those in Models 1 and 2. However the

[80] Annual average exchange rate is $1=RMB 4.78 in 1990. RMB 35,235 is equal to about RMB 71,040 in 2004 prices, which is approximately $ 8,580 at the 2004 exchange rate ($1=RMB 8.28).

estimated turning point in Model 4 is higher than that in Model 2.[81] No city in our sample has passed this income level. It confirms our expectation that economic growth induces more wastewater pollution at current income levels for all cities in China.

Amongst the firms with different ownerships, industrial output of domestic firms is found to have the strongest positive impact on wastewater emissions. Firms owned by Hong Kong, Taiwan and Macao, are also found to generate more industrial wastewater, but the magnitude is small, only ten per cent of that on domestic firms. In contrast, the coefficient on the industrial output of foreign invested firms is negative and is not statistically different from zero. These results are supported by Table 5.4.1, in which Chinese-sourced firms have a significant share in wastewater pollution intensive sectors like textiles and textile related products; while foreign-funded firms have a high share in sectors that have discharged less wastewater, for example, transport equipment, electrical machinery and equipment. Nevertheless, the results support our expectations that foreign invested firms are generally the cleanest while domestic firms are the dirtiest.

The final issue relates to the results for our year dummy variables and province dummy variables (not reported here). The year dummies are negative and significant in 2003 and 2004, with a value around -0.1, indicating a general decline of wastewater emission over time. Most of the province dummies are positive, but none of them are significant.

[81] RMB 57,561 equals to $12,042 at 1990 annual average exchange rate. At the price and exchange rate in 2004, the corresponding turning point is RMB 116,054 or $14,016.

Chemical Oxygen Demand (COD)

With regards to COD, we do not find any significant relationship between per capita income and per capita emissions of COD. This result is different from Shen (2006), who finds a standard EKC relationship between income and COD emissions using province level data, and the turning point is around the sample mean.

As with wastewater, industrial output has the strongest positive effect on COD discharges, indicating the importance of structural changes in determining environmental quality. Domestic firms are found to have significant influence on COD emissions only in Model 4, at 10% significance level. Hong Kong, Taiwan and Macao invested firms significantly increase COD pollution. A 10 per cent increase in the output from such firms will rise up the COD emissions by 1.1 per cent. Table 5.4.1 illustrates that Chinese-sourced capital takes a significant share in several COD intensive sectors, such as paper products, food processing, beverage, textiles, and chemical products. Foreign invested firms also have positive impact on COD but the influence is not significant.

Finally, time effects are significant and negative and province-specific effects are broadly significant and positive.

Table 5.5.1 Linear and Quadratic Log Estimation Results with Random-effects for Industrial Wastewater and COD

Variables	Wastewater				COD			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Y	0.43 (4.29)***	0.98 (4.24)***	0.50 (5.01)***	1.00 (3.92)***	0.050 (0.29)	-0.60 (1.00)	0.17 (0.99)	-0.48 (0.90)
Y^2		-0.14 (2.62)***		-0.12 (2.15)**		0.16 (1.20)		0.16 (1.32)
GIP/GDP	0.52 (3.91)***	0.52 (4.04)***			0.69 (2.53)**	0.68 (2.50)**		
GIPd/GDP			0.46 (3.82)***	0.44 (3.70)***			0.36 (1.58)	0.38 (1.71)*
GIPh/GDP			0.048 (1.73)*	0.044 (1.57)			0.11 (2.26)**	0.11 (2.36)**
GIPf/GDP			-0.014 (0.59)	-0.019 (0.82)			0.030 (0.55)	0.039 (0.72)
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.12 (0.13)	-0.58 (0.68)	0.15 (0.18)	-0.19 (0.24)	0.15 (0.14)	0.76 (0.58)	1.08 (1.12)	1.57 (1.40)
R^2 (overall)	0.62	0.63	0.65	0.65	0.37	0.36	0.43	0.43
DM	0.56	0.12	0.09	0.02	1.81	0.82	2.51	1.46
Hausman	0.36	1.03	5.12	5.74	3.05	0.17	4.33	3.96
AR(1)	No	No	No	No	No	No	No	No
Turning point RE (FE)		35,235 (32,577)		57,561 (33,913)				
Observations	423	423	398	398	431	431	407	407

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Turning point is in RMB at 1990 price.

Hexavalent Chromium Compounds (CrVI)

Table 5.5.2 provides the results for hexavalent chromium compounds and petroleum-like matter.

In respect to CrVI, first-order autocorrelation exists within panels. We therefore employ a random-effects GLS regression with AR(1) disturbances model. Results suggest positively linear relationship between per capita income and emissions of such compounds. The income elasticity is relatively high, at around 0.7-0.8 according to Models 1 and 3. Again, gross industrial output significantly increases the discharges of CrVI, and domestic firms contribute a lot to such effects. Turning to the activities of foreign affiliates, Chinese-sourced firms increase the discharge of such compounds with an elasticity of 0.21, while non-Chinese-sourced firms decrease the discharges but the effects are not statistically significant. CrVI is highly discharged in manufacture of non-ferrous and metal products, leather, fur, feather and related products. Comparing the paid-in capitals of Chinese investors and non-Chinese investors in Table 5.4.1, the former have invested more in metal products, leather, fur feather and related products, and plastics. However, non-Chinese investors show considerable shares in chemical products and communication equipment products, which are also relatively CrVI polluting industries. Although it is not significant, the negative sign of *GIPf/GDP* is conflicting with the correlation ratio shown in Table 5.4.3.

In addition, year dummy for 2004 is negative and significant. Province-specific dummies for Zhejiang, Fujian, Hubei, Chongqing, Gansu and Xinjiang are positively significant. A possible explanation is that Zhejiang and Fujian are well known for their manufacturing in wearing apparel (including leather related products); Chongqing municipality and cities in other three provinces specialise in heavy industries and may concentrate in sectors like ferrous and metal products, and transport equipment.

Petroleum-like Matter (Petroleum)

As with wastewater, the results for petroleum-like matter provide evidence of a robust inverted-U-shaped-relationship between per capita income and emissions. The estimated turning point is around RMB 22,089 on average (about $4,621 at the 1990 exchange rate), which is lower than *Wastewater*.[82] In our sample, nine cities have passed this income level, indicating the scale effects have been overcome by technique effects in these cities. The estimated turning points are robust across random-effects and fixed-effects models. Additionally, the estimated elasticity at mean of income is 1.0 in Model 2, much higher than other pollutants.

Again, the coefficients on *GIP/GDP* and *GIPd/GDP* are both positive and significant. The coefficient on *GIPh/GDP* is not statistically different from zero. The coefficient on *GIPf/GDP* is significant with the magnitude around 0.2, which is higher than that on *GIPh/GDP*. A possible explanation is that foreign funded enterprises have invested a great amount in the sectors discharging more petroleum-like matter, e.g. raw chemical materials and chemical products, medicines, and transport equipment.

Time effects are negative and significant in 2003 and 2004. The province dummy for Hainan province is significantly negative. Provinces such as Xinjiang and Gansu, which have a high share of extraction and processing of petroleum, have positive and significant coefficients on their dummies.

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82 Equivalent to RMB 44,536 ($5,379) at 2004 prices and exchange rate.

Table 5.5.2 Linear and Quadratic Log Estimation Results with Random-effects for Industrial CrVI and Petroleum-like matter

Variables	CrVI				Petroleum			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Y	0.67 (2.22)**	0.23 (0.24)	0.76 (2.50)**	-0.16 (0.16)	0.92 (3.17)***	2.64 (3.01)***	0.73 (2.78)***	2.45 (2.85)***
Y^2		0.11 (0.47)		0.23 (0.95)		-0.43 (2.22)**		-0.42 (2.21)**
GIP/GDP	0.71 (1.71)*	0.69 (1.64)			0.85 (1.95)*	0.87 (1.95)*		
GIPd/GDP			0.69 (1.95)*	0.72 (2.03)**			0.91 (2.45)**	0.83 (2.18)**
GIPh/GDP			0.21 (1.88)*	0.22 (1.93)*			0.068 (0.97)	0.063 (0.93)
GIPf/GDP			-0.12 (1.25)	-0.11 (1.17)			0.22 (3.06)***	0.21 (3.04)***
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-6.61 (3.20)***	-6.15 (2.69)***	-6.51 (3.47)***	-5.83 (2.91)***	-2.61 (1.23)	-4.18 (1.78)*	-2.79 (1.47)	-3.95 (1.97)**
R^2 (overall)	0.48	0.48	0.48	0.49	0.45	0.47	0.46	0.47
DM	0.98	1.17	0.93	1.12	0.59	2.04	0.12	0.95
Hausman	3.85	2.37	6.32	6.05	1.03	3.52	4.12	1.08
AR(1)	Yes	Yes	Yes	Yes	No	No	No	No
Turning point RE (FE)						22,089 (21,385)		18,436 (14,102)
Observations	383	383	364	364	423	423	403	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Turning point is in RMB at 1990 price.

Waste Gas

Considering waste gas, the Davidson-MacKinnon test results reject the null hypothesis that per capita income is exogenous in most logged models. Therefore, we employ generalised two-stage least square (G2SLS) random-effects IV regression in all logged models. Lagged income is used as the instrumental variable. In addition, our random-effects specification is rejected in Model 4; however it does not affect our conclusions because only a linear relationship is found between income and emissions. The income elasticity is approximately 0.6. Total industrial output and the output of domestic firms remain positive and significant effects on the total waste gas emissions. The coefficients on *GIPh/GDP* and *GIPf/GDP* are both positive with similar and small value, but neither of them is significant.

Contrary to the water pollution indicators, time effects are positive, indicating deterioration of air pollution in recent years. The results for province dummies are mixed in sign and mostly are not statistically different from zero, except the strong negative coefficient on that of Hainan province.

Sulphur Dioxide (SO_2)

The results of SO_2 are broadly similar to those for waste gas. We find that per capita GDP has positive effects on SO_2 emissions and the income elasticity is approximately 0.53.[83] Such a linear relationship is different from previous studies on Chinese SO_2 emissions, i.e. Liang (2006) and Shen (2006). The finding in Liang (2006) is optimistic and conflicting

[83] Although significant coefficients are found on all income terms in cubic specifications, the function is monotonic increasing, i.e. no turning point is found.

with the fact that SO_2 emissions have continued increasing in recent years. However, our results, to some extent, are consistent with the findings in Shen (2006).[84]

The coefficient on *GIP/GDP* is positive and significant, which is consistent with the expectation, indicating that the greater industrial output is produced, the more pollution will be emitted.

The results in Models 3 and 4 support our expectation that domestic firms are the most pollution-intensive. Although the coefficients are both positive, we do not find any significant environmental impact for the firms owned either by Hong Kong, Taiwan and Macao or by other foreign economies. A possible explanation is that the SO_2 polluting sectors (production and distribution of electric and heat powers, smelting and processing of ferrous metals) are mostly funded by domestic capital as shown in Table 5.4.1. Such neutral effect of output from both foreign groups on SO_2 emissions is different from the negative effects in Liang (2006) and small positive effects in He (2006).[85]

Additionally, year dummies are not significant. Province-specific characteristics generally have a positive and significant influence on SO_2 emissions, probably due to the large consumption of coal across China. Among the 30 observed provinces, only Hainan province has a negative coefficient.

[84] Shen (2006) finds a U-relationship between per capita income and per capita emissions, and the turning point is 3000-5000 RMB, indicating at least 50% provinces are on the increasing side of the curve.

[85] The elasticity in Liang (2006) is -0.6 to -0.7, and that in He (2006) is 0.098.

Table 5.5.3 Linear and Quadratic Log Estimation Results with Random-effects for Industrial Waste Gas and SO_2

Variables	Waste Gas				SO_2			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Y	0.55 (4.08)***	0.85 (2.66)***	0.64 (5.00)***	0.97 (2.87)***	0.53 (4.61)***	0.52 (1.89)*	0.56 (5.49)***	0.50 (1.84)*
Y^2		-0.070 (1.02)		-0.075 (1.03)		0.0039 (0.06)		0.016 (0.27)
GIP/GDP	0.72 (5.85)***	0.72 (5.84)***			0.62 (4.37)***	0.62 (4.37)***		
GIPd/GDP			0.58 (5.70)***	0.57 (5.56)***			0.52 (4.46)***	0.52 (4.45)***
GIPh/GDP			0.026 (0.88)	0.024 (0.81)			0.043 (1.30)	0.043 (1.30)
GIPf/GDP			0.027 (0.98)	0.024 (0.84)			0.025 (0.80)	0.026 (0.83)
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.15 (3.76)***	-3.43 (3.88)***	-2.60 (3.60)***	-2.85 (3.74)***	1.09 (1.68)*	1.10 (1.62)	1.55 (2.83)***	1.60 (2.78)***
R^2 (overall)	0.63	0.63	0.68	0.68	0.69	0.69	0.71	0.71
DM	3.04*	3.71*	2.12	2.74*	0.07	0.06	1.44	1.47
Hausman	0.19	0.19	7.46	26.79**	1.51	1.73	0.05	1.37
AR(1)	No	No	No	No	No	No	No	No
Turning point								
Observations	438	438	413	413	427	427	407	407

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Turning point is in RMB at 1990 price.

Soot

Table 5.5.4 shows the main results for industrial soot and dust. For soot, we do not find a significant coefficient on per capita income in Models 1 and 2. In light of the Dickson-MacKinnon test results, current income is endogenous in Models 3 and 4. We thus employ G2SLS random-effects IV regression with lagged income as instrumental variable. The results show per capita income increases industrial soot pollution.

With regards to other explanatory variables, results of *GIP/GDP* and *GIPd/GDP* confirm the evidence that structural changes within the economy are important for the environmental quality, and domestic firms are dirtier than foreign affiliates. Coefficient on *GIPh/GDP* is positive and that on *GIPf/GDP* is negative but neither is significant.

Nevertheless, the coefficients on our year dummy variables are negative and significant in 2002. A number of provinces have positive and significant coefficients on their province dummy variables, among which Shanxi has the largest impact, due to its endowments of coal. A negative and significant provincial-specific effect is found only for Hainan province.

Dust

Finally, we consider the results for industrial dust. We do not find any significant relationship between income and emissions, although the correlation matrix shows that we might expect a negative effect. This finding is consistent with Shen (2006). Results of industrial output and its three components are similar to those for *Soot*. We do not find any significant year-specific effects. Again, Hainan has a negative and significant province-specific effect.

Table 5.5.4 Linear and Quadratic Log Estimation Results with Random-effects for Industrial Soot and Dust

Variables	Soot				Dust			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Y	0.055	-0.31	0.35	0.070	-0.089	-0.63	0.021	-0.53
	(0.36)	(1.02)	(2.99)***	(0.20)	(0.33)	(1.16)	(0.08)	(0.96)
Y^2		0.090		0.065		0.13		0.13
		(1.40)		(0.88)		(1.03)		(1.02)
GIP/GDP	0.71	0.70			0.75	0.73		
	(5.35)***	(5.23)***			(3.81)***	(3.66)***		
GIPd/GDP			0.45	0.46			0.95	0.96
			(4.08)***	(4.17)***			(4.83)***	(4.85)***
GIPh/GDP			0.041	0.042			0.054	0.056
			(1.20)	(1.23)			(1.16)	(1.19)
GIPf/GDP			-0.0039	0.00068			-0.022	-0.018
			(0.13)	(0.02)			(0.56)	(0.43)
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.76	1.11	1.29	1.50	1.17	1.70	0.39	0.82
	(1.12)	(1.57)	(1.87)*	(2.01)**	(0.78)	(1.05)	(0.25)	(0.50)
R^2 (overall)	0.61	0.60	0.62	0.62	0.38	0.38	0.40	0.39
DM	1.42	0.38	9.11***	5.96**	0.06	0.05	1.93	0.61
Hausman	1.90	4.51	5.51	8.16	0.45	1.24	10.78	11.40
AR(1)	No	No	No	No	No	No	No	No
Turning point								
Observations	435	435	415	415	423	423	403	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Turning point is in RMB at 1990 price.

In sum, our main results for random-effects models show that the standard EKC relationship between income and pollution is only found for wastewater and petroleum-like matter. The estimated turning points exceed the income level of at least 95% cities. The results of other pollution indicators generally show a positive linear income-pollution nexus, except COD and industrial dust. Therefore, at current income level, the net effects of economic development on environmental quality are negative.

The results of industrial output are broadly robust across all models for all pollutants, confirming that structural changes within the economy play an important role in determining water and air pollution levels in China.

When we decompose industrial output by ownership, domestic firms are shown to be the most polluting. The net effects of the firms invested by Hong Kong, Macao and Taiwan are positive in all models for all pollutants, but only significant for three water pollution indicators, i.e. Wastewater, COD and CrVI. It is probably because such investment is preferred to produce for export and locate in sectors such as textiles, wearing apparel and leather products, which are wastewater polluting. The impact of the activities of foreign enterprises is only positive and significant on petroleum-like matter emissions. No significant effects are found on other pollutants.

Year-specific effects are negative for some pollutant, but positive for waste gas. The province-specific effect of Hainan province is strongly negative for five pollutants, petroleum-like matter, waste gas, SO_2, soot and dust.

5.5.2 Results in Appendices

Appendix 5.3

The cubic term of income is significant in the models of Petroleum and SO_2 but turning points are not found. The cubic term of income in other regressions is statistically insignificant. The results for other explanatory variables are robust to those in linear and quadratic models.

Appendix 5.4

The results from fixed-effects models are broadly similar to those with random-effects models for most of the pollutants. A notable difference is that foreign funded firms are found to have positive and significant effects on waste gas emissions and SO_2 emissions. However, the coefficient of determination R^2 appears to be quite low for most of the emissions, suggesting that fixed-effects models do not fit well. In addition, models on COD, CrVI, and Petroleum fail the *F*-test on the overall significance of the regression.

Appendix 5.5

The level results between random-effects and fixed-effects models are broadly similar. We find a few differences between level results and log results. Firstly, the estimated turning points for wastewater and petroleum-like matter are lower than those using logged data. However, it does not change our conclusion that the majority of cities are located on the increasing part of the environmental Kuznets curve. Second, although we find U-shaped relationship between per capita income and SO_2 emissions for Model 5 in Table 5.5.3, the Hausman specification test suggests that the random-effects model is inconsistent and inefficient. Third, we find an inverted-U relationship between income and dust emissions.

The estimated turning point, again, confirms the positive relationship between growth and pollution emissions at current income levels in majority Chinese cities. In addition, we find significantly positive relationship between *GIPf/GDP* and CrVI emissions, which are consistent with our expectations. Finally, we find positive and significant impact of *GIPf/GDP* on COD emissions in fixed-effects models. Other results are roughly consistent with log results.

5.6 Conclusions and Policy Implications

In this chapter, we use a panel of 112 Chinese cities over four years to examine the income-pollution nexus for several water and air pollution indicators. We also compare the net environmental effects of economic activities of domestic firms, Chinese-sourced affiliates from Hong Kong, Taiwan and Macao, and non-Chinese-sourced affiliates from other foreign economies.

Our pollution indicators include four industrial water pollution emissions, i.e. wastewater, chemical oxygen dioxide, hexavalent chromium compounds, and petroleum-like matter; and four industrial air pollution emissions, i.e. waste gas, sulphur dioxide, soot, and dust.

We find that the linear and quadratic log specifications with random-effects fit the models very well. Although the environmental Kuznets curve is found to exist for two pollutants, the evidence of the majority pollution emissions (except COD and dust) confirms that at current income level in China, economic development (with current technology levels and policies) will induce more industrial pollution emissions, i.e. the net effects of economic growth on environment quality is negative. We also find that total industrial output has strong positive effects on industrial pollution emissions, and the impacts of industrial output differ by ownership. Domestic firms have the strongest positive effects on industrial pollution emissions; Chinese-sourced affiliates have moderate positive effects on three of the four water pollution emissions, but an insignificant impact on air pollution; and foreign invested firms have significant and positive influences on the emissions of petroleum-like matter, but neutral impacts on all the other pollutants.

If the environmental Kuznets curve exits for all the pollution emissions at higher income levels in China, it does not suggest that China can outgrow the environmental problems by simply emphasising economic growth without the need for special attention to the environment itself. Panayotou (2003) argues that government policy can affect the shape and height of the EKC through three channels. First, the turning point of the EKC may be delayed or advanced, weakened or strengthened by policy intervention. In addition to higher incomes, the environment could be improved by the policy responsiveness to the growing demand for environmental quality, through the enactment of environmental legislation and development of new institutions to protect the environment. Second, since it may takes decades for low-income countries to pass the turning point, the accumulated damage in the meantime may far exceed the present value of higher future growth and a cleaner environment. Therefore, active environmental policy at present may be justified and the present cost of prevention may be more cost effective than future treatments. Third, the height of the EKC reflects the environmental price of economic growth, which depends on income levels, as well as market efficiency and policies. Therefore, to reduce the environmental price, it is important to remove environmental harmful subsidies, for example on energy and transport; enforce property rights; price resources at full-cost; and internalise environmental costs though pollution taxes and tradeable permits.

Thus, in order to make environmental improvements and to reduce the environmental damage for each increment of income per capita, the Chinese government is recommended to enforce their environmental protection at the earlier stages of economic development, through the improvement and reinforcement of environmental regulations at every administrative level of the country. The Law of Property Rights, which has been executed from 1st October 2007, may help to reduce the environmental price of economic growth.

In 2006, Chinese Premier Wen Jiabao pointed out the importance of green development in his government work report. "Wen has ordered local governments to establish accountability rules for implementing caps on sulphur dioxide and other pollutants, and demanded that local officials face inspections for pollution control" (Reuters, 16/08/2006). GDP (or economic growth) is not any more the key theme considered by the local policy makers, and environmental protection has been a factor to assess the achievement of local official in some provinces. Reuters also reported that China will rigorously enforce limits on industrial pollution to rein in rampant pollution and cool the frenetic economic growth. Zhou Shengxian, head of SEPA, said that the central leadership and State Council are treating reductions in energy use and major pollutant emissions as two major hard targets and using the reduction of major pollutant emissions as an important means to promote coordinated, sustainable development. These two targets are the red lines that cannot be crossed. In 2004, Wen Jiabao announced that the green GDP would replace the traditional GDP as a measure of economic growth, as well as the performance measure for government officials. Green GDP deducts the depreciation costs of environmental damage and resource depletion from gross GDP. A recent report indicates that growth of green GDP was virtually zero in some provinces in the first half of 2007, suggesting that "true" economic growth in China may be significantly lower than it appears once the depreciation of natural capital is taken into account (Shanghai Securities News, 03/08/2007). Although there are some technical hitches to implement green GDP as a performance measure of local government officials, it at least helps local government to pay more attention on environmental problems and increases public concerns of environmental protection. Central government should promote the process of wide implementation of green GDP index.

Our results show that structural changes in the economy, especially those of domestic firms, to some extent, have important roles in determining pollution levels. Therefore, the future structural changes within domestic enterprises at higher income levels, from manufacturing to service sectors, are vital to improve environmental quality. Foreign invested firms seem to be the most efficient and have better environmental practices. Foreign firms may also have technology spillovers to local firms through imitation, employment turnover and supply chain requirements. However, the technology transfer does not happen automatically. Local institutions are vital to promote the local capacity to assimilate, diffuse and retain the technologies (OECD, 2002).

Since foreign affiliates have a significant impact on the emissions of some pollutants, especially Chinese-sourced foreign affiliates, the government is recommended to control the investment in high energy consumption and high pollution sectors, but encourage more environmental friendly investment. These will be enhanced by the new policies of the Chinese government. The National Development and Reform Commission released a new and substantially revised "*Catalogue for the Guidance of Foreign Invested Enterprises*", which became effective on 1st December, 2007 and replaces the former catalogue adopted in 2004. The new catalogue implies that China is going to put emphasis on the "quality" of investment, which is opposite to the past emphasis on "quantity". For example, the catalogue shows that the Chinese government will 1) continue to encourage investment in all advanced technology and modern manufacturing, and services business such as modern logistics and service outsourcing, but discourage investment in traditional enterprise sectors; 2) encourage investment in sustainable resources and environmental protection, but restrict or prohibit investment in high-resource-use, high-energy-use and high-pollution enterprises, as well as mining of certain rare minerals and energy resources; and 3) discourage investment in export-oriented enterprises, which is dramatic reverse to the former policy.

Finally, the major limitation of this chapter is that we use reduced form equations. The reduced-form approach gives us the net effects of income and industrial foreign investment on pollution but can not explain why the estimated pollution-income and pollution-FDI nexus exist. An alternative approach is to model the structural equations relating environmental regulations, technology, and industrial composition to GDP and then to link the level of pollution to the regulations, technology and industrial composition (Grossman and Krueger 1995). However, the unavailability and/or validity of data on pollution regulations and technology make the reduced-form approach necessary.

Appendix 5.1 Variable Definitions and Data Sources

Variable	Definition/Source
Wastewater	Per capita emissions of industrial wastewater (tons per person). Source: China Environment Yearbook; population data from China City Statistical Yearbook.
COD	Per capita emissions of industrial chemical oxygen demand (tons per 10 000 persons). Source: as above.
CrVI	Per capita emissions of industrial hexavalent chromium compounds (kg per 10 000 persons). Source: as above.
Petroleum	Per capita emissions of industrial petroleum-like matter (tons per 1 000 000 persons). Source: as above.
Waste Gas	Per capita emissions of industrial waste gas (10 000 m^3 per person). Source: as above.
SO_2	Per capita emissions of industrial sulphur dioxide (tons per 10 000 persons). Source: as above.
Soot	Per capita emissions of industrial soot (tons per 10 000 persons). Source: as above.
Dust	Per capita emissions of industrial dust (tons per 10 000 persons). Source: as above.
Y	Gross domestic product (GDP) per capita (1 000 yuan at 1990 price). Source: China City Statistical Yearbook.
GIP/GDP	Gross industrial product (GIP) normalised by city GDP (100 yuan per yuan). Source: as above.
GIPd/GDP	GIP normalised by GDP for the domestic firms (100 yuan per yuan). Source: as above.
GIPh/GDP	GIP normalised by GDP for Hong Kong, Taiwan and Macao invested firms (100 yuan per yuan). Such firms refer to all industrial enterprises registered as the joint-venture, cooperative, sole investment industrial enterprises and limited liability corporations with funds from Hong Kong, Macao and Taiwan. Source: as above.
GIPf/GDP	GIP normalised by GDP for foreign countries invested firms (100 yuan per yuan). Such firms refer to all industrial enterprises registered as the joint-venture, cooperative, sole investment industrial enterprises and limited liability corporations with foreign funds. Source: as above.

Appendix 5.2 Cities in the Sample (number of cities of subgroups in brackets)

East (52)		Central (31)	West (29)
Municipalities (3)	Shandong (10)	Shanxi (5)	Municipality (1)
Beijing	*Jinan*	*Taiyuan*	*Chongqing*
Tianjin	*Qingdao*	*Datong*	Inner Mongolia AR (3)
Shanghai	*Zibo*	*Yangquan*	*Huhhot*
Hebei (5)	*Zaozhuang*	*Changzhi*	*Baotou*
Shijiazhuang	*Yantai*	*Linfen*	*Chifeng*
Tangshan	*Weifang*	Jilin (2)	Guangxi Zhuang AR (4)
Qinhuangdao	*Jining*	*Changchun*	*Nanning*
Handan	*Taian*	*Jilin*	*Liuzhou*
Baoding	*Weihai*	Heilongjiang (4)	*Guilin*
Liaoning (6)	*Rizhao*	*Harbin*	*Beihai*
Shenyang	Guangdong (8)	*Qiqiharr*	Sichuan (5)
Dalian	*Guangzhou*	*Daqing*	*Chengdu*
Anshan	*Shaoguan*	*Mudanjiang*	*Panzhihua*
Fushun	*Shenzhen*	Anhui (3)	*Luzhou*
Benxi	*Zhuhai*	*Hefei*	*Mianyang*
Jinzhou	*Shantou*	*Wuhu*	*Yibin*
Jiangsu (8)	*Foshan*	*Maanshan*	Guizhou (2)
Nanjing	*Zhanjiang*	Jiangxi (2)	*Guiyang*
Wuxi	*Zhongshan*	*Nanchang*	*Zunyin*
Xuzhou	Hainan (2)	*Jiujiang*	Yunan (2)
Changzhou	*Haikou*	Henan (6)	*Kunming*
Suzhou	*Sanya*	*Zhengzhou*	*Qujing*
Nantong		*Kaifeng*	Shaanxi (5)
Lianyungang		*Luoyang*	*Xi'an*
Yangzhou		*Pingdingshan*	*Tongchuan*
Zhejiang (7)		*Anyang*	*Baoji*
Hangzhou		*Jiaozuo*	*Xianyang*
Ningbo		Hubei (3)	*Yan'an*
Wenzhou		*Wuhan*	Gansu (2)
Jiaxing		*Yichang*	*Lanzhou*
Huzhou		*Jingzhou*	*Jinchang*
Shaoxing		Hunan (6)	Qinghai (1)
Taizhou		*Changsha*	*Xining*
Fujian (3)		*Zhuzhou*	Ningxia Hui AR (2)
Fuzhou		*Xiangtan*	*Yinchuan*
Xiamen		*Yueyang*	*Shizuishan*
Quanzhou		*Changde*	Xinjiang Uyghur AR (2)
		Zhangjiajie	*Urumuchi*
			Karamay

Appendix 5.3 Cubic Log Results with Random-effects

Table A5.3.1 Cubic Log Estimation Results with Random-effects for Industrial Water Pollution Emissions

Variables	Wastewater		COD		CrVI		Petroleum	
Y	1.11	1.06	-2.11	-1.02	2.51	2.33	5.79	6.98
	(2.05)**	(1.76)*	(1.10)	(0.58)	(0.79)	(0.70)	(2.02)**	(2.36)**
Y^2	-0.21	-0.15	0.94	0.43	-1.12	-1.11	-2.09	-2.80
	(0.81)	(0.53)	(1.07)	(0.53)	(0.67)	(0.64)	(1.58)	(2.04)**
Y^3	0.012	0.0048	-0.13	-0.044	0.20	0.22	0.27	0.39
	(0.30)	(0.11)	(0.98)	(0.37)	(0.75)	(0.78)	(1.38)	(1.89)*
GIP/GDP	0.52		0.68		0.69		0.88	
	(4.04)***		(2.55)**		(1.65)*		(1.90)*	
GIPd/GDP		0.44		0.38		0.74		0.85
		(3.68)***		(1.72)*		(2.09)**		(2.13)**
GIPh/GDP		0.045		0.11		0.22		0.067
		(1.58)		(2.34)**		(1.94)*		(1.01)
GIPf/GDP		-0.019		0.039		-0.12		0.21
		(0.82)		(0.72)		(1.20)		(3.01)***
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.66	-0.22	1.58	1.87	-7.39	-7.28	-5.93	-6.51
	(0.73)	(0.26)	(0.90)	(1.15)	(2.62)***	(2.67)***	(1.95)*	(2.25)**
R^2 (overall)	0.63	0.65	0.36	0.42	0.48	0.49	0.47	0.46
DM	0.05	0.06	0.52	0.84	1.67	1.89	2.66	1.65
Hausman	1.08	5.67	10.02	7.13	8.34	7.51	3.67	2.43
AR(1)	No	No	No	No	Yes	Yes	No	No
Observations	423	398	431	407	383	364	423	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively.

Table A5.3.2 Cubic Log Estimation Results with Random-effects for Industrial Air Pollution Emissions

Variables	Waste Gas		SO_2		Soot		Dust	
Y	0.90	1.26	1.98	2.19	0.0087	0.44	-0.71	0.26
	(0.95)	(1.23)	(3.05)***	(3.41)***	(0.01)	(0.43)	(0.52)	(0.19)
Y^2	-0.096	-0.23	-0.76	-0.86	-0.078	-0.12	0.17	-0.28
	(0.21)	(0.46)	(2.41)**	(2.75)***	(0.20)	(0.25)	(0.23)	(0.37)
Y^3	0.00423	0.025	0.12	0.14	0.027	0.029	-0.0067	0.067
	(0.06)	(0.31)	(2.56)**	(2.96)***	(0.44)	(0.39)	(0.05)	(0.52)
GIP/GDP	0.72		0.63		0.71		0.73	
	(5.84)***		(4.38)***		(5.25)***		(3.65)***	
GIPd/GDP		0.57		0.53		0.46		0.97
		(5.57)***		(4.36)***		(4.17)***		(4.87)***
GIPh/GDP		0.025		0.045		0.043		0.057
		(0.83)		(1.37)		(1.24)		(1.23)
GIPf/GDP		0.023		0.028		0.00059		-0.017
		(0.82)		(0.91)		(0.02)		(0.43)
Province Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-3.46	-3.03	0.25	0.62	0.92	1.27	1.75	0.36
	(3.36)***	(3.20)***	(0.32)	(0.89)	(1.13)	(1.36)	(1.00)	(0.20)
R^2 (overall)	0.63	0.68	0.70	0.71	0.60	0.62	0.38	0.39
DM	3.42*	2.40	0.40	1.55	0.35	5.68**	0.06	0.59
Hausman	0.15	0.73	3.16	1.95	1.35	3.38	1.28	8.20
AR(1)	No	No	No	No	No	No	No	No
Observations	438	413	427	407	435	415	423	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively.

Appendix 5.4 Log Results with Fixed Effects

Table A5.4.1 Log Results with Fixed-effects for Industrial Wastewater and COD

Variables	**Wastewater**						**COD**					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.38	0.85	0.92	0.40	0.89	0.77	-0.42	0.53	2.07	-0.18	-1.02	-2.20
	(2.26)**	(3.15)***	(1.51)	(2.11)**	(3.21)***	(1.15)	(1.16)	(0.72)	(1.06)	(0.27)	(1.12)	(1.11)
Y^2		-0.12	-0.16		-0.13	-0.063		-0.26	-1.10		0.21	0.83
		(1.98)**	(0.54)		(1.76)*	(0.19)		(1.48)	(1.10)		(1.40)	(0.93)
Y^3			0.0059			-0.010			0.14			-0.099
			(0.13)			(0.20)			(0.86)			(0.78)
GIP/GDP	0.48	0.48	0.48				0.28	0.34	0.44			
	(2.30)**	(2.28)**	(2.27)**				(0.85)	(1.07)	(1.30)			
GIPd/GDP				0.31	0.29	0.29				0.14	0.16	0.15
				(1.66)*	(1.52)	(1.51)				(0.45)	(0.53)	(0.52)
GIPh/GDP				0.053	0.051	0.051				0.055	0.060	0.0578
				(1.63)	(1.54)	(1.54)				(0.93)	(0.99)	(0.96)
GIPf/GDP				-0.012	-0.017	-0.017				0.034	0.041	0.040
				(0.48)	(0.66)	(0.66)				(0.52)	(0.63)	(0.61)
Constant	0.52	0.14	0.090	1.27	0.95	1.02	-3.05	-2.90	-2.82	3.82	4.47	5.19
	(0.52)	(0.14)	(0.08)	(1.31)	(1.02)	(1.01)	(2.27)**	(2.12)**	(2.05)**	(2.34)**	(2.53)**	(2.35)**
R^2 (within)	0.10	0.11	0.11	0.10	0.11	0.11	0.10	0.11	0.11	0.03	0.04	0.04
End. Of *Y*	No	No	No	No	No	No	No	No	No	No	No	No
AR(1)	No	No	No	No	No	No	Yes	Yes	Yes	No	No	No
Observations	423	423	423	398	398	398	321	321	321	407	407	407

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.4.2 Log Results with Fixed-effects for Industrial CrVI and Petroleum-like matter

Variables	CrVI						Petroleum					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.73	1.00	4.79	0.86	1.14	5.05	0.76	2.25	6.08	0.52	2.21	7.43
	(0.79)	(0.76)	(1.30)	(0.74)	(0.76)	(1.36)	(1.39)	(2.35)**	(2.03)**	(0.98)	(2.50)**	(2.39)**
Y^2		-0.073	-2.10		-0.078	-2.17		-0.37	-2.38		-0.42	-3.15
		(0.26)	(1.15)		(0.27)	(1.19)		(1.79)*	(1.72)*		(1.98)**	(2.14)**
Y^3			0.34			0.35			0.33			0.44
			(1.19)			(1.21)			(1.60)			(2.03)**
GIP/GDP	-0.19	-0.19	-0.11				0.51	0.52	0.57			
	(0.33)	(0.33)	(0.19)				(0.93)	(0.95)	(1.02)			
GIPd/GDP				-0.22	-0.23	-0.14				0.49	0.42	0.47
				(0.45)	(0.47)	(0.30)				(1.09)	(0.92)	(1.01)
GIPh/GDP				0.19	0.19	0.19				0.074	0.069	0.073
				(1.40)	(1.40)	(1.41)				(0.84)	(0.81)	(0.90)
GIPf/GDP				-0.0821	-0.085	-0.088				0.25	0.23	0.23
				(0.47)	(0.49)	(0.52)				(2.48)**	(2.67)***	(2.94)***
Constant	-1.30	-1.52	-4.06	-1.58	-1.76	-4.35	-0.56	-1.94	-4.36	-0.36	-1.59	-4.82
	(0.43)	(0.51)	(1.13)	(0.52)	(0.58)	(1.23)	(0.21)	(0.72)	(1.36)	(0.15)	(0.71)	(1.66)*
R^2 (within)	0.03	0.03	0.04	0.04	0.04	0.04	0.02	0.04	0.05	0.05	0.08	0.10
End. Of Y	No	No	No	No	No	No	No	No	No	No	No	No
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Observations	383	383	383	364	364	364	423	423	423	403	403	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.4.3 Log Results with Fixed-effects for Industrial Waste Gas and SO_2

Variables	Waste Gas						SO_2					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.68	0.94	0.94	0.77	1.11	1.07	1.09	0.76	2.75	1.08	0.64	2.23
	(2.59)***	(2.24)**	(0.84)	(1.98)**	(2.01)**	(0.80)	(5.24)***	(1.75)*	(2.46)**	(5.31)***	(1.52)	(2.10)**
Y^2		-0.058	-0.055		-0.067	-0.046		0.089	-0.96		0.12	-0.72
		(0.77)	(0.11)		(0.83)	(0.08)		(0.86)	(1.74)*		(1.19)	(1.37)
Y^3			-0.00041			-0.0032			0.16			0.13
			(0.01)			(0.04)			(1.93)*			(1.63)
GIP/GDP	0.72	0.72	0.72				1.14	1.12	1.24			
	(5.08)***	(5.07)***	(5.06)***				(5.79)***	(5.60)***	(5.96)***			
GIPd/GDP				0.49	0.48	0.48				0.88	0.87	0.93
				(4.10)***	(4.00)***	(3.99)***				(5.43)***	(5.37)***	(5.63)***
GIPh/GDP				0.035	0.034	0.034				0.023	0.025	0.028
				(1.13)	(1.07)	(1.07)				(0.69)	(0.74)	(0.85)
GIPf/GDP				0.061	0.059	0.059				0.056	0.057	0.061
				(2.04)**	(1.97)**	(1.97)**				(1.99)**	(2.03)**	(2.16)**
Constant	-3.40	-3.66	-3.66	-2.57	-2.89	-2.86	-1.91	-1.54	-3.17	-0.55	-0.16	-1.31
	(4.89)***	(4.77)***	(3.50)***	(3.14)***	(3.23)***	(2.25)**	(3.19)***	(2.35)**	(3.85)***	(1.03)	(0.28)	(1.81)*
R^2 (within)	0.45	0.45	0.45	0.45	0.45	0.45	0.39	0.39	0.40	0.44	0.44	0.45
End. Of *Y*	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
AR(1)	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	438	438	438	413	413	413	320	320	320	302	302	302

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.4.4 Log Results with Fixed-effects for Industrial Soot and Dust

Variables	Soot						Dust					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	-0.076	-0.19	2.69	1.19	0.49	0.89	-0.24	-0.96	-0.67	-0.091	-0.81	0.39
	(0.30)	(0.36)	(1.98)**	(2.71)***	(0.76)	(0.63)	(0.62)	(1.38)	(0.42)	(0.22)	(1.11)	(0.25)
Y^2		0.030	-1.48		0.13	-0.056		0.18	0.029		0.17	-0.45
		(0.24)	(2.21)**		(1.43)	(0.10)		(1.20)	(0.03)		(1.16)	(0.51)
Y^3			0.23			0.028			0.024			0.10
			(2.29)**			(0.34)			(0.16)			(0.67)
GIP/GDP	1.15	1.14	1.32				0.84	0.82	0.83			
	(4.67)***	(4.60)***	(5.11)***				(3.53)***	(3.39)***	(3.39)***			
GIPd/GDP				0.56	0.59	0.59				1.04	1.06	1.07
				(3.79)***	(3.97)***	(3.98)***				(4.38)***	(4.39)***	(4.49)***
GIPh/GDP				0.030	0.031	0.032				0.039	0.041	0.042
				(0.77)	(0.81)	(0.81)				(0.71)	(0.73)	(0.78)
GIPf/GDP				0.0073	0.012	0.013				0.00092	0.0059	0.0062
				(0.20)	(0.33)	(0.34)				(0.02)	(0.14)	(0.15)
Constant	-0.39	-0.27	-2.61	0.081	0.78	0.50	0.69	1.43	1.25	-0.21	0.37	-0.38
	(0.50)	(0.31)	(2.45)**	(0.08)	(0.71)	(0.34)	(0.63)	(1.20)	(0.86)	(0.19)	(0.32)	(0.28)
R^2 (within)	0.18	0.18	0.20	0.06	0.09	0.09	0.08	0.08	0.09	0.13	0.13	0.14
End. Of *Y*	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No
AR(1)	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Observations	326	326	326	415	415	415	423	423	423	403	403	403

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Appendix 5.5 Level Results

Table A5.5.1 Level Results with Random-effects for Industrial Wastewater and COD

Variables	Wastewater						COD					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.041	2.80	3.17	0.18	2.92	2.55	-0.32	1.14	0.38	-0.076	1.16	0.60
	(0.07)	(3.70)***	(2.46)**	(0.26)	(3.76)***	(1.73)*	(0.26)	(0.46)	(0.07)	(0.06)	(0.45)	(0.11)
Y^2		-0.060	-0.082		-0.059	-0.037		-0.039	0.0066		-0.033	0.0013
		(5.03)***	(1.15)		(5.28)***	(0.43)		(0.80)	(0.03)		(0.70)	(0.00)
Y^3			0.00029			-0.00029			-0.00069			-0.00051
			(0.30)			(0.25)			(0.22)			(0.15)
GIP/GDP	0.37	0.33	0.33				0.63	0.61	0.61			
	(4.97)***	(4.75)***	(4.70)***				(2.72)***	(2.58)***	(2.55)**			
GIPd/GDP				0.38	0.34	0.34				0.50	0.49	0.49
				(4.76)***	(4.50)***	(4.53)***				(1.84)*	(1.76)*	(1.75)*
GIPh/GDP				0.56	0.44	0.43				1.57	1.52	1.52
				(2.26)**	(1.89)*	(1.88)*				(3.20)***	(3.13)***	(3.10)***
GIPf/GDP				0.21	0.18	0.17				0.30	0.31	0.29
				(1.60)	(1.85)*	(1.24)				(0.80)	(0.81)	(0.69)
Constant	-7.08	-29.92	-31.80	-6.73	-29.65	-27.58	-17.77	-28.31	-24.88	-13.84	-23.22	-20.60
	(0.31)	(1.21)	(1.31)	(0.29)	(1.18)	(1.07)	(1.04)	(1.23)	(0.73)	(0.77)	(1.00)	(0.59)
R^2 (overall)	0.53	0.55	0.55	0.53	0.55	0.55	0.25	0.25	0.25	0.26	0.26	0.26
DM	0.10	0.39	1.03	0.16	0.15	0.78	0.00	0.02	0.02	0.01	0.07	1.21
Hausman	0.15	3.46	13.34	1.48	0.93	6.10	8.19	0.56	0.18	8.19	10.15	10.26
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Turning point		23,176			24,822							
RE (FE)		(32,846)			(33,137)							
Observations	423	423	423	418	418	418	431	431	431	426	426	426

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables and province dummy variables are included. Turning point is in RMB at 1990 price.

Table A5.5.2 Level Results with Random-effects for Industrial CrVI and Petroleum-like matter

Variables	CrVI						Petroleum					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.067	0.067	0.075	0.0072	-0.0071	-0.0092	-0.88	2.91	6.53	0.25	3.56	6.94
	(1.40)	(0.67)	(0.34)	(0.15)	(0.07)	(0.04)	(0.91)	(1.49)	(1.77)*	(0.20)	(1.70)*	(1.81)*
Y^2		-4.80e-06	-0.00059		0.00053	0.00068		-0.11	-0.37		-0.11	-0.36
		(0.00)	(0.03)		(0.16)	(0.04)		(2.51)**	(1.46)		(2.19)**	(1.33)
Y^3			0.000012			-3.02e-06			0.0053			0.0051
			(0.03)			(0.01)			(1.03)			(0.91)
GIP/GDP	0.019	0.019	0.019				0.55	0.55	0.55			
	(2.92)***	(2.91)***	(2.87)***				(3.92)***	(3.89)***	(3.87)***			
GIPd/GDP				0.017	0.017	0.017				0.66	0.62	0.62
				(2.92)***	(2.91)***	(2.88)***				(4.09)***	(3.78)***	(3.76)***
GIPh/GDP				0.056	0.056	0.056				0.17	0.14	0.19
				(3.18)***	(3.16)***	(3.15)***				(0.58)	(0.46)	(0.60)
GIPf/GDP				0.029	0.028	0.029				0.24	0.49	0.42
				(2.36)**	(1.97)**	(1.82)*				(0.96)	(1.86)*	(1.51)
Constant	-2.57	-2.57	-2.59	-2.32	-2.20	-2.20	6.96	-23.24	-35.10	-1.56	-29.89	-39.69
	(3.72)***	(2.67)***	(2.78)***	(1.35)	(1.18)	(1.14)	(0.22)	(0.71)	(1.16)	(0.04)	(0.88)	(1.25)
R^2 (overall)	0.56	0.56	0.56	0.56	0.56	0.56	0.43	0.47	0.47	0.45	0.48	0.48
DM	0.18	0.23	0.10	3.01*	3.44*	3.08*	0.00	0.43	0.43	0.01	0.12	0.13
Hausman	0.24	0.23	1.60	3.82	2.87	3.29	2.78	7.58	1.50	3.06	0.91	0.31
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Turning point RE (FE)								13,090 (-)			15,601 (-)	
Observations	383	383	383	379	379	379	423	423	423	418	418	418

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables and province dummy variables are included. Turning point is in RMB at 1990 price.

Table A5.5.3 Level Results with Random-effects for Industrial Waste Gas and SO_2

Variables	Waste Gas						SO_2					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.24 (3.32)***	0.29 (2.24)**	0.75 (2.18)**	0.32 (4.59)***	0.32 (2.53)**	0.67 (1.85)*	20.67 (4.82)***	11.79 (1.80)*	32.70 (2.51)**	21.94 (4.83)***	12.00 (1.71)*	30.91 (2.20)**
Y^2		-0.0016 (0.39)	-0.033 (1.51)		0.00018 (0.05)	-0.025 (1.04)		0.20 (1.71)*	-0.97 (1.40)		0.22 (2.02)**	-0.87 (1.10)
Y^3			0.00060 (1.63)			0.00047 (1.15)			0.016 (1.77)*			0.015 (1.41)
GIP/GDP	0.039 (3.19)***	0.039 (3.18)***	0.038 (3.19)***				2.56 (3.71)***	2.71 (3.93)***	2.83 (4.10)***			
GIPd/GDP				0.050 (4.10)***	0.050 (4.04)***	0.048 (3.90)***				2.63 (4.17)***	2.78 (4.31)***	2.76 (4.33)***
GIPh/GDP				-0.011 (0.39)	-0.011 (0.40)	-0.0057 (0.20)				3.25 (1.40)	3.69 (1.58)	3.86 (1.64)
GIPf/GDP				0.0035 (0.18)	0.0031 (0.16)	0.0040 (0.21)				1.43 (1.19)	1.48 (1.30)	2.26 (1.77)*
Constant	-2.18 (1.23)	-2.57 (1.40)	-4.16 (2.29)**	-2.40 (1.23)	-2.36 (1.17)	-3.60 (1.76)*	-362.45 (2.54)**	-290.78 (2.06)**	-399.77 (3.00)***	-358.56 (2.49)**	-275.83 (1.97)**	-381.96 (2.79)***
R^2 (overall)	0.56	0.56	0.56	0.58	0.58	0.58	0.60	0.60	0.61	0.61	0.61	0.62
DM	1.73	1.46	0.29	0.35	0.51	0.00	0.62	0.62	0.05	0.00	0.00	1.50
Hausman	0.28	9.17	0.63	2.13	0.13	0.08	66.03***	11.13*	12.98**	26.38***	16.26**	7.64
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Turning point RE (FE)								29,934 (-)			27,516 (-)	
Observations	438	438	438	433	433	433	427	427	427	422	422	422

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables and province dummy variables are included. Turning point is in RMB at 1990 price. The relationship between income and SO_2 emissions is U-shaped curve.

Table A5.5.4 Level Results with Random-effects for Industrial Soot and Dust

Variables	Soot						Dust					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	2.91	6.33	11.55	3.94	7.65	11.19	-3.03	8.86	3.44	0.11	8.21	3.18
	(1.43)	(1.71)*	(1.96)*	(1.72)*	(2.03)**	(1.75)*	(1.49)	(2.00)**	(0.35)	(0.05)	(1.76)*	(0.32)
Y^2		-0.081	-0.37		-0.088	-0.29		-0.33	0.052		-0.24	0.12
		(1.36)	(1.38)		(1.38)	(0.96)		(2.89)***	(0.08)		(1.90)*	(0.18)
Y^3			0.0041			0.0029			-0.0074			-0.0071
			(1.13)			(0.69)			(0.60)			(0.56)
GIP/GDP	0.76	0.70	0.73				1.20	1.15	1.14			
	(2.55)**	(2.28)**	(2.39)**				(4.41)***	(4.28)***	(4.26)***			
GIPd/GDP				0.93	0.87	0.86				1.49	1.42	1.43
				(2.64)***	(2.41)**	(2.39)**				(5.16)***	(4.92)***	(4.92)***
GIPh/GDP				0.17	0.015	0.060				0.31	0.16	0.059
				(0.38)	(0.03)	(0.14)				(0.45)	(0.24)	(0.08)
GIPf/GDP				0.27	0.27	0.42				-0.15	0.23	0.25
				(0.55)	(0.60)	(0.85)				(0.27)	(0.37)	(0.41)
Constant	-56.56	-82.38	-110.70	-60.47	-89.50	-109.90	4.95	-90.84	-70.74	-7.76	-77.69	-60.33
	(1.12)	(1.55)	(2.01)**	(1.08)	(1.54)	(1.81)*	(0.05)	(0.85)	(0.65)	(0.08)	(0.72)	(0.55)
R^2 (overall)	0.45	0.46	0.47	0.45	0.46	0.46	0.32	0.35	0.35	0.35	0.37	0.37
DM	0.05	0.11	1.29	1.65	1.82	2.03	9.96***	3.21*	3.49*	4.45**	2.50	2.38
Hausman	0.74	17.67**	10.40	0.64	0.45	2.12	1.27	3.74	11.44*	5.06	0.37	29.50***
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Turning point								13,508			16,967	
RE (FE)								(-)			(-)	
Observations	435	435	435	430	430	430	423	423	423	418	418	418

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables and province dummy variables are included. Turning point is in RMB at 1990 price. Endogeniety of *Y* is also controlled in Models 5 and 6 of Dust.

Table A5.5.5 Level Results with Fixed-effects for Industrial Wastewater and COD

Variables	Wastewater						COD					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.26	4.13	3.69	0.28	4.39	3.97	-0.41	1.06	-4.12	-0.57	2.89	7.08
	(0.39)	(2.93)***	(1.49)	(0.42)	(3.08)***	(1.51)	(0.16)	(0.17)	(0.33)	(0.23)	(0.52)	(0.64)
Y^2		-0.063	-0.039		-0.066	-0.043		-0.029	0.23		-0.066	-0.28
		(3.09)***	(0.34)		(3.24)***	(0.34)		(0.34)	(0.48)		(0.89)	(0.61)
Y^3			-0.00031			-0.00030			-0.0035			0.0028
			(0.22)			(0.19)			(0.62)			(0.51)
GIP/GDP	0.31	0.27	0.27				0.64	0.63	0.60			
	(3.98)***	(3.54)***	(3.50)***				(1.98)**	(1.96)*	(1.81)*			
GIPd/GDP				0.32	0.28	0.29				0.39	0.37	0.36
				(3.83)***	(3.45)***	(3.44)***				(1.01)	(0.96)	(0.92)
GIPh/GDP				0.23	0.17	0.16				2.44	2.37	2.45
				(0.91)	(0.69)	(0.62)				(3.89)***	(3.78)***	(3.77)***
GIPf/GDP				0.29	0.25	0.24				1.39	1.40	1.60
				(1.57)	(1.44)	(1.22)				(2.59)***	(2.59)**	(2.64)***
Constant	5.57	-18.98	-17.06	5.53	-20.88	-18.99	40.14	32.95	56.27	36.90	19.77	1.63
	(0.95)	(2.52)**	(1.85)*	(0.88)	(2.63)***	(1.89)*	(1.39)	(0.79)	(0.83)	(1.22)	(0.49)	(0.03)
R^2 (within)	0.12	0.16	0.16	0.12	0.17	0.17	0.05	0.05	0.05	0.07	0.07	0.08
End. Of *Y*	No	No	No	No	No	No	No	No	No	No	No	No
AR(1)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Observations	317	317	317	312	312	312	431	431	431	426	426	426

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.5.6 Level Results with Fixed-effects for Industrial CrVI and Petroleum-like matter

Variables	CrVI						Petroleum					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.084	0.15	0.34	-0.066	-0.15	-0.40	-2.14	-0.074	1.43	-1.43	-0.60	1.79
	(0.93)	(0.72)	(0.79)	(0.69)	(0.67)	(0.74)	(1.48)	(0.02)	(0.25)	(0.75)	(0.16)	(0.28)
Y^2		-0.0018	-0.013		0.0022	0.016		-0.052	-0.15		-0.024	-0.17
		(0.35)	(0.55)		(0.40)	(0.57)		(0.80)	(0.47)		(0.31)	(0.51)
Y^3			0.00022			-0.00025			0.0018			0.0029
			(0.46)			(0.48)			(0.31)			(0.46)
GIP/GDP	0.018	0.018	0.017				0.56	0.57	0.57			
	(2.24)**	(2.27)**	(2.27)**				(3.35)***	(3.42)***	(3.41)***			
GIPd/GDP				0.011	0.012	0.013				0.63	0.62	0.62
				(1.26)	(1.30)	(1.37)				(3.53)***	(3.40)***	(3.41)***
GIPh/GDP				0.066	0.065	0.064				0.39	0.41	0.43
				(2.80)***	(2.77)***	(2.70)***				(0.94)	(1.00)	(1.05)
GIPf/GDP				0.042	0.038	0.040				0.28	0.34	0.31
				(2.54)**	(1.92)*	(1.92)*				(0.92)	(1.22)	(1.11)
Constant	-0.53	-0.91	-1.53	0.38	0.81	1.78	15.21	3.42	-2.06	9.85	5.35	-3.53
	(0.56)	(0.68)	(0.78)	(0.44)	(0.60)	(0.77)	(1.29)	(0.19)	(0.09)	(0.70)	(0.27)	(0.13)
R^2 (within)	0.03	0.03	0.04	0.04	0.04	0.03	0.07	0.07	0.07	0.08	0.08	0.08
End. Of *Y*	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Observations	383	383	383	379	379	379	423	423	423	418	418	418

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.5.7 Level Results with Fixed-effects for Industrial Waste Gas and SO_2

Variables	Waste Gas						SO_2					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	0.28	0.34	0.96	0.40	0.34	0.80	31.71	25.49	49.16	34.075	28.48	57.06
	(2.64)***	(2.06)**	(2.39)**	(3.54)***	(1.87)*	(2.29)**	(5.68)***	(2.52)**	(2.65)***	(6.43)***	(2.67)***	(2.68)***
Y^2		-0.0016	-0.039		0.0017	-0.026		0.12	-1.07		0.10	-1.34
		(0.38)	(1.53)		(0.42)	(1.21)		(0.72)	(1.28)		(0.63)	(1.41)
Y^3			0.00067			0.00048			0.016			0.019
			(1.51)			(1.30)			(1.49)			(1.58)
GIP/GDP	0.037	0.037	0.036				2.69	2.75	2.95			
	(1.52)	(1.52)	(1.55)				(3.09)***	(3.14)***	(3.37)***			
GIPd/GDP				0.050	0.050	0.048				2.756	2.80	2.76
				(2.71)***	(2.74)***	(2.64)***				(3.41)***	(3.39)***	(3.42)***
GIPh/GDP				-0.042	-0.042	-0.034				3.893	4.05	4.65
				(0.58)	(0.58)	(0.49)				(1.55)	(1.60)	(1.81)*
GIPf/GDP				-0.0085	-0.012	-0.0062				1.751	1.78	3.05
				(0.21)	(0.28)	(0.15)				(1.14)	(1.17)	(1.85)*
Constant	-1.20	-1.52	-3.84	-1.92	-1.60	-3.38	-183.28	-152.77	-266.78	-205.958	-178.06	-306.99
	(0.52)	(0.63)	(2.13)**	(0.95)	(0.70)	(1.65)	(2.30)**	(1.67)*	(2.40)**	(2.70)***	(1.99)**	(2.49)**
R^2 (within)	0.31	0.31	0.32	0.34	0.34	0.34	0.48	0.48	0.49	0.49	0.49	0.50
End. Of *Y*	No	No	No	No	No	No	No	No	No	No	No	No
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Observations	438	438	438	433	433	433	427	427	427	422	422	422

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

Table A5.5.8 Level Results with Fixed-effects for Industrial Soot and Dust

Variables	Soot						Dust					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model5*	*Model6*
Y	4.88	10.64	17.48	6.53	13.60	16.89	-4.25	11.68	-4.53	0.90	8.17	-2.50
	(2.02)**	(1.74)*	(1.65)	(2.52)**	(2.14)**	(1.21)	(1.41)	(1.61)	(0.26)	(0.24)	(0.94)	(0.12)
Y^2		-0.11	-0.44		-0.13	-0.29		-0.36	0.58		-0.17	0.40
		(1.31)	(1.13)		(1.51)	(0.53)		(2.30)**	(0.63)		(0.85)	(0.37)
Y^3			0.0044			0.0021			-0.017			-0.010
			(0.98)			(0.33)			(1.00)			(0.51)
GIP/GDP	0.88	0.82	0.88				1.49	1.49	1.50			
	(2.25)**	(2.07)**	(2.21)**				(4.37)***	(4.44)***	(4.44)***			
GIPd/GDP				1.15	1.10	1.09				1.83	1.77	1.78
				(2.47)**	(2.32)**	(2.29)**				(4.99)***	(4.79)***	(4.80)***
GIPh/GDP				-0.052	-0.25	-0.16				0.67	0.69	0.61
				(0.08)	(0.41)	(0.23)				(0.75)	(0.77)	(0.69)
GIPf/GDP				0.072	0.049	0.20				-0.19	0.10	0.15
				(0.13)	(0.10)	(0.29)				(0.27)	(0.12)	(0.18)
Constant	18.81	-10.18	-44.46	3.52	-32.56	-47.94	8.56	-78.88	-15.48	-27.74	-65.94	-22.45
	(0.67)	(0.29)	(0.77)	(0.12)	(0.89)	(0.72)	(0.30)	(1.70)*	(0.20)	(0.85)	(1.25)	(0.24)
R^2 (within)	0.17	0.18	0.18	0.19	0.20	0.20	0.12	0.15	0.15	0.16	0.17	0.17
End. Of Y	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	No	No	No	No	No	No	No	No	No	No	No	No
Observations	435	435	435	430	430	430	423	423	423	418	418	418

Robust z-statistics in parentheses; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively. Year dummy variables are included.

CHAPTER SIX

CONCLUSIONS

This thesis includes four empirical chapters. The first three studies examine the determinants of FDI in China from different perspectives and using different methodologies. The last examines the environmental effects of economic growth and foreign investment. In this chapter, we provide a brief review of the empirical results in Chapters 2-5, including the contributions and limitations. The second part of this chapter discusses plans for further research.

6.1 Summary of Results

In Chapter two, we test the intra-country pollution haven effect within China using a panel of 30 regions from 1999 to 2003, i.e. we examine whether differences in the environmental stringency affect the location choice of foreign investors in China. We use two measures of FDI, FDI per unit of GDP and FDI per capita. Distinct from abatement cost based or 0-3 type measures employed in previous empirical PHH studies, we employ three measures of environmental regulations: the industrial pollution treatment investment, the administrative punishment cases related to environmental issues, and the pollution emission charge, which respectively reflects local government effort on environmental protection, the enforcement of regional environmental legislation, and the implementation of regional pollution levy system. We employ a FGLS estimator and address certain methodological weaknesses in the previous literature. The results suggest that, everything else being equal, FDI is attracted by weak environmental regulations. Therefore, to a certain extent, the findings support the existence of intra-country pollution havens within China. In terms of other control variables, we find that FDI prefers to locate in those regions with high income, good infrastructure, and low labour costs. These findings are consistent with previous empirical studies. However, we also find that FDI is attracted to regions with low population density and low education levels.

Chapter two is the first study that uses Chinese province data to examine the existence intra-country pollution havens. We address a number of limitations in previous PHH empirical studies. However, we do not include another structural determinant of FDI: the impact of corruption and/or bureaucracy due to the unavailability of existing data. This problem is addressed in Chapter three by constructing two indices to measure government characteristics. Chapter three firstly looks at the differences in regional government characteristics in China, and examines their impact on FDI inflows.

Since we cannot find any established indices that proxy the regional government corruption and governance, we construct indices using the available objective data. According to the quality and properties of the data, and the corruption situation in China, we develop a variable that proxies the effort of the local government fighting against corruption, and an index that measures the local government efficiency. We follow the methodology in Chapter two and the results suggest that FDI is attracted to regions that have done the most to tackle corruption cases and that have the most efficient local government. We keep environmental stringency and other control variables in our estimating models and the results are broadly consistent with those in Chapter two.

In Chapters two and three, we address most of the methodological limitations in previous PHH papers. However, we just take one year lags for all independent variables to control for the potential endogeneity of environmental stringency. Chapter four improves on this work by treating environmental regulation as endogenous, which has rarely been considered in previous PHH studies.

In Chapter four, the exogeneity test suggests that, of the three environmental regulation measures, the industrial pollution treatment investment is endogenous. We thus apply an instrumental variable approach to control for the endogeneity. The first stage results show that neither government effort fighting against corruption nor government efficiency has significant impact on the pollution treatment investment. The second stage results illustrate consistent negative effects of environmental regulation stringency on FDI inflows. And the larger elasticity suggests that the impact of pollution treatment investment is biased downwards in pervious chapters. However, this finding is not robust for sensitivity checks. In terms of our government variables, we find that government anti-corruption effort has a positive and significant effect on FDI inflows.

The major difficulty of Chapter four is looking for the applicable instrumental variables. Our selected instrumental variables are valid but provide relatively weak results in the first stage regressions. Seeking out other better instrumental variables may help to improve the results.

Chapter five investigates the relationship between FDI and the environment from another aspect. It examines the impacts of economic growth and foreign investment on environmental quality using a panel of 112 Chinese major cities from 2001 to 2004. A range of industrial pollution emissions are considered, including four water pollutants and four air pollutants. In order to find out the environmental effects of foreign firms, we split the total industrial output into three groups according to the ownership: output from domestic firms, output from firms funded by Hong Kong, Taiwan and Macao, and output from firms invested by other foreign economies. We address many limitations of previous EKC literature, and report the log linear and quadratic random-effects estimation results. On balance, the results suggest that economic development have negative effects on environmental quality at current income levels in China. Total industrial output generally has positive effect on industrial pollution emissions and domestic firms always have the strongest effects among the three groups. Firms invested by Hong Kong, Taiwan and Macao have moderate positive effects on three of the four water pollutants; while foreign invested firms are only found to have positive and significant impact on one water pollution emissions: petroleum-like matter. Therefore, foreign invested firms seem to be the most environmentally efficient.

Chapter five makes two major contributions to the current literature. First, it considers the effects of economic growth on various environmental indicators using Chinese city level data, and the results are broadly robust across pollutants. Second, it reveals differences in the effects of firms by ownerships.

The findings in this thesis provide important policy implications to both central and local governments in China. FDI has played an important role in China's economic growth. It is regarded as an engine for economic growth, and a carrier of advanced technologies. My thesis suggests that FDI is not always blessing. Certain type of FDI from certain sources in certain sectors may seek to locate in 'pollution heavens' where environmental regulation is weak. Although my thesis shows that foreign firms are generally cleaner than the domestic firms, they are still polluting especially for water pollution emission.

If Chinese government would like to retain the fast economic growth, a sustainable development policy is required. The government has to rethink about the location, the sector and types of foreign direct investment. The government is recommended to put an emphasis on the 'quality' of FDI rather than the 'quantity of FDI; encourage more environmental friendly knowledge and human capital intensive FDI and control FDI in high energy consumption and high pollution sectors. The negative effect of environmental stringency on FDI can be offset by the improvement of some factors that are attractive to

FDI, for example the quality of infrastructure, the enforcement of anti-corruption, the improvement of government efficiency.

Current economic growth in China is found to have negative effect on the environmental quality. The existence of environmental Kuznets curve does not mean that environmental problem can be solved automatically without any special attention to the environment. To alleviate the pressure on the natural environment, the government has to enforce the environmental protection at the earlier stage of the development, through the improvement of environmental regulations at every administrative level. Now the State Environmental Protection Administration has been promoted to the cabinet ministry level during the March 2008 China National People's Congress Session in Beijing. We hope that it will help for the reinforcement of regulation stringency and environmental protection.

In addition, the government has to promote the structural change of Chinese industry, from manufacturing to services sectors, in order to reduce the industrial pollution emissions. Finally, the local government is recommended to promote environmental technology transfer of foreign firms to domestic firms, and increase the absorptive capacity of local firms by increasing the investment in, for example, R&D and education.

Three of the four chapters have been turned into papers. The paper from Chapter two is going to be published in *Journal of the Asia Pacific Economy*, Volume 13, No. 3, August 2008, pp. 332-353. The paper from Chapter three was submitted to *Journal of Development Studies* and got minor revision from the referees. We believe that it will be accepted when we resubmit after the revision. The paper from Chapter five is now under the review of *Regional Science and Urban Economics*.

6.2 Further Research

In order to improve the thesis chapters, we plan to add the most recent years' data and construct a panel for a longer time period. For chapters 2-4 we are able to construct the proxies of environmental regulations, government anti-corruption effort and government efficiency for the most recent years. In that case, we will establish a dynamic model, including lagged FDI variables on the right-hand-side of the model to control the AR(1) autocorrelation using model specification rather than econometric techniques. Other variables on the right-hand-side of the model will be at time t rather than $t-1$. Thus system GMM estimator is appropriate for such model and panel data with N>T and hence could be used to control the potential endogeneity of environmental regulations. We can control the impact of FDI and other variables to the stringency of environmental regulations. In addition, FDI may have causality impact to other variables, such as income, wage, infrastructure, anti-corruption effort and government efficiency. A simultaneous equation model is probably required and system GMM estimator is also suitable for such model.

In terms of chapter five, we may also add more years' data to the dataset. Then we are able to check whether we get similar turning points for wastewater and petroleum-like matter emissions, i.e. whether the cities that had passed the turning point during the observed period did reduce their emissions in the most recent years. With longer time period, EKC relationship may exist for other pollution emissions. A further improvement for Chapter five is to develop a simultaneous equations model in which the pollution emissions are determined by regulations, technology and industrial composition. In this case, we can estimate the scale effects, technique effects and composition effects caused by economic growth and foreign investment. Therefore, a major task is to find out valid measurements for regulations and technology at city level.

In terms of new research based on this thesis, the following three topics can be considered as noteworthy in the area of economic growth, FDI, governance, and the environment.

This thesis considers the relationship between FDI and the environment from regional dimensions. Further research could be applied to industrial level data, i.e. from an industrial dimension. This has not been considered in any previous studies. The research questions could be: 1) whether FDI is attracted to the industrial sectors that have low environmental regulations; 2) whether FDI is attracted to heavy pollution-intensive industries; and 3) whether FDI have negative effects on the pollution emissions across industrial sectors. The recent released industrial FDI data make this research possible. Similar methodology that has been used in this thesis could be employed.

The second is to investigate some interesting questions relating to environment using Chinese firm-level data rather than aggregated regional data. A problem we faced was that the current widely used firm-level databases do not provide any environmental information. Recently, the nongovernmental Institute of Public and Environmental Affairs has reported the names of enterprises, which have emitted excessive water and air pollutants above the national standards in recent years and are forced to make changes within a certain period. It is possible to link this information with a commonly used firm-level database and employ a Probit model to examine the factors that may affect the differences in environmental performance, including endogenous drivers such as firm size and ownership, and exogenous drivers such as industry, market and regulatory forces.

Finally, the anti-corruption and government efficiency indices could be used in a wider range of topics. Such bureaucracy characteristics could be used as factors that influence the regional differences in economic growth and income inequality.

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