A WELFARE ANALYSIS OF POLLUTION CONTROL AND FDI

Kanthasat Boontem

A Dissertation Submitted in Partial

Fulfillment of the Requirements for the Degree of

Doctor of Philosophy (Economics)

School of Development Economics

National Institute of Development Administration

2017

A WELFARE ANALYSIS OF POLLUTION CONTROL AND FDI

Kanthasat Boontem

School of Development Economics

Assistant Professor..Major Advisor
(Santi Chaisrisawatsuk, Ph.D.)

Associate Professor..Co-Advisor
(Adis Israngkura, Ph.D.)

Lecturer..Co-Advisor
(Niramol Ariyaarpakamol, Ph.D.)

The Examining Committee Approved This Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Economics).

Professor..Committee Chairperson
(Nattapong Thongpakde, Ph.D.)

Assistant Professor..Committee
(Santi Chaisrisawatsuk, Ph.D.)

Associate Professor..Committee
(Adis Israngkura, Ph.D.)

Lecturer..Committee
(Niramol Ariyaarpakamol, Ph.D.)

Assistant Professor..Dean
(Nada Chunsom, D.B.A.)

August 2017

ABSTRACT

Title of Dissertation	A Welfare Analysis of Pollution Control and FDI
Author	Mr. Kanthasat Boontem
Degree	Doctor of Philosophy (Economics)
Year	2017

Foreign Direct Investment (FDI) inflows to the host country can drive economic growth especially in developing countries. It is then the strategic planning of such a host country to create a roadmap appealing to these foreign interests. Several policies are then looked at, whereby host countries would implement them in order to attract and leverage these FDI inflows into their economies. On the other hand, when we consider how companies look at their expenditures in terms of overall cost minimization, foreign investors are looking to regions with specific dynamics and countries that can minimize their business while creating economies of scale in the process. Since there are pollution emits from the production process and there are promulgated pollution control regulations in the host country, the cost of pollution abatement is therefore embedded into production costs. Since 1970s there has been a debatable topic among economists about the relation between stringent level of pollution control enforcements and amount of FDI inflows which is related to the pollution heaven hypothesis. The hypothesis states that foreign investors invest in the host countries that having low enforcements of pollution controls and less environmental regulations which perpetually reduce their expenditures and thus create the formula and basis for their decision making. A cycle is then created, with a global conscience saying that these countries are considered by foreign investors as pollution heavens. So, though the countries benefit from constant FDI inflows into their economies, they are also confronted with the inevitability of major environmental impact issues. In this regard, greater economic problems may occur in the long run when the country is forced to look at its overall welfare and wellbeing while weighing their opportunity costs.

This dissertation reexamines the relation between pollution control enforcements and FDI inflows, using measurable environmental indicators to quantify the laxity of pollution control enforcements. It examines the impact of pollution control enforcements on FDI inflows, with the null hypothesis that less enforcement will attract more FDI, in industries across the spectrum as well as individual industries. The study was done on a global platform with separate groups of ASEAN countries and domestically within Thailand. Data from the World Bank, UNCTAD and Thailand's Board of Investment between the years 2008 to 2013 were used with panel data regression. Mixed results were obtained; low levels of pollution control enforcements significantly attracted FDI inflows to ASEAN countries and East Asia Pacific Regions, while in the cases of Europe, Central Asia and the Latin Americas no significant results were found. For Thailand, as a host country, firm-level evaluation procedures using pollution intensity value together with laxity of pollution control enforcements were evaluated. There existed a significant relation between low levels of pollution control enforcements in Thailand and FDI inflows from foreign investors.

Evidence of a relation between pollution control enforcements and FDI inflows in Thailand is continuously determined by Computable General Equilibrium (CGE) model in order to investigate the welfare effect to economic agents and also the country as a whole. Thailand's Social Accounting Matrix (SAM) of the year 2005 was used in CGE to evaluate changes in household's income as well as for corporate, the government, outputs, exports, imports, aggregate consumption, and the GDP. The welfare investigation by comparison, looks at gains from the increase in household income and GDP versus the loss from the devastating environmental impacts which is not measured or determined in this study. However, evaluation of such welfare loss from the environmental impacts is introduced as a conceptual dimension in the appendix at the end of this study.

ACKNOWLEDGEMENTS

This dissertation in fulfillment of my pursuant in my Ph.D. would have never been completed without my advisories and support system from benefactors who gave me inspiration to do this research. They continue to teach and advise me so that I may gain the greatest knowledge in economics and research methodologies, providing me with important research data, always encouraging me to overcome all obstacles along my studying journey.

I would like to express my sincere gratitude to my major advisor, Assistant Professor Santi Chaisrisawatsuk, who provided guidance for this dissertation and always spent his time advising me when I had problems needed to be solved. His suggestions are invaluable to me. Besides my major advisor, I am also much indebted to Associate Professor Adis Israngkura, the co-advisor, who inspired me to look at the environmental issues included in this dissertation as well as his encouragement about welfare analysis. I also received helpful advice and great support in my English writing from Lecturer Niramol Ariyaarpakamol, who has been a co-advisor since the beginning of my dissertation proposal until its completion. Her advisory in econometrics is greatly appreciated. In addition, a special gratitude to Assistant Professor Anan Wattanakuljarus and Assistant Professor Wisit Chaisrisawatsuk for their advice in computable general equilibrium theory and applications.

The most important to this pursuant is my family, including my spouse who sacrificed her time to take care of my three beautiful children. She encouraged me to fight and strive to the end, knowing that my two sons and one daughter have less time with their father during my study period. The sacrifices we have all made are invaluable and have proven to be a great contribution to me.

Kanthasat Boontem

August 2017

TABLE OF CONTENTS

LIST OF TABLES

Tables **Page**

LIST OF FIGURES

Figures **Page**

ABBREVIATIONS

Abbreviations	Equivalence
AIC	Akaike's Information Criterion
ASEAN	Association of Southeast Asian Nations
BOD	Biochemical Oxygen Demand
BOI	Thailand Board of Investment
BOT	Bank of Thailand
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
COD	Chemical Oxygen Demand
CO2	Carbon Dioxide
GAMS	General Algebraic Modeling System
GDP	Gross Domestic Product
GLS	Generalized Least Square
HH	Household
ILO	International Labour Organization
ISIC	International Standard Industrial Classification
LSDV	Least Squares Dummy Variables
NAICS	North America Industry Classification System
NGOs	Non-Government Organizations
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
PACE	Pollution Abatement Costs Expenditures
PI	Pollution Intensity

PM	Particulate Matter
ROW	Rest of the World
SAM	Social Accounting Matrix
SCF	Standard Conversion Factor
UNCTAD	United Nations Conference on Trade and Development
WDI	World Development Index

CHAPTER 1

INTRODUCTION

Foreign Direct Investment (FDI) inflows benefit the host country's economy but at the same time there is increasing pollution caused by industrial activities. Economists have been discussing the pollution heaven hypothesis since the 1970s. It appears the poorer countries that needed FDI inflows from richer countries will relax their environmental regulations. Hence Since environmental protection and the increase in quality of life around the world has become more and more a global concern, the argument of the pollution heaven was challenged. Many developed countries imposed some regulations on imported goods and 'green products' being promoted on the world market stage especially in developed countries. This implies that goods produced from better pollution controlled countries have a higher potential of being exported to developed countries. If such an argument is true, then the pollution heaven hypothesis will be rejected and the countries that enforce pollution control will attract more FDI inflows. In this regards, there is other school of thought, it is not necessary that pollution will increase due to pollution heaven; it would have more FDI inflows from other factors and then more productions activities from FDI will result in higher pollution.

Many recent empirical studies demonstrated that many foreign industrial investors are still looking for countries having lower levels of pollution control enforcements. Such evidence challenges the countries that promote domestic production, imports and consumption of green products while some of their investors from abroad are trapped in their pollution heaven. Not only are some of the foreign investors stuck in this aforementioned condition but some government entities of the host countries also face this predicament. Described later in a more detailed fashion in this study, are countries including Thailand, that had created a lot of environmental regulations aiming to control the pollution from industrial activities but later had measurements showing negative results while at the same time they were obtaining FDI inflows. This presented a contradiction to what the host countries tried to do with environmental regulations and the measured pollution indicators, implying that the governments had weak pollution control enforcements.

Lax of pollution control enforcements by the government of host countries would create both positive and negative impact to the country's economy. Since there is evidence that relation of low pollution control enforcements and more FDI inflows still exists, the positive impact to the host country's welfare would be more FDI inflows, and more goods produced. The negative impact would be a social welfare that the countries need to pay for, such as the environmental abatement cost.

1.1 Economic Problems

1.1.1 Alternative of Pollution Control Enforcements to Attracts FDI Inflow

The first economic problem in this study is according to the relation between low level of pollution control enforcements which would attract more FDI inflows. Since most governments worldwide recognized that pollution from industries would harm the environment; laws and regulations to control environmental related activities had been promulgated, not only in the developed countries but also in the developing ones. At the global level, a lot of international treaties with regards to the environment were developed, and such policies encouraged member countries to implement them. Examples relate to the air pollution treaty protocols of the 1979 Convention on Long range Tran boundary Air Pollution on Heavy Metals, Aarhus, 1998; Association of South East Asian Nations Agreement on Tran boundary Haze Pollution, Kuala Lumpur, 2002 (United Nations Environment Programme. Environmental Law Branch. Division of Policy Development and Law, 2005).

Quantity of environmental laws and regulations that the countries promulgated and participated in could affect the pollution level and consequently impact FDI, there is supportive evidence that FDI from pollution intensive multinational firms is lower for the host countries who participate with higher standards for international environment treaties (Smarzynska and Wei, 2001). However, the number of regulations alone could not tell how stringent these countries are implementing their environmental laws, so there is an argument about what would be changed if the countries have weak enforcements on their environmental regulations. Recent evidence from China found that, for the polluting industries, there were significant relations between measured pollution indicators and foreign investment in Hong Kong, Macao and Taiwan (Dean, Lovely and Wang, 2009).

Low level pollution control enforcements are easily investigated with the measured pollution indicators like dust content in ambient, carbon dioxide (CO2) emissions and Biological Oxygen Demand (BOD) in water. Foreign investors can use that data to anticipate how the host countries give effort to their pollution control systems for future results and then estimate for the pollution control cost which is one of business cost driver. Enforcements on promulgated environment regulations require not only serious effort from government institutions but also government budget. However, high pollution control enforcements will cost the investors which would detract investments and benefits from FDI inflow would disappear. In another theory, high enforcement levels would push the firms to produce environmental care goods which could be sold in the global market according to the current trends of environmental concerns.

Either stringent or lax enforcement challenges the government's policies; therefore, the impact of pollution control enforcements on FDI inflow is the first economic problem to be solved.

1.1.2 Welfare Gain and Loss

The extended economic problems from pollution control enforcements on FDI inflow relates the welfare of the host countries, in either the increasing or decreasing factors, and there would be the groups of people who gain and groups of people who lose. There are many economic values indicating that there are welfare issues relating to FDI inflows and the environment, the indicators can be household income and its distribution, value of exported goods, value of goods consumed domestically, and government expenditure according to environment. The government can implement various policies according to FDI inflows to improve aforementioned economic indicators, but each policy might not deliver positive results for all things at the same time. One of the ultimate goal from the economic perspective is about Pareto's improvements from any policy implementation, however, in the real world there are many groups of people who have different interests; and so the government's decision to satisfied and improve welfare to all groups are rarely investigated.

1.2 Research Questions

Stringent environment regulations and strong pollution control enforcements would enhance the host country's environment quality and contribute to some economic values. The impacts of such strong enforcements are not only to the environment but also to other economic areas such as international trade and FDI. According to the pollution heaven hypothesis, if the host country relaxes its environmental regulations, that would attract FDI inflows; consequently, there would be a change in the welfare of the host country. We see a global trend nowadays concerning the environment and industrial care so the pollution heaven hypothesis shall be reexamined. In this regard, the study attempts to find answers for Thailand, as illustrated in figure1.1. The research questions are;

1) Does the relation between laxity of pollution control enforcements and more FDI inflows significant exists in Thailand?

2) How much is the value of the welfare impact if Thailand has stronger pollution control relating to FDI inflows?

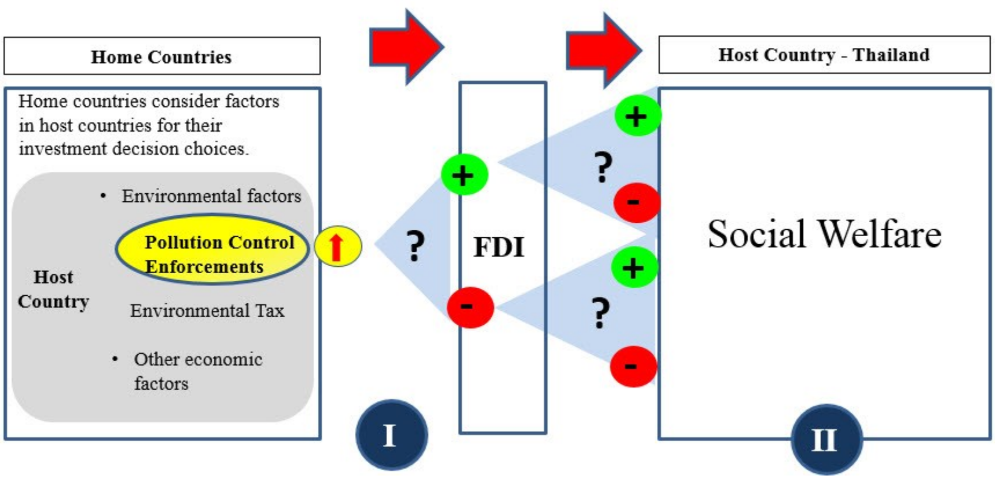

Figure 1.1 Illustrate of Research Question

1.3 Research Objectives

The objectives of this study in order to answer the research questions are;

1) Examine the relation between pollution control enforcements and FDI inflow for worldwide groups of countries aiming to disclose foreign investors' behaviors with regards to the pollution heaven hypothesis.

2) Examine the relation between pollution control enforcements and FDI inflow to Thailand in both overview and by industrial groups.

3) Investigate the impact to Thailand's welfare value and identify which groups of people will have welfare lost and which groups will have welfare improvements.

1.4 Scope of the Study

Following the research objectives, the scope of this study is comprised of three major works. Firstly, the updated examinations of the relation between pollution control enforcements and FDI inflows for the countries in the world using data during year 2008 to year 2013. Countries are grouped by geographical and by income levels following the World Bank identification process. The special groups of ASEAN countries are also examined both as whole and as individual countries. This examination will discover the current situation of the relation between laxity of pollution control enforcements and more FDI inflows and show Thailand's position in such framework.

Secondly, a similar examination in particular to the case of Thailand by narrowing down the scope of FDI by industries, which was approved by the Board of Investment (BOI) of Thailand during year 2009 to year 2013. Examining both the overall impact to the country and each industry group, the results will be used as parameters input to the third scope of work.

The third work is about the investigation of the welfare value in the case of Thailand, by using the Computable General Equilibrium (CGE) method to identify groups of people who will have welfare gains and losses from FDI and environmental policies. Since the CGE is used, the welfare value in this work will examine the changed percentages.

1.5 Contribution of the Study

The study examines the relation that pollution control enforcements which affects the FDI inflows to host countries, especially in the case of Thailand. Changes in amount of FDI inflows to the country is caused by laxity levels in pollution control enforcements. It determines and investigates the welfare impact to groups of people in the country. Contributions from this study are the new methodology to create a quantitative pollution control enforcement variable from multiple measurable environment indicators to examine the relation between pollution control enforcements and FDI inflows, as well as the country's welfare analysis when FDI inflows are changed from such relation in Thailand.

1.6 Organization of the Study

This study begins with the economic problems which lead to the research questions and its scope of work described in Chapter 1. The overview information of FDI and related environmental data at the global and regional levels which includes Thailand, is described in Chapter 2 in order to augment details of the economic problems and provide basic information used in this study. Chapter 3 is the literature review for the theory and previous studies. Chapter 4 is the examination of relation between pollution control enforcements on FDI inflows, it results in the case of Thailand are used as inputs for the next Chapter. Regarding Thailand, an investigation to welfare changes in the area of household income, institution incomes and GDP of the country is the main study in Chapter 5. The last Chapter 6 discusses the overall findings, recommendations and contributions of this study.

CHAPTER 2

FOREIGN DIRECT INVESTMENT AND THE ENVIRONMENT

2.1 Overview of Global FDI and Pollution

Mentioned in the World Investment Report 2013 by UNCTAD, this situation was because of the economic fragility at the time and also policy uncertainties surrounding global FDI which had declined, for example, in 2012 it fell by 18 per cent. It tells us that developing countries were accounting for 52 per cent of global FDI flows which was much larger than FDI for developed countries. FDI inflows to developed countries dramatically fell by 32 percent and the outflow also dropped to the level of the year 2009 while the FDI inflows to developing regions had a smaller decline percentage in 2012. Africa had a 5 per cent growth which was driven by extractive industries, Asia fell by 7 percent but remained at high levels when compare to other regions. Latin America and Caribbean regions also fell by 2 per cent however, the South America region increased by 12 percent.

The report also mentioned the issue of the new investment policy which says that at least 53 countries and economies adopted 86 policy measures affecting foreign investments in 2012. About 75 percent of those measures related to investment liberalization, facilitation and promotion, and an establishment of special economic zones. Another 25 percent of those measures are regulations and restriction that was increasing from 6 per cent in 2001. One key regulation relates to providing a strong environmental, social and governmental framework for maximizing the sustainable developmental impact of the global value chain.

2.1.1 Global FDI Statistic

FDI data used in this dissertation was collected from United Nations Conference on Trade and Investment (2015) and World Development Indicators reported by World Bank (2014). Both net inflows and outflows are reported using US dollars and calculated at the price of the year 2013. Investigation of FDI net inflows statistic during 1970 to 2012 is separated in two dimensions according to the group of countries categorization by the World Bank, detailed in Appendix A. First, the seven regions which consists of East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia and Sub-Sahara Africa. Second, is by five groups of income levels, consisting of High Income non-OECD, High Income OECD, Low Income, Lower Middle Income and Upper Middle Income. Both dimensions showed that FDI net inflows started an increasing trend in 1986 but had two decreasing periods in 2001 to 2004 and 2008 to 2010. By regions, Europe & Central Asia, East Asia & Pacific and North America are major regions having a proportion of 42.9%, 21.1% and 20.9% respectively. As shown by graph in figure 2.1, East Asia & Pacific had a continuous increasing trend when compared to other regions, in periods of 2001 to 2004 and 2008 to 2010. Europe & Central Asia and North America showed a high declination but East Asia & Pacific showed a lower decline rate. By income levels, High Income OECD, Upper Middle Income and High Income non-OECD are major countries having a proportion of 62.8%, 21.9% and 10.4% respectively. As shown by graph in figure 2.2, Upper Middle Income and High Income non-OECD countries had a continuous increasing trend when compared to High Income OECD.

Aforementioned in the previous chapter, was the pollution heaven which indicated that poorer countries needed FDI inflows from richer countries, a comparison between FDI net inflows and net outflows by % of the GDP during 2008 to 2012 as shown in figure 2.3. This depicts that it is not necessarily that rich or developed countries will always have more FDI outflows than FDI inflows, and the example is the case of The United Kingdom (GBR) and Australia (AUS). While most developing countries, for example Thailand, Indonesia, Philippines and Vietnam; have larger proportions of FDI inflows. The comparison implies that FDI inflows are attracted by various factors and the level of pollution control enforcements would be one very important factor which will be further investigated as evidence in Chapter 4.

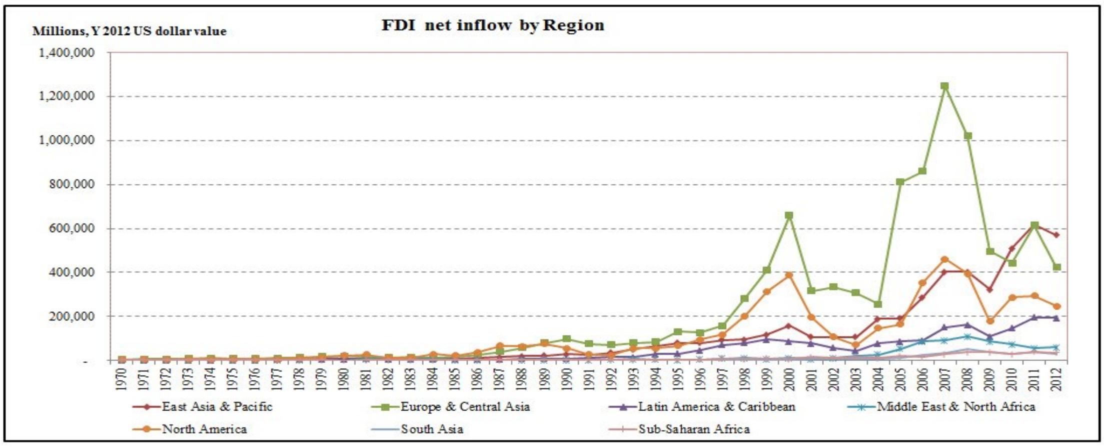

Figure 2.1 FDI Net Inflows by Region 1970-2012

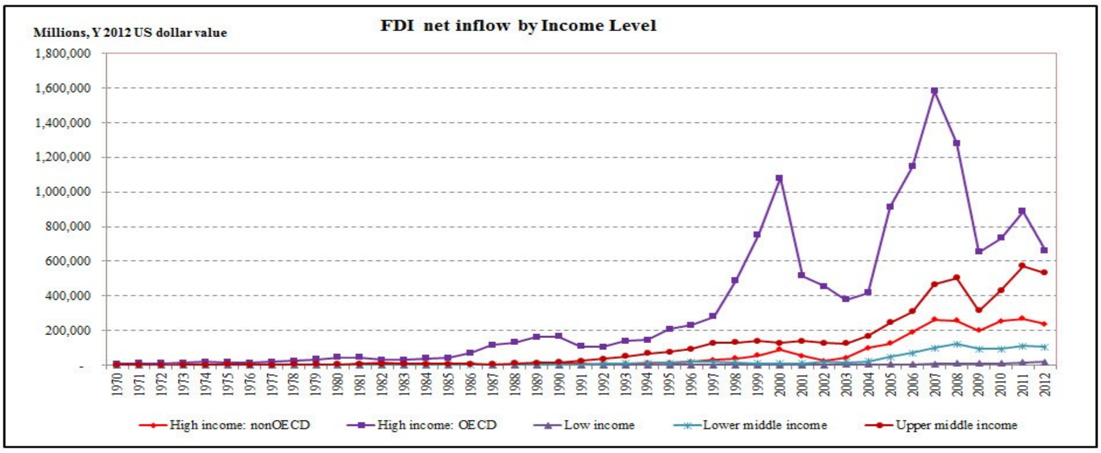

Figure 2.2 FDI Net Inflows by Income Level 1970-2012

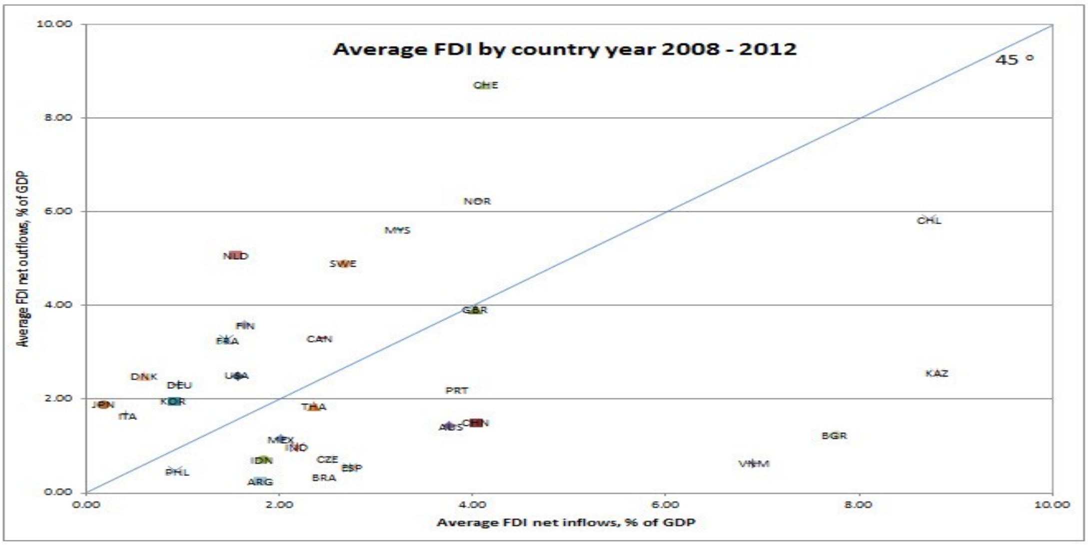

Figure 2.3 Comparison of FDI Net Inflow versus FDI Net Outflow

2.1.2 Pollution Statistic

There were several studies that link environmental regulation and pollution statistic, for example Gouldson, Carpenter and Afionis (2014) compared the outcomes among the U.S., EU, Australia, Canada and Japan. However, in this study the statistic is collected from the World Development Index (WDI) year 2013 and 2014. Although there were a lot of international treaties in area of environmental that reported in United Nations Environment Programme. Environmental Law Branch. Division of Policy Development and Law (2005), but the actual pollution statistic reveal high level of pollution in the globe.

The pollution statistics are covered for all air and water, from WDI 2013 which consists of CO2 emissions measured in kg per 2005 US$ of GDP and Organic water (BOD) emissions in kg per day per worker; from WDI 2014 it is ambient particle pollution PM2.5 pollution for mean annual exposure measured in micrograms per cubic meter. All of these three indicators calculate the environmental variables used in the analysis in Chapter 4. Since PM2.5 is lacking continuous data, the statistics shown in this section is presented only for the trend of CO2 and BOD.

Average CO2 emissions considered by region, in figure 2.4, shows a decreasing trend for East Asia & Pacific, Europe & Central Asia and North America while others have a lower decreasing trend. Europe & Central Asia during 1992-2010 had higher emission levels than other regions; investigated deeply and detailed its affect and difference in country income level. Most Western Europe countries are in the High Income OECD group which has lower emissions than Eastern Europe and Central Asia countries that are mostly grouped in High Income non-OECD and Upper Middle Income categories. Therefore, another CO2 emission statistic will consider group of income levels as shown in figure 2.5 with two trending regimes. The first regime from 1970 to 1991, all income groups had an increasing trend especially for Lower Middle Income class. The second regime started from the year 1992 with all groups showing a decreasing trend; however, the Lower Middle Income, Upper Middle Income and High Income non-OECD still has high emission levels.

When we look at average value, CO2 emission trends are quite similar for both developed and developing countries and when we take a closer more detailed look at individual countries, we find that there are in fact differences. Figure 2.6 is an example of CO2 emission comparison for selected countries; developed countries like USA, United Kingdom (GBR) and Germany (DEU) obviously show a decreasing trend while developing countries in the ASEAN region like Thailand (THA), Indonesia (IDN) and Malaysia (MYS) have a contrasting trend. Such difference in value implies that there is also a difference in enforcements by the government to reduce CO2 emissions which would reflect their laxity in pollution control.

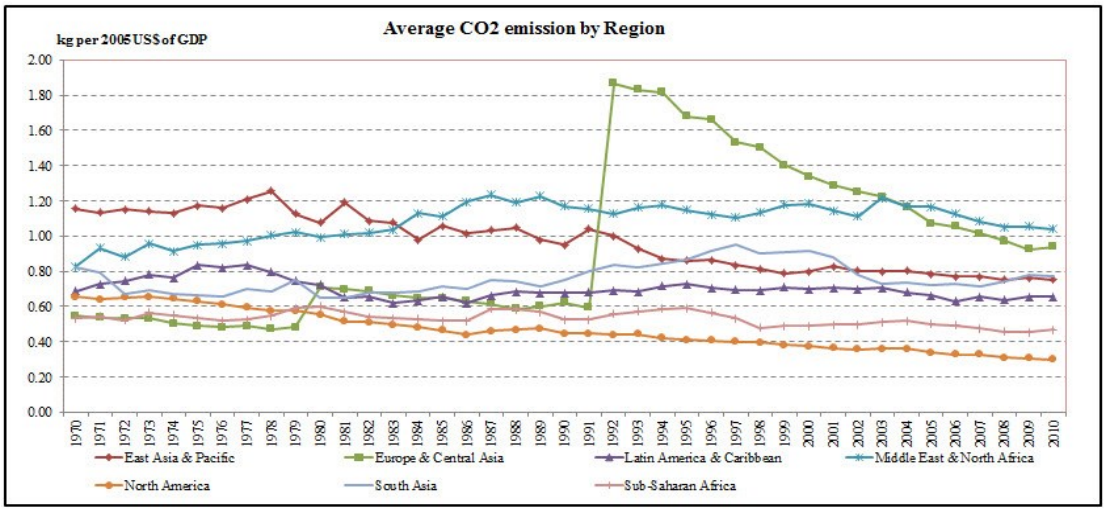

Figure 2.4 Average CO2 Emission by Region 1970-2010

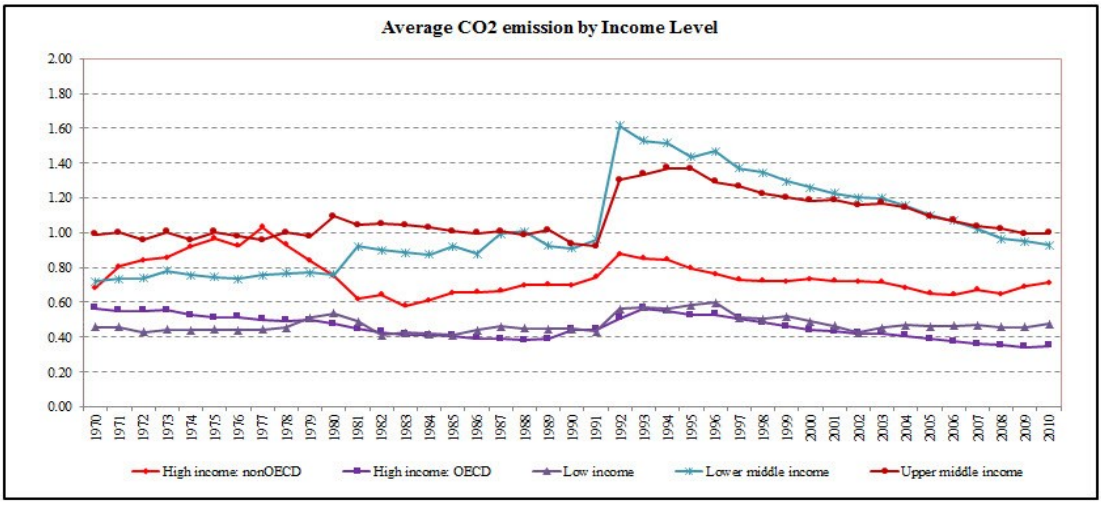

Figure 2.5 Average CO2 Emission by Income Level 1970-2010

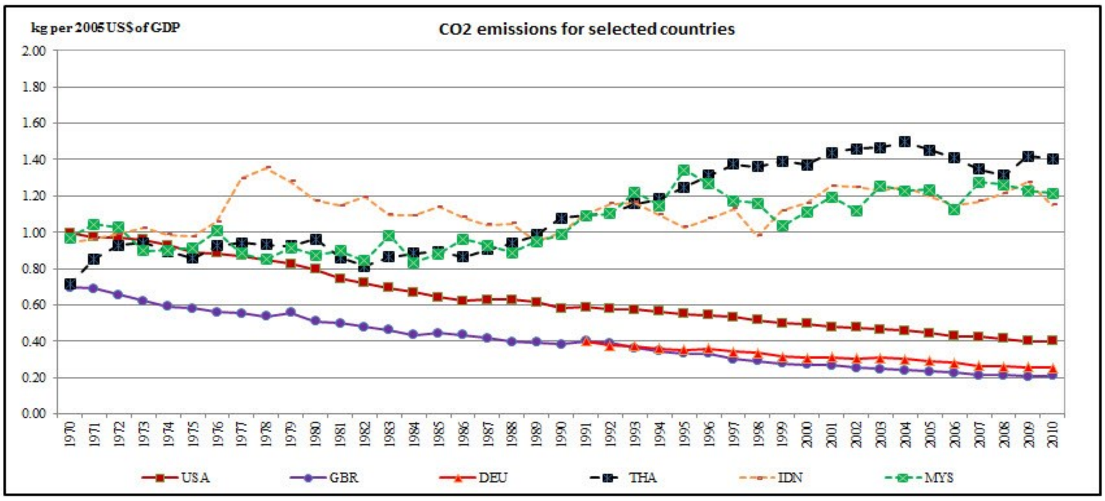

Figure 2.6 Comparison of CO2 Emission for Selected Countries 1970-2010

An important water pollution indicator in the year 2013 WDI is called Organic water (BOD) emissions in kg per day per worker. It is defined as:

"Emissions per worker that are total emissions of organic water pollutants divided by the number of industrial workers. Organic water pollutants are measured by Biochemical Oxygen Demand (BOD), which refers to the amount of oxygen that bacteria in water will consume in breaking down waste. This is a standard water treatment test for the presence of organic pollutants."

Statistics of this pollution indicator available for the year 1986-2007; as shown in figure 2.7, when we consider the average value by region, East Asia & Pacific, Europe & Central Asia and North America had decreasing trends in 1980s to the mid of the 1990s and then it stabilized. Water pollutant in those three regions looks similar to their CO2 emission trend, but other regions like Latin America & Caribbean, Middle East and North Africa had an increasing trend of water pollutant even though their CO2 emission demonstrated a low decrease. When we consider water pollutant by income level in figure 2.8, High Income countries both in OECD and non-OECD had a huge decreasing trend in 1980s to mid of 1990s and a small increase for non-OECD groups. For Low Income, Lower Middle Income and Upper Middle Income groups; they all showed an increasing trend. When we consider the selected developed and developing countries as shown in figure 2.9, water pollutant trend was quite similar for all selected countries with a difference from CO2 emission trends.

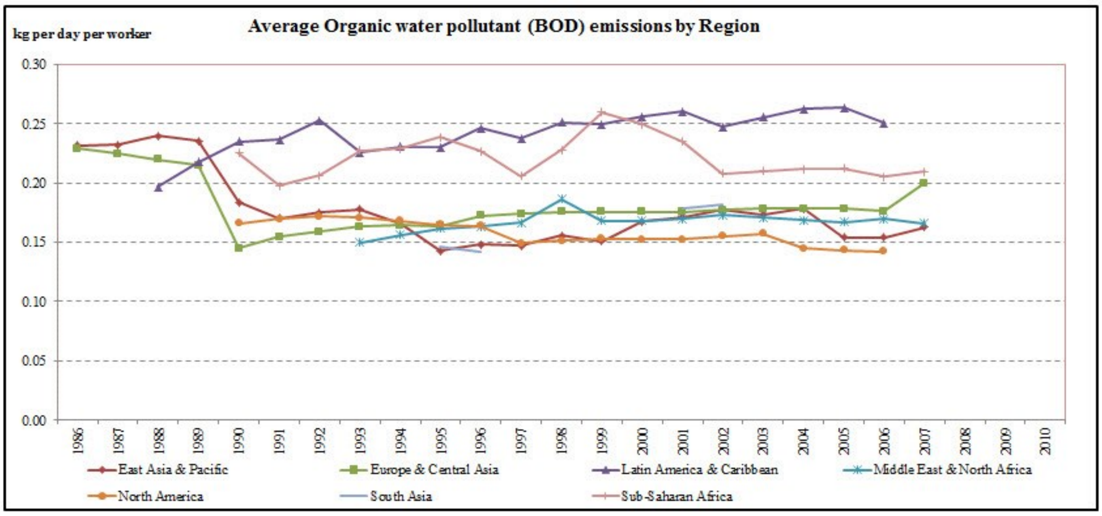

Figure 2.7 Average Organic Water Pollutant Emissions by Region 1986-2007

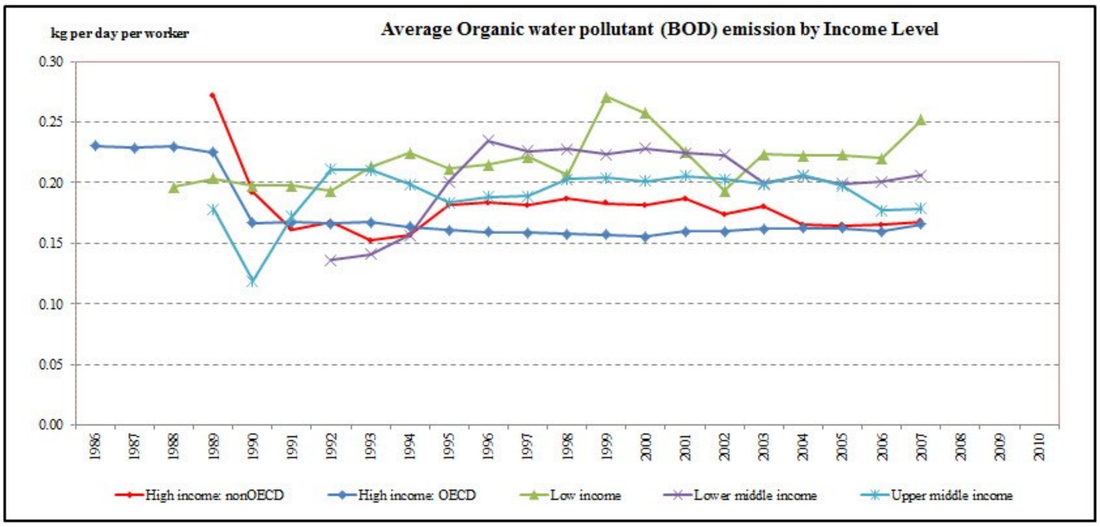

Figure 2.8 Average Organic Water Pollutant Emissions by Income Level 1986-2007

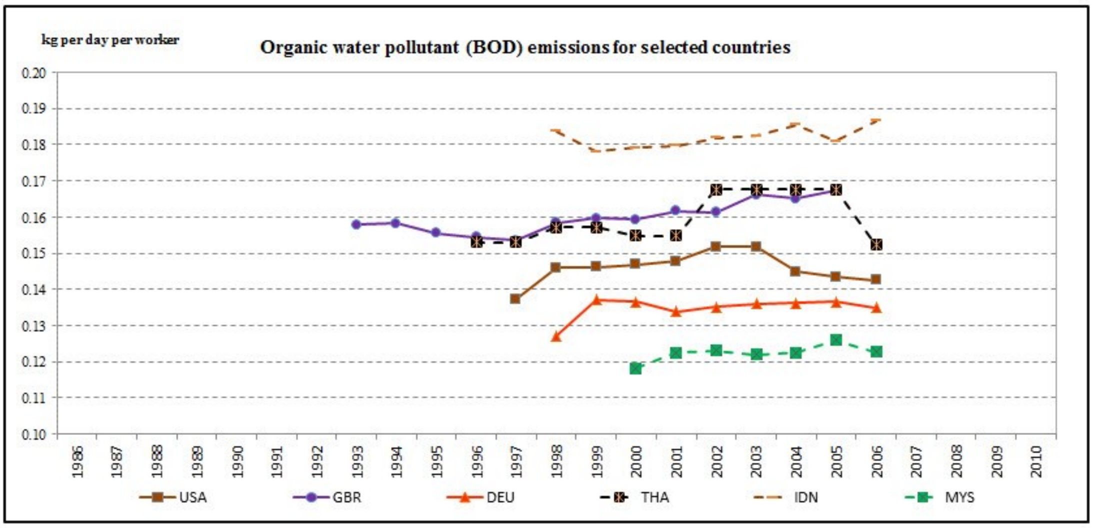

Figure 2.9 Organic Water Pollutant Emissions for Selected Countries

2.1.3 FDI and Pollution Perspective

The previous sections show different trends for different pollution indicators that will explain the reason for using multiple environmental values in the calculation of environmental variables in this dissertation. A change in environmental value implies that levels of environmental control enforcements, restrictions and regulations were also changed in the country. Reported in the World Investment Report for the year 2013 by United Nations Conference on Trade and Investment (UNCTAD), as shown in figure 2.10, trade liberalization and investments were reduced when a country increased its restrictions. Environmental regulations and included areas of restriction are shown in that report, but the specific effects of these regulations in relation overall investments, will be reexamined in this dissertation. In reference to the economic problem, if low levels of pollution control enforcements attract more FDI inflows, then the FDI inflow and outflow comparisons leads us to pose the question: is it true for developed countries such as the United Kingdom? What about the current status of the relation between pollution control enforcements and FDI from the global perspective? That is the reason why this research will reexamine the relation between pollution control enforcements and FDI in global level before narrowing down the scope to ASEAN countries and specifically Thailand.

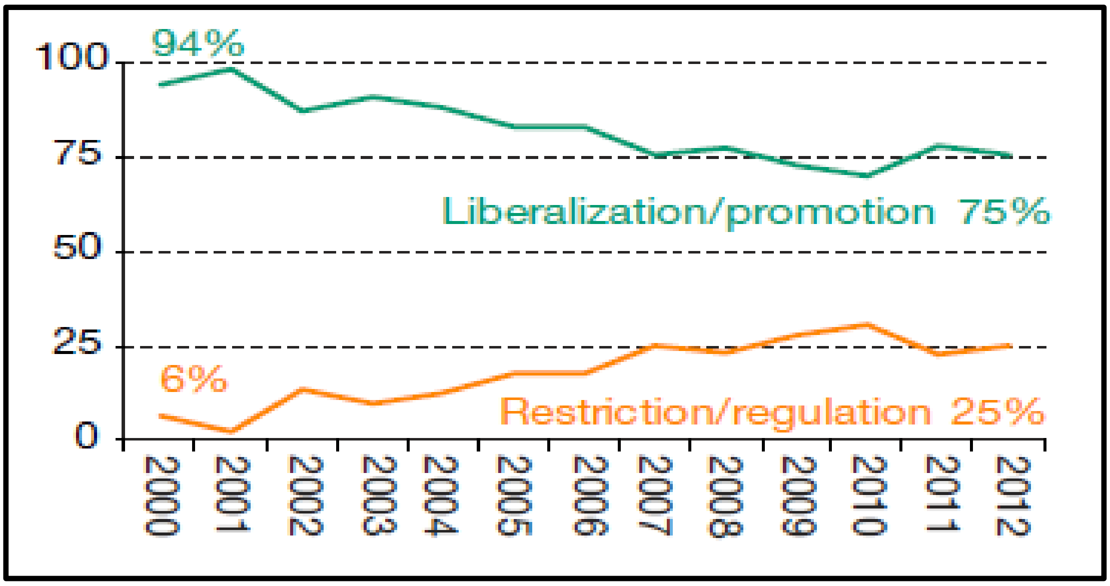

Figure 2.10 Change in National Investment Policies 2000-2012 (per cent)
Source: United Nations Conference on Trade and Investment, 2015.

2.2 FDI Inflows to Thailand

There are various sources of Thailand's FDI inflow data with small deviation among them, for example, data from the Bank of Thailand (BOT), data from WDI by the World bank and data from Thailand Board of Investment (2014). In this dissertation, I used data from WDI for a long period overview and data from BOI which was used in the analysis in Chapter 4. Figure 2.11 and shows the development of FDI inflows to Thailand from 1975 to 2012 using data from WDI; it started an increasing trend in 1987, after a crisis in the year 1997 it was faced with significant declination during 1999-2002, then increased again until 2007 and then fluctuated during 2008-2012. Such data include FDI inflows for both the manufacturing and service sectors.

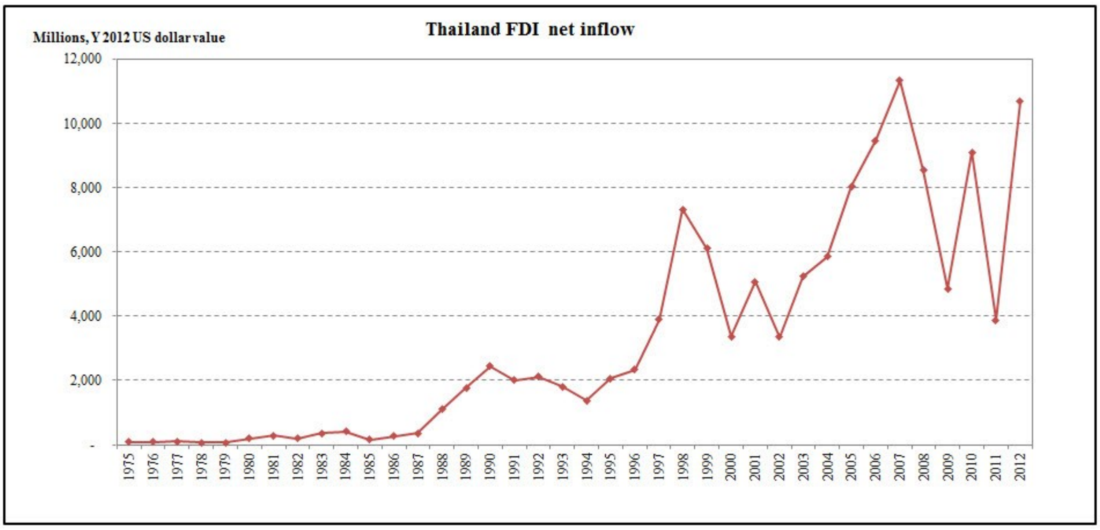

Figure 2.11 Thailand Net FDI Inflows 1975-2012

Since this dissertation focuses on the relation between pollution control enforcements and FDI inflows, the service sector is excluded from the analysis. Investment data with detail of the manufacturing sectors between years 2009-2013 from BOI is applied, even though the BOI uses data of the promotion application which sometimes has no real investment within the application year, but it reflects the investor's intention to invest in Thailand. Moreover, BOI's data has specific investment information by the industrial sector which is important to analyze whether FDI is attracted by high pollution intensity. In the overview of BOI's data during a period of five years, total investments in the service sector was 269,322 million Baht while the manufacturing sectors was 1,457,834 million Baht as shown in table 2.1.

Table 2.1 Thailand Investment According to BOI 2009-2013

Industry Name	Total Investment 2009-2013 (Million Baht)
Agricultural Products	101,935
Minerals and Ceramics	116,232
Light Industries/Textiles	65,813
Metal Products and Machinery	574,563
Electric and Electronic Products	410,324
Chemicals and Paper	188,966
Services	269,322

For unknown reasons, the pollution data is mostly available for the manufacturing sectors, so the BOI's data, regardless of the service sector, will be selected for that industry and for the investing country, that value of pollution can then be embedded into the analysis. For example, British Virgin Island had invested in Thailand and applied for BOI promotion but it had no pollution indicator data, so data from this country was taken out from the analysis. Such modifications result in a small amount of reduction of FDI inflows from 1,457,834 million Baht to 1,414,059 million Baht. Reported in table 2.2, the largest sector is the Metal Products and Machinery industry followed by the Electric and Electronics industry. When considered by source of investment, in regional dimensions, the highest amount came from East Asia & Pacific, and in income level, the highest came from High Income OECD countries.

Table 2.2 Thailand Investment According to BOI 2009-2013 for Manufacturing Sectors

Industry Name	**Year**					
	2009	**2010**	**2011**	**2012**	**2013**	**Total**
Agricultural Products	15,667	16,461	15,424	20,946	18,383	86,881
Minerals and Ceramics	3,284	33,449	24,961	22,444	29,629	113,768
Light Industries/Textiles	5,612	8,929	11,345	21,333	17,072	64,292
Metal Products and Machinery	44,035	49,213	85,834	191,091	202,040	572,213
Electric and Electronic Products	37,624	102,160	59,734	121,930	79,265	400,713
Chemicals and Paper	14,923	18,467	37,856	62,799	42,147	176,192
Total	**121,145**	**228,679**	**235,154**	**440,543**	**388,538**	**1,414,059**
Investor by Region						
East Asia & Pacific	81,063	128,913	200,068	372,684	331,348	1,114,076
Europe & Central Asia	11,247	70,721	16,008	28,529	35,678	162,183
Latin America & Caribbean	82	21,677	7,765	16,456	4,743	50,723
Middle East & North Africa	345	323	20	191	228	1,107
North America	25,801	5,946	9,512	17,529	13,199	71,988
South Asia	1,179	729	946	2,782	1,762	7,398
Sub-Saharan Africa	1,427	371	834	2,372	1,580	6,584
Total	**121,145**	**228,679**	**235,154**	**440,543**	**388,538**	**1,414,059**
Investor by Income Level						
High income: non-OECD	15,082	41,318	30,428	44,661	39,898	171,387
High income: OECD	93,595	171,203	183,324	381,437	331,827	1,161,387
Low income		21	2	170		193
Lower middle income	1,330	1,617	1,553	2,978	4,270	11,748
Upper middle income	11,139	14,520	19,845	11,297	12,543	69,345
Total	**121,145**	**228,679**	**235,154**	**440,543**	**388,538**	**1,414,059**

Note: Investment in Million Baht

2.3 The Thai's Environment Regulations

In relation to the pollution heaven hypothesis that rose up in 1970s, I surveyed Thailand's environmental regulations related to air and water pollution from 1970 until 2012; the data are retrieved from Ministry of Industry. Department of Industrial Works. Public Information Center (2014); Ministry of Natural Resources and Environment. Office of Natural Resources and Environmental Policy and Planning (2014); Ministry of Natural Resources and Environment. Pollution Control Department (2014). Following to figure 2.12, with a total of 85 regulations, they can be considered for two regimes for issuing environmental regulations. The first regime during 1970-1991 had issued only 10 regulations, while the second regime stated since 1992, with 17 regulations issuing in that single year. Those regulations are categorized for three groups, as shown in figure 2.13, consisting of regulations for water pollution, regulations for air pollution and regulations for both air & water pollution. The use of those pollutant indicators can refer to the studies by other researchers such as Becker and Henderson (2000). All of the three categories have small and different proportions which would imply that the Thai government took a similar approach and concern for air and water pollution. One other environmental regulation relates to waste and hazard management that had issued 30 regulations during the years 1970-2012. However, it is not focused in this dissertation because of the difficulty and lack of data to quantify such waste and hazards into the environmental variable in the analysis in Chapter 4.

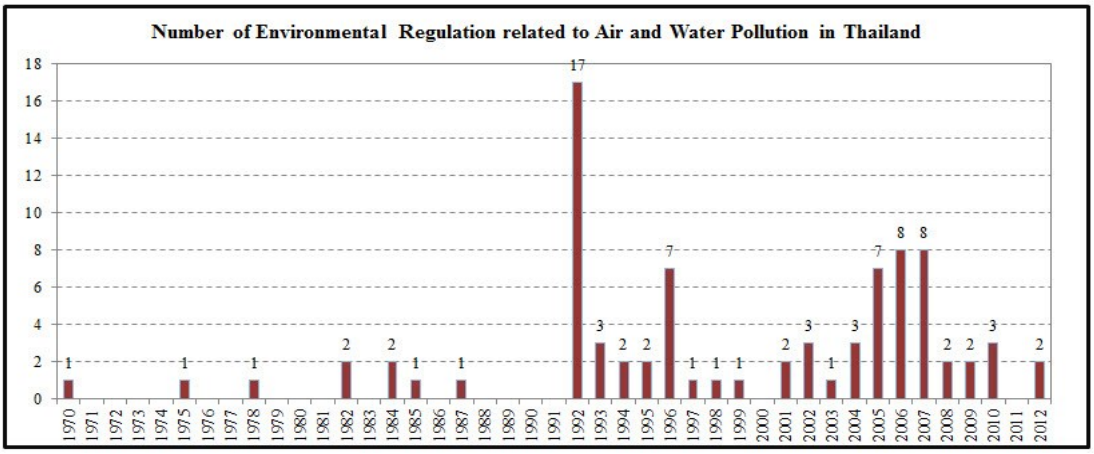

Figure 2.12 Environmental Regulation Related to Air and Water Pollution in Thailand 1970-2012

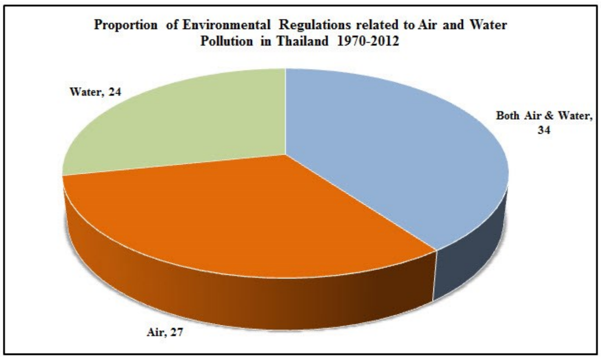

Figure 2.13 Proportion of Thailand's Air and Water Environmental Regulation

A quantity result for the environmental issue issued overtime doesn't mean policies were stringent, when investigated for more detail on Thailand's environmental regulations. There were a lot of reissued regulations but pollutants remained with the same limitations as previous ones. Table 2.3 is a comparison of industrial waste water pollutant limits for regulations announced in 1970, 1982 and 1996; it shows the same limit number for heavy metal contained in waste water, for example, Mercury has a constant limit with not more than 0.005 mg/l and this number was still effective in the year 2014. Imagine that over four decades there would be a huge change in science and technology; hence new environmental standards should have been more stringent, yet they retained the same pollutant limits which could easily be investigated by investors when they thought about the pollution heaven, it also mirrored a situation of laxity of environmental controls in Thailand. Looking back at the CO2 emission in figure 2.6 and water pollutant in figure 2.9, we can obviously see that Thailand has both increasing trends, which is not surprising since polluters have seen laxity as aforementioned.

Table 2.3 Comparison of Industrial Waste Water Pollutant Limit in Thailand

	Notification the Ministry of Science, Technology and Environment, No. 3, B.E.2539 (1996) issued under the Enhancement and Conservation of the National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 113 Part 13 D, dated February 13, B.E.2539 (1996)	Notification the Ministry of Industry No. 12, B.E. 2525 in the Royal Government Gazette, Vol. 99 Part 33, dated March 5, B.E.2525 (1982)	Notification the Ministry of Industry No. 2, B.E. 2513 in the Royal Government Gazette, Vol. 87 Part 70, dated August 1, B.E.2513 (1970)
Total Dissolved Solids (TDS)	not more than 3,000 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 5,000 mg/l	Dissolved Solids not more than 2,000 mg/l depending consideration of officer but not exceed 5,000 mg/l	Dissolved Solids not more than 2,000 mg/l depending consideration of officer but not exceed 5,000 mg/l
Heavy metals			
1. Zinc (Zn)	not more than 5.0 mg/l	not more than 5.0 mg/l	not more than 5.0 mg/l
2. Chromium (Hexavalent)	not more than 0.25 mg/l	not more than 0.5 mg/l	not more than 0.5 mg/l
3. Chromium (Trivalent)	not more than 0.75 mg/l		
4. Copper (Cu)	not more than 2.0 mg/l	not more than 1.0 mg/l	not more than 1.0 mg/l
5. Cadmium (Cd)	not more than 0.03 mg/l	not more than 0.03 mg/l	not more than 0.03 mg/l
6. Barium (Ba)	not more than 1.0 mg/l	not more than 1.0 mg/l	not more than 1.0 mg/l
7. Lead (Pb)	not more than 0.2 mg/l	not more than 0.2 mg/l	not more than 0.2 mg/l
8. Nickel (Ni)	not more than 1.0 mg/l	not more than 0.2 mg/l	not more than 0.2 mg/l
9. Manganese (Mn)	not more than 5.0 mg/l	not more than 5.0 mg/l	not more than 5.0 mg/l
10. Arsenic (As)	not more than 0.25 mg/l	not more than 0.25 mg/l	not more than 0.25 mg/l
11. Selenium (Se)	not more than 0.02 mg/l	not more than 0.02 mg/l	not more than 0.02 mg/l
12. Mercury (Hg)	not more than 0.005 mg/l	not more than 0.005 mg/l	not more than 0.005 mg/l

2.4 Investigation to Thailand's FDI Inflows and Pollution Indicators

Three graph of FDI inflow data and pollution indicators, as shown in figure 2.14, figure 2.15 and figure 2.16 depicts the same increasing trend overtime, especially for CO2 emission. Despite a lack of other continuous pollutant data, such similar trend shall be proven in the statistical correlation test, a question about lax in pollution control enforcement to attract FDI inflows and the reality of such a scheme which remains in Thailand. There are facts that the Thai government had concerns about the environment and this was shown by the issuing many regulations in 1992, which resulted in rapid FDI growth in that same period, but it seems that the quantity of regulations had very little effect no pollutant emission.

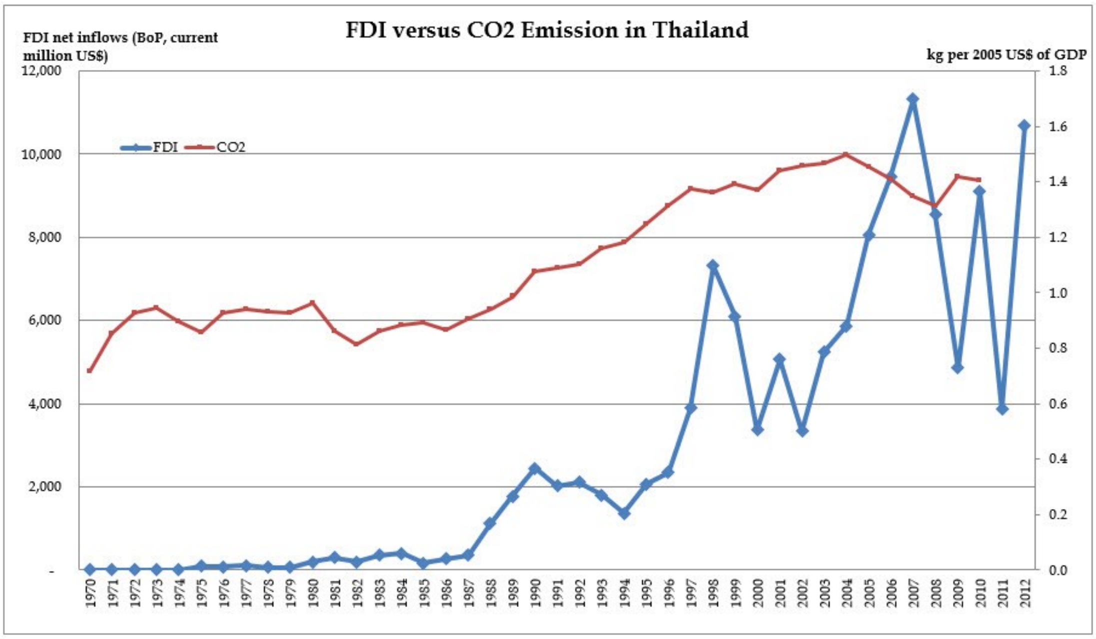

Figure 2.14 FDI versus Pollution CO2 Emission in Thailand

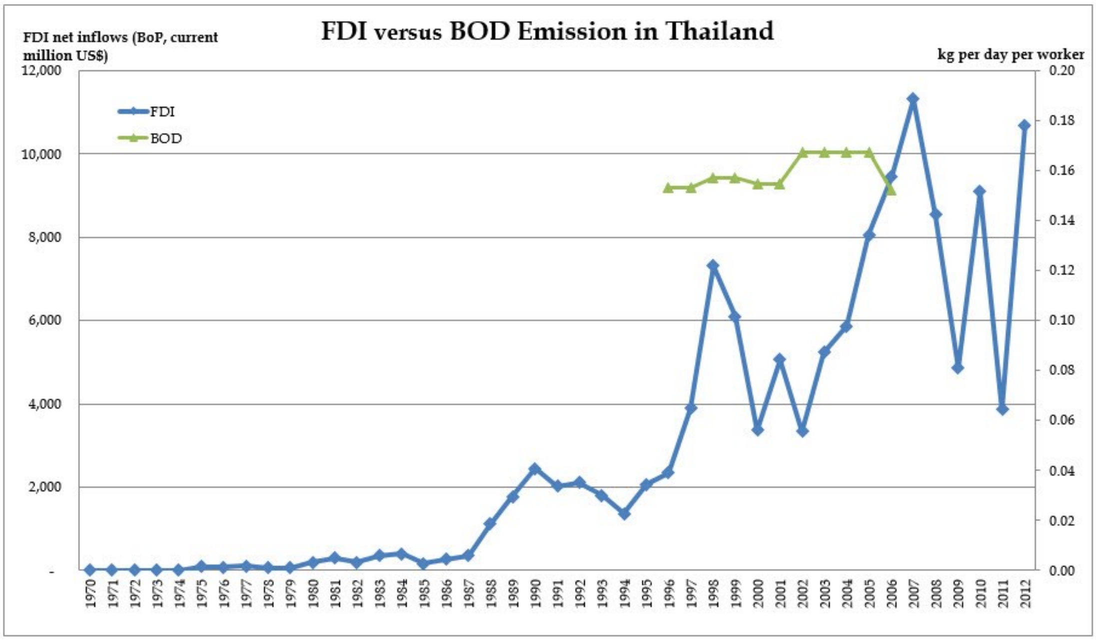

Figure 2.15 FDI versus Pollution BOD Emission in Thailand

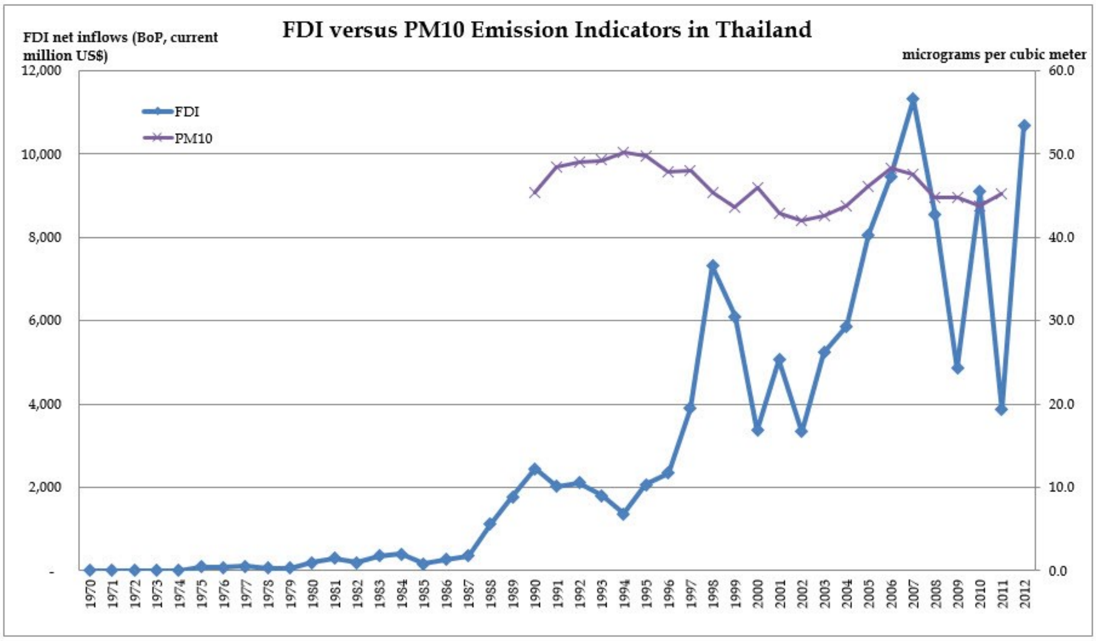

Figure 2.16 FDI versus Pollution PM10 Emission in Thailand

There is no evidence to allege that the Thai government intended to lax their pollution control enforcement as an aim to attract for FDI inflow. By reason of the country's reputation and a global trend which focuses on environmental care, the government will never reveal or announce that they have laxity in their policies for the environment. However, according to the costs that both institutions and the private sectors need to pay for a stringent environmental control, it would discourage the government, especially in developing countries, to put less effort in its regulation enforcements. On other hand, the higher the pollution the higher the social costs that the government needs to pay not only in the present but also in future. This brings us to the understanding that weather their policies are stringent or lax in environmental control enforcements; the government will incur a cost either way.

Benefits from more FDI inflows would be a counter reason for the government; the country would gain from higher household income, higher exports and higher GDP growth that may result in higher government revenue. The government would make a trade-off between aforementioned costs and benefits. This situation could also be applied in the case of Thailand.

CHAPTER 3

LITERATURE REVIEW

3.1 Theory Relate to FDI and Environment

Globalization, according to trade, investment liberalization and the environment, has been debated for several decades, and the topic of global climate change is a consequence of that liberalization. Supporters like the international trade and investment communities enjoyed with their business expansions, economic growth, and increasing income, meanwhile, environmentalists opposed stating that more liberalization could result in more harm to the environment if improper rules and regulations remain. With this suspected matter, Copeland and Taylor (2003: 2-4) asking two questions relating to international economics activities; the first is 'how does the increase in economic activity induced by international trade affect the environment' and the second is 'how does environmental policy affect a nation's trade pattern'. Following the second question, one question of this study is asking how stringent pollution control enforcements affect a nation's FDI inflow. Thus, the main theory related to FDI and the environment in this study is follows that of Copeland and Taylor (1994, 2003: 11-26, 2004).

3.1.1 FDI Fundamental

The basic explanation of FDI is about people or firms from one country investing for the production of goods or services in other countries. In this context, we could say that it's investing in 'real sector'; financial or capital investment is excluded. The investing countries are so called the "home country" and countries that receive investments are so called the "host country", these two words are generally used in the studies as directly related to FDI. In general, two kinds of FDI are widely studies by many researchers, FDI inflow and FDI outflow. The 'inflow' is about FDI that the country receives, while the 'outflow' is about FDI that the country invests abroad.

There are two distinct fundamentals of FDI which was originated by two different economists. First, the "Vertical" FDI initiated by Helpman (1984) explain that when multinational firms consider investing abroad they will look for the host countries that have lower production costs. The firms benefit from cheaper prices in production factors; especially when that production uses factors intensively and the host country also has an abundant of factors. Because of the lower production costs, the firms can distribute and sell goods produced in host countries not only back to the home countries but also to the rest of the world, hence, the firms will receive higher profits for goods and services produced outside their home countries. By this concept, host countries that these firms look for would be the countries having abundant factor endowments. Second, the "Horizontal" FDI initiated by Markusen (1984) who thought that multinational firms invested abroad to serve local markets in the host countries. The firms will consider host countries that have large market size; consider if there are high transportation costs from home to the host countries or other trade barriers, and so, setting up production in host countries would have more benefits than to export their goods to sell in host countries.

Both these fundamentals are obviously related to a firms' production cost, but the differences are that the vertical produce goods in host countries are sold back to the home and other countries while the horizontal idea focuses on serving the local host countries' market by establishing production facilities locally which is better than trading from abroad. By applying fundamentals of FDI together with the concept of gravity model which is widely used in the study international trade, and apply from Chung (2014), the baseline equation, in this study is

$$FDI_{it} = \exp(\beta Vertical_{it} + \emptyset Horizontal_{it}) \quad (3.1)$$

This equation is a condition for the host country receiving FDI inflows, where horizontal and vertical are two distinct fundamentals of FDI motivation to host country i, in year t.

3.1.2 Production Cost Function with Pollution

Production cost function that includes pollution factor was developed by Copeland and Taylor (2003: 11-26), assume a small open economy and an industry that jointly produces two outputs; good of industry X and pollution Z. Since pollution abatement is possible and suppose that the firm allocates an endogenous fraction θ of its inputs to environmental abatement activities, hence increasing in θ will reduce pollution but at the cost of diverting primary factors from X production. The primary factors in this production technology are capital K and labor L. Thus, to produce a unit where x unit is good produced and F is increasing concave, and linearity homogeneous, $0 \leq \theta \leq 1$; it deploys the production function in equation (3.2) as follow;

$$x = (1 - \theta) \cdot F(K_X, L_X) \tag{3.2}$$

This is because when one unit X is produced, one unit of pollution Z is also produced, where z is unit pollution, it allows to create a pollution production function. Let function $\varphi(\theta)$ imply efficiency of fraction, higher θ cause lower pollution Z, and $0 \leq \theta \leq 1$; $\varphi(0) = 1$ and $\varphi(1) = 0$, $\frac{\partial \varphi}{\partial \theta} < 0$; thus a pollution production function is created in equation (3.3) as follow;

$$z = \varphi(\theta) \cdot F(K_X, L_X) \tag{3.3}$$

From equation (3.2) and (3.3), if $\theta = 0$, there is no pollution abatement activity, and by choice of unit, each unit of output x generates one unit of pollution z. Since $F(K_X, L_X)$ can be considered as potential output, then the unit of output X that would be generated if there is no pollution abatement is $x = F(K_X, L_X)$. Again with no pollution abatement all output would be pollution, such that $z = x$. Next, where $0 < \alpha < 1$, let the function form of abatement be

$$\varphi(\theta) = (1 - \theta)^{1/\alpha} \tag{3.4}$$

From equation (3.2), (3.3) and (3.4), x and z will be combined in a single Cobb-Douglas function form with elimination of θ, thus the join production technology for output of unit good x using unit of pollution z as a production factor is

$$x = z^{\alpha} \cdot [F(K_X, L_X)]^{1-\alpha} \quad (3.5)$$

In addition to equation (3.5), it provides that even pollution is a joint output of production it can equivalently be treated as an input. Since the firms will have at least abatement activity because they must produce goods to sell in markets that cannot produce only pollution, it is valid that $z \leq F$. When we consider such relationship of the output and resources that the firms allocate for pollution abatement, with the assumption of constant return to scale, it can be illustrated isoquants as in figure 3.1 for level of net output of X. The isoquants show trade-off between production factor input F and pollution emission Z to keep a constant amount of output; while the dashed-line, that $\theta = 0$, corresponds for no abatement activity. Like example isoquant lines X_1 , it slopes down from no abatement at point A, to maintain constant output level the production input factor will increase as the pollution level fall; and of course, production cost is higher. Thus, if the firms can reduce production cost, such a reduction leads to more pollution.

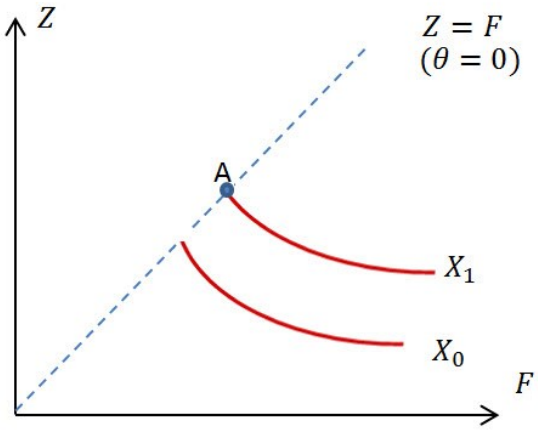

Figure 3.1 Isoquant for the ***X*** Output

Pollution as a production input is reasonable; let us think that when the firms produce goods, they must pay for some environmental services such as a disposal fee for the rejected goods, water and air emission treatment costs according to laws, apply to government authorities for their emission permits, etc. Once we consider pollution as a production input factor, in regard to cost minimization, the firms will look for minimum pollution cost.

3.1.3 The Cost Minimizing Choice

The firms have primary production factors include capital K and labor L; their prices are denoted by r and w respectively. Since pollution is treated as a production input, let its price be τ for each unit of emissions the firms generate. At first step, let production be constant return to scale and potential output C means for the best possible output with no pollution; the firms can find minimum cost to produce the potential output F as in equation (3.6). To produce one unit of F the firms have unit cost $c^F(w,r)$, thus total cost is $c^F(w,r) \cdot F$.

$$c^F(w,r) = \min_{k,l}\{rk + wl\} \quad \text{; w.r.t. } F(k,l) = 1 \qquad (3.6)$$

Next, when the firms allocate resources for pollution abatement activity, the pollution is now treated as an input and τ is the cost to produce one unit of pollution z; the production output would be X as per isoquants. Therefore, to produce one unit of X, unit cost function is

$$c^x(w,r,\tau) = \min_{z,F}\{\tau z + c^F(w,r) \cdot F\} \text{ ; w.r.t. } z^\alpha F^{1-\alpha} = 1 \qquad (3.7)$$

Solving for the optimal cost of equation (3.7) by using the first order condition it obtains

$$\frac{c^F}{\tau} = \left(\frac{1-\alpha}{\alpha}\right) \cdot \frac{z}{F} \qquad (3.8)$$

Solution in equation (3.8) is illustrated in figure 3.2; the isoquant line to produce net output X has slope $-\frac{c^F}{\tau}$ which is relative cost of two inputs, including potential output F with its cost c^F and pollution with its cost τ.

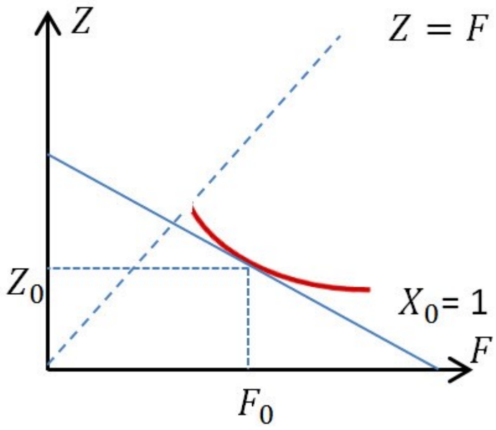

Figure 3.2 Cost Minimization to Produce Output ***X***

Vertical FDI is assumed to play a more important role than the horizontal in this study. Even though there are many horizontal factors, such as local market size and similarity between home and host countries which influences economy of scale and having relation to cost of production, but they have less relationship with pollution and the environment. The vertical FDI has more of a relation to cost minimization obtained from equation (3.8), and it is looked at more relative to the pollution heaven hypothesis.

3.2 Pollution Heaven Hypothesis and the Relation Between Pollution Control Enforcements and FDI

From the outlook of cost minimization, the firms always look for technology or locations that provides a minimum cost of production; Smarzynska and Wei (2001: 2) defined this behavior as "the possibility that pollution intensive multinational firms relocate to developing countries with less stringent environmental standards, labeled as the pollution heaven hypothesis". The hypothesis has been debated for many decades, Dean (1992: 4-12) surveyed for literatures studied during years 1972 to 1990 about the impact of inter-country differences in environmental regulations of production pollution, he also mentioned the pollution heaven hypothesis. Behavior of the multinationals in aspect the pollution heaven is still being debated nowadays, a recent study by Dean, Lovely and Wang (2009: 1) still raise the issue as "one of the most contentious issues debated today is whether inter-country differences in environmental regulations are turning poor countries into pollution heavens". This is a corollary that the pollution heaven hypothesis as well as the relation between low level of pollution control enforcements and amount of FDI inflows are still a major issue for international trade and investment considerations and studies.

3.2.1 Pattern of Trade and Pollution

There is a term called pattern of trade that is widely studied in international economic, it describes countries that exports goods that uses its abundant factor most intensively. Since pollution is treated as a factor input to produce net output of X, and extend equations in section 3.1 by write output available for sale in typical industry,η,it obtains the equation system constructed by Levinson and Taylor (2008: 226-229). Extend equation (3.3) to obtain pollution production function of any industry η as in equation (3.9); and extend equation (3.5) to obtain the output produced via a Cobb-Douglas function of pollution emitted and traditional production factors as in equation (3.10)

$$z(\eta) = \varphi(\theta(\eta)) \cdot F(K(\eta), L(\eta)) \quad (3.9)$$

$$x(\eta) = z(\eta)^{\alpha(\eta)} \cdot [F(K(\eta), L(\eta))]^{1-\alpha(\eta)} \quad (3.10)$$

When labeling industries appropriately, the higher η means higher pollution intensity, and then it obtains $\alpha'(\eta) > 0$ and extends the primitive $\alpha(\eta)$ to the endogenous variable $\theta(\eta)$. By that mean, the pollution intensive industries also exhibit the high pollution abatement cost. Such that for each industry, it appears unit cost function apply from equation (3.10) as

$$c(\eta) = k(\eta) \cdot \tau^{\alpha(\eta)} \cdot (c^F)^{1-\alpha(\eta)} \quad (3.11)$$

Where $\tau(\eta)$ is a cost for each unit of pollution z; $c^F = c^F(w,r)$ is cost of producing one unit of potential output F, and $k(\eta)$ is a constant. Let a * indicates for host (foreign) country, then $c(\eta), \tau, c^F$ are for the home country and $c^*(\eta), \tau^*, c^{F*}$ are for the host country. The home country will produce and export all industries η that $c(\eta) \leq c^*(\eta)$, whereas ship the remain industries to produce in host country. Comparison for the unit cost between home and host countries by rearrange from equation (3.11), show that the host country will produce for industry η when

$$\left(\frac{c^F}{c^{F*}}\right) \leq \left(\frac{\tau^*}{\tau}\right)^{\alpha(\eta)/1-\alpha(\eta)} \equiv \Gamma(\eta; \tau, \tau^*) \quad (3.12)$$

Following to the pollution heaven, the host country has lower cost for each unit of pollution, then $\tau > \tau^*$; and because of $\alpha'(\eta) > 0$, the right-hand side of equation (3.12) is declining in η.

3.2.2 Estimation Models for a Pollution Control Enforcements and FDI

Recall for function form of pollution in equation (3.3) that $z = \varphi(\theta) \cdot F(K_X, L_X)$ and equation (3.4) for abatement that $(\theta) = (1-\theta)^{1/\alpha}$. Since $\varphi(\theta)$ is efficiency of fraction, where $0 \leq \theta \leq 1$; and $0 < \alpha < 1$; and α imply laxity of pollution abatement activity, then at same θ the higher α the higher $\varphi(\theta)$ and consequence for higher pollution z.

Assume the same technology is being produce either in the home or host countries, then both countries have same F. At the same level of pollution control enforcement, $\alpha^* = \alpha$, and same pollution, $z^* = z$, if the host country has a lower cost for each unit of pollution, $\tau^* < \tau$, where * indicates the host country, then production cost at the host countries is less than the home country, $c^{F*} < c^F$. This assumption exhibits a direct effect of unit pollution cost to production cost.

Considering cost minimization, when investing abroad, the firms will use the production technology that has the lowest costs, then both host and home shall also face with same F; and also look for lower total pollution costs, which is equal to τz. Since higher α affect for a higher pollution z, then the firms can use a level of pollution control enforcements as a proxy indicator to anticipate the total pollution cost τz. According to this concept, taking out τz from equation (3.8) together with same F, it obtains $c^F = \left(\frac{1-\alpha}{\alpha}\right)$. Suppose that the host country has weaker enforcement, $\alpha^* > \alpha$, then production cost at the host countries is less than the home country, $c^{F*} < c^F$ because $\left(\frac{1-\alpha^*}{\alpha^*}\right) < \left(\frac{1-\alpha}{\alpha}\right)$. By these assumptions; the cost of production is a function of environment laxity or level pollution control enforcement and other variables as shown in equation (3.13).

$$c^F = f(\alpha \text{ , set of economic variables}) \tag{3.13}$$

Put the production cost in equation (3.13), which is according to Vertical FDI, into FDI function in equation (3.1) it obtains the function of the relation between pollution control enforcements and FDI in equation (3.14) which will be applied for major econometric models in this research.

$$FDI_{it} = f(LAXITY_{it} \text{ ,} Set\ of\ Economic\ Variables_{it}\ ) \tag{3.14}$$

3.3 Previous Studies

Many empirical studies found evidence in certain countries at certain periods which are consistent with the pollution heaven hypothesis, but some of them found different results. Such evidences told that pollution control enforcements and FDI would have a different relation regarding different time periods and countries. Among all of previous studies, and because of the important concerning points related to this research, three major references will be more detailed than others, firstly, Smarzynska and Wei (2001) from NBER used firm level data of multinational firms which invested in 24 countries and found supportive evidence that there was lower FDI inflows in countries with higher environmental standards. Second, Dean, Lovely and Wang (2009) found different result. They studied FDI inflows to China during the years 1993-1996, using provincial level data. The results suggested that investors from developed counties (implying higher environment standard countries) were not attracted by weak environmental regulation province; contrasting with investors from weaker environmental standard countries, such as Taiwan and Hong Kong. Third, Chung (2014) examined patterns of South Korea's FDI outflows during years 2000-2007, using industrial level data. He found significant evidence that Korean investors, especially those from the high polluting industries, tend to invest in the countries having laxer environmental regulations.

Wethang Phaungsap, Suthee Luangaramkul, Chanin Manopiniwes and Nattapong Puttanapong (2008) used Computable General Equilibrium (CGE) to find Thailand's welfare effects from foreign direct investment, foreign equity investment and foreign credit. Chadin Rochananonda (2004) used CGE, with set of equations from International Food Research Institute (IFPRI), to analyze effect of trade liberalization and government finance in Thailand.

3.3.1 International Economics and Environment

Because FDI is one part of international economics, this section surveyed literatures in order to provide a general perspective about the effects of international economics activities to the environment.

Dean (1992) collected information for trade and the environment, literatures which debated the major questions about the impact of environmental regulations on trade patterns. He pointed out that, theoretically, the environment is most often treated as a third production input factor alongside the two standard factors of labor and capital. Not only the physical ability of water, air and land to absorb waste influencing the assimilative capacity but also the level of pollutants that the society is willing to tolerate (Blackhurst, 1977 quoted in Dean, 1992: 3). According to the impact of inter-country difference in environmental regulations to competitive advantages, he summarized numerous studies (Dean, 1992: 4-5) and found that environmental cost controls tend to have very low impact. The abatement costs are a very small portion of industry costs on average. The reductions in output caused by environmental cost controls are also a small and insignificant on average, although they can be significant for some individual sectors.

Dean (1992) further expressed about the pollution heaven hypothesis and most of the referenced studies found no significant evidence. For example; there is no reason to believe that increased output in the environmentally abundant country will be captured by multinationals as opposed to domestic firms (Pearson, 1987 quoted in Dean 1992: 9), there is no evidence of widespread relocation of US industries to pollution heavens (Duerksen and Leonard, 1980 quoted in Dean 1992: 10).

However, different periods may have different empirical results about trade liberalization and the environment, Dean (2002: 819-942) did his own reexamination using Chinese data during years 1987-1995, and found strong evidence that trade liberalization has multiple effects on emission growth. A similar situation happened for that relatively lenient environmental standards give developing countries a comparative advantage goods, evidences that were examined during the 1970s-1980s showed quite a contrast to later studies of Dean and Lovely (2008) which applied data during 1990s-2000s and found that increased FDI and production fragmentation have contributed positively to the decline in the pollution intensity of China's trade.

Grossman and Kruger (1991) evaluated an environmental issue that impacted the trade and investments behavior in the North America region. Motivated from the anxiety of an environmentalist about the North American Free Trade Agreement (NAFTA), a look at free trade and FDI flows between the United State and Mexico would aggravate the pollution problem in Mexico and in the bordering areas. There is also a concern that free trade may cause industrial groups in the United State to demand less stringent pollution controls to preserve their international competitiveness. They separated the three mechanisms by which a change in trade and foreign investment can affect pollution; the first one is called “scale effect”, which is trade and investment liberalization that causes economic activity expansions and if such nature of activities remains, he total amount of pollution will increase. The second is called “composition effect”; it relates to the result of changes in trade policies that a country will extend in sectors where it has a competitive advantage. If such advantages caused from a difference in environmental regulations, then the “composition effect” will harm the environment. The third is called “technical effect”; which states that trade and investment liberalization will induce new technologies from foreign producers to local economy; normally modern technologies are cleaner due to a global trend for environmental awareness and care.

Grossman and Kruger (1991) started the study with empirical evidence across 42 countries in accordance with “scale and technology effect”; they found that two pollutants consist of sulfur dioxide and smoke increased the per capita GDP for the low level income countries, but decreased with GDP growth at higher income level countries. Next, they addressed the “composition effect”, and found that lax in pollution controls had no significant effect to trade and investment flows between the United State and Mexico.

Questions relating to international trade agreements and the environment had been continuously debated. Ederington and Minier (2003) raised their question: Should international trade agreement be extended to include negotiations over an environmental policy? Since the country can create a secondary trade barrier by relaxing its environmental standards, international cooperation over environmental policies will therefore deter such environment laxity and consequently lead to an increased global welfare issue. The hypothesis is that, if stringent environmental regulations are a major source of comparative disadvantages, a country’s most regulated industries should have the highest levels of import penetration. The US panel data on pollution abatement costs of various manufacturing industries from years 1978 to 1992, with reason that stringency environmental laws and degree of enforcement should be reflected by the pollution abatement costs incurred by firms. Such costs are provided by United State. Department of Commerce. Census Bureau (2014) which collect for Pollution Abatement Costs and Expenditures (PACE) survey. By modeling the policy endogenously, empirical results support the hypothesis by showing that environmental policies had been used as a secondary trade barrier and strong evidence about higher levels of net imports penetration. This shows that stringent environmental regulations can be a major source of comparative disadvantages.

Since the US had imposed its stringent environmental regulations that cause comparative disadvantage; Levinson (2009) reported that from years 1987 to 2001, air pollution emitted by the US manufacturers decreased by 25 percent while the real value of manufacturing output grew 24 percent. Such cleanup came from two sources; first, technology advancement which is a major contribution to the green trends. Second, and with a much smaller effect comes from international trade, increase in international trade explains less than one-third of pollution reductions from composition changes in the US manufacturing. However, Levinson (2009: 2190) expressed that “the composition of imports which has shifted toward clean goods faster than the composition of domestic goods does not mean there is no pollution heaven effect.”

Not only FDI were studied in term of international economics and the environment but also others international trade and economic development. Dasgupta, Laplante, Wang and Wheeler (2002) studied the environmental Kuznets curve. They surveyed a lot of previous studies that emphasize an inverted-U shaped graph of relationship between pollution and economic development. Harbough, Levinson and Wilson (2002) did a reexamination of an environmental Kuznets curve using panel data set in cities worldwide and found a little empirical support for an inverted-U shaped relationship between several important air pollutants and national income. The using of panel data for empirical study for the effects of tariff and nontariff trade barriers was demonstrate in Lee and Swagel (1997); Haveman, Nair-Reichert and Thursby (2003). They methodology is one of reference of this study.

3.3.2 The Studies of FDI and Environment

According to difficulties when researchers try to measure pollution heaven, Smarzynska and Wei (2001) summarized four areas of such a problem. First, the study by Damania, Fredriksson and List (2003) claims it is reasonable to expect that corruption and laxity of environmental protection go together. Therefore, if statistical analysis on the effect of environmental policies on FDI omits local corruption, it might fail to detect an effect. So, when the host country’s prevalence in bureaucratic corruption which results in less environmental stringency that could attract more FDI inflows, that corruption problem will also discourage FDI inflows to the host country. Several studies have opposite results from Damania et al. (2003), demonstrated that corruption in a host country a significant deterrent of FDI inflows. By this contradiction, it is of importance to control corruption measurements which causes difficulties in empirical research.

The second difficulty which was raised by Zarsky (1999) is about the quality of evidence, both statistical and case study, quite low for research needs. A lot of studies relate to the investment locations decisions rely on aggregate data about industrial choice, which will not represent the decision of firms. Third, it is very hard to measure level of environmental stringency, number of laws and regulations may not be the actual enforcement. Fourth, assigning pollution intensity measures to production activities of different multinational firms is a very challenging task. Those four difficulties are taken into consideration of this research especially for the third and fourth, while the first will be omitted because of it gives contradicting results of previous study and the second is still too difficult to find firm data level for this study.

In the study of Smarzynska and Wei (2001), it tackles the problem as follows. First, explicitly take into account the corruption factor. Second, using data from 534 multinational firms that invested in only 24 countries. Third, set its own measured index of environmental stringency in the host country, this will be a guideline for this study relating to the methodology to quantify the level of environmental laxity. Fourth, it computed pollution intensity based on pollution emission data and abatement cost of the U.S. firms which were acquired from the U.S. Environmental Protection Agency, such concepts are also applied in this research. Most interesting is the third one, there are three groups of environmental stringency variable used in that study. First is the treaty group with two definition indices as follow:

(1) Treaties = participation in international treaties using information from United Nations Economic Commission for Europe. Five treaties are considered, index is created by awarding each country 1 point for rectifying each treaty prior to year 1996 and 0.5 point for signing each treaty before year 1996 or rectifying it after that time.
(2) Enforcement-adjust treaty index = Treaties * number of environmental NGOs per million people in the host country

Second, environmental stringency group is about quality of air and water ambient and emission standards, this group also have two definition indices as follow:

(1) Standards = index of air and water ambient and emission standards in the host country, which ranges from 1 denoting the weakest to 3 denoting the strongest standard.

(2) Enforcement-adjust standard index = Standards * number of environmental NGOs per million people in the host country

The third group is about observed actual reduction in various pollutants consisting of water pollutants, lead and carbon dioxide (CO2). Water variable is percentage reduction in emission of organic water pollutants between years 1990 to 1994, using data from the World Development Indicators database. Lead variable is percentage reduction in total lead emission between years 1990 to 1996 which is adjusted by plus percent change in GDP during corresponding period, using data from OECD. CO2 variable is percentage reduction in CO2 emission between years 1992 to 1995 which is adjusted by plus percent change in GDP during corresponding period, using data from the World Development Indicators database.

They found some support for the pollution heaven hypothesis; the most supportive is FDI inflows from pollution intensive multinational firms were lower when the host country participated in international treaties. When we put enforcements proxy by the number of environmental NGOs in host country, there still exist some supportive evidences that participating in international treaties has an effect FDI inflow. While other important variables, environmental standards and observed actual reduction in various pollutants have no effect to FDI inflow.

Major contribution from Smarzynska and Wei (2001) is about the idea to construct pollution control enforcements variables which will be applied in this research. However, I have an argument about enforcements that proxy by the number on NGOs; it could have either influenced or uninfluenced pollution control enforcements. In the host country where non-governmental organizations play strong roles in social activities, which would relate to a strong democratic country, it could have environmental enforcements effect. Only the number of NGOs may not be true for all countries, it is possible that large numbers could have a low role in social activities; it would depend on the development level of the host country as well. Even in the study about Enforcement-adjust standard index, number of NGOs has no effect, which is one example of an argument. One more thing about observed actual reduction in various pollutants is its interesting environment enforcements indicator even though it has no significant effect in the study. It is an argument that using such reduction value in absolute number may not be enough, what would happen if it is calculated into index number by comparing value in each host country with one reference source. It is inspiring to apply for environment enforcements measurements in this research.

Evaluating about foreign investors are attracted to weak environmental regulations in emerging economic countries like China was done by Dean, Lovely and Wang (2009). They used 2,886 samples of manufacturing equity joint ventures across Chinese provinces between years 1993-1996, then classified data by provinces and by industry according to International Standard Industrial Classification (ISIC). Two-thirds of the samples, by province, in that period, are the investments funded from ethnically Chinese sources. When considered across industries, there is a similar proportion of fund from ethnically Chinese sources. Modeling for foreign investor behavior in that study is based on theory as described in section 3.1 with slightly different in detail of variables. Beside labor wages and index price for locally provided services, marginal tax rate of emissions is included as a factor price in their model; and all factor prices varied across provinces. They assumed that the firm adjusted its emission by altering the effluent concentration of its wastewater. Since each province set its own allowable concentration standard, total fine for noncompliant, which is a proxy of marginal tax rate of emissions, is varies across provinces. Not only is the tax rate of emissions in each province an embedded consideration for investment location choice but also the pollution intensity of each industry. Measured of Chemical Oxygen Demand (COD) emission (kg) per 1,000 Yuan of real output is used as dummy variable for pollution intensity (PI) in their model. By maximizing profit and transforming a function form into log-linear, they further used conditional logit and nested logit methods to estimate investor's decision choice.

The estimation found that highly polluting industries funded through Hong Kong, Macao and Taiwan, were attracted by weak environmental standards. While equity joint ventures funded from other counties which were ethnically non-Chinese, were not significantly attracted by weak standards, regardless of the pollution intensity of the industries. This study says that FDI inflows are attracted by weak environmental standards but not for the investors from high income countries; and such effect is only for high pollution industries. However, there is evidence only in China, while evidence in other developing countries still requires further investigation.

From aforementioned results, it destroys the classical perception that the investors from rich country seeks locations which has low production cost according to weak environmental standard. However, there is evidence only in China; the argument still exists for other developing countries which this research will try to discover. One other important thing from such results is about pollution intensity (PI) which shows its significant role on the effect of environmental stringency to FDI inflows.

Recent study by Chung (2014: 222-236) used environmental laxity interaction with pollution intensity in his evaluation of South Korea's investor's behavior when investing abroad. He studied about how environmental regulation shapes pattern in South Korea FDI outflows to 50 host countries in 121 industries over the period from years 2000-2007; and thereby assesses the effect from environmental laxity in the host countries to attract Korean investors. His study provides two important things that relate to this research, first is the measurement of environmental laxity and pollution intensity and the second is about empirical frame work.

Despite measurement of environmental laxity being a frequently used pollution abatement cost (Keller and Levinson, 2002 quoted in Chung, 2014: 224; Eskeland and Harrison, 2003), argued that only a few countries have such data and difficult for comparison among host countries. He unsteadily measured environmental laxity by using survey data from the Global Competitiveness Report (GCR) from 2000 to 2007-2008 editions. Chung (2014: 225) provided two advantages of such survey data:

> First, its covers a wide range of countries around the world with standardized method of measurement which allows for direct comparison across countries. Second, as the survey is conducted by representative business executives located in each country, the measure reflects de facto environmental regulations that are more relate to firms' investment decision.

For more understanding about measurement methodology, in Global Competitive Report 2008-2009 (World Economic Forum, 2014), I found the surveyed score is rated from 1 to 7; where an answer of 1 corresponds to the lowest possible score and an answer of 7 corresponds to the highest possible score. Based on that methodology; would it be a question that businessmen, who provide score for environmental laxity in each country, used aggregate information about level of environmental enforcement to make their decisions for a firm's investment? Since those executives can score by using both analytical evidence and judgment from their experiences; such argument in this point can still be debated. Chung (2014: 225) also mentions that the measurement is not without flows, legislative and macroeconomic shocks may be sensitive to the survey respondents.

Chung (2014: 222-236) calculated pollution intensity from energy use per production output, it measures in industry level data and assumed that pollution emissions are monotonically increasing in energy use. He mentions that there is a relationship between energy use and major air pollutants consisting of sulfur dioxide (SO2), nitrogen oxide (NOx), carbon monoxide (CO) and particulate matter (PM10) (Cole et al., 2005 quoted in Chung, 2014: 225). By such evidence, it is reasonable to use energy consumption as a proxy of pollution intensity, this research intends to apply this similar idea but with different details which will be described in the next chapter. In his empirical methodology, FDI inflow to the host country is exponential function of the horizontal plus the vertical. Variables in the horizontal consist of market size of host country, similarity between home and host country, average plant level scale of economies in an industry, and host country tariff. Beside relative environmental laxity in host country and pollution intensity, and interaction between them; other variables in the vertical consist of relative capital abundance, relative skill abundance, relative raw material abundance, capital intensity, skill intensity, raw material intensity and tariff.

Once that exponential function is transformed to log-linear, the effect of environmental laxity in the host countries will be captured by coefficient of interaction term between relative environmental laxity in host country and pollution intensity. The positive coefficient is interpreted as mentioned in Chung (2014: 227) as "environmental laxity in a host country increase relative to the home country, the host country receives a disproportionately greater amount of FDI from polluting industries in comparison to non-polluting industries". The technical interpretation is that the elasticity of FDI to relative environmental laxity is linearly increasing in pollution intensity.

He used panel data analysis in the estimation of effect of environmental laxity on the amount of FDI outflows from South Korea to host countries, all estimations include country-year and industry-year fixed effects. The hypothesis is tested with 3,196 observations, there are mixed results up on omitting variables. It shows insignificancies of the environmental laxity if there is only interaction term between relative environmental laxity in host country and pollution intensity. But when we include all other interaction terms of capital abundance with its intensity, skill abundance with its intensity and material abundance with its intensity; there is significant evidence of an environmental laxity in the host countries to attract the investment from Korean investors. The estimation results say that the behavior of South Korea's investors tended to invest more for polluting industries in the host countries with laxer environmental regulations. However, there is the econometric issue mentioned in the study about endogeneity of environmental regulations; one reason is about reverse causality of FDI on environmental policies. For example, foreign polluting firms may lobby policymakers to lower environmental regulation in host countries (Cole et al., 2006 quoted in Chung, 2014: 227).

Beside those major studies, there are several literatures regarding FDI and the environments that are used as referenced research. Levinson (1996) studied the effect of differences in the stringency of state environmental regulations on investment location choice in the U.S. He used pollution abatement cost expenditure and firm level data in his conditional logit model to show that interstate differences in environmental regulations do not systematically affect the location choice of manufacturing plants. Gray and Shadbegian (1998) constructed their own model and tested whether environment regulation affects investment decision in the U.S. They employed plant level data and assigned them into five technology categories, then examined investment allocation across existing plant. They found that the firms will shift investment towards plants facing less stringent pollution abatement requirements. List and Co (2000) did empirical study in the U.S. by employed a conditional logit model to estimate the effects of state environmental regulation on foreign multinational firms during year 1986-

1993. They found heterogeneous results that environmental policies in some states can attract multinational corporation.

Xing and Kolstad (2002) examined whether lax in environmental regulations in host countries attract the FDI from several US industries which have both high and modest pollution control costs. They found that the laxity of environmental regulations in a host country is a significant determinant of FDI from US for heavily polluting industries and insignificant for less polluting ones. Keller and Levinson (2002) estimated the effect of changing environmental standard on pattern of international investment. They also examined it across states in the U.S. and found robust evidence that pollution abatement costs have had moderate effects on foreign investment. Eskeland and Harrison (2003) tested the pollution heaven hypothesis in four countries that consists of Cote d'Ivoire, Morocco, Venezuela and Mexico. In overall, they found no robust association between pattern of pollution abatement costs and investment.

Wagner and Timmins (2009) did empirical research about the agglomeration effects of FDI and the pollution heaven hypothesis. They used panel data on outward FDI of the German manufacturing as well as demonstrated that externalities associated with FDI agglomeration can bias estimates away from finding a pollution haven effect if omitted from the analysis. They also included the stock of inward FDI as a proxy for agglomeration and employed GMM estimator to control for endogenous time-varying determinants of FDI flows. Finally, they found robust evidence of pollution heaven effect in the chemical industry. Leiter, Parolini and Winner (2011) estimated the impact of environmental stringency focusing on European data of manufacturing industries between 1998 and 2007. They found a positive but diminishing impact of stringency in environment regulations on industry's investment. Zeng and Eastin (2012) examined the environmental effects of FDI from less developed countries. They pointed out that he less developed country's FDI can increase the level of environmental stewardship of the host country firms that is a contrast to pollution heaven.

Rather than those empirical studies, there are several theoretical studies too. Dijkstra, Mathew and Mukherjee (2011) applied a Cournot duopoly with a foreign firm and a domestic firm to set up a mathematic model that the foreign firm may want to relocate to the domestic country with stricter environment regulation. Elliott and Zhou (2013) used a game theoretic model to present for a greater stringency in environmental standards can lead to a strategic increase in FDI inflows. Those models have more complicate than Copeland and Taylor (2003), however, it still interesting if there are available data to do empirical study.

In summary, of literature review, there are theories related to trade and environment that can also be applied for FDI and environment. The relation between pollution control enforcement and FDI inflows had been studied in various approach, some had done a causality analysis following to pollution heaven hypothesis and found both significant and insignificant results regarding different time periods and location or countries as well as difference methodologies used in the studies. However, many of previous studies did an examination about relation between pollution control and FDI with causality analysis, since pollution heaven effects are mostly the firm decision behavior which have difficulty in data determination. In this regard, macro data at country level and other proxy data to represent firm's decision had been used to examine the relation of pollution control and FDI.

3.3.3 CGE with Trade Liberalization, FDI and Welfare

Effect of trade liberalization to a country's welfare was widely studied using Computable General Equilibrium (CGE); such research of Grossman and Kruger (1991); Devarajan and Chalongphop Sussangkarn (1992); Chadin Rochananonda (2004). Most of them considered the welfare impact in areas of a country's income contribution, wages, production structure, import-export and some considered the environmental impact. Besides the overall trade liberalization, there are also several studies for a specific issue of FDI and welfare such as research from Wethang Phaungsap et al. (2008).

Continued from the previous section, Grossman and Kruger (1991) borrowed CGE model from Brown, Deardorff and Stern (1991) to evaluate the environmental impact. Since their study found that, according to NAFTA, Mexico will produce goods in unskilled labor intensive industries while the United State and Canada produced goods in sectors that use relatively high capital and skilled labor. So that most of the FDI from the United State and Canada inflowing to Mexico could be for the industries that have scarcity in local resources, which are capital and skilled labor intensive. Then the problem is about the impact from resource re-allocation according to trade liberalization by NAFTA. There are 23 categories of tradable goods and 6 categories of non-tradable goods and services used in that CGE model; output of each is produced from intermediate input and aggregate of capital and labor. They treated all industries in the model either as perfect competitive or monopolistically competitive which exhibited economies of scale, homogeneous labor input is allowed for varying degree of substitution to capital.

Once the framework in model is set, they collected data for which industries expand in each country and to what extent. They further collected pollution intensity data which had difficulties; data of pollution generated by each industry is available in the United State while no such data was collect in Mexico. Together with technical effect that response to trade agreement, production technique in Mexico might change but is quite difficult to assess how such a change will be distributed across industries. They overcame the problem by using available data from the U.S. EPA's Toxic Resources Inventory; and applied it for all three partner countries to analyze how level of hazardous waste released from industries affected countries in NAFTA. The end result found that trade liberalization, with absence of increased capital flow, shifts Mexico production to less pollution generated industries which have more production output, especially in Electrical Equipment industry. However, there are two industries of Chemical Products and Rubber & Plastic Product which have significant less production output. When considering the effect from both trade and investment liberalization, by assuming a ten percent increase in capital stock, result shows that Mexico expanded production output in every industry, with the top three groups consisting of Chemical Products, Primary Metal and Electrical Equipment. This study by Grossman and Kruger (1991) links the effect from trade and investment liberalization to environment, and then to resources allocation and finally production output. At the end of impact to country's production output, it can be considered as one kind of welfare impact analysis.

Using CGE for analyzing cross country trade in the case of Thailand can be traced back to the 1990s decade, Devarajan and Chalongphop Sussangkarn (1992) pioneered the case study about one kind of import tariff called effective rates of protection. Traditional effective rates of protection on an industry were calculated by the price of value added in that industry with the presence and absence of tariff, and with the assumption of perfect substitution of domestic and imported goods. They pointed out that imported goods and domestic goods would not be the same thing even though they are in same industry, hence calculation in the traditional way would be unrealistic. One example is the canned food industry, where 10% imported tariff of canned caviar lead to a 10% price increase of domestic canned fruits. They turned the assumption to domestic and imported goods which are imperfect substitutions, by using CGE for the case of Thailand with 54 industrial sectors and assuming Thai consumers have CES utility function, their computation show that effective rates of protection will varies with the elasticity of substitution.

Chadin Rochananonda (2004) used CGE analysis for trade liberalization and government finance in Thailand; he simulated to show the Thai government's decision whether to compensate the loss of tariff revenue or run a budget deficit under the fluctuation of investment. His economic problem is about dual effects to income distribution caused by the reduction in import tariffs; firstly, trade liberalization would promote higher economic performance in Thailand and the benefits trickled down to the poor. Second, government would lose the tariff revenue and compensates it by taxation that will cause some household to be worse-off and some might be better-off. Therefore, the Thai government shall consider appropriate policies to finance the loss tariff revenue whether by adjusting the proportional income tax or without any government compensation that creates a budget deficit. Not only does tariff reduction impact economic performance and income distribution but also the level of investments, because more investments in industrial sectors tend to benefit industries themselves and increase employment. Then Chadin Rochananonda (2004) expanded his CGE simulations for two alternatives; the first case, Thailand investment relies on both domestic and foreign saving, the second case relies only on domestic saving. Such expansion poses the question about how would the response of investment affect the benefits on the Thai economy and the income distribution? That is one kind of question related to the welfare impact caused by FDI which is also an expansion in this dissertation.

In the study of Chadin Rochananonda (2004) he used data from Social Accounting Matrix (SAM) for Thailand in 1998. That 1998 SAM classified economic for 3 major sectors consisting of Agriculture, Manufacturing and Services.

Manufacturing has four sub sectors including Agro-industry, Trade-oriented industry, Intermediate good industry and Utilities. While Services has three sub sectors including Finance-Insurance-Real Estate (FIRE), Transportation and Other Services. There are three household groups for income distribution in the 1998 SAM, consisting of Agricultural, Non-agricultural and Government-employed. Chadin Rochananonda (2004) used CGE model with equation system from the International Food Policy Research Institute (IFPRI) which was developed by Lofgren, Harris, Robinson, Thomas and El-Said (2002). The IFPRI CGE model consists of 48 equations; because of some unavailable data in Thailand 1998-SAM, he modified the model to 44 equations and chose Leontief production function instead of CES production function.

With aforementioned methodology, Chadin Rochananonda (2004) concluded his studied that trade liberalization enhances Thailand's economic performance and improves income distribution at the same time. However, such benefits are sensitive to the level of investments; when the government runs budget deficit, foreign direct investment plays important roles while the domestic private sector lessens its investment and tend to save more. He also found that free trade regimes only enhance the expansion production and private consumption caused by lower imported prices, while most of its benefits rely on the structure of Thailand's economy and level of investments. This study is one of the important references about using CGE in analysis for welfare impact due to trade liberalization and investment in Thailand.

Beside free trade, impact of capital flow to the country can be analyzed by CGE model. Barry (2009) used CGE to analyze for who would gain and who would loss after Turkmenistan, Uzbekistan, and Kazakhstan adopted significant legislative changes to attract FDI into their energy sector. Wethang Phaungsap et al. (2008) provided a research for Thailand Fiscal Policy Office by developing its own CGE model to analyze impacts of three types of foreign capital flow to Thailand's economy; first is the impact from foreign direct investment (FDI), second is the impact from foreign equity investments and the third is impact from foreign credit. They use SAM for Thailand in 2005 combined with Flow-of-Fund information from various sources, such as the Bank of Thailand, Commercial banks in Thailand and Socio-economic survey by the National Statistic Office, to create Financial SAM. They developed the CGE model with five major blocks of equation systems, comprised of Prices, Production & Trade, Revenue & Income, Expense and Market; totally there are 54 equations.

Assuming capital inflow is 1% of the GDP, results from Wethang Phaungsap et al. (2008) showed that foreign direct investment (FDI), foreign equity investment and foreign credit affected Thailand's economy by increasing in GDP, consumption, investment, export, import and income distribution for five household bands. Focus on the impacts from FDI, GDP increased by 1.6%, consumption increased by 1.2%, Investment increased by 3.0%, export increased by 2.1%, import increased by 1.9%; household from band 1 (poorest) to 5 (richest), with each of 20%, income increased by 1.0%, 1.2%,1.3%,1.4% and 1.7% respectively. They further mentioned that effects from all capital inflows caused the richest income, in terms of value, greater than the poorest between 24.3-6.3 times.

In summary, there were the studies of welfare analysis according to environment issues from trade liberalization and FDI. Moreover, there are several studies relate welfare analysis in Thailand that using both CGE model and other methods. Umaporn Wongwatanasin (1999) used CGE in evaluation of the industrial output, trade flows and income distribution that are impacted from industrial policies. Kulnida Waewweerawong (2014) applied CGE to analyze a distribution impacts of export, FDI, and also the Foreign Portfolio Investment (FPI). For the methodology beside CGE, Wilaiwan Sirirotjanaput (2012) used Equivalent Variation (EV) and Compensating Evaluation (CV) to analyze welfare of household demand for vehicle fuel. However, the analysis which starts from relation of pollution control enforcement that effect to FDI inflows and then consequently impact to the countries welfare in Thailand had not been studied.

CHAPTER 4

A RELATION BETWEEN POLLUTION CONTROL ENFORCEMENTS AND FDI INFLOWS

4.1 The Data

Data arrangement is one of the crucial parts in this study because of its complexity. Net FDI inflow data, reported by UNCTAD and WDI by the World Bank in value of million in US dollar, is used for the analysis in the global and ASEAN countries levels. But for Thailand (country level) the data was reported by Thailand's Board on Investment Promotion (BOI) in value of million in Thai Baht. Environmental indicators, reported in the World Development Index (WDI) by the World Bank, will be used to calculate the pollution control enforcement variable. Pollution intensity for each industry is calculated from production data of the US Census of Manufacturing while data for other control variables are from WDI, except wage rate, which is reported by the International Labour Organization (2014). For the analysis of Thailand which is the major purpose of this dissertation, data were determined in five years during years 2009-2013 because details of investment data from Thailand's BOI is available and quite complete in that period. For homogeneity, analysis at the global and ASEAN level is also determined using data from that same period. Since hundreds of countries are involved, there are some missing data which will be reasonably adjusted.

4.1.1 FDI Data

There are two FDI data set used in this dissertation with different approaches, first is the analysis at the global and ASEAN level which is collected from UNCTAD and WDI; the second is collected from BOI which is used in the analysis for Thailand.

Following the FDI statistics described in Chapter 2; I include the year 2013 FDI data that was reported in the WDI December 2014 version, and then choose the data during period of 2008 to 2013. The reason for combining data from two sources was caused from Taiwan's case; its data was included in the UNCTAD report but no data in the WDI. Since Taiwan is one of the important investors to Thailand, then it should include Taiwan for the completeness of such analysis. One important thing is about the analysis for group of countries by region and by income levels, is to follow the structure in WDI. There are 202 countries included in the analysis of global level. In actuality, UNCTAD and WDI have more countries in their reports but due to the insufficiency of important environmental data, which will together be used in the econometrics model, some countries had therefore been taken out. For global and ASEAN level, the value is FDI net inflow in the year 2013 in million US dollars.

With more complications of data arrangement for global level, investment data for BOI during years 2009-2013 was used for specific analysis in the case of Thailand. Foreign investment projects approved by BOI had listed by project codes and classified in to seven sectors by indicating numbers from 1 to 7 consisting of 1) Agricultural Products, 2) Mineral and Ceramics, 3) Light Industries/Textiles, 4) Metal Products and Machinery, 5) Electric and Electronic Products, 6) Chemicals and Paper, and 7) Services. Each sector has details of activities, with a total of 217 sub activity codes, to identify a specific manufacturing product; for example, code 2.17 indicates Gypsum Board under sector 2) Mineral and Ceramics or code 6.9.1 indicates plastic products under sector 6) Chemicals and Paper. Because of the difficulty of finding data for pollutants in the service sector and this dissertation focuses on manufacturing industries where related pollutant data are available, hence the Service sector is excluded from examination.

Data arrangement in this subject is required because BOI reports a bundle amount of foreign investments for each project code. Table 4.1 is part of the actual report by BOI for projects approved in 2009, besides the Thai shareholder, there are more than one foreign countries investing in the same project. Difficulty happens because of the bundle data, it has no exact amount of investment value of each shareholder. To solve this problem, by reason of focusing FDI, I assumed that all investments contributed by foreigners whether in the list or whether it is a Thai shareholder or not and each of them invest equally. As in the first line in Table 4.1, investors from Switzerland and United Kingdom together with Thai shareholders invested 76 million Baht in Palm Seeds. This project was adjusted for FDI data showing that Switzerland invested 38 million Baht and United Kingdom equally invested 38 million Baht as well. Not counting the investment amount of Thai shareholders, reason being that not all projects were reported for Thai shareholders so to arrange for a similarity, I assumed that foreigners contributed for holistic investments. Even with these assumptions, such data modification supports the hypothesis about foreign investors from each country and will compare its own laxity in environmental regulations with Thailand prior to making investment decisions and then separate investment data for each country as necessary. Investment value in BOI's data is million Baht without inflation adjustment, therefore it is to be noted that any effect of pollution control enforcements to value of Thailand's FDI inflows in this study, is calculated based on the current money value of that year.

Table 4.1 Foreign Investment Project Approved by BOI 2009

Projects Code	Company Name	Location	Export %	Total Investment (million Baht)	Share Holder		Act. Code	Products	Employment		Approved Date
									Thai	For.	
521064	UNIVANICH PALM OIL PUBLIC CO., LTD.	Krabi	50	76.0	Thai	Switzerland, UK	1.1	Palm Seed; Palm Sapling	59	-	28.12.2009
520687	SAKATA SIAM SEED CO., LTD.	Khon Kaen	100	64.9	Thai	Japan	1.1	Vegetable Seeds/Flower Seeds	100	2	29.09.2009
520339	MAJOR GREEN CO., LTD.	Lop Buri	0	42.0	Thai	India	1.1	Sapling (Eucalyptus)	137	2	16.06.2009
520977	FOOD COATINGS INTERNATIONAL LTD.	Samut Prakan	40	70.0	Thai	Australia	1.11	Food Ingredient	203	-	30.11.2009
520546	SHINE PRODUCT CO., LTD.	Phetchabun	80	12.6	Thai	India	1.11	Pastes; Fruit	226	8	31.08.2009
520420	LUCKY UNION FOODS CO., LTD.	Samut Sakhon	90	505.0	Thai	Korea	1.11.1	Surimi-Based Product	100	-	28.07.2009
520324	GOLDEN SEAFOOD INTERNATIONAL CO., LTD.	Ranong	100	300.0	Thai	PRC.	1.11.1	Frozen Aquatic Animal	605	-	23.06.2009
511335	SICHON DAILY FRESH CO., LTD.	Nakhon Si Thammarat	90	8.0	Thai	Canada	1.11.1	Crab Meat	104	2	10.02.2009
520118	FORTUNE FROZEN FOODS (THAILAND) CO., LTD	Songkhla	100	1.7		Taiwan	1.11.1	Frozen Aquatic Animal	80	-	17.08.2009
520851	DOLE THAILAND LTD.	Prachuap Khiri Khan	95	157.1	Thai	Others	1.11.2	Vegetable/ Fruit Products	69	-	26.10.2009
511473	THAI SOON FOODS CO., LTD.	Nong Khai	100	48.8	Thai	Taiwan	1.11.2	Packed Vegetable/Fruit	130	8	02.03.2009
520224	CHIANGRAI AGRO - INDUSTRY CO., LTD.	Chaing Rai	100	31.5	Thai	Taiwan, Japan	1.11.2	Packed Vegetable/Fruit	107	1	14.05.2009
520019	PRANBURI PINEAPPLE CANNING CO., LTD.	Prachuap Khiri Khan	90	7.8	Thai	Korea	1.11.2	Packed Vegetable/Fruit	62	-	20.04.2009
520465	MR. PATRICK NOWAK	Rayong	95	379.2	Thai	France	1.11.3	Bakery	130	5	18.08.2009
511153	THAI AGRI FOODS PUBLIC CO., LTD.	Samut Prakan	100	338.6	Thai	Aust, France, Others	1.11.3	Dried Noodle	158	-	10.03.2009
520654	THAI PRESIDENT FOODS PUBLIC CO., LTD.	Chon Buri	10	229.3	Thai	Others	1.11.3	Preserved Noodle	24	-	15.09.2009

Source: Thailand Board of Investment, 2014.

4.1.2 Environmental Indicators and Pollution Intensity Data

Similar to what was described in Chapter 2, environmental indicators were collected from WDI air and water pollutant emission statistics, but select only for the period of 2008 to 2013. Following the WDI indicator code number; those three indicators consist of, 1) indicator code EN.ATM.CO2E.KD.GD measure for CO2 emissions in kg per 2005 US$ of GDP with, 2) indicator code EE.BOD.WRKR.KG measure for Organic water (BOD) emissions in kg per day per worker, and 3) indicator code EN.ATM.PM25.MC.M3 measure for ambient particle pollution PM2.5 pollution for mean annual exposure in micrograms per cubic meter.

Not all countries and all years have complete data of environment indicators, for example Malaysia has CO2 emission data for years 2008 to 2010 but has none the years 2011 to 2013, Sri Lanka has no data for BOD emissions for years 2008 to 2013. Since the analysis was done by balance panel regression technic, then some incomplete information needs to be attuned for balance panel data. There are three methods of data adjustment. First, if data available during 2008 to 2013, in some year during 2008 to 2013, the missing data will use the latest year data instead, for example Malaysia will use CO2 emissions for the year 2010 and for years 2011 to 2013. It is reasonable to use the latest year data because of its best possible number that investors can find. Second, if data is not available for the latest year, with same reason as the first method, the data that is available not before year 2001 will be used instead. Sri Lanka is an example for the second method, it used year 2006 BOD emission data to represent years 2008 to 2013. Third, if the countries have no indicators data from years 2001 to 2013, average data from other countries in the same region and follow by the same income level will be used instead; by reason of average value in the region with same income level would be the best proxy data. Mexico is an example for the third method, it has no BOD emission data since year 2001, because it is in Latin America & Caribbean Region and in the Upper Middle Income group, then the average BOD emission of Latin America & Caribbean-Upper Middle Income countries will be used instead.

In summary, those methodologies come from the conceptual idea that investors will use the latest data they know; if there is no data for this year, previous year data will be considered. If the investors would like to invest in one country, suppose Asia

Pacific region for example, but missing some data, they will use the best possible data as a proxy of that country's data by using average number of Region-Income Level.

Pollution intensity of each manufacturing industry is required to create a consensus with detail action code of BOI's investment data. Pollution intensity will be use as a proxy value for how much manufacturing activity pollutes. Since there are an excessive number of manufacturing activities and it is too difficult to collect the exact number of pollutant of each activity, then proxy value from the group of industries is reasonably used. Pollution intensity value is calculated by using data from the 2011 Annual Survey of Manufactures by US Census of Manufacturing, 'energy spending ratio as per value of product shipment' of each industry is used as a proxy value; and the industry code number in that survey follows the 2007 North America Industry Classification System (NAICS) which is retrieved from United State. Environmental Protection Agency (2015). Calculation example is shown in table 4.2.

Using energy spending ratio as per value of product shipment for proxy of pollution intensity has reasons from the thought that the more energy consumed the more natural resource excavated; and high consumption of natural resources lead to high emission. Imagine that most of electricity energize by fossil fuels which contain a lot of pollutant elements, for example, using coal fire in power plant will pollute Sulfur Oxides (SOx) and ambient particle. Furthermore, when industries need more electricity they need to expand their electricity grid line, to construct more grid lines they need more cable wires which is produced from copper and more steel used in construction; all of that also consumes natural resources and pollute during manufacturing process. This can also be seen when industries purchase fuels, for example, natural gas and bunker oil, to use in the production process. Even though modern product technologies can reduce emissions by transforming pollutant substances to other elements, but reducing substances that will pollute public space doesn't mean it reduces the intensity of pollutant generated from the production process. There is a reference of this calculation methodology used by Chung (2014: 222-236) as aforementioned in Chapter 3.

Table 4.2 Example of Pollution Intensity Calculation

2007 NAICS codes and NAICS-based rollup code	Meaning of 2007 NAICS codes and NAICS-based rollup code	Cost of purchased fuels ($1,000)	Quantity of electricity purchased for heat and power (1,000 kWh)	Purchased electricity ($1,000)	Total cost of Energy [Fuel & Electricity] ($1,000)	Value of products shipments ($1,000)	Pollution Intensity Energy spending ratio as per value of product shipment x 100
31-33	Manufacturing	42,176,817	828,905,610	51,951,349	94,128,166	5,197,513,368	**1.81102**
311	Food manufacturing	4,981,932	90,238,628	6,075,490	11,057,422	683,193,138	**1.61849**
31111	Animal food manufacturing	305,487	5,723,646	357,976	663,463	49,071,174	**1.35204**
321	Wood product manufacturing	606,393	20,178,210	1,444,206	2,050,599	66,923,613	**3.06409**
3211	Sawmills and wood preservation	210,871	7,392,883	533,780	744,651	20,458,915	**3.63974**
3212	Veneer, plywood, and engineered wood product manufacturing	204,625	6,633,474	438,667	643,292	13,569,375	**4.74076**
3262	Rubber product manufacturing	227,069	7,942,465	533,297	760,366	40,667,767	**1.86970**
32621	Tire manufacturing	130,543	4,382,150	257,294	387,837	20,361,814	**1.90473**
32622	Rubber and plastics hoses and belting manufacturing	22,018	773,269	59,247	81,265	4,649,951	**1.74765**
331	Primary metal manufacturing	4,491,906	137,591,225	6,848,989	11,340,895	271,889,155	**4.17115**
3311	Iron and steel mills and ferroalloy manufacturing	2,943,350	65,567,314	3,217,152	6,160,502	113,435,167	**5.43086**
3399	Other miscellaneous manufacturing	131,294	5,480,098	444,786	576,080	55,997,507	**1.02876**
33991	Jewelry and silverware manufacturing	8,782	262,884	23,500	32,282	7,206,784	**0.44794**
33992	Sporting and athletic goods manufacturing	27,627	852,684	69,914	97,541	8,434,903	**1.15640**
33999	All other miscellaneous manufacturing	64,171	3,187,500	246,415	310,586	26,096,476	**1.19015**

Note: Data from the 2011 Annual Survey of Manufactures by US Census of Manufacturing, Calculation by Author.

4.1.3 Integration of Industrial Products and Pollution Intensity

Reexamination for the relation between pollution control enforcements and Thailand's FDI inflows will integrate BOI data for the firm industrial level with pollution intensity; it aims to distinguish effects of the enforcements to different kinds of polluted industries. Because BOI data has its own industry group with details of activity code, the pollution intensity is calculated according to NAICS industry code, therefore matching BOI activity to NAICS codes and then to pollution intensity value is an important step.

From BOI's seven industry sectors, Services will be taken out from the reexamination because of lack of pollution intensity data. Matching pollution intensity for the remaining six sectors found difficulties about same BOI's activity code which has different names caused from different details of the products, for example, in Chemicals and Paper sector, there is the activity code 6.12 which is used for Preform Bottle, Pressure Sensitive Adhesive Sheet, Silicone Sheet and Synthetic Rubber for Industries. Then identification of each product's pollution intensity is not just matching BOI's activity code to NAICS code, it needs to consider in detail the product's name as well. Because there are 2,071 products detail that needs matching for pollution intensity, while table 4.3 is an example of integration of industrial products and pollution intensity.

Table 4.3 Example of Matching BOI Activity to NAICS Codes and to Pollution Intensity

BOI Industrial Name	BOI Act. Code	BOI Products	NAICS code	NAICS Description	Pollution Intensity
Agricultural Products	1.1	Eryngii Mushroom	3114	Fruit and vegetable preserving and specialty food manufacturing	2.09631244
Agricultural Products	1.1	Sapling (Eucalyptus)	33311	Agricultural implement manufacturing	0.62450752
Agricultural Products	1.11.5	Milk/Drinking Yoghurt (U.H.T.); Yoghurt	3115	Dairy product manufacturing	1.29711281
Agricultural Products	1.11.5	Sterilized Milk, Evaporated Milk; Sweet Beverage Creamer552	31151N	Fluid milk and butter manufacturing	1.29041106
Minerals and Ceramics	2.13.1	Galvanized Coated Wire Product	3312	Steel product manufacturing from purchased steel	1.86658014
Minerals and Ceramics	2.13.2	Coated Steel Sheet	3328	Coating, engraving, heat treating, and allied activities	3.22812805
Minerals and Ceramics	2.13.2	Cold Rolled Steel Strip	33122	Rolling and drawing of purchased steel	1.80808261
Light Industries/Textiles	3.1.1	Polyester Fiber	32522	Artificial and synthetic fibers and filaments manufacturing	4.3458932
Light Industries/Textiles	3.1.2	Silk Yarn	31311	Fiber, yarn, and thread mills	4.30798861
Light Industries/Textiles	3.1.8	Plastic Fabric Roof	3261	Plastics product manufacturing	2.42154489
Metal Products and Machinery	4.10.1	Auto Body Parts	336211	Motor vehicle body manufacturing	0.7803309
Metal Products and Machinery	4.10.1	Auto Seat	33636	Motor vehicle seating and interior trim manufacturing	0.56288317
Metal Products and Machinery	4.10.1	Automotive Battery	335911	Storage battery manufacturing	2.3453348
Metal Products and Machinery	4.10.1	Chain; Lever; Guide	333613	Mechanical power transmission equipment manufacturing	1.36053182
Electric and Electronic Products	5.3	Condenser for Electrical Product	333415	Air-conditioning and warm air heating equipment and commercial and industrial refrigeration equipment manufacturing	0.64159313
Electric and Electronic Products	5.3	LED Lighting	3351	Electric lighting equipment manufacturing	1.12641598
Electric and Electronic Products	5.4.2	Printer	3341	Computer and peripheral equipment manufacturing	0.66606938
Electric and Electronic Products	5.5	Hard Disk Drive	334112	Computer storage device manufacturing	0.66606938
Chemicals and Paper	6.12	Preform Bottle	32616	Plastics bottle manufacturing	2.26776668
Chemicals and Paper	6.12	Pressure Sensitive Adhesive Sheet	3259	Other chemical product and preparation manufacturing	1.96800564
Chemicals and Paper	6.12	Silicone Sheet	3261	Plastics product manufacturing	2.42154489
Chemicals and Paper	6.12	Synthetic Rubber for Industries	32521	Resin and synthetic rubber manufacturing	3.17649168

4.1.4 Other Data

Besides FDI which is explained variable and environmental indicators and pollution intensity data which will be transformed to explanatory variable; there are eleven other control variables, as shown in table 4.4, to be used in the econometric model. Reasons for choosing those variables follows the two distinct fundamentals of FDI, ‘Horizontal’ and ‘Vertical’, related theory and previous studies which was explained in Chapter 3. Details of data archiving for those eleven variables are described as follows.

Starting with the variable named “Environmental Tax” which is the concerned point of economist that appeared in the studied of Söderholm (2006, 2011). It is a proxy of τ which is a cost to produce unit of pollution according to equation (3.8) from theory of Copeland and Taylor (2003). Since pollutants produced by production process have social cost, then environmental tax is one of important control variable besides environmental laxity. However, there is no direct data of environmental tax of each county around the world, and then other indicators archived from WDI by World Bank are used in calculation. Following the WDI indicator code number; those three indicators consist of, 1) indicator code NY.ADJ.DNGY.GN.ZS measure for adjusted savings of energy depletion as % of GNI, 2) indicator code NY.ADJ.DRES.GN.ZS measure for adjusted savings of natural resources depletion as % of GNI and 3) indicator code NY.ADJ.DPEM.GN.ZS measure for adjusted savings of particulate emission damage as % of GNI. When we look into the detailed definition for those three kinds of 'adjusted saving', they relate to the ratio of value of energy and resources stock to remaining reserve lifetime, and relate to a willingness to pay to avoid mortality in case of particulate emission; hence if there is high value it implies that a country is willing to pay more for its environmental protection. In conclusion, those indicators relate to value of environment which would be the best possible choice to proxy for environmental tax. It is observed that three indicators for environmental tax have similar themes to the three indicators used for environmental indicators (CO2, BOD and PM2.5).

Capital price and labor wage are variables that have direct relation to cost minimizing choices when investors consider investing abroad. Lending interest rate from WDI, with indicator code FR.INR.LEND, is a major data source for capital price. If some countries have no data in WDI, government bond or treasury rates data are used, similar to WDI both data are provided by The World Bank. Average wage from International Labour Organization (ILO) year 2012 database is a data source for labor wage, it reports for monthly average wage in local currency of each country. There are incomplete wage data for some years; therefore, latest data from previous year will be used for the missing. Since there are local currencies, annual official exchange rate reported by WDI is used in calculation to US dollar.

Import tariffs, costs of business set up, costs of export goods and costs of import goods are four direct costs related indicators the investors would consider. They are considered as Horizontal FDI factors; because investors will compare import tariffs, import and export costs and then look for the best choice whether goods shall be produced in host or home countries to serve the host country's local market. Furthermore, costs to set up business in the host country is also considered, if there are high costs or high barriers, selling imported goods would be better. All of those four variables archive data from WDI, indicator code TM.TAX.MANF.SM.AR.ZS measures for percent of import tariff rate applied simple mean of manufactured products. Cost of business set up uses indicator code IC.REG.COST.PC.ZS that reports in % of GNI per capita. Cost of export goods uses indicator code IC.EXP.COST.CD that reports in US dollar per container while cost of import goods also reports in US dollar per container using indicator code IC.IMP.COST.CD.

Similar to the four variables in the previous paragraph, development level of infrastructures in the host country is another area in Horizontal FDI factors. Road intensity, energy abundant and water abundant are selected indicators from WDI, because all of them indicate a host country's capability in transportation and available resources as a production input factors. Road intensity uses indicator code IS.ROD.DNST.K2 which measures in kilometer the road per 100 square kilometer of land area. Energy abundant uses indicator code EG.EGY.PROD.KT.OE which measures energy production in kiloton of oil equivalent. Water abundant uses indicator code ER.H2O.FWTL.K3 which measures annual fresh water withdrawal in billion cubic meters.

Lastly, control variable is GDP in US Dollars at year 2005 price which is reported in WDI, it uses indicator code NY.GDP.MKTP.KD. It is neither Vertical nor Horizontal FDI factor, but it is widely used as an explanatory variable in study of growth and international economics, especially for a Gravity model which will be applied in this study as well.

All variables described in this section also face difficulties because of incomplete data for some countries; hence same data adjustment method which was used in the previous section for the environmental indicator was applied. If there is no data for this year, previous year data will be considered; if there is no previous year data using average number of Region-Income Level is used instead.

Table 4.4 Notation of Variables

Notation	Type	Description in relative term	Refer to variable in theory	Measurement	Source of Data
FDI		Net FDI inflow		In million US Dollars at current prices and current exchange rates for Global and ASEAN level In million Thai Baht for the study in Thailand level	UNCTAD and BOI of Thailand
LAX	Vertical	Laxity of country's pollution control	α	Average of CO_2, BOD, PM2.5 emission	World Bank
ENVITAX,	Vertical	Environmental tax	τ	Average of adjusted saving for energy depletion, natural resources depletion and particulate emission damage	World Bank
R	Vertical	Capital price	F	Government bond or Lending Rate or Treasury rate 2012	World Bank
W	Vertical	Labor wage	F	Average Monthly wage, in million US dollar at Y2005 price	ILO
TARIFF	Horizontal	Import tariff		Tariff rate, applied, simple mean, manufactured products (%)	World Bank
BUSET	Horizontal	Cost of business set up		Cost of business start-up procedures (% of GNI per capita)	World Bank
EXCOST	Horizontal	Cost of export good		Cost to export and import (US$ per container)	World Bank
MCOST	Horizontal	Cost of import good		Cost to import (US$ per container)	World Bank
ROAD	Horizontal	Road intensity		Road density (km of road per 100 sq. km of land area)	World Bank
ENERGY	Horizontal	Energy abundant		Energy production (kt of oil equivalent)	World Bank
WATER	Horizontal	Water abundant		Annual freshwater withdrawals, total (billion cubic meters)	World Bank
GDP				In US Dollars at Year 2005 prices	World Bank

4.2 Methodology to Develop the Variables

Data collected in previous sections will be developed for variables used in the econometric model. In order to compare each variable that would affect FDI inflows among countries globally, all indicators exclude FDI; will be transformed to index value. The index value can be used easily, either in comparison with reference country; in this case it is the United State, or bilateral comparison. This especially so for environmental variables, where the data is collected from multi indicators and reported by WDI, but aren't necessarily transformed to index value.

4.2.1 Developing for Environmental Variables

The critical question in this kind of study is about how to quantify environmental variables. Mentioned in Chapter 3 in literature review of previous study, there are various methodologies used by other researchers in the studies after the year 2000, including Smarzynska and Wei (2001), Dean, Lovey and Wang (2009) and Chung (2014). Those three methodologies are summarized in table 4.5.

Table 4.5 Methodologies to Quantify Environmental Variables by Other Researchers

Researcher	Methodology
Smarzynska and Wei (2001)	• Enforcement-adjusted treaty index = Treaties*number of environmental NGOs per million people in country • Enforcement-adjusted standard index = Standards*number of environmental NGOs per million people in country
Dean, Lovey and Wang (2009)	• Use pollution intensity data and levy charge per pollution. • COD (kg) / 000 tons waste water as a variable of pollution intensity • Total collected water pollution levies/ waste water (Yuan/ton)
Chung (2014)	• Use the survey score in annual the Global Competitiveness Report as a variable of environmental laxity in countries • Use pollution intensity data from the Worldbank and own calculation

In general thought of environmental variables development in this study, measuring pollution control enforcements employs the methodology from Dean, Lovey and Wang (2009) which will be used for evaluating the environmental laxity variable. Another thing is to combine pollution intensity with the environmental laxity variable, which aims to distinguish the effect of the enforcements to different kinds of polluted industries in the study of Thailand; methodology is referenced and applied from Chung (2014).

Three environmental indicators are used to calculate laxity on pollution control. The first is LAX1, which is a notation for CO2 emissions (kg per 2005 US$ of GDP); second is LAX2 which is a notation for Organic water pollutant (BOD) emissions (kg per day per worker); and the third is LAX3 which is a notation for PM2.5 pollution, the dust content in ambient, measured by mean annual exposure (micrograms per cubic meter). Each indicator is calculated in relative number to the benchmarked country to transform from nominal to index value. Weighted average value of LAX1, LAX2 and LAX3 is applied, as shown table 4.6, by using Pollution Abatement Cost Expenditure (PACE) of year 2005 reported by the U.S. Environmental Protection Agency.

4.2.1.1 Environmental Variables for Global Level

There are three kinds of quantified environmental laxity variables. First, ILAX (Index laxity) is an index of laxity in environmental control for individual countries using an analysis for global level. Second, RLAX (Relative Laxity) is a relative laxity in environmental control for the host country using an analysis for individual countries in the ASEAN level. Third, RLAXPI (Relative Laxity with Pollution Intensity) is a combination between pollution intensity of specific industries and relative laxity in environmental control of the host country, using firm level data in the analysis of Thailand's level. ILAX and RLAX variables refer to α in equation (3.8) while RLAXPI referring to a combination of α term with z, where z is considered as a proxy of pollution intensity. Following that equation, the higher α value the lower the unit cost (c^F) and the higher z value the higher the unit cost.

ILAX uses the U.S. as a benchmarked country in the calculation of relative number of three environmental indicators; hence ILAX for the U.S is set equal to 1. Countries having ILAX value greater than 1 means that these countries have weaker pollution controls than the U.S.; the higher the value the larger degree that these countries would be considered as pollution heavens. ILAX calculation follows the equation (4.1), where host country i, year t = 2008 to 2013.

$$ILAX_i^t = \left(\frac{LAX1_i^t}{LAX1_{us}^t}\right)\times 0.281 + \left(\frac{LAX2_i^t}{LAX2_{us}^t}\right)\times 0.438 + \left(\frac{LAX3_i^t}{LAX3_{us}^t}\right)\times 0.281 \quad (4.1)$$

Following are calculation examples for three countries, Malaysia, France and Thailand for year 2009.; The U.S. has $LAX1_{US}^{2009}$ = 0.4005, $LAX2_{US}^{2009}$ =0.1425 and $LAX3_{US}^{2009}$ = 13.7376; Malaysia (MYS) has $LAX1_{MYS}^{2009}$ = 1.2258, $LAX2_{MYS}^{2009}$ = 0.1227 and $LAX3_{MYS}^{2009}$ = 13.0863; France (FRA) has $LAX1_{FRA}^{2009}$ = 0.1589, $LAX2_{FRA}^{2009}$ = 0.1599 and $LAX3_{FRA}^{2009}$ = 15.6156; and Thailand (THA) has $LAX1_{THA}^{2009}$ = 1.4195, $LAX2_{THA}^{2009}$ = 0.1522 and $LAX3_{THA}^{2009}$ = 20.877; then ILAX of those countries are calculated as;

$$ILAX_{MYS}^{2009} = \left(\frac{1.2258}{0.4405}\right)\times 0.281 + \left(\frac{0.1227}{0.1425}\right)\times 0.438 + \left(\frac{13.0863}{13.7376}\right)\times 0.281 = 1.5051$$

$$ILAX_{FRA}^{2009} = \left(\frac{0.1589}{0.4405}\right)\times 0.281 + \left(\frac{0.1599}{0.1425}\right)\times 0.438 + \left(\frac{15.6156}{13.7376}\right)\times 0.281 = 0.9226$$

$$ILAX_{THA}^{2009} = \left(\frac{1.4195}{0.4405}\right)\times 0.281 + \left(\frac{0.1522}{0.1425}\right)\times 0.438 + \left(\frac{20.877}{13.7376}\right)\times 0.281 = 1.8909$$

Higher laxity number means lower pollution control enforcements. In relation to the U.S. where ILAX is equal to 1, the above calculation for ILAX indicates that Malaysia and Thailand are weaker, while France has better pollution control enforcements than the U.S.

4.2.1.2 Environmental Variables for Individual Countries in ASEAN

RLAX is a relative laxity of pollution control enforcements that was used in the study of individual countries in ASEAN. It is calculated from ILAX according to equation (4.2), and measured relatively between host and home countries for how much the home countries considers the host to having laxity in pollution control enforcements when compared to their own level.

$$RLAX_{i,Host}^t = \left(\frac{ILAX_{Host}^t}{ILAX_i^t}\right) \text{, where home country i, year t} \quad (4.2)$$

For example, Thailand as a host country, compared with Malaysia and France in year 2009, Thailand had ILAX = 1.891, Malaysia = 1.505 and France = 0.922; then RLAX of those countries are calculated as;

$$RLAX_{THA,THA}^{2009} = \left(\frac{1.8909}{1.8909}\right) = 1.000$$
$$RLAX_{MYS,THA}^{2009} = \left(\frac{1.8909}{1.5051}\right) = 1.2564$$
$$RLAX_{FRA,THA}^{2009} = \left(\frac{1.891}{0.922}\right) = 2.0496$$

The above calculations are interpreted as follow; Malaysia (the home) considers Thailand (the host), in general, to have more laxity in pollution control enforcements than its own about 1.2564 time; France (the home) considers Thailand (the host), in general, to have more laxity in pollution control enforcements than its own about 2.0495 times. The higher the RLAX number, the higher the probability that the host country will consider the home country as having weaker pollution controls.

4.2.1.3 Environmental Variables for Thailand Level

RLAXPI is another important pollution control enforcement variable for Thailand in specific, it is calculated by multiplying pollution intensity (PI) with $RLAX_{i,THA}$ value. Similar to Chung (2014), only relative laxity in pollution control enforcements have less on an effect when focused on the industrial level, including PI into relative laxity will distinguish high pollution industries from low ones. Table 4.7 demonstrates an example of RLAXPI calculation in Year 2009; Malaysian investor invested in project code 521092 for block rubber & compound rubber, with calculated value of $RLAXPI_{MYS,THA}$. It is interpreted that such an industry in Thailand has more laxity in pollution control enforcements than Malaysia by 2.3373 times. Similar to RLAX, the higher the RLAXPI number the higher the probabilities that a host country considers the home country for weaker pollution controls in a specific industry.

Table 4.6 Weighted Calculation for Environmental Variables

Variables	Description	Abatement Cost (million USD)	Weighted
ILAX, RLAX			
LAX1	CO_2 emissions (kg per 2005 US$ of GDP)	4,314.6	0.2810
LAX2	Organic water pollutant (BOD) emissions (kg per day per worker)	6,725.2	0.4380
LAX3	PM2.5 pollution, mean annual exposure (micrograms per cubic meter)	4,314.6	0.2810
	Total	15,354.3	1.0000
IENVITAX, RENVITAX			
ENVT1	Adjusted savings: energy depletion (% of GNI)	5,712.3	0.2763
ENVT2	Adjusted savings: natural resources depletion (% of GNI)	5,709.7	0.2761
ENVT3	Adjusted savings: particulate emission damage (% of GNI)	9,255.48	0.4476
	Total	20,677.5	1.0000

Table 4.7 Example of RLAXPI Calculation

Foreign	Projects Code	Company Name	Act. Code	Products	PI	RLAX	RLAXPI
Malaysia	521092	THAI HUA RUBBER PUBLIC CO., LTD.	1.14	Block Rubber & Compound Rubber	1.8604	1.2564	2.3373
Malaysia	520835	YPC PRECISION (THAILAND) CO., LTD.	3.8	Plastic Lens	2.2678	1.2564	2.8492
Malaysia	520293	LH TOMO AUTOPARTS (THAILAND) CO., LTD.	4.8	Wiper Blade; Steering Wheel; Brake Piston; Spark	1.241	1.2564	1.5591
Malaysia	520723	YPC PRECISION (THAILAND) CO., LTD.	5.5	Digital Camera Parts	0.8145	1.2564	1.0233
Malaysia	520855	FLEXOPRINT (THAILAND) CO., LTD.	6.14	Printing Item	1.0147	1.2564	1.2748
France	511153	THAI AGRI FOODS PUBLIC CO., LTD.	1.11.3	Dried Noodle	1.5365	2.0496	3.1492
France	511301	PEWOC CO., LTD.	1.3	Organic Fertilizer	3.4771	2.0496	7.1267
France	511327	BLOSSOM ID CO., LTD.	3.11	Wooden Product	1.2993	2.0496	2.6630
France	511420	CHALET & BAMBOO CO., LTD.	3.11	Finger Joint and Finger Joint Product	1.2993	2.0496	2.6630
France	520245	QUALITECH ENGINEERING AND CONSTRUCTION	4.19	Steel Structure & Industrial Machinery	1.0821	2.0496	2.2179

4.2.1.4 Others Related Environmental Variables

The other two variables related to the environment are: IENVITAX and RENVITAX. Both variables are proxies of the pollution price of each country, and the higher the value the higher the product unit cost (c^F). There is a similar calculation methodology to ILAX and RLAX, where IENVITAX is the variable notation for global level and RENVITAX is for individual countries in ASEAN and Thailand level. Three environmental indicators are used in calculation, following the aforementioned in section 4.1.4, ENVT1 from adjusted savings of energy depletion as % of GNI, ENVT2 from adjusted savings of natural resources depletion as % of GNI and ENVT3 from adjusted savings of particulate emission damage as % of GNI. Each indicator is calculated in relative number to the benchmarked country to transform from nominal to index value. Weighted average value of ENVT1, ENVT2 and ENVT3 is applied, as shown table 4.6, by using Pollution Abatement Cost Expenditure (PACE) of year 2005 reported by U.S. Environmental Protection Agency. IENVITAX also uses the U.S. as a benchmarked country in the calculation of relative number of three environmental indicators; hence IENVITAX of the U.S is set equal to 1. IENVITAX calculation follow the equation (4.3) and RENVITAX calculation follow the equation (4.4) where host country i, year t = 2008 to 2013.

$$IENVITAX_i^t = \left(\frac{ENVT1_i^t}{ENVT1_{us}^t}\right)\times 0.2763 + \left(\frac{ENVT2_i^t}{ENVT}\right)\times 0.2761 + \left(\frac{ENVT3_i^t}{ENVT3_{us}^t}\right)\times 0.4476 \qquad (4.3)$$

$$RENVITAX_{i,Host}^t = \left(\frac{IENVITAX_{Host}^t}{IENVITAX_i^t}\right) \qquad (4.4)$$

Example of year 2009, the U.S. has $ENVT1_{US}^{2009} = 0.6026$, $ENVT2_{US}^{2009} = 0.6569$ and $ENVT3_{US}^{2009} = 0.1943$; France has $ENVT1_{FRA}^{2009} = 0.0133$, $ENVT2_{FRA}^{2009} = 0.0141$ and $ENVT3_{FRA}^{2009} = 0.2636$; Thailand (THA) has $ENVT1_{THA}^{2009} = 2.9739$, $ENVT2_{THA}^{2009} = 3.8997$ and $ENVT3_{THA}^{2009} = 0.3623$; then $IENVITAX_{FRA}^{2009}$ is calculated to 0.6191 and $IENVITAX_{THA}^{2009}$ is calculated to 3.8371 while $RENVITAX_{FRA,THA}^{2009}$ is equal to 6.197.

4.2.2 Developing for Other Control Variables

Ten of other control variables follow the idea of Horizontal and Vertical FDI, collection of their data is described in section 4.1.4 with notations explained in table 4.4. All of them are also calculated to index and relative values, the index with notation 'I' is used in global level and the relative with notation 'R' is used in ASEAN and Thailand level. Equation (4.5) is a calculation for index variables using the U.S. as a benchmarked country. Equation (4.6) is a calculation for relative variables on how the investor from the home country considers their investment factors in the host country when compared to home standards.

$$IVARIABLE_i^t = \left(\frac{VARIABLE_i^t}{VARIABLE_{us}^t}\right) \quad (4.5)$$

$$RVARIABLE_{i,Host}^t = \left(\frac{IVARIABLE_{Host}^t}{IVARIABLE_i^t}\right) \quad (4.6)$$

Example of the ROAD variable which indicates road intensity in kilometer of road per 100 sq. km of land area; since it is important infrastructure using transportation high road intensity would imply higher transportation capability that relate to transportation cost. The U.S. has $ROAD_{US}^{2009} = 66.3072$; France has $ROAD_{FRA}^{2009} = 189.4171$; Malaysia has $ROAD_{MYS}^{2009} = 40.8785$ and Thailand has $ROAD_{THA}^{2009} = 35.0898$; then $IROAD_{US}^{2009} = 1$, $IROAD_{FRA}^{2009} = 2.8566$, $IROAD_{MYS}^{2009} = 0.6165$ and $IROAD_{THA}^{2009} = 0.5292$. When investors from France and Malaysia intend to invest in Thailand they will compare their country's road intensity to Thailand, therefor $RROAD_{FRA,THA}^{2009} = 0.1853$ which mean France (the home) considers Thailand (the host) road intensity for 0.1853 times of its own, and $RROAD_{MYS,THA}^{2009} = 0.8584$ which means Malaysia (the home) considers Thailand (the host) road intensity for 0.8584 times of its own. By this methodology, all variables are transformed to the same basis which allows the gravity model comparison.

4.3 Econometric Models

Panel data analysis is used in this study. The panel in the global level and cross-sectional countries data is unbalanced due to missing FDI data in some countries and in some year during 2008-2013. Studies for individual countries in ASEAN and at firm level for Thailand, the panels are also unbalanced because of missing data for some home countries. The firm level in Thailand' consists of a pooled data observed during years 2009-2013. The model includes environmental laxity (or degree of pollution control enforcements) and other economics variables as written in equation (3.14) and variables notation are described in table 4.8, with null hypothesis to pollution control enforcements which does not affect FDI inflow. Regarding the analysis technique, I initially used time dummy variables to model difference in intercept terms between periods. Interaction terms between time dummy and environmental variables, ILAX, RLAX and RLAXPI, are further analyzed to determine a difference of slope coefficients. Other dummy variables including country dummy, regional dummy and income level dummy are also analyzed; but when these dummies enter the model in global level it leads to a heteroscedasticity problem, therefore time fixed effects is a major technique used in this study. To emphasize the use of time fixed effects, Hausman test to examine whether the time fixed effect model is better than the random effects model.

4.3.1 Panel Data Regression

In order to find evidence about the relation between pollution control enforcements in the host country and the affect it has to the home country's decision for investment, variables have been measured for these home countries at multiple points in time, therefore, panel data technique was applied. In detail of observations, the panel is short because of the number of countries, which is a cross-sectional subject, greater than the number of time periods. Although there are 202 countries included in a survey of global FDI statistics in Chapter 2, not all countries have complete data during years 2008 to 2013 that resulted in a total 1,021 observations for a study of the global level. Studying individual countries in the ASEAN level which is comprised of

10 countries also has unbalanced panel data. There were 54 observations during years 2008 to 2013 and incomplete data from some countries like Brunei, Vietnam and Myanmar. A similar situation occurred when studying at the firm level in Thailand where some countries did not invest in Thailand every year during years 2009 to 2013, therefore the panel data is unbalanced.

Since there is a cross-sectional time series data with hundreds of countries involved, but with a short period of five to six years, hence using the panel data technique has the advantage for more variability, more degree of freedom and less collinearity among variables. Due to hundreds of subjected countries, there is bound to be heterogeneity or unobserved effect, however panel regression technique allows us to control variables we cannot observe and takes heterogeneity explicitly into account by using various techniques. According to the econometric theory, panel regression techniques using Pooled OLS, fixed effect least square dummy variable (LSDV) and random effect model are used to determine model selection in this study. Comprehensive reviews of those three techniques are followed to the books of Gujarati and Porter (2009) and Greene (2012) as well as the lecture of Torres-Reyna (2007) and Parker (2014). Those are described in following sub sections.

4.3.1.1 Pooled OLS with Dummy Variables

Pooled OLS is a simplest method to estimate a panel regression, the model was written in equation (4.7) has the same intercept term for all units or entities. By using standard OLS it would assume that the error term is $e_{it} \sim iid(0, \sigma_e^2)$ and no correlation between unit i's observation in different periods.

$$Y_{it} = b + \beta_1 X_{1,it} + \cdots \beta_k X_{k,it} + e_{it} \tag{4.7}$$

The major problem of pooled OLS is that it does not distinguish between various units, in other words, by lumping together different units at different times will camouflage the heterogeneity. In order to distinguish units and time, extension of pooled OLS by introducing dummy variables into the model was applied. The first extension is about time-specific intercepts, as shown in equation (4.8) that time dummy D_t is introduced in the model with value equal to 1 for a point of time t = t, 0 otherwise.

$$Y_{it} = b + \sum_{t=2}^{T} \lambda_t D_t + \boldsymbol{\beta X}_{it} + e_{it} \quad (4.8)$$

Where unit i = 1 to N, time t = 1 to T, b is intercept term, $\boldsymbol{\beta}$ is row vector of coefficient, $\boldsymbol{X}_{it}$ is column vector of control variables. λ's capture effects of all variables that do not vary across unit i at a point of time, and any X's that do not vary across individual are subsumed by λ's. Time dummies can interact with X's to allow β's to vary over time. Inclusion of all time dummies, and all interactions between time dummies and$X$'s equivalent to OLS period by period.

Besides time dummies, other kinds of dummy variables can be added into the pooled OLS as well. There would be examinations to distinguish between groups of unit, for example group of countries by region or by income level, those dummies are introduced as shown in equation (4.9).

$$Y_{it} = b + \sum_{s=2}^{S} \gamma_s D_s + \boldsymbol{\beta X}_{it} + e_{it} \quad (4.9)$$

Where b is the intercept term of the unit s =1, γ_s is coefficient of unit dummies and D_s is unit dummy variable which value is equal to 1 for unit $s = s$, 0 otherwise. For example, if there are 7 regional groups of countries to be considered as a unit rather than individual country i, then S = 7. To avoid dummy variable trap D_1 of a base region is omitted, D_2 = 1 for region group 2, 0 otherwise; D_3 = 1 region group 3, 0 otherwise; and so on. For interpretation of the regional group dummy, base region has intercept value =b; region group 2 has intercept value =$b + \gamma_2$; region group 3 has intercept value = b+γ_3.

4.3.1.2 Fixed Effect Least Squares Dummy Variables (LSDV) Model

The fixed effect least squares dummy variables (LSDV) model allows for heterogeneity among subjects by allowing each unit or entity to have its own intercept value. As shown in equation (4.10), c_i represents for fixed effect that intercepts value may differ across unit but does not vary over time, that is time-invariant.

$$Y_{it} = c_i + \beta_1 X_{1,it} + \cdots \beta_k X_{k,it} + e_{it} \quad (4.10)$$

To allow for the intercept to vary among unit, it is easily to do by using the differential intercept dummy technique that can be written in equation as:

$$Y_{it} = c_1 + \sum_{j=2}^{J} c_j D_{ji} + \boldsymbol{\beta X}_{it} + e_{it} \tag{4.11}$$

Where unit i = 1 to J, time t = 1 to T, c is intercept term, $\boldsymbol{\beta}$ is row vector of coefficient, $\boldsymbol{X}_{it}$ is column vector of control variables and D_{ji} is dummy variable which value equal to 1 if $j =$ i, 0 otherwise. Suppose there are six units, the model according to equation (4.11) introduces only five dummy variables to avoid falling into dummy variable trap. As a result, c_1 is intercept value of unit 1 and other c coefficients are represented by how much the intercept value of other units differ from the intercept value of unit 1, for example sum of $c_1 + c_2$ is intercept value of unit 2.

4.3.1.3 Time Fixed Effects Model

Using time dummies is a very general way of modeling differences in intercept terms. If there are unobserved characteristics that are common to all units but vary across time, then using time fixed effect model which are modified from LSDV, allows the intercept to have a different value in each period. Just like the time dummies discussed in the pooled OLS, the model is then written as:

$$Y_{it} = c + \sum_{t=2}^{T} \lambda_t D_t + \boldsymbol{\beta X}_{it} + e_{it} \tag{4.12}$$

Where c is intercept term of time t=1, λ_t is coefficient of time dummies that capture effects of all variables that do not vary across unit i at a point of time t, and D_{ti} is time dummy variable which value equal to 1 for a point of time t = t, 0 otherwise. Suppose there are six years, T = 6, to avoid dummy variable trap there are five time dummy variables in the model; D_2 = 1 for time t = 2, 0 otherwise; D_3 = 1 for time t = 3, 0 otherwise; and so on. For interpretation of time dummy, time t=1has intercept value = c; time t=2 has intercept value = $c + \lambda_2$; time t=2 has intercept value = $c + \lambda_3$.

4.3.1.4 Unit Fixed Effects Model

Unit fixed effects explores the relationship between explanatory and explained variables within a unit or entity. When using this fixed effect, it assumes that something within the individual unit, which has been omitted from the model, may impact or bias the explanatory or explained variables and then needs to control this. Therefore, there is an assumption about the correlation between unit's error term and explanatory variables and $\text{Cov}(c_i, X_{it}) \neq 0$. Model for unit fixed effect regression is truly following LSDV according to equation (4.11) that implies the need to estimate separate regression of each unit i. This fixed effects method controls for time-invariant variables that have not been measured but affects Y, for example, it could control the effect of land area if the information on land area was not available in the data set. However, if period of time is too small, this fixed effects method may be impractical.

4.3.1.5 Random Effects Model

When there is no correlation between unit's error term and explanatory variables, because the time-invariant variables are omitted or because the variables that are omitted are does not correlated with the variables that are in the model, then a random effects model can provide unbiased estimates.

$$\begin{aligned} Y_{it} &= \bar{c} + \mu_i + \beta_1 X_{1,it} + \cdots \beta_k X_{k,it} + e_{it} \\ &= \bar{c} + \mu_i + \beta_1 X_{1,it} + \cdots \beta_k X_{k,it} + v_{it} \text{ , where } v_{it} = \mu_i + e_{it} \end{aligned} \quad (4.13)$$

The random effects model thinks of intercept term c_i as random variable with a mean value of $\bar{c}$ (no subscript i here). The intercept value for an individual unit or entity can be express as $c_i = \bar{c} + \mu_i$ where μ_i is random a error term with $E(\mu_i) = 0$; $\text{Cov}(u_i, u_j) = 0$, $i \neq j$; and var $(u_i) = \sigma_\mu^2$. As a result, random effect model can be written as shown in equation (4.13) which will be estimated via Generalized Least Square (GLS).

4.3.1.6 Interactive and Multiplicative Forms in Using Dummy Variables

When comparing regression models that use dummy variables, there are four possibilities that would be found. The first is called 'coincident regressions' where both the intercepts and the slope coefficients are the same for all regressions. The second is called 'parallel regression' where the intercepts are allowed to differ across groups but the slopes are the same. The third is called 'concurrent regressions' where the intercepts that are the same but the slopes are allowed to differ across groups. The fourth is called 'dissimilar regressions' where both the intercepts and the slopes are allowed to differ across groups.

There are two techniques used for dummy variables and aims to test whether the parameters differ across groups of observation. The first is called 'Interactive' that will be used when investigating for the difference in intercepts and the second is called 'Multiplicative' that will be used when investigating for the slopes differentiation across groups. Equation (4.14) is a combined form of interactive and multiplicative for two observation groups that can detect a dissimilar regression. Suppose observation group one is a baseline group, dissimilar regression would interpret as group one has intercept value equal to α_1 while slope coefficient has value equal to β_1 ; and group two has value equal to $\alpha_1 + \alpha_2$ while slope coefficient has value equal to $\beta_1 + \beta_2$

$$Y_i = \alpha_1 + \alpha_2 D_i + \beta_1 X_i + \beta_2 D_i X_i + e_i \tag{4.14}$$

It is an interaction form or parallel regression if the term $\beta_2 D_i X_i$ is taken out from equation (4.14), that can be interpreted that group one has intercept value equal to α_1 while slope coefficient has value equal to β_1 ; and group two has value equal to $\alpha_1 + \alpha_2$ while slope coefficient has value equal to β_1 same as group one. If the term $\alpha_2 D_i$ is taken out, there is a multiplication form or concurrent regression, that can interpret as group one has intercept value equal to α_1 while slope coefficient has value equal to β_1 ; and group two has value equal to α_1 same as group one while slope coefficient has value equal to $\beta_1 + \beta_2$. Those kinds of described forms will be investigated in order to select the most appropriate model for studying the Global, ASEAN and Thailand levels.

4.3.2 The Models

Many researchers had applied econometric in their studies of environmental, trade and FDI. For example, Jaffe and Palmer (1997) used panel data of the firm level; Milner, Reed and Pawin Talerngsri (2004) also used firm level panel data in their model to about FDI from Japanese multinationals in Thailand. While Quazi (2014) applied the Feasible Generalized Least Squares (FGLS) with panel data in their studies about effect of corruption and environmental regulation on FDI in African countries. There are many models that have the potential to predict the relation between pollution control enforcements and FDI inflows, however, all models to be tested in this study follows panel regression methodologies which are comprised of pooled OLS, time fixed effects, and unit fixed effects and random effects models. Furthermore, interactive and multiplicative forms are used to determine whether that impact should be coincident, parallel, concurrent and dissimilar regressions are also applied. The models are firstly created and tested for an analysis in global level, and then the most appropriate model according to the selection criteria will further be used for separated analyses in the regional group and the income group of a country, and also used for ten countries in ASEAN level. For an analysis of Thailand, since it is a different data set from the global level, retesting for model selection is then required.

4.3.2.1 Model for Global and ASEAN Level

There are four series of models which will be experimented on for the global and ASEAN levels. Model 1serie is a combination of pooled regression with time fixed effect that consists of four sub-models as the following description. Model 1-1, which is a full term of the series, delineates for dissimilar regression of time fixed effect. Model 1-2 is for basic pooled regression by taking out all dummies term. Model 1-3 is time fixed effect by dropping an interaction between time dummy and explanatory variable, it delineates for time parallel regression. Model 1-4 drops time dummy but keeps the interaction term that will depict concurrent regression of time fixed effect. Values of time dummies are $YEAR_1$ = 1 if year 2008 which is a base year, 0 otherwise; $YEAR_2$ = 1 if year 2009, 0 otherwise; $YEAR_3$ = 1 if year 2010, 0 otherwise; $YEAR_4$ = 1 if year 2011, 0 otherwise; $YEAR_5$ = 1 if year 2012, 0 otherwise; and $YEAR_6$ = 1 if year 2013, 0 otherwise.

Model 1-1:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \lambda_t YEAR_t + \sum_{t=2}^{T=6} \alpha_t ILAX_{it} \cdot YEAR_t$$
$$+ \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.15)$$

Model 1-2:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.16)$$

Model 1-3:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \lambda_t YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.17)$$

Model 1-4:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \alpha_t ILAX_{it} \cdot YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.18)$$

Model 2 series is a combination of pooled regression with regional dummy that consists of three sub-models as the following description. Model 2-1, which is a full term of the series, delineates for dissimilar regression among regions. Model 2-2 delineates for regional parallel regression by dropping an interaction between regional dummy and explanatory variable. Model 2-3 drops regional dummy but keeps the interaction term that will depict for concurrent regression among regions. Values of regional dummies are $REGIONID_1$ = 1 if East Asia & Pacific which is a base region, 0 otherwise; $REGIONID_2$ = 1 if Europe & Central Asia region, 0 otherwise; $REGIONID_3$ = 1 if Latin America & Caribbean region, 0 otherwise; $REGIONID_4$ = 1 if Middle East & North Africa region, 0 otherwise; $REGIONID_5$ = 1 if North America region, 0 otherwise; $REGIONID_6$ = 1 if South Asia region, 0 otherwise; and $REGIONID_7$ = 1 if Sub-Saharan Africa region, 0 otherwise.

Model 2-1:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s REGIONID_s + \sum_{s=2}^{S=7} \gamma_s ILAX_{it} \cdot REGIONID_s +$$
$$\boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.19)$$

Model 2-2:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s REGIONID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.20)$$

Model 2-3:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s ILAX_{it} \cdot REGIONID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.21)$$

Model 3 series is a combination of pooled regression with income group of country dummies that consists of three sub-models as the following description. Model 3-1, which is a full term of the series, delineates for dissimilar regression among income group of country. Model 3-2 delineates for income group parallel regression by dropping an interaction between income dummy and explanatory variable. Model 3-3 drops income dummy but keeps the interaction term that will depict concurrent regression among income groups. Values of income group dummies are $INCOMEID_1$ = 1 if High income OECD which is a base income group, 0 otherwise; $INCOMEID_2$ = 1 if High income non-OECD group, 0 otherwise; $INCOMEID_3$ = 1 if Upper middle income group, 0 otherwise; $INCOMEID_4$ = 1 if Lower middle income group, 0 otherwise; $INCOMEID_5$ = 1 if Low income group, 0 otherwise.

Model 3-1:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s INCOMEID_s + \sum_{s=2}^{S=5} \gamma_s ILAX_{it} \cdot INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.22)$$

Model 3-2:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.23)$$

Model 3-3:

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s ILAX_{it} \cdot INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.24)$$

Model 4 is a LSDV which each individual country from a total of 202 countries having its own identification number, it will be used in the experiment for both fixed effect and random effect.

Model 4:

$$logFDI_{it} = c_1 + \alpha_1 ILAX_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it} \quad (4.25)$$

The selected model for global analysis will continue estimates for the global level by regional and by income groups. However, there is special re-estimation for the most appropriate model series when analysis in ASEAN level because there are only 10 countries in ASEAN, a small number which would affect model selection. When estimating individually each of the ten countries in the ASEAN region, the explanatory variables in the selected model will be changed from index to relative, for example, ILAX is changed to RLAX. This is because of measurements in relative between host and home country.

4.3.2.2 Model for Thailand Level

The analysis of Thailand level uses details of firm investments that had been approved by BOI, hence data set is different from global and ASEAN levels. According to model selection, country fixed effect is introduced to compare with time effect; and because the investment categories is divided into industrial group, then industrial group dummies are introduced in the model experiment. Two types of fixed effects with four models are used in the experiment. Model 5 in equation (4.26) is pure time fixed effect model while Model 6 in equation (4.27) is time fixed effect with industrial dummies aimed to investigate a difference slope coefficients across industrial groups or concurrent regressions across industries. Model 7 in equation (4.28) is unit or country fixed effect while Model 8 in equation (4.29) is country fixed effect with industrial dummies aimed to investigate for concurrent regressions across industries. Industrial dummies which are categorized by BOI have values as follow; IND_1 = 1 if Agricultural Products industry which is a base industrial group, 0 otherwise; IND_2 = 1 if Minerals and Ceramics industry, 0 otherwise; IND_3 = 1 if Light Industries/Textiles industry, 0 otherwise; IND_4 = 1 if Metal Products and Machinery industry, 0 otherwise; IND_5 = 1 if Electric and Electronic Products industry, 0 otherwise; and IND_6 = 1 if Chemicals and Paper industry, 0 otherwise.

Model 5:

$$logFDI_{it} = c + \alpha_1 RLAXPI_{it} + \sum_{t=2}^{T=5} \lambda_t YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{RX}_{k,it}) + \varepsilon_{it} \quad (4.26)$$

Model 6:

$$logFDI_{it} = c + \alpha_1 RLAXPI_{it} + \sum_{t=2}^{T=5} \lambda_t YEAR_t + \sum_{s=2}^{S=6} \gamma_s RLAXPI_{it} \cdot IND_s + \boldsymbol{\beta_k}\left(\boldsymbol{RX}_{k,it}\right) + \varepsilon_{it} \quad (4.27)$$

Model 7:

$$logFDI_{it} = c_1 + \alpha_{it} RLAXPI_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \boldsymbol{\beta_k}\left(\boldsymbol{RX}_{k,it}\right) + \varepsilon_{it} \quad (4.28)$$

Model 8:

$$logFDI_{it} = c_1 + \alpha_{it} RLAXPI_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \sum_{s=2}^{S=6} \gamma_s RLAXPI_{it} \cdot IND_s + \boldsymbol{\beta_k}\left(\boldsymbol{RX}_{k,it}\right) + \varepsilon_{it} \quad (4.29)$$

4.3.3 Regression Diagnostic Test

4.3.3.1 Detection of Heteroscedasticity

All models described in the previous sections will be estimated and compared among Pooled OLS, fixed effect least square dummy variable (LSDV) and random effect model. Notwithstanding three techniques, but all are estimated by OLS which makes the assumption that the variance of the error term is constant. Since one combination of panel data used in this study is cross-sectioned by countries, the error terms would have non-constant variance that causes a heteroscedasticity problem. Therefore, detection of heteroscedasticity is required in order to select the most appropriate model of each analysis in global, ASEAN and Thailand level. There are several methods to detect heteroscedasticity, such as virtual inspection by plotting the residues against the fitted values of explained variable, Breusch-Pagan test and White's general test.

The Breusch-Pagan test assumes that the error variance is a linear function shown as $\sigma_i^2 = a_1 + a_2 Z_{2i} + \cdots + a_m Z_{mi}$; some or all explanatory variables can serve as Z's. The null hypothesis is that $a_1 = a_2 = \cdots = a_m = 0$ or all variances are equal. It can be written as H_0: error variances are all equal versus H_a: error variances are a multiplicative function of one or more variables. To reject or do not reject the null hypothesis, critical value of chi-square of chosen significant level is used in judgment. Considering the White's general test, it uses auxiliary regression of the error variance which the square residuals from the original regression are regressed on the explanatory variables. The auxiliary regression can be written as $\widehat{\varepsilon_i^2} = a_1 + a_2X_{2i} + \ldots + a_mX_{mi} + b_2X_{2i}^2 + \ldots + b_mX_{mi}^2 + c_2X_{2i}X_{3i} + c_3X_{2i}X_{4i} + \ldots + c_{m-1}X_{2i}X_{mi} + c_mX_{3i}X_{4i} + c_nX_{(m-1)i}X_m + v_i$. The null hypothesis of that auxiliary regression is H_0: homoscedasticity which is all coefficients of *a*, *b* and *c* are equal to zero while alternative hypothesis is H_a: unrestricted heteroscedasticity, however, it is too much of a complexity when the number of observation or value *m* is high. Since there are a total 213 variables in Model 4, including 12 explanatory variables and 201 country dummies, it is a problem when Stata is used for the White's general, because the number of variables is limited at five thousand and that is not enough for its error variance's auxiliary regression.

In summary, there are limitations when using White's general test with unit LSDV fixed effect model in Stata computing program, while Breusch-Pagan test can be used for all models, hence Breusch-Pagan test is the selected testing method.

4.3.3.2 Testing for Time Fixed Effect

Determination for whether time fixed effects are needed when running a fixed effect model uses a joint test to see if the dummies for all years are equal to zero. F-test is used and the null hypothesis can be written as H_0: all year dummies are equal to zero, if the null hypothesis is rejected then time fixed effects are needed. This diagnostic test after estimation will emphasize the decision when time fixed effect is selected.

4.3.3.3 Hausman Test

Hausman test is used to determine which one, between the fixed effect and the random effect, is an appropriate model. It compares an estimator of fixed effect model which is known to be consistent with an estimator of random effect that is known to be efficient. The null hypothesis is whether the fixed effect estimates are the same as the random effect estimates that can be written as H_0: difference in coefficients not systematic. If the estimates do not have a significant systematic difference between two estimators, or do not reject the null hypothesis, then the random effect estimator is preferable. The Hausman statistic is distributed as chi-square and is computed as $H = (\boldsymbol{B}_F - \boldsymbol{B}_R)'(\boldsymbol{V}_F - \boldsymbol{V}_R)^{-1}(\boldsymbol{B}_F - \boldsymbol{B}_R)$ where $\boldsymbol{B}_F$ is the coefficient vector from the fixed effect estimator, $\boldsymbol{B}_R$ is the coefficient vector from the random effect estimator, $\boldsymbol{V}_F$ is the covariance matrix of the fixed effect estimator and $\boldsymbol{V}_R$ is the covariance matrix of the random effect estimator.

4.3.4 Model Selection Procedure

Multiple criteria's will be used for model selection. The heteroscedasticity test is the first consideration with an objective model that has prediction efficiency according to BLUE; it is the initial determination for using polled OLS or LSDV with time dummies or LSDV with unit dummies. Testing for time fixed effect is a next diagnostic, once the LSDV with time dummies is initially selected due to no heteroscedasticity problem. Comparing AIC is an option in consideration and is not a final selection criterion, if AIC values among models are close to each other the model that has significant results according to theory and expectation will be selected. Huasman test is a last determination criterion when there are no heteoroscedaticity problems for both LSDV with time dummies and LSDV with unit dummies, it is tested to compare time fixed effect versus the random effect models and unit fixed effect versus random effect models.

Table 4.8 List of Variables

Description	Global Level	ASEAN Level	Thailand Level	Remark
Net FDI inflow (log value)	$log\ FDI$	$log\ FDI$	$log\ FDI$	
Laxity of country's pollution control	$ILAX$	$RLAX$	-	
Laxity of country's pollution control with pollution intensity	-	-	$RLAXPI$	
Vector of Variables				
	$\boldsymbol{IX_{k,it}}$	$\boldsymbol{RX_{k,it}}$	$\boldsymbol{RX_{k,it}}$	
Environmental tax	$IENVITAX$	$RENVITAX$	$RENVITAX$	
Capital price	Ir	Rr	Rr	
Labor wage	Iw	Rw	Rw	
Import tariff	$ITARIFF$	$RTARIFF$	$RTARIFF$	
Cost of business set up	$IBUSET$	$RBUSET$	$RBUSET$	
Cost of export good	$IEXCOST$	$REXCOST$	$REXCOST$	
Cost of import good	$IIMCOST$	$RIMCOST$	$RIMCOST$	
Road intensity	$IROAD$	$RROAD$	$RROAD$	
Energy abundant	$IENERGY$	$RENERGY$	$RENERGY$	
Water abundant	$IWATER$	$RWATER$	$RWATER$	
GDP	$IGDP$	$RGDP$	$RGDP$	
Dummy Variable				
Year	$YEAR_t$	$YEAR_t$	$YEAR_t$	2008-2013 for Global and ASEAN level 2009-2013 for Thailand Level
Regional Dummy	$REGIONID_s$	$REGIONID_s$	$REGIONID_s$	7 Regions
Income group dummy	$INCOMEID_s$	$INCOMEID_s$	$INCOMEID_s$	5 Income groups
Country dummy	$CONID_{ji}$	$CONID_{ji}$	$CONID_{ji}$	202 Countries
Industrial dummy	-	-	IND_s	6 Industries

4.4 The Estimations and Selected Models

Estimations in this section will be a consequence from global level analysis to ASEAN level and then finally at Thailand's level. All models will be estimated and diagnostic tested according to model selection procedures.

4.4.1 Global Level

Estimations and diagnostic test results of Model 1 series and Model 4, Model 2 series and Model 3 series are in table 4.9, table 4.10 and table 4.11 respectively. Starting from the series of Model 1, a focused explanatory variable, ILAX has significant impact to FDI inflows in all models; furthermore Breusch-Pagan tests show that all of them have no heteroscedasticity problems. Model 1-1 has the highest R-square and AIC value but insignificant for dissimilar regression terms. Model 1-2 has the lowest R-square value but it cannot detect the difference in intercept and difference in slope coefficient. Model 1-3 has the highest R-square but the lowest AIC value; however, it delineates for time parallel regression since all of the time dummies show significant results. Model 1-4 shows some significant result for concurrent regression of time fixed effect.

About the estimations of Model 2 series for pooled regression with regional dummies, all models in the series have a heterosecasticity problem even though the focused explanatory variable, ILAX, have significant results in dissimilar regression of Model 2-1 and parallel regression of Model 2-2. Similar problems happen in series of Model 3 for pooled regression with income group dummies that all models are faced with the heteroscedasticity problem even though there are significant results of ILAX in all models. These two series can estimate impact of pollution control enforcements on FDI inflows with unbiased estimator but there are inefficiencies. The last estimation of Model 4 in which the individual country is considered as a unit in LSDV unit fixed effect model, estimations show insignificant results of ILAX and there is the heteroscedasticity problem detected by the Breusch-Pagan tests. Such a result provides a reason to reject Model 4 from the analysis of global level.

Because there are more significant results than others and consistencies with theory and expectation, Model 1-3 was selected as the best one from series of Model 1. It can be said that time fixed effect model has a good potential to explain the relation between environmental control enforcements and the amount of FDI inflows in the global level. To emphasize this determination, testing for time fixed effect was examined where $YEAR_1$ to $YEAR_6$ were dummies for the years 2008 to 2013 respectively. It is to confirm that time fixed effects are needed, since results rejects the null hypothesis with details as follows;

H_0: $YEAR_1 = YEAR_2 = YEAR_3 = YEAR_4 = YEAR_5 = YEAR_6 = 0$
$F_{(5,1003)} = 2.6$
Prob. > F = 0.0238

Although time fixed effect is an appropriate model for all countries in the globe, due to the differences in location and the economics of each country, there would be different results even when using the same estimation model. Table 4.12 and 4.13 depicts estimation results when using time fixed effects from Model 1-3 with regional dummies and income group dummies respectively. Those tests aim to evaluate whether the countries that differ in regional or income levels have different characteristics about the relation between pollution control enforcements and FDI inflows, testing not only the significant of estimators but also diagnostic tests.

By regional, ILAX is significant with positive signs for East Asia and the Pacific, North America and Sub-Sahara African regions, but North America and Sub-Sahara Africa are faced with a heteroscedasticity problem, same as the Middle East, North Africa and South Asia regions. Without a heteroscedasticity problem and a significantly focused explanatory variable, it is to be said that time fixed effect model is suited for East Asia and the Pacific region. This is such an important finding, since countries in ASEAN are in East Asia and the Pacific region and specific estimations for ASEAN will further be evaluated, then the results for ASEAN can be anticipated.

By income group, there are significant ILAX with positive signs for Upper Middle Income and Lower Middle Income groups, but only Lower Middle Income group is efficient due to the heteroscedasticity problem found in other groups. Findings about significant estimators in both to income groups is also important because such results can anticipate results for countries in ASEAN, that some countries are in the Upper Middle Income groups and some are in the Lower Middle Income groups.

Table 4.9 Estimations and Diagnostic Test Results of Model 1 and Model 4

VARIABLES	Model 1-1	Model 1-2	Model 1-3	Model 1-4	Model 4
	log FDI	log FDI	log FDI	log FDI	log FDI
ILAX	0.496**	0.558***	0.535***	0.764***	-0.429
	(0.213)	(0.105)	(0.105)	(0.130)	(0.440)
IENVITAX	0.0571***	0.0514***	0.0571***	0.0567***	-0.00362
	(0.00980)	(0.00964)	(0.00976)	(0.00979)	(0.0133)
Ir	0.0114	-0.0149	0.0108	0.00699	-0.0798**
	(0.0351)	(0.0340)	(0.0350)	(0.0349)	(0.0328)
Iw	1.861***	1.828***	1.861***	1.858***	2.202***
	(0.163)	(0.162)	(0.162)	(0.162)	(0.604)
ITARIFF	-0.112***	-0.116***	-0.111***	-0.112***	0.136*
	(0.0375)	(0.0374)	(0.0374)	(0.0374)	(0.0751)
IBUSET	-0.00786***	-0.00703***	-0.00786***	-0.00766***	-0.00225***
	(0.00101)	(0.000958)	(0.00101)	(0.00100)	(0.000608)
IEXCOST	0.0623	0.106	0.0639	0.0798	0.107
	(0.208)	(0.204)	(0.207)	(0.207)	(0.190)
IIMCOST	-0.179	-0.211	-0.179	-0.195	0.0690
	(0.197)	(0.192)	(0.197)	(0.196)	(0.152)
IROAD	-0.0269	-0.0245	-0.0268	-0.0264	1.175
	(0.0285)	(0.0285)	(0.0284)	(0.0284)	(0.770)
IENERGY	-1.967***	-1.958***	-1.960***	-1.941***	0.829
	(0.530)	(0.530)	(0.528)	(0.529)	(3.253)
IWATER	1.799***	1.771***	1.796***	1.789***	-4.536
	(0.485)	(0.486)	(0.484)	(0.485)	(11.22)
IGDP	7.229***	7.183***	7.227***	7.211***	3.360
	(0.858)	(0.859)	(0.856)	(0.857)	(9.248)
YEAR 2009	-0.468		-0.468**		
	(0.484)		(0.209)		
YEAR 2010	-0.688		-0.701***		
	(0.486)		(0.210)		
YEAR 2011	-0.384		-0.367*		
	(0.491)		(0.209)		
YEAR 2012	-0.766		-0.586***		
	(0.485)		(0.209)		
YEAR 2013	-0.680		-0.507**		
	(0.490)		(0.213)		
ILAX x YEAR 2008	0			0	
	(0)			(0)	
ILAX x YEAR 2009	-0.00121			-0.254**	
	(0.294)			(0.127)	
ILAX x YEAR 2010	-0.00821			-0.380***	
	(0.294)			(0.127)	
ILAX x YEAR 2011	0.0106			-0.191	
	(0.300)			(0.128)	
ILAX x YEAR 2012	0.120			-0.296**	
	(0.294)			(0.127)	
ILAX x YEAR 2013	0.115			-0.251*	
	(0.295)			(0.128)	
Constant	6.148***	5.724***	6.088***	5.660***	5.489***
	(0.397)	(0.256)	(0.280)	(0.257)	(1.330)
Observations	1,021	1,021	1,021	1,021	1,021
R-squared	0.407	0.399	0.407	0.405	0.052
Number of CONID					179
Breusch-Pagan test for heteroskedasticity Ho: Constant variance	Do not Reject	Do not Reject	Do not Reject	Do not Reject	Reject
Chi Square	1.160	1.360	0.990	0.590	49.220
Prob. Chi Square	0.282	0.243	0.319	0.442	0.000
AIC	4166.948	4160.547	4157.376	4160.422	2301.327

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.10 Estimations and Diagnostic Test Results of Model 2

VARIABLES	Model 2-1	Model 2-2	Model 2-3
	log FDI	log FDI	log FDI
ILAX	1.121***	0.305***	0.158
	(0.251)	(0.115)	(0.175)
IENVITAX	0.0624***	0.0547***	0.0472***
	(0.0102)	(0.0101)	(0.0101)
Ir	-0.0408	-0.0229	-0.0150
	(0.0346)	(0.0351)	(0.0352)
Iw	1.594***	1.699***	1.821***
	(0.175)	(0.171)	(0.165)
ITARIFF	-0.0460	-0.0815*	-0.112***
	(0.0424)	(0.0422)	(0.0418)
IBUSET	-0.00712***	-0.00684***	-0.00709***
	(0.000993)	(0.000991)	(0.00102)
IEXCOST	0.202	0.225	0.220
	(0.204)	(0.205)	(0.210)
IIMCOST	-0.293	-0.304	-0.277
	(0.191)	(0.193)	(0.196)
IROAD	0.00506	-0.0184	-0.0254
	(0.0281)	(0.0282)	(0.0284)
IENERGY	-1.324**	-1.330**	-1.473**
	(0.659)	(0.558)	(0.610)
IWATER	1.009	2.356***	2.355***
	(0.721)	(0.511)	(0.567)
IGDP	7.529***	7.740***	7.890***
	(1.099)	(0.934)	(0.978)
$REGIONID_2$	2.261***	0.920***	
	(0.428)	(0.224)	
$REGIONID_3$	4.958***	1.103***	
	(0.692)	(0.218)	
$REGIONID_4$	1.320*	1.018***	
	(0.797)	(0.252)	
$REGIONID_5$	-8.882*	-1.274**	
	(5.091)	(0.583)	
$REGIONID_6$	-2.303*	0.00667	
	(1.335)	(0.331)	
$REGIONID_7$	0.727	0.480**	
	(0.535)	(0.231)	
ILAX x $REGIONID_1$	0		0
	(0)		(0)
ILAX x $REGIONID_2$	-0.995***		0.289**
	(0.277)		(0.144)
ILAX x $REGIONID_3$	-2.800***		0.471***
	(0.471)		(0.154)
ILAX x $REGIONID_4$	-0.533		0.462***
	(0.422)		(0.149)
ILAX x $REGIONID_5$	9.257*		-1.742***
	(5.529)		(0.632)
ILAX x $REGIONID_6$	1.361		-0.0232
	(0.855)		(0.217)
ILAX x $REGIONID_7$	-0.307		0.233
	(0.387)		(0.168)
Constant	4.318***	5.288***	5.818***
	(0.376)	(0.268)	(0.265)
Observations	1,021	1,021	1,021
R-squared	0.453	0.426	0.412
Breusch-Pagan test for heteroskedasticity	Reject	Reject	Reject
Ho: Constant variance			
Chi Square	6.230	6.010	3.040
Prob. Chi Square	0.013	0.014	0.081
AIC	4088.330	4125.456	4149.719

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.11 Estimations and Diagnostic Test Results of Model 3

VARIABLES	Model 3-1	Model 3-2	Model 3-3
	log FDI	log FDI	log FDI
ILAX	1.655**	0.545***	1.751***
	(0.742)	(0.102)	(0.245)
IENVITAX	0.0494***	0.0456***	0.0482***
	(0.0103)	(0.0102)	(0.0103)
Ir	0.0746**	0.0819**	0.0603*
	(0.0359)	(0.0354)	(0.0353)
Iw	1.102***	0.950***	1.316***
	(0.259)	(0.217)	(0.186)
ITARIFF	-0.0919**	-0.0866**	-0.0811**
	(0.0369)	(0.0369)	(0.0372)
IBUSET	-0.00427***	-0.00430***	-0.00483***
	(0.00105)	(0.00104)	(0.00105)
IEXCOST	-0.0447	-0.00114	0.0371
	(0.200)	(0.199)	(0.201)
IIMCOST	-0.00768	-0.0348	-0.0725
	(0.189)	(0.189)	(0.191)
IROAD	-0.0523*	-0.0329	-0.0142
	(0.0308)	(0.0295)	(0.0284)
IENERGY	-1.930***	-2.332***	-2.220***
	(0.560)	(0.539)	(0.562)
IWATER	2.141***	2.261***	2.073***
	(0.485)	(0.483)	(0.489)
IGDP	6.006***	6.196***	6.337***
	(0.874)	(0.867)	(0.874)
$INCOMEID_2$	0.818	-1.051***	
	(0.963)	(0.296)	
$INCOMEID_3$	0.430	-1.153***	
	(0.979)	(0.291)	
$INCOMEID_4$	-1.230	-2.155***	
	(1.003)	(0.320)	
$INCOMEID_5$	-1.122	-2.499***	
	(1.180)	(0.365)	
ILAX x $INCOMEID_1$	0		0
	(0)		(0)
ILAX x $INCOMEID_2$	-1.516**		-1.041***
	(0.765)		(0.230)
ILAX x $INCOMEID_3$	-1.316*		-0.987***
	(0.759)		(0.225)
ILAX x $INCOMEID_4$	-0.888		-1.371***
	(0.759)		(0.234)
ILAX x $INCOMEID_5$	-1.154		-1.700***
	(0.877)		(0.269)
Constant	5.686***	6.941***	5.269***
	(0.988)	(0.342)	(0.259)
Observations	1,021	1,021	1,021
R-squared	0.442	0.437	0.428
Breusch-Pagan test for heteroskedasticity	Reject	Reject	Reject
Ho: Constant variance			
Chi Square	4.250	5.340	5.000
Prob. Chi Square	0.039	0.021	0.025
AIC	4100.370	4101.996	4118.854

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.12 Estimations of Selected Model 1-3 by Region Using Global Data Set

VARIABLES	Model 1-3						
	East Asia and Pacific	**Europe and Central Asia**	**Latin America and Caribbean**	**Middle East and North Africa**	**North America**	**South Asia**	**Sub-Sahara Africa**
	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI
ILAX	2.610***	0.101	-0.603	-0.0784	784.6**	-2.357	0.522*
	(0.502)	(0.146)	(0.394)	(0.269)	(27.01)	(2.334)	(0.271)
IENVITAX	0.121***	0.0504**	0.122***	0.00353	-190.3**	0.201	0.0791***
	(0.0421)	(0.0213)	(0.0339)	(0.0177)	(6.837)	(0.211)	(0.0147)
Ir	0.0729	-0.199***	-0.175***	-0.472***	4,091**	0.0582	0.0865*
	(0.223)	(0.0644)	(0.0509)	(0.139)	(145.0)	(0.290)	(0.0479)
Iw	4.182***	0.624***	6.826***	-1.141**	-10,456**	2.289	-2.753
	(0.715)	(0.154)	(1.751)	(0.472)	(370.9)	(16.95)	(1.676)
ITARIFF	0.621**	-0.306*	0.0259	-0.178***	-30.20**	0.341	0.0327
	(0.254)	(0.169)	(0.0523)	(0.0499)	(1.063)	(0.381)	(0.103)
IBUSET	-0.0104	-0.0173*	-0.0107***	-0.00421**	-3,858**	-0.0373***	-0.0067***
	(0.00652)	(0.00986)	(0.00191)	(0.00175)	(136.9)	(0.0134)	(0.00125)
IEXCOST	-1.747	-0.0210	2.561***	-0.261	1,979**	2.035	0.335
	(3.024)	(0.530)	(0.549)	(0.484)	(70.33)	(1.214)	(0.253)
IIMCOST	-0.682	0.0105	-1.281**	0.522	-1,364**	-1.823	-0.256
	(3.734)	(0.552)	(0.550)	(0.630)	(48.42)	(1.179)	(0.224)
IROAD	0.0840	0.334***	-0.651***	-0.178***	-	1.401***	0.679*
	(0.0550)	(0.0694)	(0.170)	(0.0283)		(0.258)	(0.404)
IENERGY	-4.614**	3.644***	-42.48***	-11.39***	-	-17.29**	-11.46
	(1.824)	(0.824)	(6.297)	(3.907)		(7.509)	(8.305)
IWATER	0.310	9.321***	4.819	7.082***	-	15.63***	-2.346
	(2.327)	(2.523)	(3.839)	(2.448)		(5.273)	(4.159)
IGDP	11.19***	6.864***	102.8***	163.1***	-602.3**	-139.2**	293.4***
	(3.777)	(1.804)	(13.30)	(34.99)	(21.40)	(54.37)	(64.86)
YEAR 2009	-0.940	-0.101	-0.455	-0.273	-0.758**	-0.162	-0.603*
	(0.718)	(0.260)	(0.309)	(0.319)	(0.0578)	(0.585)	(0.334)
YEAR 2010	-1.114	-0.445*	-0.634**	-0.514	-0.437*	-1.209	-1.068***
	(0.738)	(0.261)	(0.301)	(0.323)	(0.0578)	(0.755)	(0.357)
YEAR 2011	-0.999	0.00349	-0.488*	-0.388	-0.314	-1.148	-0.652*
	(0.747)	(0.258)	(0.288)	(0.314)	(0.0578)	(0.770)	(0.360)
YEAR 2012	-1.170	-0.349	-0.389	-0.862***	-0.634*	-1.208	-0.895**
	(0.710)	(0.262)	(0.297)	(0.305)	(0.0566)	(0.808)	(0.364)
YEAR 2013	-1.057	-0.376	-0.203	-0.578*	-0.503*	-0.794	-0.913**
	(0.724)	(0.290)	(0.310)	(0.319)	(0.0566)	(0.772)	(0.369)
Constant	2.400**	7.360***	6.377***	9.625***	9,658**	5.809***	4.756***
	(1.059)	(0.367)	(0.847)	(0.780)	(343.1)	(1.988)	(0.612)
Observations	164	267	167	105	16	48	254
R-squared	0.527	0.601	0.757	0.755	1.000	0.934	0.395
Number of Country	37	53	35	20	3	8	46
Breusch-Pagan test for Heteroskedasticity Ho: Constant variance	Do not Reject	Do not Reject	Do not Reject	Reject	Reject	Reject	Reject
Chi Square	1.38	0	1.35	27.37	8.44	16.62	7.08
Prob. Chi Square	0.2393	0.9917	0.245	0	0.0037	0	0.0078
AIC	768.1681	848.8746	496.9341	259.8876	-71.25088	121.0027	929.0416

Note: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4.13 Estimations of Selected Model 1-3 by Income Group Using Global Data Set

VARIABLES	Model 1-3				
	High Income OECD	**High Income non-OECD**	**Upper Middle Income**	**Lower Middle Income**	**Low Income**
	log FDI	log FDI	log FDI	log FDI	log FDI
ILAX	-1.025	-0.0185	0.283*	0.768***	0.494
	(0.713)	(0.175)	(0.159)	(0.149)	(0.445)
IENVITAX	0.230***	0.0228*	0.0283	0.0550***	0.0919**
	(0.0698)	(0.0133)	(0.0174)	(0.0172)	(0.0431)
Ir	-0.474***	-0.0236	0.0268	-0.0787	0.192***
	(0.129)	(0.167)	(0.0553)	(0.0679)	(0.0523)
Iw	-0.191	0.806*	-0.661	-4.814**	1.581
	(0.246)	(0.420)	(1.028)	(2.073)	(4.437)
ITARIFF	0.848***	0.148***	-0.0607	0.0880	0.0555
	(0.241)	(0.0558)	(0.0511)	(0.0726)	(0.120)
IBUSET	-0.00283	0.0163**	-0.00300	-0.00883***	-0.00262*
	(0.0197)	(0.00776)	(0.00311)	(0.00234)	(0.00137)
IEXCOST	1.975	0.626	0.888**	-0.794**	0.232
	(1.609)	(0.682)	(0.418)	(0.359)	(0.267)
IIMCOST	-1.200	-2.276***	-1.179**	0.423	-0.326
	(1.909)	(0.768)	(0.462)	(0.315)	(0.253)
IROAD	0.419***	-0.0256	-0.725***	-0.561**	-4.462***
	(0.0825)	(0.0204)	(0.155)	(0.238)	(0.779)
IENERGY	6.229***	-14.95***	-6.866***	-23.45***	-171.7***
	(1.929)	(2.823)	(1.050)	(2.823)	(51.04)
IWATER	-8.925***	11.56***	-4.063***	-11.22***	6.405
	(2.407)	(2.831)	(1.541)	(1.248)	(5.368)
IGDP	6.280***	226.9***	61.15***	324.6***	2,409***
	(1.945)	(19.74)	(3.897)	(23.83)	(343.7)
YEAR 2009	-0.280	-0.567	-0.509*	-0.511	-0.640
	(0.319)	(0.356)	(0.293)	(0.325)	(0.408)
YEAR 2010	-0.625*	-0.295	-0.485*	-0.879**	-0.843*
	(0.329)	(0.334)	(0.293)	(0.344)	(0.450)
YEAR 2011	-0.0115	-0.0411	-0.275	-0.744**	-0.316
	(0.322)	(0.328)	(0.288)	(0.345)	(0.445)
YEAR 2012	-0.361	-0.369	-0.355	-0.844**	-0.529
	(0.327)	(0.322)	(0.293)	(0.334)	(0.456)
YEAR 2013	-0.203	-0.123	-0.241	-0.929***	-0.610
	(0.379)	(0.330)	(0.304)	(0.334)	(0.459)
Constant	8.404***	7.247***	7.930***	7.122***	3.867***
	(1.006)	(0.643)	(0.490)	(0.493)	(0.870)
Observations	169	139	277	256	180
R-squared	0.517	0.772	0.650	0.639	0.380
Number of Country	31	39	52	47	33
Breusch-Pagan test for heteroskedasticity Ho: Constant variance	Reject	Reject	Reject	Do not Reject	Reject
Chi Square	13.52	10.57	4.84	0.03	6.71
Prob. Chi Square	0.0002	0.0011	0.0278	0.8695	0.0096
AIC	549.6493	403.8922	949.2844	902.9448	662.3564

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.4.2 ASEAN Level

ASEAN consists of 10 countries in South East Asia that is a part of the Asia Pacific region, as shown in table 4.14 most of them are developing countries with income level are in Upper Middle Income and Lower Middle Income groups. Because ASEAN was considered as a competitive economic region as mentioned in Wisarn Pupphavesa, Santi Chaisrisawatsuk, Sasatra Sudsawasd and Sumet Ongkittikul (2009); and most developing countries are looking for foreign investments which will significantly drive for their economic growth, then specific evaluations for ASEAN nations will display the group's characteristics. Moreover, evaluation for individual countries in ASEAN is used to make comparisons among countries in group.

In reference to model selection in global level shows that LSDV unit fixed effect in Model 4 has heteroscedasticity problem while Model 1 series does not, then because of the same data set, Model 4 is also rejected in the analysis of ASEAN levels. Notwithstanding that Model 1-3 was selected in global level, but observations in ASEAN group is smaller than global levels so Model 1 series will be re-estimated and re-selected for ASEAN levels.

Estimation and diagnostic results are shown in table 4.15, heterscedasticity problems are found for pooled regression in Model 1-2 and concurrent regression in Model 1-4, while no problems are found for dissimilar regression in Model 1-1 and parallel regression in Model 1-3. Beside AIC value, selection for the appropriate model between Model 1-1 and Model 1-3 is also considered to see which one produces results according to theory and expectation. Finally, the dissimilar regression that have both difference in year intercept and slope coefficient in Model 1-1 is selected for ASEAN countries analysis by reason of better significant results even if it has a lower AIC value but not much of a difference when compared. To emphasize this, determination testing for time fixed effect is examined. It is to confirm that time fixed effects are needed, since results reject null hypothesis with details as follows;

$H_0: YEAR_1 = YEAR_2 = YEAR_3 = YEAR_4 = YEAR_5 = YEAR_6 = 0$

$F_{(5,31)} = 3.43$

Prob. > F = 0.0139

Not only was the relation between pollution control enforcements and FDI inflows is tested the entire ASEAN, but each country in the group will also be examined according to Model 1-1. Relative measurement of variables described in section 4.2.1.2 was applied in this analysis. Results shown in table 4.16 demonstrate a heteroscredasticity problem only for Malaysia, while Myanmar has no GDP data and will therefore be omitted in the regression analysis. There are different results for focused explanatory variable, RLAX; significant results appear for Singapore, Vietnam and Laos with negative signs. Insignificance for RLAX is in countries like Thailand, Indonesia, Malaysia and Philippines.

It is to be observed that a small number of observations of each country would cause problems to the estimations and mislead interpretation of their results. An analysis at firm level in the same period with a higher number of observations could be a better methodology, however, to collect more detailed data at firm level for each individual country in ASEAN is not a focused area in this study but only an overview comparison among countries in the group. Only estimations with details on FDI inflows at firm level in Thailand was focused and continued because that is a main objective of this study.

Table 4.14 Income Level of ASEAN Countries

Country	Income Group
Thailand	Upper Middle Income
Indonesia	Lower Middle Income
Malaysia	Upper Middle Income
Philippines	Lower Middle Income
Singapore	High Income non-OECD
Vietnam	Lower Middle Income
Brunei	High Income non-OECD
Cambodia	Low Income
Laos	Lower Middle Income
Myanmar	Lowe Income

Table 4.15 Estimations and Diagnostic Test Results of Model 1 for ASEAN Level

VARIABLES	Model 1-1	Model 1-2	Model 1-3	Model 1-4
	log FDI	log FDI	log FDI	log FDI
ILAX	3.788***	1.197**	2.584***	1.920***
	(0.710)	(0.591)	(0.655)	(0.602)
IENVITAX	-0.0898*	-0.0814*	-0.0558	-0.0546
	(0.0465)	(0.0411)	(0.0430)	(0.0414)
Ir	-0.166	0.0104	-0.115	0.0180
	(0.152)	(0.141)	(0.162)	(0.161)
Iw	-0.398	0.638	-1.079	-0.129
	(1.378)	(1.319)	(1.368)	(1.348)
ITARIFF	-0.0782	0.281	-0.245	-0.00635
	(0.315)	(0.293)	(0.333)	(0.333)
IBUSET	-0.00113	-0.00690**	0.000667	-0.00223
	(0.00307)	(0.00295)	(0.00330)	(0.00335)
IEXCOST	-0.461	-1.525	-0.678	0.204
	(2.525)	(2.320)	(2.768)	(2.866)
IIMCOST	-1.800	-1.166	-1.219	-2.591
	(2.862)	(2.546)	(3.139)	(3.241)
IROAD	0.713***	0.545***	0.731***	0.593***
	(0.162)	(0.176)	(0.175)	(0.178)
IENERGY	13.09*	10.64	8.418	5.575
	(7.382)	(6.944)	(7.319)	(7.225)
IWATER	-0.0335	0.775	-0.401	0.626
	(2.086)	(2.272)	(2.243)	(2.299)
IGDP	-78.54	-32.24	-45.10	-14.57
	(55.16)	(48.88)	(54.66)	(53.58)
YEAR 2009	2.833**		-0.0865	
	(1.037)		(0.325)	
YEAR 2010	2.463**		0.526	
	(0.941)		(0.351)	
YEAR 2011	3.044***		0.637	
	(0.865)		(0.379)	
YEAR 2012	3.054***		0.883**	
	(0.878)		(0.378)	
YEAR 2013	3.059***		0.920**	
	(0.878)		(0.345)	
ILAX x YEAR 2008	0			0
	(0)			(0)
ILAX x YEAR 2009	-2.110***			-0.293
	(0.685)			(0.229)
ILAX x YEAR 2010	-1.424**			0.104
	(0.635)			(0.252)
ILAX x YEAR 2011	-1.824***			0.0924
	(0.612)			(0.277)
ILAX x YEAR 2012	-1.627**			0.292
	(0.612)			(0.276)
ILAX x YEAR 2013	-1.578**			0.390
	(0.615)			(0.252)
Constant	4.796***	7.411***	6.183***	6.491***
	(1.055)	(1.121)	(1.035)	(1.090)
Observations	54	54	54	54
R-squared	0.961	0.914	0.944	0.939
Breusch-Pagan test for heteroskedasticity	Do not Reject	Reject	Do not Reject	Reject
Ho: Constant variance				
Chi Square	0.01	4.23	1.14	3.12
Prob. Chi Square	0.9099	0.0397	0.2857	0.0775
AIC	74.75621	97.41266	83.67131	88.55893

Note: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4.16 Estimations and Diagnostic Test Results of Model 1-1 for the Countries in ASEAN

VARIABLES	Model 1-1 with Relative Variables									
	Thailand	Indonesia	Malaysia	Philippines	Singapore	Vietnam	Brunei	Cambodia	Laos	Myanmar
	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI
RLAX	0.838	-1.027	2.950	-0.557	-2.964*	-2.949***	16.45	0.253	-8.211*	-1.885
	(0.684)	(0.945)	(1.910)	(1.879)	(1.658)	(0.727)	(8.960)	(1.024)	(4.240)	(3.282)
RENVITAX	0.141	-0.00402	-0.0838	0.132	0.0107	0.279***	-0.0011	0.00929	0.393	-0.0426
	(0.0862)	(0.0484)	(0.0563)	(0.144)	(0.0249)	(0.0694)	(0.0922)	(0.0447)	(0.327)	(0.185)
Rr	0.187	0.182***	0.311***	0.253	0.185	0.0639	0.501	0.0387	-0.110	0.136
	(0.121)	(0.0455)	(0.106)	(0.160)	(0.116)	(0.0393)	(0.277)	(0.0234)	(0.338)	(0.108)
Rw	-0.623***	-3.942***	-1.216*	-6.013**	-0.065***	-2.625***	-0.115	0.327	-2.492	0.706
	(0.206)	(0.805)	(0.615)	(2.356)	(0.0229)	(0.746)	(0.284)	(0.799)	(2.202)	(3.644)
RTARIFF	0.0203*	0.116***	0.0294	-0.000325	4.443	0.062***	0.170	-0.00849	0.555	0.0120
	(0.0120)	(0.0275)	(0.0397)	(0.0299)	(17.61)	(0.0194)	(1.114)	(0.00654)	(0.436)	(0.0929)
RBUSET	-0.0394	-0.00738	-0.0354**	0.00202	-0.0542	-0.00879	-0.152	-0.000397	-0.455	-0.00121
	(0.0266)	(0.00470)	(0.0146)	(0.0180)	(0.240)	(0.0229)	(0.186)	(0.00130)	(0.332)	(0.00639)
REXCOST	-2.388	6.478*	13.42*	13.96***	1.150	3.936	2.947	3.355*	-3.210*	-5.253
	(2.173)	(3.723)	(6.942)	(4.189)	(4.618)	(2.544)	(20.10)	(1.786)	(1.633)	(4.399)
RIMCOST	3.165*	-6.395*	-13.71*	-11.68***	-1.414	-0.386	-15.11	-0.763	2.579**	5.643
	(1.734)	(3.684)	(7.165)	(3.598)	(4.604)	(2.538)	(14.30)	(1.471)	(1.208)	(4.237)
RROAD	-0.0979	0.613	0.00828	-0.0843	0.00412	0.135	-0.681	0.266*	6.330**	-1.593
	(0.119)	(0.374)	(0.165)	(0.103)	(0.0214)	(0.129)	(0.689)	(0.147)	(2.687)	(2.364)
RENERGY	0.000708	0.00044*	-0.000357	0.00380	0.0809	0.0046***	0.00752	0.00624	0.0267	0.0104
	(0.00102)	(0.00023)	(0.00173)	(0.00386)	(0.115)	(0.00097)	(0.206)	(0.0114)	(0.0219)	(0.00990)
RWATER	-0.00139	0.000272	0.00172	0.00418	0.679	-0.000280		-0.00767	-2.030	-0.00561
	(0.00134)	(0.00074)	(0.00945)	(0.00321)	(0.513)	(0.00027)		(0.00845)	(2.108)	(0.00857)
RGDP	0.00337	0.00389	-0.0112	0.00599	-0.266**	0.023***	288.9*	-0.181***	96.20	
	(0.00296)	(0.0144)	(0.0206)	(0.0481)	(0.102)	(0.00797)	(153.9)	(0.0625)	(71.66)	
YEAR 2009	0.783	1.330	2.842	-2.316	-0.215			0.122	-1.056	-2.327
	(1.409)	(1.804)	(2.257)	(2.169)	(1.400)			(1.049)	(2.125)	(3.096)
YEAR 2010	1.073	1.485	4.483**	0.202	0.655		13.69**	-0.235	-0.241	-1.484
	(1.537)	(1.777)	(1.871)	(2.101)	(1.368)		(4.444)	(1.060)	(2.071)	(4.043)
YEAR 2011	0.785	1.412	1.172	1.383	1.160		14.92**	0.330	0.803	-6.903**
	(1.458)	(1.763)	(1.838)	(2.123)	(1.407)		(4.523)	(1.067)	(2.152)	(3.273)
YEAR 2012	1.668	1.443	2.384	0.915		-1.455		0.920	2.066	0.648
	(1.407)	(1.730)	(1.801)	(2.432)		(1.181)		(1.096)	(2.271)	(3.600)
YEAR 2013										
RLAX x YEAR 2008	0	0	0	0	0		0	0	0	0
	(0)	(0)	(0)	(0)	(0)		(0)	(0)	(0)	(0)
RLAX x YEAR 2009	-0.590	-1.274	-1.918	2.516	1.431			-0.760	-0.734	-0.246
	(0.807)	(1.110)	(1.473)	(2.135)	(1.961)			(1.020)	(2.704)	(3.751)
RLAX x YEAR 2010	-0.470	-0.827	-2.704**	1.034	0.554		-11.64**	-0.0820	-3.062	-1.913
	(0.862)	(1.102)	(1.202)	(1.886)	(1.953)		(4.373)	(1.029)	(2.742)	(3.757)
RLAX x YEAR 2011	-0.276	-0.967	-0.529	-0.000782	0.171	0	-12.12**	-0.614	-2.969	3.455
	(0.814)	(1.079)	(1.188)	(1.925)	(1.951)	(0)	(4.389)	(1.022)	(2.938)	(2.986)
RLAX x YEAR 2012	-0.798	-0.785	-1.744	0.581		0.441		-0.739	-4.004	-4.184
	(0.821)	(1.064)	(1.128)	(2.218)		(0.728)		(1.037)	(3.085)	(4.459)
RLAX x YEAR 2013										
Constant	0.841	4.811***	1.446	0.440	7.392***	3.986***	-8.692	0.0773	9.152*	8.141**
	(1.308)	(1.714)	(3.657)	(2.527)	(1.717)	(1.307)	(7.054)	(1.402)	(4.617)	(3.267)
Observations	168	111	66	75	87	70	25	111	36	40
R-squared	0.288	0.497	0.625	0.482	0.453	0.641	0.924	0.440	0.772	0.601
Breusch-Pagan / test for heteroskedasticity Ho: Constant variance	Do not Reject	Do not Reject	Reject	Do not Reject	Do not Reject	Do not Reject	Do not Reject	Do not Reject	Do not Reject	Do not Reject
Chi Square	2.07	0.01	4.76	0.07	1.8	1.75	0.01	0.16	0.22	1.78
Prob. Chi Square	0.1505	0.9324	0.0291	0.7859	0.1801	0.1862	0.9328	0.6911	0.6412	0.1826
AIC	726.4833	477.5987	223.9043	314.0495	336.0108	269.1381	77.6163	376.2131	115.770	185.6043

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.4.3 Thailand Level

With regards to the research questions about whether laxity in pollution control enforcements will attract for FDI inflows to Thailand, if it does in fact exist, then how much is the value of welfare impact if Thailand has stronger pollution controls relating to these inflows? So, a main objective in this study is to examine the relation between pollution control enforcements and FDI inflows to Thailand in both overview and by industrial groups. Because applying the same data set from the global level to Thailand's level has a low number of observations that estimates only the overview in relative terms between countries, hence reexamination using data set with details of firm level, could be better to explain foreign investors' behavior. The focused explanatory variable, RLAXPI, as explained in section 4.2.1.3 together with other control variables in relative terms as explained in section 4.2.2, are applied in estimations of Thailand's level.

Data of foreign investments at firm level was collected from Thailand's BOI during years 2009-2013 which was the period with less global data set for one year, but it expands to 3,285 observations which is much higher beyond 168 observations when compared with using global data set. Following the explanations in section 4.3.2.2, estimation and diagnostic results are shown in table 4.17; both time fixed effects in Model 5 and country fixed effects in Model 7 have significant results for the focused explanatory variable, RLAXPI. However, when industrial dummies were added into the models that aim to distinguish effects of each industry or for concurrent regressions across industries, the time fixed effects in Model 6 has found a heteroscedasticity problem while the country fixed effects in Model 8 has not. By this finding, it is to be said that models with country fixed effects would be better than time fixed effects even though they have less AIC value. Despite findings of countries fixed effects, it is necessary to check and compare with random effects regression in order to select the most appropriate model for Thailand's level.

Hausman's test for comparing fixed effects or random effects of Model 7 demonstrated a systematic difference in coefficient, then it emphasizes that the fixed effects model is better. The null hypothesis is rejected at 1% significant level, so the test results can be reported as follows;

H_0: difference in coefficients not systematic

Chi-square = $(\boldsymbol{B}_F - \boldsymbol{B}_R)'(\boldsymbol{V}_F - \boldsymbol{V}_R)^{-1}(\boldsymbol{B}_F - \boldsymbol{B}_R)$ = 30.55

Prob. > Chi-square = 0.0023

The Hausman test for comparing fixed effects or random effects with concurrent regressions across industries in Model 8 also demonstrated a systematic difference in coefficient, then it emphasized that the fixed effects model is better. The null hypothesis is rejected at 1% significant level that the test result can be reported as follows;

H_0: difference in coefficients not systematic

Chi-square = $(\boldsymbol{B}_F - \boldsymbol{B}_R)'(\boldsymbol{V}_F - \boldsymbol{V}_R)^{-1}(\boldsymbol{B}_F - \boldsymbol{B}_R)$ = 34.04

Prob. > Chi-square = 0.0083

Following the model selection procedures, the country fixed effects with concurrent regressions across industrial is the most appropriate due to significant results of the focused explanatory variable and significant difference in slope coefficients for four industries. Therefore, Model 8 was selected for the analysis of relation between pollution control enforcements and FDI inflows to Thailand.

Table 4.17 Estimations and Diagnostic Test Results for Thailand Level

VARIABLES	Model 5	Model 6	Model 7 Fix Effects	Model 7 Random Effects	Model 8 Fixed Effects	Model 8 Random Effects
	log FDI	log FDI	log FDI	log FDI	log FDI	log FDI
RLAXPI	0.0384***	0.0878***	0.0424***	0.0420***	0.113***	0.107***
	(0.0109)	(0.0323)	(0.0108)	(0.0108)	(0.0323)	(0.0321)
RENVITAX	0.0362**	0.0380**	-0.00570	-0.0730**	-0.00448	-0.0722**
	(0.0163)	(0.0164)	(0.0765)	(0.0368)	(0.0763)	(0.0315)
Rr	0.0285	0.0295	0.313***	0.129***	0.317***	0.0978***
	(0.0193)	(0.0192)	(0.0662)	(0.0400)	(0.0660)	(0.0339)
Rw	-0.187***	-0.204***	-0.326	-0.189*	-0.319	-0.206**
	(0.0678)	(0.0677)	(0.550)	(0.104)	(0.548)	(0.0929)
RTARIFF	0.0109***	0.0116***	-0.142*	0.00574	-0.135	0.00760
	(0.00173)	(0.00173)	(0.0829)	(0.00684)	(0.0827)	(0.00504)
RBUSET	-0.0354***	-0.0344***	-0.00134	-0.0297*	-0.00666	-0.0330***
	(0.00687)	(0.00686)	(0.0366)	(0.0156)	(0.0365)	(0.0125)
REXCOST	5.668***	5.561***	-0.837	-0.116	-0.800	0.388
	(0.767)	(0.769)	(1.130)	(0.852)	(1.127)	(0.813)
RIMCOST	-4.352***	-4.315***	0.186	-0.257	0.132	-0.633
	(0.624)	(0.625)	(1.229)	(0.766)	(1.225)	(0.706)
RROAD	-0.0630	-0.0733	-0.201	-0.129	-0.253	-0.130*
	(0.0456)	(0.0455)	(1.804)	(0.0809)	(1.798)	(0.0687)
RENERGY	0.000349**	0.000439***	0.00354	0.000373	0.00259	0.000356
	(0.000166)	(0.000169)	(0.00671)	(0.000499)	(0.00670)	(0.000380)
RWATER	-0.000248	-0.000257	-0.000321	-0.000359	-0.00231	-0.000366*
	(0.000196)	(0.000195)	(0.0301)	(0.000248)	(0.0300)	(0.000222)
RGDP	-0.000464	-0.000296	0.0166	0.00188	0.0199	0.00166
	(0.000992)	(0.000992)	(0.0353)	(0.00133)	(0.0353)	(0.00118)
YEAR 2010	0.315***	0.326***				
	(0.105)	(0.105)				
YEAR 2011	0.0324	0.0551				
	(0.114)	(0.113)				
YEAR 2012	0.560***	0.571***				
	(0.101)	(0.101)				
YEAR 2013	0.516***	0.532***				
	(0.103)	(0.103)				
RLAXPI x IND_1		0			0	0
(Agricultural)		(0)			(0)	(0)
RLAXPI x IND_2		-0.00278			-0.0228	-0.0187
(Minerals and Ceramics)		(0.0356)			(0.0355)	(0.0353)
RLAXPI x IND_3		-0.0747*			-0.0952**	-0.0878**
(Light Industries/Textiles)		(0.0404)			(0.0403)	(0.0400)
RLAXPI x IND_4		-0.0859**			-0.106***	-0.102***
(Metal Products and Machinery)		(0.0346)			(0.0345)	(0.0343)
RLAXPI x IND_5		-0.172***			-0.154***	-0.160***
(Electric and Electronic Products)		(0.0427)			(0.0425)	(0.0424)
RLAXPI x IND_6		-0.0753**			-0.0963***	-0.0909***
(Chemicals and Paper)		(0.0324)			(0.0324)	(0.0321)
Constant	3.316***	3.425***	5.513***	4.197***	5.658***	4.331***
	(0.193)	(0.196)	(1.953)	(0.324)	(1.949)	(0.281)
Observations	3,285	3,285	3,285	3,285	3,285	3,285
R-squared	0.121	0.128	0.014		0.022	
Number of CONID			65	65	65	65
Breusch-Pagan test for heteroskedasticity	Do not Reject	Reject	Do not Reject		Do not Reject	
Ho: Constant variance						
Chi Square	1.64	3.03	2.44		1.72	
Prob. Chi Square	0.1997	0.0818	0.1179		0.1895	
AIC	12698.17	12680.17	12584.81		12568.01	

Note: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.5 Discussion

4.5.1 Pollution Control Enforcements and FDI in the Globe

A time fixed effect with parallel regression model is the selected model for analysis at global level. Following the table 4.9, estimations and diagnostic test demonstrated in general during the period of years 2008 to 2013, there is significant evidence that the countries who had higher laxity in pollution control (or weaker in environmental control) enforcements will attract more FDI inflows. Individual countries which had increasing trends in the indexed laxity of pollution control (ILAX) for 1 point, will impact FDI inflows by an increase of 53.5%. In conclusion, relation between laxity in pollution control enforcements and increasing in FDI inflows had existed globally during that period. Considering the significance of intercept terms for all years, as the illustration of parallel regression shows in figure 4.1, without effects from explanatory variables the FDI inflows has a decreasing trend globally. There was a continuous decrease from years 2008 to 2010, then year 2011 had a little bit of an increase from year 2010 but reduced again in year 2012 and then increased in year 2013. The last five years however, never reversed back to the level of year 2008, which is consistent with FDI statistics shown in Chapter 2. According to FDI's decreasing trend in that global economic downturn period, investors would look for location or countries that have cost competitiveness, then the countries having characteristics of low pollution control enforcements would be in their focus. On the other hand, because of the economic downturn, countries would compete with each other to attracted more FDI inflows to its own country since there was a lower amount of investments in such a period, hence the laxity in pollution control enforcements was probably a choice made by host country's government.

Considering the variable IENVITAX which is a proxy of environmental tax, its value is indirectly measured by indicators that relate to value of the environment which would be the best possible choice to proxy for environmental tax, hence, if there is high value it implies that a country is willing to pay more for its environmental protection. Estimation results demonstrate that if the proxy of environmental tax index increases for 1 point, it will impact with an increase in FDI inflows by 5.71%. This finding is contrasting with the null hypothesis about more FDI inflows has relation with low pollution control enforcements; it looks like foreign investors have a willingness to pay for environmental care. This finding may have an effect on developed and high income countries that have huge proportions of FDI inflows as statistics show in Chapter 2 and are expected to have more environmental concerns. To re-emphasize, estimation of IENVITAX found in the entire global level, will be compared to the results when estimations are separated by regional and income groups.

Compare environmental tax with laxity in pollution control enforcements, since most of the pollution control indicators need physical measurements, then there are government's costs to monitoring and control, for example, to monitor CO2 emissions of all manufacturing plants it must install measurement tools and then require government agents to audit whether the plants have operations that follows these regulations. Because of the monitoring and control costs the governments have to pay, laxity in pollution control enforcements would then happen easier. Even though there are significant results of IENVITAX, its effect is nine times lower than the effects of ILAX. An analysis on the resulting contradictions of ILAX and IENVITAX would imply foreign investors have no objections to pay for environmental related costs, but if they found a choice in low pollution control enforcements countries that would be more beneficial to their investments then they would more likely to be influenced in such situations and thus invest in those countries.

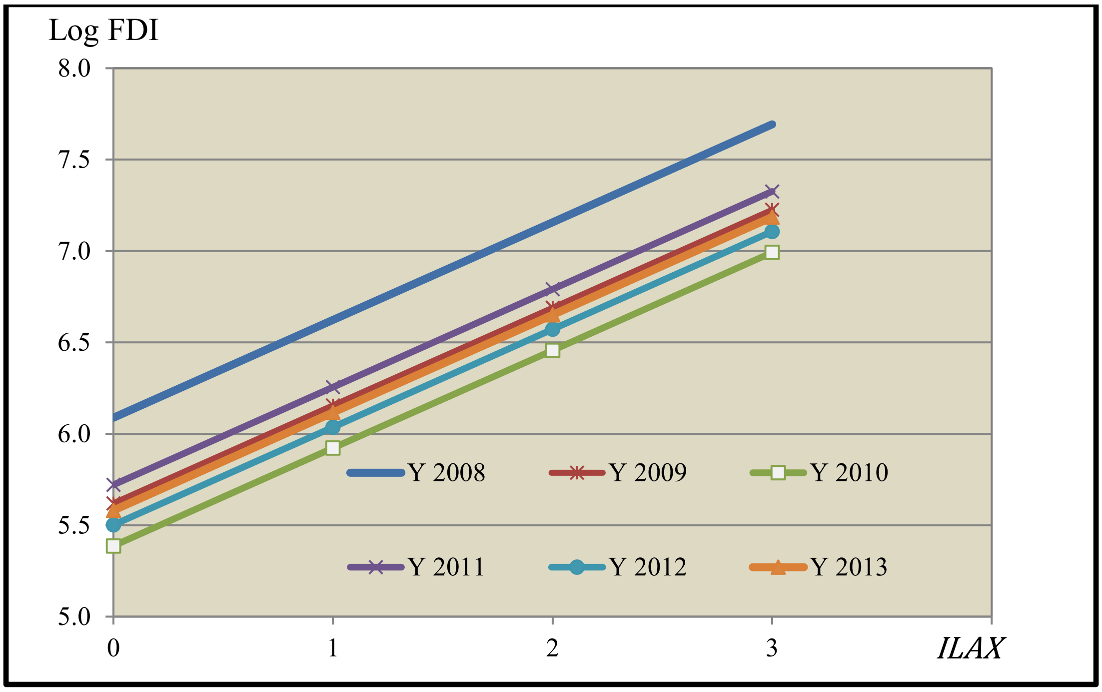

Figure 4.1 Relation of ILAX and Log FDI in Parallel Regression of Global Level

Estimations of the other ten control variables found mixed results both as expectations and differences from expectations, which is also either significant or insignificant. Four variables of the indexed capital price (Ir), the indexed cost of export goods (IEXCOST), the indexed cost of import goods (IIMCOST) and the indexed road density (IROAD), have insignificant results and then are ignored in discussion. Significance of the indexed labor wage (Iw) shows the higher the level of labor wage the higher the FDI inflows, this result is quite contrasting to the intuition that higher wages results in higher costs. It would need a reason like the investor's concerns for labor productivity rather than labor wages, then the higher productivity the higher wages, but because of its non-focused variable in this study such results would be re-evaluated in further studies. The indexed import tariff (ITARIFF) and the indexed cost of business set up (IBUSET) have significant results with negative signs as expectations. Both variables have direct relations to international trade and investment, the tariff has a direct impact to costs of buying goods and level of selling prices which is linked to the level of trade competition, hence, the higher degree of tariffs distract investors and then causes lower FDI inflows. Similar things occur once the cost of business set up is high because it is directly related to higher cost of investments.

Two variables of infrastructures have results both as expectations and contrast, the indexed energy abundant (IENERGY) shows a negative sign that means the higher the energy abundant the lower FDI inflow, which differs from expectations. Since energy is a major resource input of manufacturing, if the host country has an abundance of energy then its cost should be low and attract investors to invest and produce goods in the country. However, this bias from expectations may have a reason like the countries have energy abundance but they are lacking other resources to use as production input which results in lower investments. Therefore, this is one of the unanswered questions that require further study for whosoever may interested in this topic. The index water abundant (IWATER) is another infrastructure variable but its results have positive signs as expected. The abundant water resource in the host countries would secure long term production since water is a vital resource, and then this factor shall have positive impact on FDI inflows. The last significant variable in the indexed GDP (GDP) which is a basic variable used in the gravity liked model as in this study, according to theory, higher GDP in countries means a higher economy scale that attracts foreign trade and investments. Then the IGDP estimation with a positive sign is consistent with the theory.

The selected time fixed effect with parallel model is continually used in group analysis by regions of the country and income level for the number of countries in the group is shown in table 4.18. By regional and with estimation result in table 4.12, there are a total seven regions but North America has only 16 observations and South Asia has only 48 observations and these numbers are too low to estimate with panel regression, hence, discussions for both regions are ignored. Europe and Central Asia, Latin America and Caribbean, and Middle East and North African regions have insignificant results of indexed laxity of pollution control (ILAX) variable. While increasing the indexed laxity of pollution control (ILAX) for 1 point will cause significant increase of FDI inflows by 261% for East Asia and Pacific region and by 52.2% for Sub-Sahara African region. It is very interesting, the high impact of laxity in pollution control enforcements to FDI inflows in East Asia and Pacific region; since most of the members in the region are developing countries and some are emerging countries. Then we can make the claim that most of the countries in this region still enjoy benefit from higher FDI inflows while their pollution control enforcements still in low level. ASEAN countries, including Thailand, that are located in East Asia and the Pacific region will further be evaluated for whether similar results still exist. Members in the Sub-Saharan region are also developing countries where the low pollution enforcements reality still has relation with FDI inflows, but at a lower degree than East Asia and the Pacific region.

Not surprising and as expected is that the insignificant results of Europe and Central Asia regions were found, since there are a lot of developed country in those regions and the majority of these members are high income countries. Moreover, the results of IENVITAX are consistent with findings in the overall global level which will re-emphasize a no relation between pollution control enforcements and FDI inflows in this region. Latin America and Caribbean regions and Middle East and North Africa regions found no evidence of such relation. This finding is also not a surprise since the majority of members are high income and upper middle income countries that are expected to have either significant or insignificant results. For other control variables in the estimation by regions, in general, the results are similar to the findings of the overall global level and therefore detailed explanation was not discussed.

When looking at the estimations by income level for group of countries in table 4.13, Upper Middle income and Lower Middle income groups show significant impact of laxity in pollution control enforcements, each increase by 1 index point will cause an increase in FDI inflows by 28.3% and 76.8% respectively. These results are consistent with expectations, since members in both groups are developing countries. Two high income country groups for both OECD and non-OECD members found no evidence of the relation between low pollution control enforcements and more FDI inflows, as it is expected that when people or countries have higher income they will be more concerned about the environment. This is consistent to the results of IENVITAX which has significant positive signs like the results in overall global level, hence, it is to re-emphasize that there is no such relation in these groups in the high income category.

Low income groups also found no evidence of the relation between low pollution control enforcements and more FDI inflows which is a bias from estimations that the countries in these groups will need FDI inflows for their economic development and so would lower their levels of pollution control enforcements to create such attractiveness. In low income countries, estimations show that the GDP contributed a very high impact on FDI inflows in these low income groups, hence, in these groups of countries; other factors will overcome the investor's interests in the laxity in pollution control enforcements.

Table 4.18 Number of Country in Region and Income groups

Region	Income Group					
	High income OECD	High income non-OECD	Upper middle income	Lower middle income	Low income	Grand Total
East Asia & Pacific	4	9	9	12	3	37
Europe & Central Asia	23	11	12	6	1	53
Latin America & Caribbean	1	10	16	7	1	35
Middle East & North Africa	1	7	7	5		20
North America	2	1				3
South Asia			1	4	3	8
Sub-Saharan Africa		1	7	13	25	46
Grand Total	31	39	52	47	33	202

4.5.2 Pollution Control Enforcements and FDI in ASEAN Countries

The dissimilar regressions that have differences in year intercept and slope coefficient in Model 1-1 is selected for estimations of the ASEAN level. First estimations for ASEAN as a whole is shown in table 4.15 and demonstrates a significant impact of pollution control enforcements to FDI inflow, every increase of 1 point of indexed laxity of pollution control (ILAX) increased FDI inflows to ASEAN by 378.8% in the year 2008. For the five following years, the relation is calculated by slope coefficient of ILAX in year 2008 less 211% and then resulted in 1 point of indexed laxity of pollution control (ILAX) that increased FDI inflows to ASEAN by 167.8% in year 2009; less 142.4% and then resulted in an FDI increase by 236.4% in year 2010; less 182.4% and then resulted in an FDI increase by 196.4% in year 2011; less 162.7% and then resulted in an FDI increase by 216.1% in year 2012; less 157.8% and then resulted in an FDI increase by 221% in year 2013. These results are plotted in figure 4.2, the impact of laxity of pollution control enforcements to FDI inflows in ASEAN has dramatically decreased from years 2008 to 2009, but showed a small difference for the following five years. However, the impact in the ASEAN region stands to have a higher impact level when compared with estimation results of regional groups in the previous sections. Besides the effect of laxity in pollution control enforcements, there are high significant amount of FDI inflows to the ASEAN region every year during the period of 2008 to 2013, which is indicated by intercept term.

IENVITAX which is a proxy of environmental tax has significant results with negative signs; this would be explained that if the indexed environmental tax has an increase for 1 point it will impact FDI inflows by 8.98% decrease. This finding is different from the findings in the Global level but consistent with the null hypothesis about more FDI inflows has relation with low pollution control enforcements. As presented in table 4.14 most of the ASEAN countries are in the Upper Middle Income and Lower Middle Income groups, but results of IENVITAX of these two groups, as shown in table 4.13, have insignificant positive signs and significant positive signs respectively. It also has significant positive signs for IENVITAX East Asia Pacific region as shown in table 4.12. Since ASEAN is a sub region of the East Asia Pacific and most are Upper Middle Income and Lower Middle Income countries, then those different results of IENVITAX will emphasize a specific of such relation that happened in ASEAN during the years 2008 to 2013.

Considering other control variables, the estimation shows that only indexed road intensity (IROAD) and indexed energy abundant (IENERGY) have significant results. Both are consistent with expectations, the higher the road intensity the more FDI inflows and the higher the energy abundance the more FDI inflows. Level of GDP is an also an important factor, while making estimations for the overall global level, by regional and by income levels, shown is significant positive results but it is a surprising result for the ASEAN region that GDP has no effect. These findings also emphasize that the FDI inflows to ASEAN is greatly affected by environmental related factors.

Second estimation is separate regressions for ten countries in ASEAN and change from index to relative variables that aims to examine how individual home countries consider each host ASEAN country in order to make their investment decisions. Following the results in table 4.16, there are different impacts of laxity in pollution control enforcements to FDI inflows for each country. Significant results of relative laxity pollution control enforcements (RLAX) appear for Singapore, Vietnam and Laos; they have negative signs which mean a lax in pollution control enforcements will detract FDI inflows to those countries. Surprisingly, for Vietnam and Laos, who are in the Lower Middle Income country group, have the sign differing from the whole group in estimations of global levels. Singapore which is a high income country has results in a similar way of the entire group so if we think back to the global analysis by income groups, there are also negative signs of ILAX coefficient for all high income group countries even if there is insignificant results. There are insignificant impacts of RLAX, which is different from expectations, in countries like Thailand, Indonesia, Malaysia and Philippines who are competitors for attracting FDI inflows to their host country.

Unlike the results of the entire ASEAN group, the relative environmental tax (RENVITAX) variable is significant only for Vietnam but with positive signs. There are mixed results of other control variables including the relative GDP (RGDP) that differs across countries, however, those variables are not the focus of this study and therefore these discussions on results are ignored.

The results of no relation between low pollution control enforcements and more FDI inflows in individual countries, requires more investigation with in-depth details. Low numbers of observations used for individual countries is a factor for estimation results; therefore, in case of Thailand, which is the focus in this study, we will continue to do estimations with more observations from BOI's data set. While the other countries are out of the scope of this study, it is a great area for further future studies for those whom have an interest this subject.

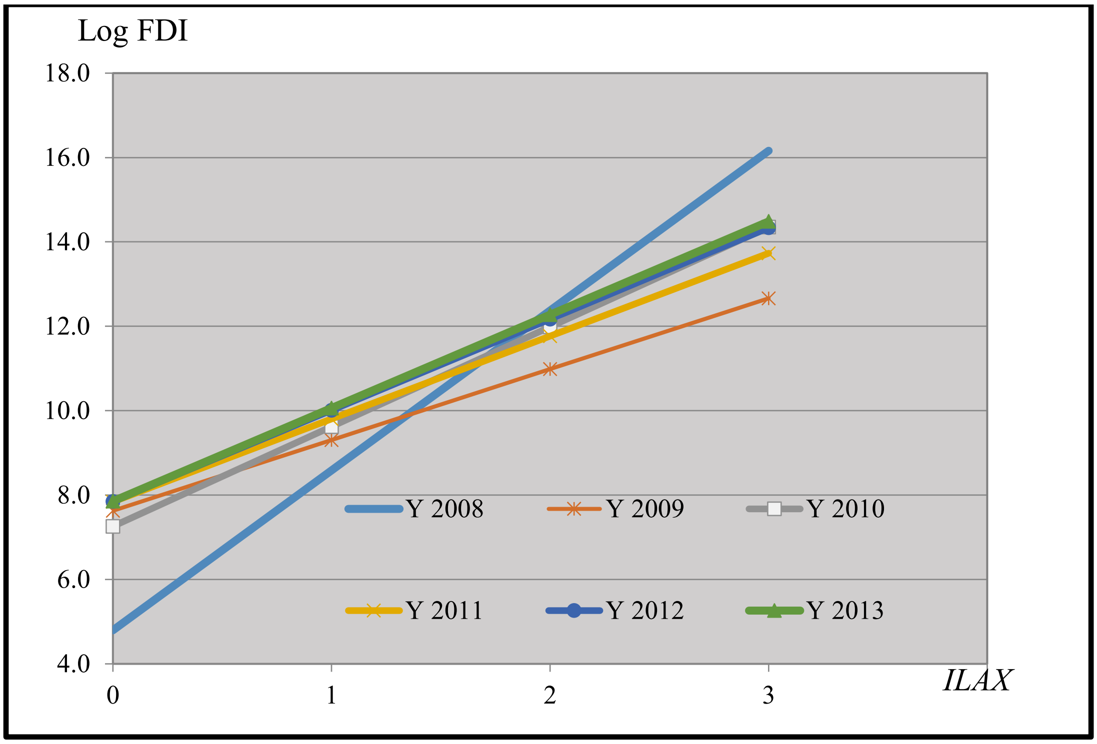

Figure 4.2 Relation of ILAX and Log FDI in Dissimilar Regression of ASEAN Level

4.5.3 Pollution Control Enforcements and FDI in Thailand

The country fixed effects with concurrent regressions across industries in Model 8 is selected for the analysis of the relation between pollution control enforcements and FDI inflows to Thailand. Following to the results in table 4.17, during years 2009 to 2013, when relative pollution control enforcements for industrial activity (RLAXPI) increases for one point, FDI inflows to Thailand in the Agricultural Industry will increase by 11.3%. For the five following industry groups, the relation is calculated using slope coefficient of RLAXPI of Agricultural Industry as a base line. Then the impacts of the other five industry groups are, insignificant increasing in FDI inflows to the Mineral & Ceramic industry by 9.02% (calculate from 11.3% minus 2.28%); significant increase to FDI inflows to Light Industries & Textiles industry by 1.78% (11.3% minus 9.52%); significant increase in FDI inflows to Metal Products and Machinery industry by 0.7% (11.3% minus 10.6%); significant decrease in FDI inflows to Electric & Electronics industry increase by 4.1% (11.3% minus 15.4%); and back to significant increase in FDI inflows to the Chemical & Paper industry by 1.67% (11.3% minus 9.63%). Those findings about the relation of RLAXPI to FDI inflows is depicted in figure 4.3 for a concurrent regression by industry groups.

RENVITAX which is a proxy of relative environmental tax of Thailand to the home countries, has insignificant results with negative signs and very low value; this would be explained that foreign investors were not concerned with the amount of environmental tax, if the Thai government asked them to pay. However, since there is no data on real environment tax and the variable is calculated from a proxy data, it would be biased from the real situation, either way; it is not a focus variable in the scope of this study. According to other control variables, only relative capital price (Rr), that represents interest rate of Thailand, compared to the home countries, has significant results with positive signs. It is reasonable, since higher interest rates in Thailand will burden local investments, and then if the Thai government still needs investments to expand the country's economy, investments from abroad would be promoted for such an increase, as a substitution for local investment. Another important variable about levels of GDP (RGDP) has similar results to estimations from the entire ASEAN region with the global data set. These findings of insignificant results for RENVITAX, RGDP and most of the other control variables, meanwhile, shows significant results of RLAXPI for five of six industries emphasizing that relative pollution control enforcements for industrial activities have a high impact to FDI inflows in Thailand. It is to be said that in general the relation between low pollution control enforcements and more FDI inflows still existed in Thailand during the years 2009 to 2013 and would be the same for future trends.

Thailand has 85 major regulations for water and air pollution as explained in Chapter 2, but the findings tells us that stringent implementation or enforcements has an effect that says, the more laxity the more FDI inflows. Then the government should therefore be concerned about quality rather than the quantity of the environmental laws and regulations. However, the cost to implement stringent pollution control enforcements would be high for a developing country like Thailand, so while some degree of laxity can induce more FDI inflows to expand the country's economy, such that trade-off between the benefits of FDI inflows and costs of stringent pollution control enforcements is another one topic that shall not be overlooked.

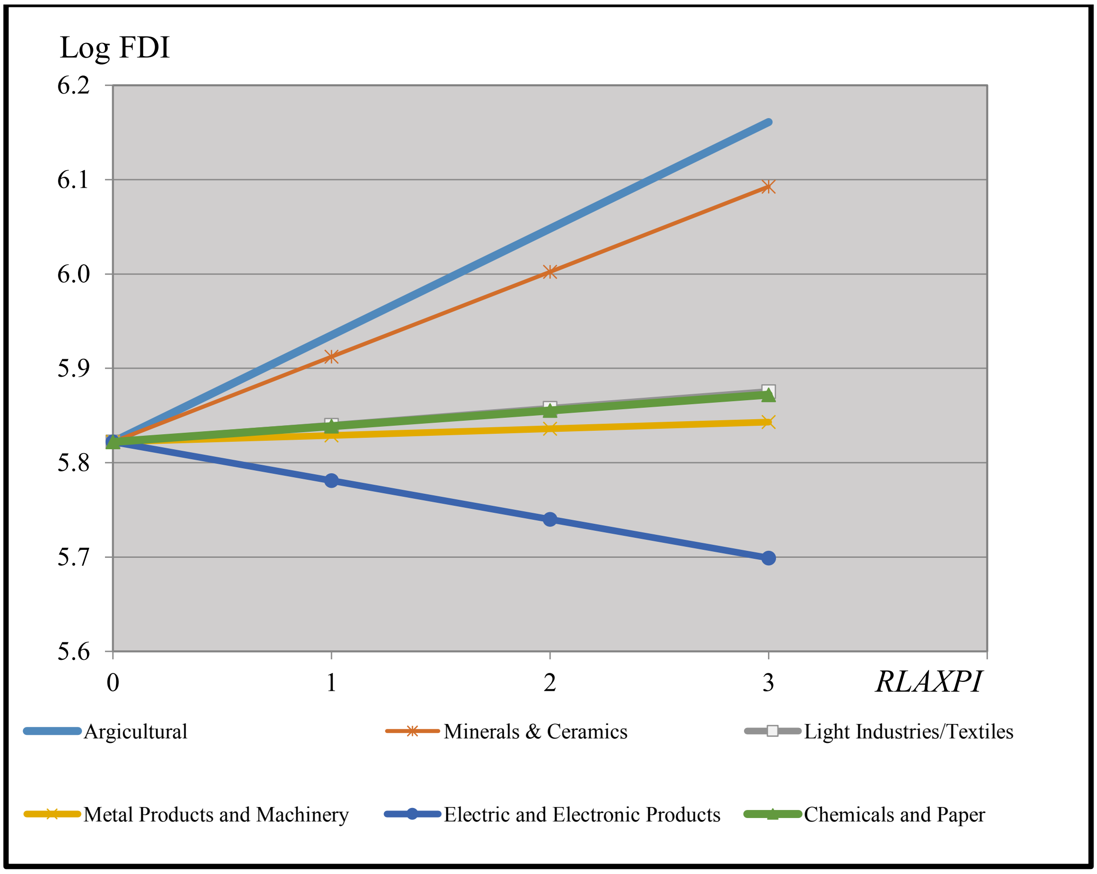

Figure 4.3 Relation of RLAXPI and Log FDI in Concurrent Regression of Thailand

CHAPTER 5

A WELFARE INVESTIGATION IN THAILAND

The second economic problem in this study is about welfare gains and losses which are the consequential effects from change in FDI inflows caused by the degree of pollution control enforcements. Although examinations by econometrics methodology demonstrates the significant results of low pollution control enforcements that attracts more FDI inflows, those could not affirm the holistic increase in welfare for the host country. Economic agents' income change and macro change in a country's aggregate consumption, exports, imports and GDP are major welfare investigation areas to determine whether the host country will gain or lose from more FDI inflows. This study specifically focuses on welfare analysis in the case of Thailand, it begins with the Social Accounting Matrix and CGE model structures that provides the economic framework for the welfare analysis; followed by detailed equation systems, variables descriptions, parameters calibrations, results and discussions.

5.1 Social Accounting Matrix and CGE Model Structure

5.1.1 Social Accounting Matrix (SAM)

The general concept and data base for computable general equilibrium are followed to Levin (2006); Anan Wattanakuljarus (2015), while the Social Accounting Matrix (SAM) for Thailand in the year 2005 is considered as the main data source. The SAM was constructed in accordance with multiple economic data provided by the Office of the National Economic and Social Development Board (NESDB), Thailand. This study modifies the original SAM by grouping the production from 79 sectors into 7 sectors according to BOI's categorization as described in section 4.3.2.2, incomes and expenditures from foreign tourists which was separately distributed to each sector are included and then grouped into 7 sectors to consolidate the value of imports and exports.

Table 5.1 shows the SAM structure that indicates variables' sub matrix which will be used in the CGE model. Each cell in the matrix shows payment from the account or economic agents in its column to the account or economic agents in its row. Therefore, the total value of each row indicates output and composite demand of goods and services in the case of activity and production accounts; and indicates incomes of other economic agents. While the total value of each column indicates activity input supply and composite supply of goods and services in the case of activity and production accounts, and indicates expenditures of other economic agents. Total value in the column must equal to the total value in the row, for the equilibrium in SAM.

According to SAM's structure, there are three sub matrices of activity-production, including the factor matrix of labor and capital which is a production factor called value added; the input-output matrix of intermediated goods and services that are used as a production factor; and the third one is the production output matrix. In this SAM, there are no sub details of other taxes, such as value added tax or excise tax or import tax; it is only one consolidated tax, and both domestic productions and imports from rest of the world will be paid to the government. Therefore, in the area of consumption and trade, the composite supply is the aggregate column value of production outputs plus import, plus tax on production, and the row value that is composite demand comprises of intermediate output consumption, household consumption, government consumption, investments and export. For the factor part, column cells are all incomes from factor and of row cells are value added. About taxes, column cell is tax revenue while row cells are value of tax on production, household tax and corporate tax. In household part, column values comprise of sum of consumption of five household groups, their income tax, spending for domestic transfer and saving, and the household row values consist of income from labor and capital factors, receiving from domestic transfers and from foreign transfers.

Moving to the institution part, corporate expenditure value in column cells are corporate income tax, spending for domestic transfers and its savings, while its receipt in row cells are income from capital factor, receiving from domestic transfers and from foreign transfers. Government expenditures include government consumption of seven industry sectors, spending for domestic transfers and government savings. For the income side in row cell, they consist of government income from the capital factor, tax revenue, receiving from domestic transfers and from foreign transfers. In the investment area-saving block, domestic investments that consume goods and services from seven industrial sectors plus other savings and investments abroad will equal to the sum of row value from household savings, corporate savings, government savings and other savings. The last one is the rest of the world (ROW), exports plus total foreign transfers and ROW transactions in column cells is equal to import plus investment abroad and ROW transactions. By equalization of column and row value, it is able to construct the equation system to use in CGE. Despite explanation of the Sam structure, actual numerical in billion Baht that entered in the year 2005 Thailand's SAM are presented in table 5.2.

Table 5.1 Social Accounting Matrix (SAM) Structure Used in the CGE Model

		Expenditures											
		Activity	Commodity	Factors		Taxes on		Household	Institutions		Investment	ROW	Total
Receipts				Labor L	Capital K	Products	Incomes		Corporate	Government			
Activity			Gross Output										Output (X)
Commodity		Intermediate Input, Output						Household Consumption		Government Consumption	Investment	Export	Composite Demand
Factors	**Labor (L) Capital (K)**	Value Added											
Taxes on	**Products**		Tax on Production										
	Income							Household Income Tax	Corporate Income Tax				
Household				Income from Factor					Corporate-Household internal transfer	Government-Household internal transfer		Foreign transfer to Household	
Corporate				Income from Factor				Household-Corporate internal transfer				Foreign transfer to Corporate	
Government				Income from Factor		Tax Revenue		Household-Government internal transfer	Corporate-Government internal transfer			Foreign transfer to Government	
Saving								Household Saving	Corporate Saving	Governmen t Saving	Other Saving		
ROW			Import								Investment Abroad	ROW transaction	
TOTAL			Composite Supply										

Table 5.2 Numerical for Year 2005 Thailand' SAM in Billion Baht for Activity Expenditures

		Activity							
		1. Agricultural Products	2. Minerals and Ceramics	3. Light Industries/ Textiles	4. Metal Products and Machinery	5. Electric and Electronic Products	6. Chemicals and Paper	7. Services	Intermediate
Activity	1. Agricultural Products								
	2. Minerals and Ceramics								
	3. Light Industries/Textiles								
	4. Metal Products and Machinery								
	5. Electric and Electronic Products								
	6. Chemicals and Paper								
	7. Services								
	Intermediate domestic								
Commodity	1. Agricultural Products	1,004.7	0.0	280.9	4.6	0.0	30.6	331.6	1,652
	2. Minerals and Ceramics	2.5	72.5	8.8	41.5	15.2	739.3	417.8	1,298
	3. Light Industries/Textiles	5.9	3.5	438.0	73.3	10.0	19.6	228.9	779
	4. Metal Products and Machinery	65.8	29.0	78.6	1,574.5	197.4	30.8	330.1	2,306
	5. Electric and Electronic Products	1.4	1.0	1.2	98.3	1,398.0	1.3	132.0	1,633
	6. Chemicals and Paper	151.8	83.6	186.2	148.5	85.6	804.4	967.4	2,428
	7. Services	284.9	104.5	328.8	375.3	247.9	252.2	1,849.6	3,443
	Intermediate domestic	1,517	294	1,323	2,316	1,954	1,878	4,257	13,539
Factors	Labor (L)	353.9	79.5	191.0	208.3	120.4	142.9	1,633.4	2,729.4
	Capital (K)	823.4	218.3	330.9	431.5	244.3	742.9	2,344.9	5,136.2
Taxes on	Products								
	Income								
Household	HH 1 (0%-20%)								
	HH 2 (20%-40%)								
	HH 3 (40%-60%								
	HH 4 (60%-80%)								
	HH 5 (80%-100%)								
Corporate									
Government									
Saving	Public								
	Private								
	Inventory								
ROW									
TOTAL		2,694.3	591.9	1,844.4	2,955.8	2,318.8	2,764.0	8,235.7	21,404.9

Table 5.2 (Continued)

		Commodity							
		1. Agricultural Products	2. Minerals and Ceramics	3. Light Industries/Textiles	4. Metal Products and Machinery	5. Electric and Electronic Products	6. Chemicals and Paper	7. Services	Intermediate
Activity	1. Agricultural Products	2,694.4							2,694
	2. Minerals and Ceramics		591.8						592
	3. Light Industries/Textiles			1,844.5					1,845
	4. Metal Products and Machinery				2,955.8				2,956
	5. Electric and Electronic Products					2,318.8			2,319
	6. Chemicals and Paper						2,763.7		2,764
	7. Services						0	8,235.8	8,236
	Intermediate domestic	2,694.4	591.8	1,844.5	2,955.8	2,318.8	2,763.7	8,235.8	21,405
Commodity	1. Agricultural Products								
	2. Minerals and Ceramics								
	3. Light Industries/Textiles								
	4. Metal Products and Machinery								
	5. Electric and Electronic Products								
	6. Chemicals and Paper								
	7. Services								
	Intermediate domestic								
Factors	Labor (L)								
	Capital (K)								
Taxes on	Products	34.1	29.8	104.9	45.4	14.7	150.5	210.7	590.1
	Income								
Household	HH 1 (0%-20%)								
	HH 2 (20%-40%)								
	HH 3 (40%-60%								
	HH 4 (60%-80%)								
	HH 5 (80%-100%)								
Corporate									
Government									
Saving	Public								
	Private								
	Inventory								
ROW		216.4	834.0	230.2	1,835.5	1,291.7	892.1	334.7	5,634.6
TOTAL		2,944.9	1,455.6	2,179.6	4,836.7	3,625.2	3,806.3	8,781.2	27,629.5

Table 5.2 (Continued)

		Factors		Taxes on		Household					
		Labor	Capital	Products	Incomes	HH 1 (0%-20%)	HH 2 (20%-40%)	HH 3 (40%-60%	HH 4 (60%-80%)	HH 5 (80%-100%)	HH Total
Activity	1. Agricultural Products										
	2. Minerals and Ceramics										
	3. Light Industries/Textiles										
	4. Metal Products and Machinery										
	5. Electric and Electronic Products										
	6. Chemicals and Paper										
	7. Services										
	Intermediate domestic										
Commodity	1. Agricultural Products					106.0	121.2	132.3	137.8	173.6	670.9
	2. Minerals and Ceramics					0.7	1.1	0.9	1.1	9.8	13.6
	3. Light Industries/Textiles					44.4	66.6	87.7	118.2	270.8	587.7
	4. Metal Products and Machinery					10.0	14.4	26.9	53.3	242.7	347.3
	5. Electric and Electronic Products					12.2	16.2	18.8	24.4	58.2	129.8
	6. Chemicals and Paper					25.6	37.2	53.8	83.2	157.2	357.0
	7. Services					169.5	262.4	467.8	523.4	871.1	2,294.2
	Intermediate domestic					368.4	519.1	788.2	941.4	1,783.4	4,400.5
Factors	Labor (L)					0	0	0	0	0	0
	Capital (K)					0	0	0	0	0	0
Taxes on	Products					0	0	0	0	0	0
	Income					10.7	18.2	26.5	40.5	94.6	190.5
Household	HH 1 (0%-20%)	104.7	146.7								
	HH 2 (20%-40%)	273.2	221.5								
	HH 3 (40%-60%	537.7	287.5								
	HH 4 (60%-80%)	657.3	386.2								
	HH 5 (80%-100%)	1,156.5	795.4								
		2,729.4	1,837.3								
Corporate			2,675.2			7.00	10.20	13.60	19.70	38.30	88.8
Government			623.6	590.1	633.2	0.30	0.50	0.70	1.00	2.40	4.9
Saving	Public										
	Private					25.30	50.00	113.1	205.2	407.6	801.2
	Inventory										
ROW											
TOTAL		2,729.4	5,136.1	590.1	633.2	411.7	598.0	942.1	1,207.8	2,326.3	5,485.9

Table 5.2 (Continued)

		Institutions		Investment			ROW	TOTAL
		Corporate	Government	Public	Private	Inventory		
Activity	1. Agricultural Products							2,694.4
	2. Minerals and Ceramics							591.8
	3. Light Industries/Textiles							1,844.5
	4. Metal Products and Machinery							2,955.8
	5. Electric and Electronic Products							2,318.8
	6. Chemicals and Paper							2,763.7
	7. Services							8,235.8
	Intermediate domestic							21,404.8
Commodity	1. Agricultural Products		9.7	0.2	1.8	12.1	597.6	2,944.7
	2. Minerals and Ceramics		0.5	1.3	9.0	-2.5	136.0	1,455.5
	3. Light Industries/Textiles		3.4	5.7	40.7	11.6	751.1	2,179.4
	4. Metal Products and Machinery		24.9	114.7	820.1	-32.9	1,256.6	4,836.9
	5. Electric and Electronic Products		4.8	63.3	453.0	-16.8	1,357.9	3,625.2
	6. Chemicals and Paper		59.3	0.3	2.3	38.4	921.6	3,806.4
	7. Services		991.6	121.6	870.0	0.7	1,059.9	8,781.2
	Intermediate domestic		1,094.2	307.1	2,196.9	10.6	6,080.7	27,629.3
Factors	Labor (L)							2,729.4
	Capital (K)							5,136.2
Taxes on	Products							590.1
	Income	442.7						633.2
Household	HH 1 (0%-20%)	37.4	107.9				15.0	411.7
	HH 2 (20%-40%)	58.7	30.4				14.0	597.8
	HH 3 (40%-60%	85.6	8.3				23.1	942.2
	HH 4 (60%-80%)	130.9	6.2				27.0	1,207.6
	HH 5 (80%-100%)	305.9	4.2				64.2	2,326.2
		618.5	157.0				143.3	5,485.5
Corporate							171.4	2,935.4
Government		5.5	0.0				6.4	1,863.7
Saving	Public		612.3					612.3
	Private	1,868.7						2,669.9
	Inventory			4.2	6.5			10.7
ROW				301.0	466.4		1,543.4	7,945.4
TOTAL		2,935.4	1,863.5	612.3	2,669.8	10.6	7,945.2	79,645.9

5.1.2 CGE Model Structure

The CGE model in this study combines four disaggregate portions of activity-factors-production markets, commodity markets, institutions, and macroeconomics balances and system constraints that are constructed into a single model as depicted in figure 5.1.

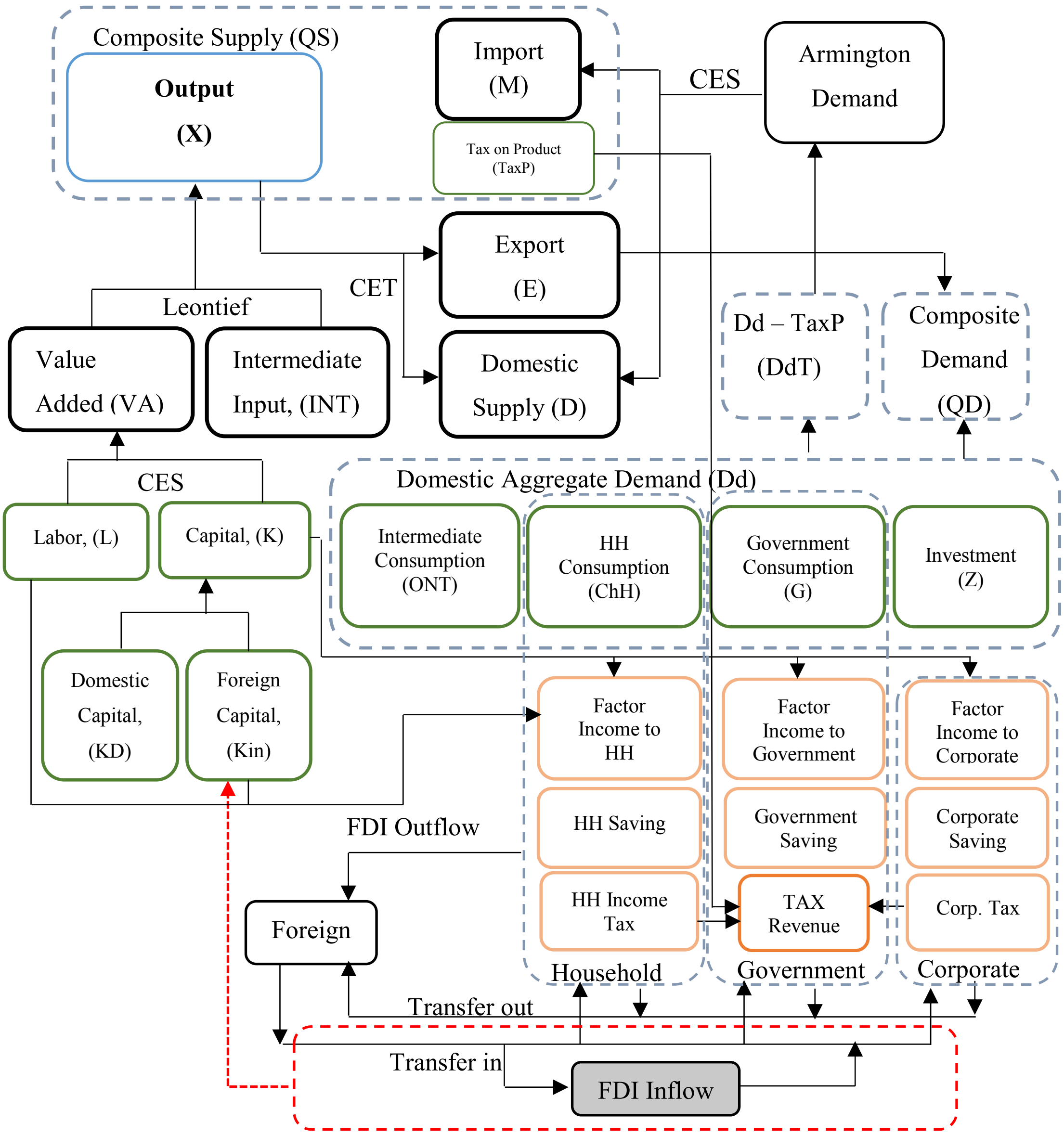

Figure 5.1 CGE Model Structure

5.1.2.1 Activity-Factor-Production Market

The top production technology is specified to a Leontief production function of the value added and intermediate input and assume that all seven industrial sectors use this same technology. The producer is assumed to maximize their profits subject to the production technology, in Leontief technology proportion between value added and intermediate input is linear fixed, however in another study it may use constant elasticity of substitution technology (CES) which are non-linear proportions of inputs. Each commodity is produced by one or more activities and each activity can also produce one or more commodities. The value added is specified to a constant elasticity of substitution (CES) function between primary factors of labor and capital. The producer can alternatively choose those primary factors according to elasticity and parameters of each industrial's CES function. Total value of primary factors used for CES value added is equal to sum of income from factor of household, corporate and government. It is to be noted that only household receive income from both primary factors while corporate and government receive only from capital factors.

The heart of an investigation of the welfare effect from change of FDI inflows according to pollution control enforcement levels is, the capital factor supply for production activities, all following assumptions are crucial for CGE model in this study. Total capital is divided into two sources, domestic capital supply and foreign capital supply, and then the capital data is modified from original data SAM. All foreign transfers to households, corporate and government plus FDI inflows are total supply to foreign capital with proportional distribution to seven industrial sectors. The proportion of foreign capital supply is assumed as a time invariant that calculated from each sector's capital divide by total capital used in year 2005 SAM. Consequently, the values of foreign capital supply of each sector are calculated by total foreign transfer into the country multiply by sector's proportion and then plus FDI shock. When the country is faced with FDI shock, which is an effect from pollution control enforcements, total capital in value added CES will also be changed, value added as a factor of Leontief production is also changed and production output change accordingly. This is a supply driven CGE model which equilibrium calculation starts from the supply side, one production output change, the value of domestic consumption, investments and exports would be changed. Changes of production outputs and its sales together with a capital supply change would also affect the changes in the income of economic agents which is one aspect of welfare to be investigated.

5.1.2.2 Commodity Market

Commodity market in this CGE model begins from production output which is allocated between sale in domestic supply and export with the assumption of maximizing sales revenue subject to constant elasticity of transformation (CET) function. Export plus domestic aggregate demand which comprises of intermediate output consumption, household consumption, government consumption and investment is expressed as the composite demand. In equilibrium, composite demand is equal to composite supply which includes production output and import from rest of the world plus tax on production of both domestic output and import. According to SAM structure mentioned in previous sections; the model has no detailed data of other taxes such as value added tax or excise tax or import tax, then all taxes are assumed including the tax on production. The domestic aggregate demand faces with composite prices while exports are given at the world prices but the seller will receive it in the local currency in Thai Baht, hence the currency exchange rate is one factor that affects revenue from exports.

Considering value of domestic aggregate demand which gives less tax on production, it expresses the pure aggregate domestic demand where consumers would minimize their cost subject to imperfect substitutability of domestic supply and imports. This minimization problem is captured by constant elasticity of substitution (CES) function or so called Armingtion function which refers to Armington (1969) who introduced imperfect substitutability between imports and domestic commodities in this economic model. Similar to exports, the imports are given at the world prices but the domestic consumers will purchase imported goods and services with local the currency in Thai Baht and then the exchange rate would affect import prices. Since pure import price that has no tax on production is one of factors for consumers to make decisions according to Armington’s function, then domestic goods as another factor is also valued without tax on production as well.

Following the data in SAM used in this study, there are no data for import and export tariffs which will be used in the equation of import and export prices; then both tariffs will be set to zero value. However, both tariff rates still be expressed in the price equation with regards to theory. Although there are no tariff rates, results in this analysis is absolutely valid because of other variables in the import and export price equations that consists of exchange rates and world prices which defines their value to more than or equal to one.

5.1.2.3 Institutions

Institutions in the CGE model are represented by households, corporate, the government, and rest of the world. Household in this study is disaggregated to five groups, each represents for 20% of total household. According to data in SAM, the first household is the bottom poorest whose income share is only 7.5% while the second group for 20% of household is the poor whose income share is 10.9%. There are two middle households; the third group is lower middle income household whose income share is 17.2% and the fourth group is upper middle income household whose income share is 22.0%. The richest is group number five whose income share is 42.4%. Primary household income is the income from labor and capital factors; however, there are secondary incomes from receiving transfers within institutions. The household will pay for income tax which is assumed to apply only for primary income from factors, while secondary income will pay no taxes. The household also save, spend, and transfer to other institutions. Aggregate household income less tax savings and transfer spending will equal to household consumption.

The government collects household income tax and corporate tax for its tax revenue while other government incomes are from capital factors and receiving of transfers within institutions. Government spending includes government consumption, its saving and spending to transfer to other institutes. Corporate receive income for capital factor and receives transfers within institutions, while its expenditures includes corporate tax, saving and spending for transfer to other institutes. In this model, it is assumed that FDI is directly distributed to corporate capital as a factor input production activity.

The last institution is the rest of the word or foreign sectors, the foreigner consumes exports and supply imports in commodity markets. Export is a foreign expenditure paid to the country while import is its income, foreign transfers to other institutions are foreign expenditures and transfers from other institutions to foreign, is foreign received. FDI is one kind of foreign transfer to other institutions; in this study, it is assumed to directly be transferred to corporate. The reason of this concept is that corporate directly uses capital for production activities but the government and households spend their own capital, with no FDI, both directly to production activities and through corporate. Because the original SAM was constructed to analyze tourism economics and has a little modification to be used in this study by combining all tourism transactions according to foreign investments, therefore it is a special named ROW transaction in the SAM used in this study which aims to keep all data as balanced as the original SAM.

5.1.2.4 Macroeconomics Balances and System Constraints

Three macroeconomics balances consisting of the government budget balance, Investment-Saving balance and Balance of payment, and eight system constraints are included in this CGE model structures and in equation system. The government income from tax revenue includes income from capital factor and transfer received from other institutes is equal to government expenditures for its consumption, saving and transfers to other institutions. Tax revenue from fixed rate on production, household and corporate income; income from capital factor with fixed proportions, and saving with the fixed rates are endogenous while fixed government consumption and all transfers are exogenous variables.

In Investment-Saving balance, domestic investment, consumer goods and services from seven sectors with fixed proportions, the investments abroad are also fixed but its value in Thai Baht currency can be changed due to the exchange rate. There are values for public and private investments for inventory in the original SAM but are combined and named as other saving in this study due to the need to simplify and reduce the number of variables used in the equation system. Therefore, total investment includes domestic investments, investments abroad and other savings. For the saving side, the aggregate saving includes household savings, corporate savings, and government savings that all have fixed saving rates and are declared as endogenous variables, plus other savings which are fixed and declared as exogenous variables. The last macroeconomics balance is balance of payment comprised of current account and capital account, the balance of payment in the country is always zero. The current account is value of exports minus imports that shows the trade balance, in this account exports and imports are endogenous variables. For the capital account, it is the sum of net foreign transfers including FDI and ROW transactions minus investments abroad and then minus ROW transactions again. All variables in capital accounts are exogenous except exchange rate which is endogenous and affect the value of capital account in Thai Baht currency.

Eight system constraints are flowing to columns and rows in SAM will have short explanation in this section because all will be expressed in the equation system. The first is total intermediate inputs for all seven sectors are equal to total intermediate output consumption of all sectors. Second is activity constraint that sum of value added and intermediate input for each activity is equal to value of each commodity output. Third is commodity constraint composite supply of each sector is equal to composite demand of each sector. Fourth is labor constraint that sum of household income from labor factor is equal to total value of labor supply. Fifth is capital constraint that sum of household income from capital factor and corporate and government income from capital factor is equal to value of total capital supply. Sixth is tax constraint where the tax revenue must equal to tax on production plus household and corporate income tax. Seventh is household constraint that Aggregate household income less tax, savings and transfer spending will equal to household consumption. Eighth is corporate constraint which is the corporate income from capital factor plus transfer received from other institutions is equal to corporate income tax plus spending for transfers to other institutions and plus corporate savings.

In the CGE calculation of this study, it is to be noted that all fixed rates, the fixed endogenous and exogenous values described in aforementioned are the base year value except the shock of FDI which is unfixed according to the effect from level of pollution control enforcements that Thailand will apply.

5.2 Mathematical Model Statements

The CGE model used in this study is applied with some modifications from various reference models. The major reference is the standard model in the General Algebraic Modeling System GAMS developed by Lofgren et al. (2002) for International Food Policy Research Institute and the second source is referenced from the study by Wethang Phaungsap et al. (2008). The Model in both reference sources are quite similar, the first one was developed to study the impact of trade policies and macroeconomics issues while the second was the extended model to study the impact of capital flows to macroeconomics issues and household income. The third reference is the simple model introduced by Devarajan, Go, Lewis, Robinson and Sinko (1998) which can solve for the equilibrium by using Microsoft Excel, even though this model focuses only in macro view of the whole country with no narrow down details to the commodity sectors and household, but it is still useful for applying programming methodology in Microsoft Excel. The fourth reference from Peng (2009) is also a simple CGE model using Microsoft Excel to solve the problem; this model includes production factors and details to welfare change of household which is an additional point when compared to Devarajan et al. (1998).

The mathematical models used in this study are stated equation by equation in this chapter. Since the SAM is square and balance of data, then it is necessary that the number equation must equal to or gather than the number of endogenous variables; and this study complies with such conditions. Total equations are divided into four blocks of price, production and trade, institutions, and system constraints. For avoidance of confusion with the equations in previous chapters, all variables as well as parameter notations stated in this CGE mathematical models are used in Latin letters instead of the Greek letters, where the principal is explained in table 5.3.

Table 5.3 Notation Principle Used in CGE Mathematical Models

Item	Notation
Endogenous Variables	Upper-case Latin letters without a bar
Exogenous Variables	Upper-case Latin letters with a bar
Parameters	Lower-case Latin letters without a bar
Set Indices	Lower-case Latin letters as subscripts to variables and parameters

5.2.1 Price Block

To reduce complexity in calculation, prices in this study are considered as a price level and assume all commodities are faced with same price level. The base prices are set equal to one, then prices in the new equilibrium according to FDI shock would either be more or less than one and their differences are percentage change. Equations in price block are linked to other prices, currency exchange rate and other endogenous variables in commodity markets. Equations in the price block are stated as follows.

Import Price

$$PM = ER \cdot wm \cdot (1 + tm) \qquad (5.1)$$

where

PM	import price in local currency, Thai Baht
ER	exchange rate in local per foreign currency
wm	world price of import
tm	import tariff rate

Import price equation states transformation of the world price of imports to import prices for domestic consumers. Currency exchange rate is an endogenous variable while the world price and import tariff rates are exogenous variables that affect the import price. It has no import transaction costs for moving the commodities from border or the ports to the consumers because there are no details of its data in SAM.

According to no import tariff rate data in the SAM used in this study, then value of import tariff rate is set to zero.

Export Price

$$PE = ER \cdot we \cdot (1 - te) \tag{5.2}$$

where

PE	export price in local currency, Thai Baht
we	world price of export
te	export tariff rate

Export prices in Thai Baht received by the sellers when they sell output to export markets. The export price equation is similar to the import with main difference being export tariff rate which reduce the price received by domestic sellers. Besides export demand, the currency exchange rate and the exogenous world price of exports take effect to the level of export price. According to no export tariff rate data in the SAM used in this study, then value of export tariff rate is set to zero.

Output Price

$$PX = (PE \cdot \textstyle\sum_i E_i + PD \cdot \sum_i D_i)/\sum_i X_i \tag{5.3}$$

where

PX	output price
PD	price of domestic supply
X_i	quantity of output of commodity i
E_i	quantity of export of commodity i
D_i	quantity of domestic supply of commodity i

Output price equation embodies the same information as CET of export and domestic aggregate supply. Both export and domestic supply are valued at the prices receive by the sellers, sum of those value divide by output quantity expresses the output price.

Composite Commodity Price

$$PQ = (PM \cdot \sum_i M_i + PX \cdot \sum_i X_i) \cdot (1 + ts) / \sum_i QS_i \qquad (5.4)$$

where

PQ	composite commodity price
M_i	quantity of import of commodity i
QS_i	quantity of composite supply
ts	average rate of tax on production

Composite commodity price equation embodies the import and output values plus their tax on production, which is the value of composite supply divide by its quantity. It is the price that all domestic consumers in all domestic institutions spends when purchasing commodities.

5.2.2 Production and Trade

Production and trade covers 7 industrial groups, i = 1,…,7 where 1 is Agricultural, 2 is Minerals and Ceramics, 3 is Light Industries/Textiles, 4 is Metal Products and Machinery, 5 is Electric and Electronic Products, 6 is Chemical and Paper, and 7 is Services. Output has elasticity for substitution between exports and domestic su pplies in accordance with CET function. Factors used in production are intermediate input and valued added; and top technology is according to Leontief production function. There are two primary factors of labor and capital that have substitutability in value added CES function. Domestic demand has elasticity for substitution between imports and domestic supplies in accordance with CES function. Export –domestic supply ratio and import-domestic supply ratio are affected by their prices and elasticity parameters. Equations in the production and trade block are stated as follows.

Output (Leontief)

$$X_i = (1 + nvf_i) \cdot VA_i \tag{5.5}$$

where

$nvf_i = INT_{i\_0}/VA_{i\_0}$

VA_i	value added as production input of activity i
INT_i	value of intermediate input of production for activity i
nvf_i	intermediate input per VA factor for Leontief production function

Note: subscription _0 of INT_{i_0} and VA_{i_0} refer to their value in base year 2005

Production technology at top level is the Leontief function, each activity use a fixed proportion of value added and intermediate input. To produce one unit of output, proportion of intermediated input used per unit of value added is a nvf_i factor; therefore, the endogenous variable in the right-hand side of output equation can represent only value added.

Value Added (CES)

$$VA_i = af_i \cdot \left(bf_i \cdot L_i^{-rf_i} + (1 - bf_i) \cdot K_i^{-rf_i}\right)^{\left(-\frac{1}{rf_i}\right)} \tag{5.6}$$

where

L_i	value of labor supply for activity i
K_i	value of capital supply for activity i
af_i	scale parameter for CES of value added of activity i
bf_i	share parameter for CES of value added of activity i
rf_i	rho parameter of substitution elasticity for CES of value added of activity i

Value added has two primary factors, labor and capital, with imperfect substitution and both are captured by the CES function. Each value added, as a production input, confronts with different labor-capital intensive of each production sector that can't freely exchange due to skill of labor and level of production technics.

Capital Supply

$$K_i = KD_i \cdot PK + KIN_i \quad (5.7)$$

where

PK	capital price
KD_i	domestic capital supply quantity of activity i
KIN_i	capital from foreign quantity of activity i

In this study, total capital is divided into domestic capital supply and foreign capital supply and both are faced with same capital price. Since it is assumed that all foreign transfer domestic institutions which include FDI inflows, are totally supplied to foreign capital, therefore this separation of capital source will distinguish the effects of FDI shock from normal capital change.

Capital from Foreign

$$KIN_i = (\overline{CAPI} \cdot kp_i \cdot PK) + \overline{DFDI_i} \cdot ER \cdot PK \quad (5.8)$$

where

$\overline{CAPI}$	foreign capital inflow endowment in local currency
$\overline{DFDI_i}$	shock of FDI inflow to activity i
kp_i	proportion of Capital used in industry sector i

All foreign transfer to domestic institutions are fixed proportional distribution to seven industrial sectors and then plus with value of the FDI inflow's shock to get total capital from foreign supplies.

Labor Supply

$$L_i = LD_i \cdot PL \tag{5.9}$$

where

PL labor price

LD_i Labor quantity supply for activity i

It is simple that the value of labor supply is the function of the amount of labor used multiplied by labor price. In this study, only domestic labor is used as a primary factor, with no labor movement between local and foreign.

Intermediate Input

$$INT_i = NT_i \cdot PQ \tag{5.10}$$

where

NT_i quantity of intermediate input for activity i

Value of intermediate input is the function of its quantity multiplied by composite commodity prices. Producers who are also considered as consumers purchase intermediate commodities are faced with the same composite commodity prices as other consumers in institutions.

Intermediate Output Consumption

$$ONT_i = OT_i \cdot PQ \tag{5.11}$$

where

OT_i quantity of intermediate output consumption of commodity i

ONT_i value of intermediate output consumption of commodity i

Value of intermediate output consumption is the function of its quantity multiplied by composite commodity price. Similar to intermediate inputs, the producers are faced with the same composite commodity prices as other consumers in institutions.

Composite Demand

$$QD_i = E_i \cdot PE + DD_i \tag{5.12}$$

where

QD_i	composite demand of commodity i
DD_i	domestic aggregate demand of commodity i

Composite demand is equal to the value of exports plus value of aggregate domestic demand which is the sum of the total value of the commodity rows in SAM.

Composite Supply

$$QS_i = QD_i \tag{5.13}$$

In the CGE model there is neither excess demand nor excess supply; then at equilibrium of the system, composite supply is equal to composite demand.

Domestic Output Supply

$$D_i = DD_i - M_i \cdot PM - TAXP_i \tag{5.14}$$

where

$TAXP_i$	Tax on production of commodity i

Domestic output supply which will be embodied to the output CET are calculated from aggregate domestic demand less import value and tax on production. It is the net value of output production that supplies the domestic market, while another portion of output is for export.

Domestic Aggregate Demand

$$DD_i = \left(\sum_H CH_{H,i} + Z_i + \overline{G_i} \right) \cdot PQ + ONT_i \quad (5.15)$$

where

Z_i	investment consumption of commodity i
$CH_{H,i}$	household H's consumption of commodity i
$\overline{G_i}$	Government consumption of commodity i

Domestic aggregate demand is the sum of all domestic consumption value for both the goods and services that are from the domestic supply or imports. In another perspective, this is a value of composite demand less export.

Domestic Aggregate Demand less Tax

$$DDT_i = DD_i - TAXP_i \quad (5.16)$$

where

DDT_i	domestic aggregate demand less tax

The domestic demand less tax is the non-tax distorted value of domestic aggregate demand which is imperfect substitution with import. It is vital to have domestic demand less tax to use in Armington function.

Output Transformation Function (CET)

$$X_i = at_i \cdot \left(bt_i \cdot E_i^{rt_i} + (1 - bt_i) \cdot D_i^{rt_i} \right)^{\left(\frac{1}{rt_i}\right)} \quad (5.17)$$

where

at_i	scale parameter for CET between export and domestic supply for commodity i
bt_i	share parameter for CET between export and domestic supply for commodity i
rt_i	rho parameter for CET between export and domestic supply for commodity i

This equation expresses an allocation of domestic output to two alternative destinations, export and domestic supply. It reflects the assumption of imperfect transformability between these two destinations. All parameters used in CET are fixed and calibrated for their values using data in year 2005 SAM.

Armington Function (CES)

$$DDT_i = aq_i \cdot \left(bq_i \cdot M_i^{-rq_i} + (1 - bq_i) \cdot D_i^{-rq_i}\right)^{\left(-\frac{1}{rq_i}\right)} \quad (5.18)$$

where

aq_i	scale parameter for CES between import and domestic supply for commodity i
bq_i	share parameter for CES between import and domestic supply for commodity i
rq_i	rho parameter for CES between import and domestic supply for commodity i

This equation expresses imperfect substitutability between consumption of imports and domestic goods and services, captured by the CES function. It is often called the Armington function, with regards to the name of the economist who introduced this concept. All parameters used in CES are fixed and calibrated for their values using data in year 2005 SAM.

Export-Domestic Supply Ratio

$$E_i/D_i = \left[\left(\frac{PE}{PD}\right) \cdot \left(\frac{1-bt_i}{bt_i}\right)\right]^{\left(\frac{1}{rt_i-1}\right)} \quad (5.19)$$

This ratio defines the optimal mix between export and domestic supply. It is derived from the forth order condition of CET function subject to export and domestic price constraint. The rho value according to elasticity in CET is greater than one; then the equation tells that, in the perfect equilibrium, increase in export-domestic price ratio generates an increase in the export-domestic supply ratio. However, when we compute for equilibrium using computer programming to find optimum equilibrium results, it allows for error relating to the values on the right-hand side as they may differ from those on the left-hand side, but in a controlled and acceptable limit.

Import-Domestic Demand Ratio

$$M_i/D_i = \left[\left(\frac{PD}{PM}\right) \cdot \left(\frac{bq_i}{1-bq_i}\right)\right]^{\left(\frac{1}{1+rq_i}\right)} \quad (5.20)$$

This ratio defines for the optimal mix between import and domestic supply. It is derived from the forth order condition of Armington function subject to export and domestic price constraints. The rho value according to elasticity in CES is lower than one, then similar to equation (5.19), in the perfect equilibrium, increase in domestic-import price ratio generates an increasing in import-domestic demand ratio and error according to computer programming is also allowed with acceptable limit.

5.2.3 Institution

Institutions in the CGE model receive income and have expenditure according to factors, taxes, transfer, consumption, saving, investment, export and import. Equations in the institution block are stated as follows.

Tax on Product

$$TAXP_i = (X_i \cdot PX + M_i \cdot PM) \cdot ts_i \qquad (5.21)$$

where

ts_i tax rate on production of commodity i

Sum value of output and import multiply with fixed rate of tax on production is the single tax related to production in this study.

Tax on Income

$$TAXIC = \sum_H (ti_H \cdot IF_H) + (ti_C \cdot IF_C) \qquad (5.22)$$

where

$TAXIC$ total tax on income that apply to household and corporate

IF_H income from factors of household H

IF_C income from factor of corporate

ti_H income tax rate applies to household H

ti_C income tax rate applies to corporate

Tax on income is calculated using the fixed rate for each household and corporate, the sum of both results is the total income tax paid to government.

Household Income from Factors

$$IF_H = al_H \cdot \sum_i L_i + ak_H \cdot \sum_i K_i \qquad (5.23)$$

where

al_H labor factor share to household H's income

ak_H capital factor share to household H's income

Household receive income from both labor and capital factors, total labor value is distributed to each household with a fixed share as well as the share of capital factors are also fixed.

Corporate Income from Factor

$$IF_C = \ ak_C \cdot \sum_i K_i \tag{5.24}$$

where

ak_C capital factor share to corporate income

Corporate receives income from factor only by fixed share from total capital value, not income from labor.

Government Income from Factor

$$IF_G = \ ak_G \cdot \sum_i K_i \tag{5.25}$$

where

ak_G capital factor share to government income

Similar to corporate, the government receives income from factor only by fixed share from total capital value.

Household Income

$$IH_H = IF_H + (\overline{TRDIN_H} + \overline{TRFIN_H} \cdot ER) \tag{5.26}$$

where

IH_H household H's total income

$\overline{TRDIN_H}$ household H received transfer from domestic institutions

$\overline{TRFIN_H}$	household H received transfer from foreign

Household total income is the income from factors plus receiving transfer from domestic institutions and from foreign.

Corporate Income

$$IC = IF_C + (\overline{TRDIN_C} + \overline{TRFIN_C} \cdot ER) \quad (5.27)$$

where

IC	corporate's total income
$\overline{TRDın_C}$	corporate received transfer from domestic institutions
$\overline{TRFın_C}$	corporate received transfer from foreign

Corporate total income is the income from capital factor plus receiving transfer from domestic institutions and from foreign.

Government Income

$$IG = IF_G + (\overline{TRDIN_G} + \overline{TRFIN_G} \cdot Er) + \sum_i TAXP_i + TAXIC \quad (5.28)$$

where

IG	government's total income
$\overline{TRDIN_G}$	government received transfer from domestic institutions
$\overline{TRFIN_G}$	government received transfer from foreign

The government income is the income from capital factor plus receiving transfer from domestic institutions and from foreign.

Household Saving

$$S_H = sr_H \cdot IH_H \tag{5.29}$$

where

S_H	household H's saving
sr_H	household H's saving rate

Household saving is the function of fixed saving rate multiply by its total income.

Corporate Saving

$$S_C = sr_C \cdot IC \tag{5.30}$$

where

S_C	corporate saving
sr_C	corporate saving rate

Corporate saving is the function of fixed saving rate multiply by its total income.

Government Saving

$$S_G = sr_G \cdot IG \tag{5.31}$$

where

S_G	government saving
sr_G	government saving rate

The government saving is the function of fixed saving rate multiplied by its total income.

Aggregate Saving

$$S = \sum_H S_H + S_C + S_G + \overline{S_O} \qquad (5.32)$$

where

S aggregate saving in the country

$\overline{S_O}$ other saving

Sum of all household saving includes corporate, the government, and other savings expresses aggregate saving in the country.

Household Income Tax

$$ICTAX_H = ti_H \cdot IF_H \qquad (5.33)$$

where

$ICTAX_H$ household H's income tax spends to government

Household pays for income tax with the fixed rate. It is specified that all transferred income pay no tax, only income from factors are counted for income tax calculations.

Corporate Tax

$$ICTAX_C = ti_C \cdot IF_C \qquad (5.34)$$

where

$ICTAX_C$ corporate income tax spends to government

Corporate pays for income tax with the fixed rate. It is specified that all transfer incomes pay no tax; only income from capital factor is counted for income tax calculations.

Household Consumption

$$CHX_H = \sum_i [IH_H - ICTAX_H - S_H - (\overline{TRDOUT}_H + \overline{TRFOUT_H} \cdot ER)] \cdot cf_{H,i} \cdot PQ \quad (5.35)$$

where

CHX_H	household H's consumption
$\overline{TRDOUT}_H$	household H's spending transfer to domestic institutions
$\overline{TRFOUT}_H$	household H's spending transfer to foreign
$cf_{H,i}$	consumption share factor of household H to consume commodity i

Household consumes goods and services according to its budget constraints. Its total income less expenditures for tax, saving and spending transfers is fixed proportionally distributed to its consumption in each commodity sector.

Investment

$$Z_i = cf_{Z,i} \cdot (S - \overline{S_O} - \overline{INVO} \cdot ER) \quad (5.36)$$

where

$\overline{INVO}$	investment abroad
$cf_{Z,i}$	consumption share factor of the investment to consume commodity i

Since total investment value in the column is equal to total saving value of the row in SAM, then investment consumption for goods and services in each sector is a fixed proportion of aggregate saving less other savings and less investment abroad.

5.2.4 System Constraint Block

Equations in system constraint block show equilibrium conditions which are balances of total value of each column in SAM that equal total value of each corresponding row. Equations in this block are stated as follows.

Intermediate Input-Output Constraint

$$\sum_i INT_i = \sum_i ONT_i \tag{5.37}$$

The first constraint is from input-output sub matrix in SAM. Each production activity consumes goods and services from each sector, and it is required to have a balance value of total intermediate input and total intermediate output consumption.

Activity Constraint

$$\sum_i (VA_i + INT_i) = \sum_i X_i \cdot PX \tag{5.38}$$

Balance of the first group of columns and rows in SAM is total value of value added plus intermediate input of equal to value of output.

Commodity Constraint

$$\sum_i (X_i \cdot PX + M_i \cdot PM) \cdot (1 + ts_i) = \sum_i (OT_i + \sum_H CH_{H,i} + Z_i + \overline{G_i}) \cdot PQ \tag{5.39}$$

Commodity constraint is the balance of total value of the commodity's column and row in SAM.

Labor Constraint

$$\sum_H (IF_{H,L}) = \sum_i L_i \tag{5.40}$$

where

$IF_{H,L}$ income from labor factor of household H

Sum of household income from labor factors according to the column in SAM is equal to total labor supply value.

Capital Constraint

$$\sum_H (IF_{H,K}) + IF_C + IF_G = \sum_i K_i \tag{5.41}$$

where

$IF_{H,K}$ income from capital factor of household H

Sum of household income from capital factor includes corporate and government income from capital factor according to column in SAM is equal to total capital supply value.

Tax Constraint

$$TAXP + TAXIC = \sum_i (X_i \cdot PX + M_i \cdot PM) \cdot ts_i + \sum_H (ti_H \cdot IF_H) + (ti_c \cdot IF_c) \tag{5.42}$$

where

$TAXP$ Total tax on product that equal to $\sum_i TAXP_i$

Tax revenue that the government receives as its income within the government row and showing as value in tax column in SAM is equal to the sum of taxes on products including household and corporate tax expenditures.

Household Constraint

$$CHX_H + ICTAX_H + S_H + (\overline{TRDOUT_H} + \overline{TRFOUT_H} \cdot ER) = IH_H \quad (5.43)$$

Household constraint is a balance value of its column and row in SAM, total expenditure including consumption, income tax, saving, and transfer spending according to column is equal to total household income according to row.

Corporate Constraint

$$ICTAX_C + S_C + (\overline{TRDOUT_C} + \overline{TRFOUT_C} \cdot Er) = IC \quad (5.44)$$

where

$\overline{TRDOUT_C}$ corporate spending transfer to domestic institutions

$\overline{TRFOUT_C}$ corporate spending transfer to foreign

Corporate constraint is a balance value of total expenditure including its income tax, saving, and transfer spending according to column that equals to its total income according to row in SAM.

Government Constraint

$$\overline{G_i} + S_G + (\overline{TRDOUT_G} + \overline{TRFOUT_G} \cdot ER) = \text{IG} \quad (5.45)$$

where

$\overline{TRDOUT_G}$ government spending transfer to domestic institutions

$\overline{TRFOUT_G}$ government spending transfer to foreign

Government constraint is a balance value of total expenditure including its consumption, saving, and transfer spending according to column that equal to its total income according to row in SAM.

Investment-Saving Constraint

$$\sum_i Z_i/PQ + \overline{INVO} \cdot ER + \overline{S_O} = S \tag{5.46}$$

Total investment value in the column is equal to total saving value of the row in SAM.

Balance of Payment

$$(\sum_i E_i - \sum_i M_i) + [(\sum_H(\overline{TRFIN_H} \cdot ER) + \overline{TRFIN_C} \cdot ER + \overline{TRFIN_G} \cdot ER + \overline{OTHF} \cdot ER + \overline{DFDI} \cdot ER) - (\sum_H(\overline{TRFOUT_H} \cdot ER) + \overline{TRFOUT_C} \cdot ER + \overline{TRFOUT_G} \cdot ER + \overline{INVO} \cdot ER + \overline{OTHF} \cdot ER)] = 0 \tag{5.47}$$

where

$\overline{OTHF}$ other transaction according to the rest of the world

Balance of payment is the current account plus capital account that always sum for zero value. The current account is the value of export minus import from the trade balance; the capital account is the sum of net foreign transfers including FDI and ROW transactions minus the sum of investment abroad and ROW transactions. In detail, the proportion of foreign transfer to each of economic agent is followed to the statistic from Bank of Thailand (2016) and Office of the National Economic and Social Development Board (2016).

In summary, there are 46 endogenous variables, 18 exogenous variables and 28 parameters used in 47 equations which satisfy necessary conditions for solving the problem solving. Microsoft Excel is a computer program used for computing for general equilibrium when the model has shock from FDI inflows, it is easy to use the program which is useful in mathematical calculations and problem solving especially for non-complex models. Procedures for using this program to solve the problem in this CGE study are described in short as follows. All of these equations are programed into the Microsoft Excel using variable data from SAM and parameters value that are calculated and calibrated with the base year data. By using the Solver in Microsoft Excel to solve the problem; it must ask the program to find optimal for one on these following commands, the maximization or minimization or equalization. This study choose the minimization solver's command, once all data with shocks are inserted to equations there are comparisons between values that are calculated by equations, especially for system constraint block, and values that directly expressed in SAM. Errors of that comparison are calculated for the sum of square value, and then ask the Microsoft Excel Solver to do the iteration calculation, subjects to change some of the endogenous variables specified in the program and subjects for minimization of the sum of square errors.

5.3 Parameters Calculation and Calibration

Parameters are the constant value in system equations and are assumed time invariance. By such assumption even the SAM used in this study is based on Thailand economics data in the year 2005, however, all parameters can be used in GCE calculations when Thailand had a shock of FDI inflows from pollution control enforcements using data between years 2009 to 2013. There are two major groups of parameters to be calculated and calibrated in this study. The first one is parameters in CES and CET functions that are required for referenced value of elasticity of transformation and substitution from other studies, such as the technic of developing CGE model by Sompote Kunnoot (2002) and Thammasat University (2004). Those referenced values are calibrated with data in the SAM. The second one is parameters that can do a calculation by using the base year 2005 data in SAM.

5.3.1 Parameters in CES and CET Functions

In this CGE model there are two CES functions, primary factors including labor and capital for value added, and imperfect substitutability of imports and domestic supplies, so called Armington function. There is one CET function of imperfect transformability of the output between exports and domestic supplies.

Value added CES function in equation (5.6) and Armington function in equation (5.18) can be written in general algebraic form as follow in equation (5.48) with CES substitution elasticity is σ_s that given in equation (5.49).

$$Y = a_s \cdot [\delta_s \cdot X_1^{-\rho_s} + (1-\delta_s) \cdot X_2^{-\rho_s}]^{-1/\rho_s} \tag{5.48}$$

$$\sigma_s = 1/(1-\rho_s)\,; -\infty < \rho_s < 1 \tag{5.49}$$

Equation (5.48) is subject to $P_1 \cdot X_1 + P_2 \cdot X_2 = I$, its Lagrange form can be expressed as $L = a_s \cdot [\delta_s \cdot X_1^{-\rho_s} + (1-\delta_s) \cdot X_2^{-\rho_s}]^{-1/\rho_s} + \lambda \cdot [I - P_1 \cdot X_1 - P_2 \cdot X_2]$ and its first order condition will result as $\frac{X_1}{X_2} = \left[\left(\frac{P_2}{P_1}\right) \cdot \left(\frac{\delta_s}{1-\delta_s}\right)\right]^{\frac{1}{1+\rho_s}}$; then value of parameter δ_s it can find by rearrange the result of that first order condition as follow;

$$\delta_s = \left(\frac{P_1}{P_2}\right) \cdot \left(\frac{X_1}{X_2}\right)^{1+\rho_s} \Big/ \left[1 + \left(\frac{P_1}{P_2}\right) \cdot \left(\frac{X_1}{X_2}\right)^{1+\rho_s}\right] \tag{5.50}$$

The CET function of output transformation in equation (5.17) can be written in general algebraic form as follows in equation (5.51) with transformation elasticity is σ_t that given in equation (5.52)

$$Y = a_t \cdot [\delta_t \cdot X_1^{\rho_t} + (1-\delta_t) \cdot X_2^{\rho_t}]^{1/\rho_t} \tag{5.51}$$

$$\sigma_t = 1/(\rho_t - 1)\,; 1 < \rho_t < +\infty \tag{5.52}$$

Similar to CES, equation (5.51) is subject to $P_1 \cdot X_1 + P_2 \cdot X_2 = I$, by first order condition it hal result as $\frac{X_1}{X_2} = \left[\left(\frac{P_1}{P_2}\right) \cdot \left(\frac{1-\delta_t}{\delta_t}\right)\right]^{\frac{1}{\rho_{t-1}}}$; then value of parameter δ_t i can be found by rearranging the results of that first order condition as follow;

$$\delta_t = 1 \Big/ \left[1 + \left(\frac{P_2}{P_1}\right) \cdot \left(\frac{X_1}{X_2}\right)^{\rho_{t-1}}\right] \tag{5.53}$$

Parameters in value added CES function in equation (5.6), Armington function in equation (5.18), and CET of output transformation in equation (5.17) will be matched with the conditions and forms from equation (5.48) to (5.53) to calculate for parameters' value by putting the base year 2005 data from SAM to X, X_2, P_1 and P_2. Notwithstanding, the most important thing that need to find for its value in order to calculate and calibrate for all parameters in CES and CET are the elasticity of substitution and the elasticity of transformation.

5.3.1.1 Referenced Elasticity of Substitution and Elasticity of Transformation

Elasticity of substitution between labor and capital for value added CES function and elasticity substitution used in Armington function are secondary referenced data in the study by Chadin Rochananonda (2004), which quoted from four primary sources. Elasticity of substitution between labor and capital by Claro (2002) quoted in Chadin Rochananonda (2004) was applied to a cross-country sample data to estimate for its value in manufacturing industries only, however, such value will also be used in this study for the case of Thailand. Besides industry sectors, other elasticity of substitution for valued added CES is collected from Lofgren, Robinson, and Thurlow, 2002 quoted in Chadin Rochananonda (2004). Elasticity of substitution used in Armington function was estimated by Warr (1998); it was used in the study of Chadin Rochananonda (2004) for the case of Thailand's trade liberalization, similar to that it is also used in this CGE study. All of these elasticity values were grouped into eight sectors as shown in table 5.4 which are different from this study, therefore it is required for sectors mapping and re-calculation for such elasticity values.

The elasticity of transformation in CET function was estimated by Nuntaporn Methakunavut and Somchai Jitsuchon, 2002 quoted in Rachananonda (2004). Their estimations were specific for Thailand's market and resulted in only single elasticity value of 1.16 as reported in table 5.4, therefore sector mapping is not required.

5.3.1.2 Parameters Calculation and Calibration for CES and CET Functions

To use those referenced elasticity values in this study, mapping the activity-commodity sectors in this CGE model to the reference sources are crucial because of conditions according to equation (5.49) and (5.52). Mapping for elasticity in value added CES goes back to the 79 activities sectors in the original SAM, each of those sectors are mapped to one of eight referenced sectors in table 5.4, then calculated for weighted average by using value of intermediate output of each sector as a weight and then again regrouped to 7 sectors. It is slightly different for the elasticity in Armigton function that use basic average method and has direct mapping with 7 sectors. Because using weighted average as in valued added CES will result final value that is inconsistent with the condition in equation (5.49) since the values in some commodity sectors are greater than one, while using basic average found no problems.

All elasticity values used for CES and CET functions in this study are denoted as follow; sf_i is an elasticity of substitution between labor and capital of activity sector i according to CES in equation (5.6); sq_i is elasticity of substitution for Armington function of commodity sector i according to CES in equation (5.18); and st_i is elasticity of transformation for output CET function of commodity sector i according to equation (5.17). Mapping results of elasticity's values reported in table 5.5 will further be used in calculation for scale parameters, share parameters and rho parameters values.

Table 5.4 Reference of Elasticity of Substitution and Elasticity of Transformation

Sector	Value of Elasticity of Substitution and Elasticity of Transformation		
	σ_s between Labor and Capital	σ_s between Import and Domestic Supply	σ_t
A. Agricultures	0.75	1.1037	1.16
B. Agro-industry	0.93	1.6171	1.16
C. Trade-oriented industry	0.91	1.0068	1.16
D. Intermediate good industry	0.95	0.3107	1.16
E. Utilities	0.9	0.84	1.16
F. Finance, Insurance, and Real Estate	1.5	0.84	1.16
G. Transportation services	0.9	0.84	1.16
H. Services	1.05	0.84	1.16

Note: Elasticity of substitution between labor and capital is from Claro, 2002; Lofgren, Robinson, and Thurlow, 2002 quoted in Chadin Rochananonda (2004). Elasticity of substitution for Armington function is from Warr, 1998 quoted in Chadin Rochananonda (2004). Elasticity of transformation is from Nuntaporn Methakunavut and Somchai Jitsuchon, 2002 quoted in Chadin Rochananonda (2004).

Table 5.5 Value of Elasticity of Substitution and Elasticity of Transformation Used in This Study

Activity-Commodity Sector i	**Referenced Sector from table 5.4**	**Value of Elasticity of Substitution and Elasticity of Transformation used in this study**		
		sf_i	sq_i	st_i
1. Agricultural Products	A,B	0.82	1.36	1.16
2. Minerals and Ceramics	D,C	0.94	0.66	1.16
3. Light Industries/Textiles	B,C	0.91	1.31	1.16
4. Metal Products and Machinery	C,D	0.94	0.66	1.16
5. Electric and Electronic Products	C,D	0.93	0.66	1.16
6. Chemicals and Paper	C,D	0.94	0.66	1.16
7. Services	E,F,H	1.09	0.84	1.16

The first step, sf_i,sq_i and st_i will use in calculation for rho parameters (ρ_s and ρ_t) according to rearrangement equation (5.49) and (5.52). The ρ_s is equivalent to rf_i in the valued added CES and equivalent to rq_i in the Armingtion function, while ρ_t is equivalent to rt_i of the output CET function. In the second step, rf_i is used in calculation for share parameter value of the value added CES, bf_i , according to equation (5.50) by specifying that labor price PL is equivatent to P_1, capital PK price is equivalent to P_2 , labor L_{i_0} is equivalent to X_1; and capital K_{i_0} is equivalent to X_2. Similar method applies to Armington function, rq_i is used in calculation for share parameter value, bq_i , and import price PM is P_1, domestic supply price PD is P_2, import M_{i_0} is X_1, and domestic supply D_{i_0} is X_2. In output CET function, this calculation and calibration is according to equation (5.53), where rt_i is in left-hand side and export price PE is P_1, domestic supply price PD is P_2, export E_{i_0} is X_1, and domestic supply D_{i_0} is X_2; then the share parameter , bt_i , is resolved. All subscript 0 are denotes for value of variable using base year 2005 SAM's data. The third step once all rho and share parameters are known, the scale parameters of value added CES and Armington function are resolved according to equation (5.48) which a_s is equivalent to af_i and aq_i of those CES functions respectively. The Y variable is equivalent to VA_{i_0} in equation (5.6) and equivalent to DDT_{i_0} in equation (5.18). For the output CET function scale parameter is resolved according to equation (5.51), in which a_t is equivalent to at_i and Y is equivalent to X_i in equation (5.17). Table 5.6 reports for all of these calculated parameters' value.

All CES and CET's parameters are calibrated for their correctness with regard to setting control conditions when computing for equilibrium result, by minimizing sum of square errors when comparing the results from related equations compare to iteration values that the program asks Microsoft Excel Solver to do.

Table 5.6 Parameters' Value in CES and CET Functions

Activity-Commodity Sector i	Parameters in CES Eq. (5.6)			Parameters in CET Eq. (5.17)			Parameters in Armington Eq. (5.18)		
	rf_i	bf_i	af_i	rt_i	bt_i	at_i	rq_i	bq_i	aq_i
1. Agricultural Products	0.220	0.263	1.814	1.862	0.747	2.349	-0.265	0.159	1.461
2. Minerals and Ceramics	0.064	0.254	1.775	1.862	0.739	2.324	0.518	0.715	1.875
3. Light Industries/Textiles	0.099	0.353	1.922	1.862	0.580	2.031	-0.238	0.234	1.660
4. Metal Products and Machinery	0.064	0.554	2.230	1.862	0.565	2.019	0.518	0.529	1.998
5. Electric and Electronic Products	0.075	0.318	1.878	1.862	0.426	2.026	0.518	0.610	1.968
6. Chemicals and Paper	0.064	0.148	1.538	1.862	0.645	2.104	0.518	0.250	1.828
7. Services	-0.083	0.418	1.971	1.862	0.839	2.840	0.190	0.025	1.162

5.3.2 Other Parameters

Besides those nine parameters of CES and CET function, other nineteen parameters are used in this CGE model which most of them are calculated from data of base year 2005 in the SAM. For the world price of export, we , and the world price of import, wm; since in the calculation all prices are set as indexed level then both world prices are set to one. For the export tariffs, and the import tariffs, their values are set to zero since there are no data in SAM. The rest of the parameters are calculated for rates, factors or shares using their corresponding values. For example, tax rate on production of each commodity, ts_i , it is the value of tax on production divided by the sum value of output and imports. As reported in table 5.7, all calculated parameters' values are fixed.

Not only used for calculation in the CGE model, but some parameters also provide some key economic knowledge. The labor and capital factor share to household's income would tell how different households receive return from their factors; these parameters' values suggest that distribution is biased to the richer who receive higher return. As well as household saving rates where the richer save more. The values of income tax rates applied to household and corporate suggests that corporate pay higher rates than households, while each household rate are not much different. Consumption share factor of household to consume each commodity tells us household's preference in consumption that is comparable among commodities as well as among household. Such interpretation of parameters' values draws a basic economic structure of the country, for example, of income distribution; that would anticipate for welfare effect when the country has any economic shock input to its system.

Table 5.7 Other Parameters' Values

Parameters	Notation	Activity-Commodity i or Household H							Consolidated
		i =1 or H=1	i =2 or H=2	i =3 or H=3	i =4 or H=4	i =5 or H=5	i =6	i =7	
Intermediate input per VA factor for Leontief production function	nvf_i	1.288	0.987	2.534	3.619	5.358	2.120	1.070	-
Proportion of capital used in industry sector i	kp_i	0.160	0.043	0.064	0.084	0.048	0.145	0.457	-
Labor factor share to household H's income	al_H	0.038	0.100	0.197	0.241	0.424	-	-	-
Capital factor share to household H's income	ak_H	0.029	0.043	0.056	0.075	0.155	-	-	-
Capital factor share to corporate income	ak_C	-	-	-	-	-	-	-	0.521
Capital factor share to government income	ak_G	-	-	-	-	-	-	-	0.121
Tax rate on production of commodity i	ts_i	0.012	0.021	0.051	0.009	0.004	0.041	0.026	-
Average rate of tax on production	ts	-	-	-	-	-	-	-	0.022
Income tax rate apply to household H	ti_H	0.043	0.037	0.032	0.039	0.048	-	-	-
Income tax rate apply to corporate	ti_c	-	-	-	-	-	-	-	0.166
Household H's saving rate	sr_H	0.061	0.084	0.120	0.170	0.175	-	-	-
Corporate saving rate	sr_C	-	-	-	-	-	-	-	0.637
Government saving rate	sr_G	-	-	-	-	-	-	-	0.329
Consumption share factor of household H to consume commodity i	$cf_{H,i}$	-	-	-	-	-	-	-	-
	$cf_{1,i}$	0.288	0.002	0.121	0.027	0.033	0.069	0.460	-
	$cf_{2,i}$	0.233	0.002	0.128	0.028	0.031	0.072	0.505	-
	$cf_{3,i}$	0.168	0.001	0.111	0.034	0.024	0.068	0.594	-
	$cf_{4,i}$	0.146	0.001	0.126	0.057	0.026	0.088	0.556	-
	$cf_{5,i}$	0.097	0.005	0.152	0.136	0.033	0.088	0.488	-
Consumption share factor of the investment to consume commodity i	$cf_{Z,i}$	0.006	0.003	0.023	0.359	0.199	0.016	0.395	-

5.4 Welfare Analysis

A welfare analysis in Thailand uses the result from the study in Chapter 4. If the relative pollution control enforcements for industrial activity in Thailand is increased once when compared to home countries, FDI inflows to Thailand has significant impact to Agricultural, Mineral & Ceramic industry, Light Industry/Textile, Metal Products and Machinery, and Chemicals and Paper sectors while Electric and Electronic Product sector has insignificant results. For the services sector, since it has difficulty of pollution data to be analyzed then it was excluded from the study in Chapter 4 and is assumed no impact from change in pollution control enforcements. All FDI shocks according to the aforementioned are inputted into the CGE model to calculate for new equilibrium, and then investigate the welfare through changes of economics institutions' income as well as changes in production output, consumption import, export and country's GDP. The value of environmental impact according to pollution control enforcements is also calculated to be compared with benefits and loss from FDI inflow.

5.4.1 Changes of Economic Values According to Shock of FDI Inflows

FDI shocks according to level of pollution control enforcements are calculated from the percentage of impact in each activity sector and then multiplied by its foreign capital inflow endowment in local currency and then multiplied by its proportion of capital used, as expressed in equation (5.54). Reasons for choosing such mathematical formula is from the assumption that all foreign capital transfer to domestic institutions will send to primary capital factor for the value added as input of Leontief production function, which is shown in figure 5.1 of CGE model structure. The value of capital inflow endowment in the base year 2005 is equal to sum of foreign transfer that is received by household, corporate, the government, and other receiving foreign transactions which can be expressed in equation (5.55) and its value in year 2005 was 1,864.5 billion Baht.

$$\overline{DFDI_i} = \overline{IMPACT_i} \cdot \overline{CAPI} \cdot kp_i \qquad (5.54)$$

$$\overline{CAPI} = \sum_H \overline{TRFIN_H} + \overline{TRFIN_C} + \overline{TRFIN_G} + \overline{OTHF} \tag{5.55}$$

Where $\overline{IMPACT_\iota}$ is percentage change in FDI inflow according to relative pollution control enforcement increase once when compared to home countries. Since Thailand's GDP in the year 2005 was 8,455.8 billion Baht, the values of FDI shocks in each sector are also expressed in percentage of the GDP. Calculation results of FDI shocks based on the year 2005 values are shown in table 5.8 which will be fixed for all analysis scenarios.

Table 5.8 FDI Shocks Used in CGE Analysis

Activity-Commodity Sector i	**FDI shocks as of base year 2005 value**		
	$\overline{IMPACT_\iota}$ (%)	$\overline{DFDI_\iota}$ (billion Baht)	% of GDP
1. Agricultural Products	+11.3%	+33.78	+0.399%
2. Minerals and Ceramics	+9.02%	+71.48	+0.845%
3. Light Industries/Textiles	+1.78%	+2.14	+0.025%
4. Metal Products and Machinery	+0.70%	+1.10	+0.013%
5. Electric and Electronic Products	-4.10%	-3.64	-0.043%
6. Chemicals and Paper	+1.67%	+4.50	+0.053%
7. Services	No FDI shock	No FDI shock	No FDI shock
Total		+109.36	+1.293%

There are fixed conditions for welfare investigation by CGE in this study. Firstly, the labor price (PL) is fixed by assumption that wages in Thailand are controlled by labor laws. Second, the capital price (PK) is fixed by assumption that the Bank of Thailand controls interest rate, even though it uses a manage float policy, the fact remains that interest rates in Thailand had small change in the period of this study. The last one, domestic price (PD) is assumed to be fixed according to the model in this study ignoring its price equation. Other reasons to fix those prices related to impact of welfare which may not be investigated by the CGE model due to no value changes if all variables in the model that are allowed to freely adjust. Four scenarios with one major case and three supposition cases are analyzed in this welfare investigation, as well as one extra case using comparison from the results of this CGE model with another study.

5.4.2 Simulation Scenarios and Results

Major scenario, the so called first case, for welfare investigation using this CGE model is both quantity of labor supply (LD_i) and quantity of domestic capital (KD_i) for each activity sector are adjustable. It is based on the assumption on a no full employment in Thailand basis in the period of this study. In actuality, the employment rate in Thailand was high but there still existed unemployment labor forces, at least the volunteer unemployment labors that could be move to the employment group if necessary. An assumption of adjustable domestic capital supply is according to capital inflows from foreign entities that can be substituted with the domestic, since the capital price is fixed then producers have indifferences between choosing domestic and foreign sources of capital. Therefore, foreign investors who also act as producers or join production with local producers will have more convenience to bring in their own capital due to investment loans from local financial institutes which has some more difficulties for foreigners. Consequently, domestic capital supply is expected to adjust down.

There are three supposition scenarios in which their assumptions have less reality than the major one. However, their valued contributions to this study still validate a strong position for policy recommendation since the government and policy makers can restrict different conditions according to those cases. The second case assumes adjustable quantity of labor supply (LD_i) to each activity sector while domestic capital (KD_i) is fixed. This case is based on the supposition that using capital has more convenience than labor, then the producers prefer to choose capital from foreign entities as a primary factor than using labor for valued added CES, and they don't care whether or not Thailand's employment level is full. This assumption, expects less labor demand, however, the value added from CES function will further be calculated and the output according to Leontief production technology will be computed by CGE model. Policy makers are supposed to apply this case to promote use of the country's abundant capital while employment rate will remain constant in a good position.

The third case assumes fixed quantity of labor supply (LD_i) to each activity sector while domestic capital (KD_i) is adjustable. This case is based on the supposition that the country is in full employment level. When there is a shock of more FDI inflows, then similar to the first case, the foreign investors who also act as producers will decide to adjust the amount of domestic capital demand because of the convenience to bring in their own capital. Then this case is expected to have less domestic capital demand and then policy makers need to consider how to impose the policies if the country has full employment while foreign investors bring in more FDI which will affect the domestic financial sectors. The fourth case, is a contrast to the first one, assuming fixed, both quantity of labor supply (LD_i) and quantity of domestic capital (KD_i) supply to each activity sector. This case bases its supposition that the country is in full employment level while the domestic capital supply is limited likely at full level. Then the shocks of more FDI inflows will totally increase capital supply which consequently affects the amount of value added and production outputs. The policy makers are supposed to consider various policy implications about promoting FDI in situations where the county has full employment and maximum limit of domestic capital supply.

There is an extra case to compare this CGE model with; it is the referenced model that was studied by Wethang Phaungsap et al. (2008) about the impact of foreign capital flows into Thailand. This comparison aims to benchmark the CGE model of this study whether it has high deviated results or has similar trends. However, Wethang Phaungsap et al. (2008) didn’t mention about details of the tested cases, just only reports for results when FDI inflows increases for one percent of the GDP, then their analysis conditions are supposed to be similar to the first scenario case in which both labor supply and domestic capital supply are adjustable. The first case in this study is used in benchmarking; because the referenced case didn’t mention for FDI distribution to each industrial sector then the FDI shocks according to increasing in FDI inflow for one percent of GDP, is assumed equally distribute to six sectors except the services sector.

Base on year 2005 SAM for Thailand and the CGE model constructed for this study, the welfare simulation results are summarized in table 5.9 that consists of thorough changes of economics institutions’ income, production outputs, consumption imports, exports, and the GDP. Changes of labor supply and domestic capital supply are also investigated for their consistency with assumptions of each case. In the extra case to benchmark with another study besides its own results using CGE model in this study, original results of the reference study are also reported for model comparison. Even though they are reported in final value, but there are many behind mechanisms to be analyzed and explained. Despite consolidated reports in table 5.9, each scenario will be separately discussed in detail.

Table 5.9 Simulation Result for Effect of FDI Inflows

Scenarios	**Impact of FDI inflow** (% change compare to base year)										
	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Extra for benchmark		
Income	Total	From Factor	Total	From Factor	Total	From Factor	Total	From Factor	Total	From Factor	Benchmarked Model
Household 1	+1.18	+1.13	-1.15	-0.94	-0.02	-0.32	-0.06	+1.01	+1.83	+1.76	+1.0
Household 2	+1.98	+1.66	-1.89	-1.52	-0.09	-0.20	+0.20	+0.64	+2.93	+2.45	+1.2
Household 3	+2.65	+2.65	-2.56	-2.48	-0.05	-0.19	+0.07	+0.60	+3.87	+3.83	+1.3
Household 4	+2.47	+2.51	-2.38	-2.34	-0.07	-0.20	+0.14	+0.64	+3.61	+3.64	+1.4
Household 5	+2.27	+2.27	-2.20	-2.10	-0.06	-0.22	+0.08	+0.71	+3.35	+3.31	+1.7
Total Household	+2.27	+2.30	-2.19	-2.13	-0.06	-0.22	+0.09	+0.70	+3.34	+3.36	
Corporate	-0.65	-1.57	+0.71	+1.79	-0.22	-0.55	+0.49	+1.73	-0.55	-1.93	
Government	-0.05	-1.57	+0.11	+1.79	-0.02	-0.55	+0.51	+1.73	-0.21	-1.93	
Output	+0.78		-0.48		-0.10		+0.82		+1.05		
Export	+5.39		-10.6		+3.05		-9.79		+3.76		+3.0
Import	+6.18		-7.69		+4.67		-6.44		+3.02		+1.9
Aggregate Consumption	+0.06		+0.24		-0.55		+1.99		+0.08		
GDP	+0.65		-0.63		-0.45		+0.95		+1.10		+1.6
PE	+0.52		+2.24		+1.52		-1.47		+0.50		
PM	-0.63		-0.37		+0.20		-4.44		+0.05		
PQ	0.00		0.00		0.00		0.00		+0.00		
PX	+0.02		+0.03		0.00		0.00		+0.04		
ER	+13.42		-15.8		+4.76		-18.67		+20.7		
LD	+4.91		-4.77		0.00		0.00		+6.92		
KD	-6.25		0.00		-4.37		0.00		-6.15		

Note: Scenario 1for adjustable labor supply and adjustable domestic capital supply
Scenario 2 for adjustable labor supply and fixed domestic capital supply
Scenario 3 for fixed labor supply and adjustable domestic capital supply
Scenario 4 for fixed labor supply and fixed domestic capital supply

5.4.2.1 Analysis of Scenario 1

Analyses of simulation results begins with the first scenario which is claimed as the most realistic case due to adjustability of both labor and domestic capital supply as in the case of the real world. Results of income changes in this case demonstrate welfare improvement of economic institutions except the government. Increases in FDI inflows for 1.293% of GDP from the effects of pollution control enforcements, will increase total household income between 1.18% and 2.65% and their components of income from factors increase between 1.13% and 2.65% which is considered as high impacts. For other institutes, total corporate income decrease increased only 0.65% meanwhile its sub-income from capital factors decreased by 1.57%; the government income had decreased by 0.05% and its income from capital factors decreased for 1.57%.

Household income, according to data in SAM, shows its distribution to household groups one to group five for 7.5%, 10.9%, 17.2%, 22.0% and 42.4% respectively. Meanwhile, labor factor share to household's income (al_H) and capital factor share to household's income (ak_H) in table 5.7, show similarities in the perspective that the richer has higher percentages. There are not many differences in percentages of income change when the country receives more FDI inflows. The poorest has the lowest total income and factor income that was increasing at 1.18% and 1.13% as well as the poor having plus 1.98% and 1.66%. For the richest, whose total income and factor income plus 2.27% and 2.27%, its percentage of change is lower than the lower middle income group who has plus 2.65% and 2.65%; and lower than the upper middle income group who has plus 2.47% and 2.51% of total income and factor income respectively. When we consider changes of labor supply which increased by 4.91% and domestic capital supply which had a minus of 6.25%; these results suggest that, except for the bottom two poor groups, the capital from more FDI inflows would be substituted for domestic capitals for the rich rather than the middle groups as well as using more labor from the middle rather than the rich groups.

By this analysis, it can reasonably explain for why percentage of income change of the top three household groups does not much of a difference. It is because the middle receives benefits from the more labor it supplies and less substitution of foreign to domestic capital while with the rich there is a contrast and also less benefit.

Therefore, when using the amount of increased income divided by based income to calculate for percentage changes the middle would result in good numbers. For the two groups of the poor, they still receive fewer benefits than the others due to their very low labor and capital factors' share. However, another thing that shall be looked over is income from received transfers, especially from foreign entities where the value is affected by the exchange rate. In this scenario, the simulation results in depreciation of exchange rate by 13.42% which is high enough to increase value in local currency for foreign transfers and cause an increasing trend in the institutes' total income.

The corporate welfare change according to its income from capital has the same reason as the rich household; since more FDI inflows could substitute the domestic capital supply then the corporate income from capital factors is forced to be reduced. According to reduction of the government income, it can be analyzed that impact from substitution of FDI inflows to domestic capital supplied by the government is also high since there is a negative number of change in factor income. Regarding total government income which major components are tax revenues and income from factor; revenue from household income tax increases because of increase in household income from factor but less revenue from corporate tax due to its lower income from factors. Because there are increases in output at 0.78% and high increases of import at 6.18% that would affect the government's revenue from tax on production which will compensates revenue from income taxes and then cause a slight decrease in total government revenues.

Other indicators regarding welfare investigation is from the macroeconomics perspective. In the scenario of increasing trend, FDI can increase the total output because of the increase in value added. Even though domestic capital supply is reduced but the increase in labor supply has enough substitution for driving up value added which is a production input in Leontief technology. Positive impacts to the output by 0.78% connect with exports, imports, aggregate consumption and then finally determine the GDP. Export in this scenario is increased by 5.39%, consistent to the theory of vertical FDI in which foreign investors invest in the host country due to the advantages from lower costs of production that will enhance the benefit of their export goods to the world markets. Even the exports have a high increasing trend, but it is a little increase in aggregate consumption by 0.06%, this means that incrementally, the output is mostly serving exports. At the same time effect from high increases in imports will compensate the gain from exports in consumption which finally causes a GDP increase by only 0.65%. With regards to low incremental change in aggregate consumption; since household consumption increased following its income and fixed government consumption, then investment consumption decreased.

In conclusion, these scenarios which are the major cases for the welfare investigation, once Thailand attracts more FDI inflows from its weak pollution control enforcements, with fixed labor and capital prices, adjustability of labor supply and domestic capital supplies, household is the economic agent who gets welfare benefits from their incremental incomes as well as the foreign investors who invest to produce the export goods. Household income improvement is most likely from return of labor supply since there is a reduction in domestic capital supplies. The middle income and rich households have higher welfare improvements than the poor; this result suggests that more FDI inflows could not lead to a better income distribution. For the corporate, there is a decreasing trend in return of its capital factor that dominates it total income, since FDI is assumed to directly pass through value added function and substitutes for corporate own domestic capital, then finally result in its lower income from capital factor. When we consider the country as a whole, there are lower percentages of welfare benefit when compared to household due to low increase in the GDP, which is affected by increasing trend in imports and decreasing trend in investments consumption regardless of the positive from an increasing trend in exports. In overview, there still exists opportunities for positive welfare benefit regardless of the comparison with the value of environmental impact which will further be discussed.

5.4.2.2 Analysis of Scenario 2

The second scenario, that assumes adjustable quantity of labor supply to each activity sector while domestic capital is fixed, demonstrates welfare improvement for the corporate and the government who have incremental income while household and other economic indicators, except aggregate consumption, have decreasing values. Both increases in corporate total income by 0.71% and its capital factor income by 1.79% can be analyzed that the corporate supplies only for capital factors, with its share more than half of the total, then its return from capital factors increases. If specific considerations are given only for change in factor income, the government factor income from capital i increase due to the same reason of the corporate while total income is only increased by 0.11%. All five household groups have a reduction in both total income and income from factors; since total labor supply reduced by 4.77% that affects all households who are the labor force, then income from labor factors would reduce. Two of the poor groups have decreasing trends in total income 1.15% and 1.89% and a decrease in factors income 0.94% and 1.52% respectively; these numbers are better than the other three groups that means the poor groups have less affects. Household number three, the lower middle income group, has the highest reduction of total income and factors income by 2.56% and 2.48% respectively; while the upper middle income group of household number four decreases by 2.38% and 2.34%; and the rich decreases by 2.20% and 2.10% respectively. These results suggest that reduction in households' income from labor factors reached the level that can dominate the income from their domestic capital, it would be reasonable since values of labor factor share to household's income are higher than capital factor shares to household's income. Higher percentages of decreasing trend in household total income than factors income is affected by reduction in value of received transfers from foreign entities since the exchange rate is simulated to appreciate by 15.84%.

According to the increase in the government income from tax revenue, increases in corporate income tax due to its higher income that will compensate the reduction in household income tax. However, there are other effects to total government income which is caused from the reduction in tax on production that is caused from the decrease in outputs by 0.48% and a decrease in imports by 7.69%. Reduction in outputs caused from lower value added used as an input factor for production; a decreasing trend in value added can be interpreted that the high percentage decrease in labor supply dominates the increasing trend in total capital supply. Exports decreased by 10.63% but aggregate consumption increased by 0.24% are the consequences of reduction of the output. The decrease in exports that is suggested by simulation while its prices increase and exchange rate is appreciated looks to contrast theory, this situation means that the world prices which are exogenous must increase to cause increase in export price. A high reduction rate for imports by 7.69% is affected by the reduction of household' income that caused a decrease in consumption of both domestic and imports as well as an increase in import prices, which shall be the consequence of the world price increase.

GDP is decreased by 0.63% because of the high decrease in exports even though there are some compensation from the high decrease in imports.

In conclusion of this scenario, corporate and the government are economic agents who have welfare improvements due to its increasing trends in incomes, while households have a negative welfare effect. Thailand as a whole country is also faced with negative welfare effect due to a decreasing GDP. In overview, this scenario causes much reduction in labor which is totally supplied by household; it affects the decrease in household income as well as production outputs and continues to impact export levels that lead to negative welfare of the entire country.

5.4.2.3 Analysis of Scenario 3

The third scenario, assumes fixed quantity of labor supply to each activity sector while domestic capital is adjustable, demonstrates welfare loss for all household as well as corporate and the government. Percentage changes of household total income differ from the second scenario since there is not much difference, total income of the poorest to the rich decreased by 0.02%, 0.09%, 0.05%, 0.07%, and 0.06%; and income from factors reduced by 0.32%, 0.20%, 0.19%, 0.20% and 0.22% respectively. The corporate and the government total income, decreased by 0.22% and 0.02%, while their incomes from factors also decreased by 0.55%. To analyze the aforementioned results, it needs to consider change in domestic capital supply which is decreased by 4.37% and the change in currency exchange rates that is depreciated by 4.76%. Smaller negative percentage change in total income but higher negative for factors incomes when labor supply is fixed and domestic capital supply is reduced, would be interpreted as reduction in domestic capital reach which is the level that dominates income from labor factors, and currency depreciation that cause more value of received transfers from foreign entities compensate the loss from factor income.

The government total income is affected by reduction of its own income from capital factor together with reduction of revenue from income tax which following to reduction in household and corporate income from factors. Increasing in import by 4.67% has positive impact to government revenue from tax on production even though there is 0.1% decreasing in output, that compensate for loss of government revenue from income taxes which is consequent effect of decreasing in household and corporate's factor incomes. A small reduction in output cause from lower value added used as an input factor for production, such decreasing in value added can be interpreted as high percentage decreasing in domestic capital supply that dominates the fixed amount of labor supply. Even the output had reduced, however export still increases by 3.05% that could either be affected from currency depreciation to enhance export value or real demand from rest of the world. The import that increase by 4.67% will dominate effect of the export to country's GDP, together with decreasing od aggregate consumption by 0.55% then the GDP affected in decreasing by 0.45%

In conclusion of this scenario, regardless of income from received transfers which is gained by currency depreciation, all institutions got a decrease in incomes from factors that caused reduction in real sector's welfare. Thailand as a whole also got negative welfare effects due to the decrease in GDP. In overview, this scenario caused much reduction in domestic capital supplies that affects the decrease in household income as well as production outputs and continued to impact consumption even if export level had an increase.

5.4.2.4 Analysis of Scenario 4

The fourth scenario is assumed to be fixed for both quantity of labor supply and domestic capital to each activity sector is adjustable, and demonstrates welfare improvement for all households except the poorest, corporate and the government through their increase in total income and income from factors. Household total income has an increasing trend in range of 0.07% to 0.20% and their components of income from factors increases in range of 0.60% to 1.01%. Specific to the poorest, its total income decreased by 0.06% but income from factors increase by 1.01% that was caused by 18.67% of currency appreciation which will reduce value of income from foreign transfers and dominate value of income from factors. In this scenario, the poorest got the most benefits in terms of factor income that is a consequence of more FDI inflows, while the rest of the household groups did not have much of a difference which would be analyzed that this benefit is fairly distributed to household. Total corporate income had increased by 0.49% meanwhile its sub-income from capital factor increased by 1.73%; the government income had increased by 0.51% and its income from capital factor increased for 1.73%.

When both labor and domestic capitals are fixed then the capital from FDI will increase the total capital and cause an increase in value added. Such increase in value added, as a production factor, leads to the increase in output which simulating result shows an increase by 0.82%, the highest among the four scenarios. Increasing output that leads to higher value of tax on production, and together with all the increasing incomes leads to higher government revenue from income tax, then total government income will increase. The incremental output is connected with exports, imports, aggregate consumption and then finally determines the GDP. Export in this scenario decreased by 9.79% which is inconsistent to the theory of vertical FDI. Regardless, the simulation result of the decreasing export price, a currency appreciation, would distract export quantities which cause its reduction. Another reason that causes low export comes from high increasing trend in aggregate consumption at 1.99%, once consumption demand is high it would dominate other effects from exports. GDP increases by 0.95% which this majority effect is from high aggregate consumption and less imports.

In conclusion, of these scenarios most institutions got an increasing trend in incomes especially from factors that cause welfare improvements. Distribution of benefits to the household looks better than other scenarios due to the case's assumption that labor supply and domestic capital supply are fixed, then more incoming capital will not be required to substitute with both primary factors and finally distributed as per their share parameters. Thailand as whole also got positive welfare effects due to an increase in GDP as well as consumption utility which was increased due to higher amount of aggregate consumption. In overview, this scenario delivers good welfare benefits of regardless comparison with value of environmental impact which will further be discussed.

5.4.2.5 Analysis of Extra Scenario for Benchmark with Another Model

The extra scenario used for benchmark with referenced model from Wethang Phaungsap et al. (2008) follows the restriction and assumption of scenario one. The difference in value of FDI inflows is supposed, according to the referenced model, to increase by 1.0% of GDP of the base year 2005; and such FDI is assumed equally distributed to six industrial sectors. This benchmark aims to test whether the model in this study suggests similar results to previous studies by comparing the indicators that consists of household incomes, exports, imports, and the GDP. The result of this extra case demonstrates a similar trend to scenario one, there are welfare improvements for all households while corporate and the government got a negative impact. Change and impact mechanism will not be explained in this extra scenario because of its similarity to the first one, but only describes impact comparison with the referenced case. Household in the referenced case is divided into five groups, the same as in this study and each of them represents twenty percent of total household, and therefore each household's welfare impact is comparable.

Beginning with household number one who is the poorest, this study shows its increasing trends in total income by 1.83% while the referenced was reported for an increase by 1.0%. Total income comparison between this study and the referenced case for the second household increased by 2.93% versus 1.20%, the third household increased by 3.87% versus 1.30%, the fourth household increasing by 3.61% versus 1.40%, and the fifth household increasing by 3.35% versus 1.70%. These results show similar increasing trends of the total households' income which affected by the same rate of more FDI inflows.

Despite similarity of impact to household's income, there is a similar positive impact to export by the increasing trend of 3.76% for this study and the increase of 3.0% that is reported in the referenced case. The import in this study increased by 3.02% and in referenced case increased by 1.90%. Aggregate consumption in this study increased by 0.08% and in referenced case increased by 1.20%. The GDP in this study increased by 1.10% and reported in the referenced case increased by 1.60%. All of those similar sign t regardless of different values of percentage of impacts tells us consistent findings from both CGE models. However, they could have some small differentiating structure and in parameters' value used in each study, for example, elasticity values and tax rates. Because of the lack of details of numerical values and calculation methodology reported in the referenced case, it cannot be said of which model is better. This comparison is just to benchmark the results of each to find for consistencies and inconsistencies from similar kinds of the study.

5.4.2.6 Impact of FDI Inflows in Percentage of GDP

One of the popular measurements evaluates economic impacts in percent of GDP which will draw all indicators into the same comparison basis. Especially in the CGE analysis of this study; since it uses year 2005 SAM which is the latest developed for Thailand, while the econometric analysis for impact of pollution control enforcements on FDI inflows to Thailand using data from the period of years 2009-2013, therefore, to evaluate the impact in percent of GDP, is proper to use with this restriction regardless time a difference. Results in scenarios one to four are reevaluated into change in percentage of GDP as shown in table 5.10 that calculates using the amount of the impact value divide by GDP of year 2005 at 8,455.4 billion Baht.

Table 5.10 Simulation Result for Effect of FDI Inflows in Percentage of GDP

Scenarios	**Impact of FDI inflow** (change in % of GDP)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Income in total				
Household1	+0.057	-0.056	-0.001	-0.003
Household 2	+0.140	-0.133	-0.007	+0.014
Household 3	+0.295	-0.286	-0.006	+0.008
Household 4	+0.353	-0.340	-0.010	+0.019
Household 5	+0.625	-0.604	-0.016	+0.021
Total Household	+1.470	-1.419	-0.039	+0.060
Corporate	-0.224	+0.246	-0.078	+0.169
Government	-0.011	+0.025	-0.005	+0.111
Output X	+1.964	-1.225	-0.249	+2.075
Export	+3.878	-7.647	+2.195	-7.038
Import	+4.121	-5.123	+3.115	-4.291
Aggregate Consumption	+0.056	+0.230	-0.517	+1.881
GDP	+0.653	-0.626	-0.453	+0.948

5.5 Discussion to the Model Restrictions and Strengths

Even though methodology is used in this study and can demonstrate overall welfare investigation results, there are another two restriction topics that requires discussing. Starting with the SAM and the CGE model that analyzed to find changes of economic indicators which was affected from more FDI inflows; since the SAM was constructed using the year 2005 data while the compared environmental impact would be determined in year 2013, then there would be some differences of the country's economic structure during the eight years. A difference in parameters' value from change in the economic structure can cause different results; for example, of import tariff (tm) and export tariff (te) where the rates in year 2013 would differ from the year 2005 and finally cause a different value of outputs, consumption and exports according to equation system in the CGE model. Labor factor shares (al_H) and capital shares (ak_H) to households as well as household saving rate (sr_H) could change overtime that causes different values of household incomes and consumptions and then consequently causes a difference in welfare value. Notwithstanding this first restriction would reduce the results' accuracy, the assumption of constant economic structure for the CGE analysis is still valid for this study since all changes and impact are measured in percent of GDP.

Besides possibility of change in economic structure, the CGE model also contains some parameters that are calculated from model assumption especially the elasticity values which has direct impact to the analysis results. Since elasticity of substitution and elasticity of transformation are collected from secondary sources and recalculate in accordance with grouping seventy-nine to seven industrial sectors as defined in this study that would reduce calculation accuracy due to their average value. For example, each activity in the Mineral and Ceramic sectors have high a difference in Armington elasticity value from referenced sources and then average value is in the middle and is an absolute effect to analysis results. However, since it takes a great deal of effort to do direct estimations for elasticity values that require complex mathematical techniques, using referenced data from secondary sources and recalculations following the constraints in theory, such as the Armington rho parameter which must be less than one, is reasonable to apply. Despite this kind of restriction, the analysis results from this CGE model are sensible and consistent with both expectations and economic theory.

The second topic is about assumptions in the analysis scenarios; the most important things that apply to all cases are fixed labor and capital prices which are vital since other variables in scenarios are allowed to be adjustable. Even though this assumption is similar to GAMS, developed by Lofgren et al. (2002), it was test with the CGE model in this study as to what would happen to the result if both prices are flexible. When allowed for flexible labor and capital prices, the model will calculate into the equilibrium that is the total amount in money value of target variables; such as household incomes, output, aggregate consumptions, exports, and imports; all do not change except for their quantity and prices. Such results happen because when all prices are adjustable the model will simulate by adjusting all prices until the values of variables in the equation system reaches the equilibrium at original amount. Therefore, such restriction requires the model to fix for some price variables in order to evaluate for changes in other variables. This finding, as explained, supports the model assumption to fix labor and capital prices which are primary inputs of the production system. It is also consistent with the vertical FDI in which the foreigners will invest to produce goods in the host country in order to export to world markets, once factor prices are fixed and the model can simulate for changes of production outputs and exports then, it can explain the impact of FDI inflows to the country's economy and welfare.

Other than the aforementioned restrictions, there is strength in using SAM and the CGE model for this investigation of welfare; they are not only examined for final impact as a percentage of the GDP, but they also tell explain changes and impact mechanisms. From scenario one which is the major case for welfare investigation; the mechanism of the increasing trend in household incomes is returned from labor supplies rather than a return from capital, as well as mechanisms of income distribution which shows gains to the middle and the rich. In this case, it also explains where corporate income improvements came from, and why corporate incomes from capital factor are reduced. For scenario two, there are mechanisms to tell why the whole country got a negative welfare effect and how the assumption in this scenario affects analysis results. Scenario three explains mechanisms and the effect of reduction in domestic capital supplies as a consequence of fixed quantity of labor supplies while domestic capital is adjustable. In scenario four, there are explanations on how income distribution is better than other cases and where the increasing trend in institutions' income came from. All of the aforesaid mechanisms enlighten how economic agents and indicators are impacted by FDI inflows rather than just reporting the end impact results which would be useful for economists and policy makers who will provide policy recommendations to the government.

In addition to the strength of methodology used in this study, the same CGE model can be used with various assumptions and scenarios for the objective of the study rather than four cases that have been analyzed. For example, instead of the assumption of fixed labor and capital prices it can change to flexible prices and fix for other variables such as intermediate inputs that would be a scenario when the country has a limited amount of intermediate goods and researcher believe in the efficient primary factor' market. Different assumptions and scenarios cause different analytical results; nevertheless, it depends on the economic problems to be analyzed as well as the economic structure of the country. Analysis with various possible scenarios does not mean playing with the number, but it means that we can consider other ideas for a varied economic perspective as long as researchers have good ethics in their works; beyond that it provides more alternatives for policy recommendations. Even in this study in which the scenario one is the case I believe most realistic to Thailand's economic structure and resulted in the best welfare improvement according to household incomes, but the government may consider implementing policies according to scenario four if it needs to build up the country's GDP rather than household income. This flexibility in analysis is one of the advantages in using the CGE model.

Discussion on restrictions and strengths of the model and methodologies which were used in this welfare investigation would provide ideas for improvement in future studies. The SAM and the CGE model including its equations are useful in an investigation for changes in economic indicators when the country has a shock from FDI inflows especially in relation to the ability to explain change mechanisms.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

With regards to economic problems, research questions, and methodologies used in this study, there exists significant evidence for the relation between laxity in pollution control enforcements and increasing in FDI inflows to Thailand. The relation has consequence to the country's welfare, in term of increasing in household income, which the rich people gains more than the poor. These findings reveal inadequate pollution control enforcements of Thailand's government and its institutions when it imposed an open economic policy to attract foreign investors to invest in the country. Even though this study is not determined for the exact environmental impacts value, the findings still lead to the trade-off considerations about environmental and welfare impacts including income distribution in Thailand. To summarize all findings, this chapter provides a conclusion, discussion to contribution of this study and recommendation for future study.

6.1 Pollution Control and FDI

6.1.1 Relation Between Pollution Control Enforcements and FDI Inflows in Global Perspective

The first objective of this study is the global reexamination to disclose foreign investors' behaviors with regards to the relation between pollution control enforcements and FDI inflows. There are separate estimations by regions and income groups of countries as well as specific groups of ASEAN countries. With the time fixed effected panel regression method, during the year 2008 to 2013, the estimation results suggests that there is a relation of laxity in pollution control enforcements and increasing in FDI inflows from the overall global perspective; however, such findings had decreasing trends during the examination period. This evidence tells us that even the world took concerns about the environmental impact problem according to international trade and investment issues, but for a while but there was not enough stringent implementation. Notwithstanding the existence of significant relation between laxity in pollution control enforcements and increasing in FDI inflows, the decreasing trends of such relation were some of good things that the 'Green' industrial movement could achieve as desired goals in the future.

With the same time fixed effected panel regression, there is evidence of a relation between laxity in pollution control enforcements and increasing in FDI inflows in East Asia and the Pacific and Sub-Sahara Africa regions while other regions do not have such a crisis. This finding is quite important to the study since Thailand and other countries in ASEAN are members of this region, and most of them are developing countries that have increasing trends of FDI inflows. This result suggests that countries in East Asia and the Pacific could have more FDI inflows to boost up their economy but at the same time they relaxing their pollution controls enforcements which would also be considered as a competition tool. Similar situations happened in the Upper Middle Income and Lower Middle Income country groups, and are also important since most of the countries in ASEAN are in both groups.

The testing for the relation between pollution control enforcements and FDI inflows for individual countries in ASEAN used the same data set of the global level but with dissimilar regressions method, because of restrictions that were explained in Chapter 4, is the additional verification step. Each country in ASEAN shows contrasting results when compared to the aforesaid results of the group as a whole. Focusing on Thailand's results, with global data sets, there is no significant evidence of such relation also. Therefore, estimations with more observations using new data sets from BOI were further examined to reemphasize whether the country has relation between laxity in pollution control enforcements and increasing in FDI inflows

6.1.2 Relation Between Pollution Control Enforcements and FDI Inflows in Thailand

According to the first research questions of this study, the specific tests using thousands of observations from BOI's data set during the years 2009 to 2013 and pollution intensity data of each industry together with concurrent regression methods demonstrated a relation of laxity in pollution control enforcements and increasing in FDI inflows in Thailand. In this regard, the Agricultural industry has the highest significant relation followed by Mineral and Ceramics, Light Industries/Textiles, Chemical and Paper, Metal Products and Machinery industries respectively, while Mineral & Ceramic industry has insignificant relation and the Electric & Electronics industry is only one sector that demonstrate no significant relation.

Even though the examination period was only five years, however, when looking into Thailand's pollution statistical data there were increasing trends of CO2 emissions in the years 1970 to 2010, increasing trends of BOD emissions from the years 1996 to 2005, and slightly constant of PM10 emissions from the years 1990 to 2011. While Thailand's emissions have a continuous increasing trend and remains at high levels when compared to developed countries, there are 85 major regulations for water and air pollution that was counted from 1970 to 2012 with most of the limited values of pollutant remaining unchanged, which would interpret that Thailand' government just promulgated for pollution control regulations but implemented with low of enforcements. At the same period from 1975 to 2012 there were continuous increasing trends in FDI inflows to Thailand, in this regard; both continuous increasing trends of polluting emissions and incremental FDI inflows together with examinations results of the latest period, could tell that Thailand continuously enjoy benefit from more FDI inflows while careless about pollution control enforcement. According to the findings in which the existence of high pollutants contrasts the number of pollution regulations and their pollutant limitations that Thailand' government had been promulgating; it suggests that the government shall focus on quality of implementation of those regulations rather than the quantity of the announced laws.

6.2 Welfare and Increasing in FDI Inflows from a Relation with Laxity in Pollution Control Enforcements in Thailand

With regards to the second research question and the third research objective of this study, the results from a welfare investigation suggest that the more FDI inflows which are related to low level of pollution control enforcements in Thailand can create household welfare gains through incremental income as well as to boost up the country's GDP. However, the gain in term of increasing in household income is contribute more to the rich people than the poor. Stringent implementation of pollution controls would enhance the quality of environment; however, the cost of such implementations may create budget problems for the government. Therefore, trade-offs between benefits of FDI inflows versus costs of stringent pollution control enforcements and value of the environmental impact shall be further determined.

Not only welfare gain according to incremental of incomes that have impact from more FDI inflow is examined but also the income distribution in accordance with the third research objective. The CGE model in this study shows no improvement of income distribution when there were more FDI inflows while pollution control was less enforcing. Thailand's economic structure according to year 2005 SAM reveals that the richer households as well as corporate own more capital factor than the poorer households; and the richer households have higher labor factor share than the poorer households in term of amount of value not in term of quantity. Regarding analysis results by CGE model, return from increasing of capital through FDI inflows still contribute more to the middle income and the rich households while the poor households have less benefit. Even in some scenarios that labor demands are increased, but money amount of return from labor factor still contribute more to the richer. It is to be said that more FDI inflows which is related to laxity in pollution control enforcements can benefit households only in terms of incremental income through more factors used in more production that creates more FDI inflows, but we cannot introduce the equality of income distribution.

A welfare analysis of pollution control and FDI begins with the reexamination of the relation between pollution control enforcements and FDI inflows that the results show of its significant existence in Thailand. We can then follow the CGE model to determine the welfare issue that is affected by such relation. Conclusions from integrated results demonstrated welfare gain from incremental incomes and GDP. However, for the incremental incomes, the rich people gain more than the poor. For the environmental impacts from laxity in pollution control enforcement which is not yet exact evaluated but introduced for a conceptual evaluation in the appendix of this study as a suggestion for future study. The findings lead us to challenge alternative options about trade-off among cost of implement stringent pollution control enforcements, welfare loss and gain as well as a fair welfare contribution to economic agents in the country.

6.3 Contributions of This Study and Recommendations

Contributions from this study are the new methodology to create a quantitative pollution control enforcement variable from multiple measurable environment indicators to examine the relation between pollution control enforcements and FDI inflows, as well as the country's welfare analysis when FDI inflows are changed from such relation in Thailand. Beside those analysis methodologies this study also provides an economic development perspective regarding the pollution control and FDI. Given to policy makers or other researchers who are interesting in similar topics, are ways in which they can weigh the options for the country's environmental position in terms of the welfare and its impact. On the whole, when considering increasing in FDI inflows which its relation to laxity in pollution control enforcements, the calculations mixed with theory and connection the models are provided for the consideration about how can Thailand has more stringent in pollution control enforcement meanwhile increasing in FDI inflows. Furthermore, the findings about inequality of income distributions as a consequent from such relation is another one contribution which challenge the thinkers to find the way for improvement.

6.3.1 Quantitative Pollution Control Enforcements Measurement

One of the loopholes in previous studies about laxity in pollution control enforcement and pollution heaven examination is about the values of environmental variables used in those researches. There were various methodologies to quantify the level of environmental stringent as mentioned Chapter 3 and Chapter 4, but most of them have less relation to actual pollutant emission. Therefore, a new methodology to create a quantitative pollution control enforcement variable from multiple actual measurable environment indicators is the important contribution of this study.

The general thought of environmental variables development in this study is the more stringent in pollution control enforcements shall be reflexed by actual decreasing pollutant emission value regardless the number of environmental laws and regulations that had been promulgated by the government. Therefore, actual values from the environmental indicators are used in quantifying the level of pollution control enforcements. Since there are incomplete data, some countries have no data for some environmental indicators, hence this study selects three common indicators which are represented to air, water and solid pollutants. They consist of CO2 emission, Organic water pollution emission (BOD) and the dust content in ambient (PM2.5). Those emission numbers are transformed from nominal number to indexed and relative value in order to benchmarked the level of pollution control enforcements among countries. Such methodology can link the real pollutant emissions of each country with its own pollution control enforcements level, and those values are comparable in the same basis.

Methodology to quantify pollution control enforcements could further be developed. There is a recommendation to the researchers who interest in similar kind of research to add more measurable environmental indicators if the problem from incomplete data is solved. Other researchers may put other kinds of data such as a survey data from investors, ranking data from reliable environmental institute or other qualitative data together with the quantitative value, and then use methodology in this study to create a pollution control enforcement variable. These recommendations would enhance creditable of quantifying pollution control enforcement from spreader to more environmental aspects.

6.3.2 Can Thailand Do More Stringent in Pollution Control Enforcements Meanwhile Increasing in FDI Inflows?

Attracting more FDI inflows to the country has several ways for policy implementation, as the results of an examination for the High Income OECD and non-OECD group of countries say, the laxity in pollution control enforcements cliché or the reduction of FDI inflows has no value if it is not looked at statistically to make improvements and look at ways to bring value to these structures instead of statistical insignificance for the country as a while. Other strings of evidence show that to consider support options a country should have systems upon contingencies and models for weighing values for evaluating and making choices while finding ways of attracting more FDI inflows, but this is not necessary to have a laxity in pollution control enforcements, as shown in Chapter 4. It is the significant examination results of Singapore, both aforementioned evidences together with significant evidence of relation between laxity in pollution control enforcements and increasing in FDI inflows in Thailand and its impact to total welfare in term of household incomes and its distribution that Thailand can transform out of being considered as a low pollution control enforcements country with a strategic plan to avoid negative impact to FDI inflows.

According to the value of FDI shocks in percentage of GDP that was mentioned in Chapter 5, if the country has more stringent in pollution control enforcement and because of significant relation to amount of FDSI inflows, Agricultural industry and Mineral & Ceramic industry are two sectors that have higher reduction in FDI inflows than other sectors. The Light Industrial/Textiles, Metal Products and Machinery, and Chemical and Paper industries will have smaller reduction in FDI inflows while the Electric and Electronic Products is only one sector that the FDI flows will increase and Services sectors are assumed to having no impact. Therefore, when implementing stringent pollution control policy; the government shall specially take care of some of their prime products in Agricultural industry and Mineral & Ceramic industry in order to mitigate negative impacts as much as possible. On the other hand, the Thai government shall promote foreign investors to invest in two sectors that have no reduction in FDI inflows, Electric & Electronic and Services, as well as implementation of new mechanisms and new incentives for those of the three small impacted sectors to compensate the effect of the environmental stringent policies. It means that, Thailand needs to change its production structure toward environmentally green concept of industry care.

Not only moving toward production with environmental care industry, but also transforming the use of labor and capital as a primary production factor. To keep production level in order to maintain or increase the output, aggregate consumption and exports, the government can promote used of domestic capital for impacted sectors while imposed incentive to attract FDI inflows for Electric & Electronic and Services sectors. Moreover, substitution between labor and capital used in each impacted sector is recommended to consider by the government. Improve labor skill to substitute for loss of capital via FDI inflows will help to maintain or even increase the value added, as a secondary production input factor, which is used in production.

6.4 Recommendations for Future Studies

There are some economic problems that still have to be researched and answers for these problems have yet to be found because they were not the specific focus in this study, therefore, the recommendations for future studies are provided to those whom are interested in similar kinds of research subjects.

The first recommendation relates to, extending the industrial pollution intensity data set for reexamination of the relation between pollution control enforcements and FDI inflows in Thailand. Pollution intensity used in this study is a proxy value from energy spending which is an indirect indicator for the level of pollutants used in the production process. It is assumed that more energy consumed leads to more natural resource excavated; and high consumption of natural resources lead to high emissions. Then the lower the value of pollution intensity is the lesser dirty the industry, which can be used in the detection for which various industries would have high FDI inflows relate to laxity in pollution control enforcements. However, high value of energy spending and high natural resources consumption do not absolutely mean high emissions for all cases. Some production activities have progressive technologies to reduce pollutants that emits into the environment, meanwhile, the product itself still consumes high energy and natural resources. Moreover, such a proxy value was collected from the U.S. data and reference used for Thailand's industries. If there exits actual emission data for each industry and production activities for Thailand in the future which will truly indicate pollution intensity, it is recommended to do a reexamination on the relation of laxity in pollution control enforcements and amount of FDI inflows.

The second recommendation is about the evaluation of the environmental impact and the evaluation of the cost to stringent implementation of environmental regulations which are the areas out of scope of this study. There would exist negative environmental impact and other potential negative social welfares that are affected by the relation of laxity in pollution control enforcements and increasing in FDI inflows, such as the impact to people's health since higher emission can directly harm us in our day to day lives, or the impact to the agricultural sector where both air and water pollution could affect to its productivity. Such kinds of unobserved welfare impacts require detailed data to be analyzed in order to evaluate the impacted values. Therefore, it is recommended to include not only both examples but also other areas in the evaluation if there is sufficient data to be used for future research. However, in the Appendix C, there is an introduction and a suggestion to environmental impact evaluation. It aims to provide a guideline for whom who interest in similar economic problem to use in future study.

BIBLIOGRAPHY

Anan Wattanakuljarus. 2015. **General Concept & Database for CGE Models (Lecture).** A Lecture Delivery at National Institute of Development Administration.

Armington, P. A. 1969. Quoted in Lofgren, H.; Harris, R. L.; Robinson S.; Thomas M. and El-Said, M. 2002. **A Standard Computable General Equilibrium (CGE) Model in GAMS.** Washington D.C.: International Food Policy Research Institute.

Bank of Thailand. 2016. **Balance of Payment.** Retrieved July 18, 2016 from https://www.bot.or.th/Thai/Statistics/EconomicAndFinancial/Pages/StatBalanceofPayments.aspx

Barry, Michael P. 2009. Foreign Direct Investment in Central Asian Energy: A CGE Model. **Eurasian Journal of Business and Economics.** 2 (3): 35-54.

Becker, R. and Henderson, V. 2000. Effects of Air Quality Regulations on Polluting Industries. **Journal of Political Economy.** 108 (April): 379-421.

Blackhurst, R. 1977. Quoted in Dean, J. M. 1992. **Trade and the Environment: A Survey of the Literature.** Working Paper. Worldbank.

Brown, Drusilla K.; Deardorff, Alan V. and Stern, Robert M. 1991. **A North American Free Trade Agreement: Analytical Issues and a Computational Assessment.** Discussion Paper. Institute of Public Policy Studies, University of Michigan.

Chadin Rochananonda. 2004. **Trade Liberalization and Government Finances in Thailand: A Computable General Equilibrium Analysis.** Doctoral dissertation, University of Kansas.

Chung, Sunghoon. 2014. Environmental Regulation and Foreign Direct Investment: Evidence from South Korea. **Journal of Development Economics.** 108 (January): 222-236.

Claro, S. 2002. Quoted in Chadin Rochananonda. 2004. **Trade Liberalization and Government Finances in Thailand: A Computable General Equilibrium Analysis.** Doctoral dissertation, University of Kansas.

Cole, M. A.; Elliott, Robert J. R. and Shimamoto, K. 2005. Quoted in Chung, Sunghoon. 2014. Environmental Regulation and Foreign Direct Investment: Evidence from South Korea. **Journal of Development Economics.** 108 (January): 222-236.

Cole, M. A.; Elliott, Robert J. R. and Fredriksson, P. G. 2006. Quoted in Chung, Sunghoon. 2014. Environmental Regulation and Foreign Direct Investment: Evidence from South Korea. **Journal of Development Economics.** 108 (January): 222-236.

Copeland, Brian R. and Taylor, M. Scott. 1994. North-South Trade and the Environment. **The Quarterly Journal of Economics.** 109 (August): 755-787.

Copeland, Brian R. and Taylor, M. Scott. 2003. **Trade and the Environment.** New Jersey: Princeton University Press.

Copeland, Brian R. and Taylor, M. Scott. 2004. Trade, Growth and the Environment. **Journal of Economic Literature.** 42 (March): 7-71.

Damania, R.; Fredriksson, Per G. and List, John A. 2003. Trade Liberalization, Corruption, and Environmental Policy Formation: Theory and Evidence. **Journal of Environmental Economics and Management.** 46 (3): 490-512.

Dasgupta, S.; Laplante, B.; Wang, H. and Wheeler, D. 2002. Confronting the Environmental Kuznets Curve. **The Journal of Economic Perspectives.** 16 (1): 147-168.

Dean, J. M. 1992. **Trade and the Environment: A Survey of the Literature.** Working Paper. Worldbank.

Dean, J. M. 2002. Does Trade Liberalization Harm the Environment? A New Test. **Canadian Journal of Economics.** 35 (November): 819-842.

Dean, J. M. and Lovely M. E. 2008. **Trade Growth, Production Fragmentation, and China's Environment.** Working Paper. National Bureau of Economic Research.

Dean, J. M.; Lovely M. E. and Wang, Hua. 2009. Are Foreign Investors Attracted to Weak Environmental Regulation? Evaluating the Evidence from China. **Journal of Development Economics.** 90: 1-13.

Devarajan, Shantayanan and Chalongphop Sussangkarn. 1992. Effective Rates of Protection When Domestic and Foreign Goods are Imperfect Substitutes: The Case of Thailand. **The Review of Economics and Statistics.** 74 (November): 701-711.

Devarajan, Shantayanan; Go, Delfin S; Lewis, Jeffrey D.; Robinson, S. and Sinko, P. 1998. **Simple General Equilibrium Modeling.** Retrieved September 10, 2015 from http://www.un.org/en/development/desa/policy/mdg_ workshops/eclac_training_mdgs/devarajanetal_1997simplegemodeling.pdf

Dijkstra B. R.; Mathew A. J. and Mukherjee, A. 2011. Environment Regulation: An Incentive for Foreign Direct Investment. **Review of International Economics.** 19 (3): 568-578.

Duerksen, C. and Leonard, H. J. 1980. Quoted in Dean, J. M. 1992. **Trade and the Environment: A Survey of the Literature.** Working Paper. Worldbank.

Ederington, J. and Minier, J. 2003. Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis. **Canadian Journal of Economics.** 36 (1): 137-154.

Elliott, Robert J. R. and Zhou, Y. 2013. Environmental Regulation Induced Foreign Direct Investment. **Environmental and Resource Economics.** 55: 141-158.

Eskeland, Gunnar S. and Harrison, Ann E. 2003. Moving to Greener Pastures? Multinationals and the Pollution Heaven Hypothesis. **Journal of Development Economics.** 70: 1-23.

Gouldson, A.; Carpenter A. and Afionis S. 2014. An International Comparison of the Outcones of Environmental Regulation. **Environmental Research Letters.** 9 (July): 1-9.

Gray, Wayne B. and Shadbegian, Ronald J. 1998. Environmental Regulation, Investment Timing, and Technology Choice. **The Journal of Industrial Economics.** 46 (June): 235-256.

Greene, William H. 2012. **Econometric Analysis.** England: Pearson Education.

Grossman, G. M. and Krueger, A. B. 1991. **Environmental Impacts of a North America Free Trade Agreement.** Working Paper. National Bureau of Economic Research.

Gujarati, Damodar N. and Porter, Dawn C. 2009. **Basic Econometrics.** Singapore: McGraw-Hill.

Harbough, W. T.; Levinson, A. and Wilson, D. M. 2002. Reexamining the Empirical Evidence for and Environmetal Kuznets Curve. **The Review of Economics and Statistics.** 84 (August): 541-551.

Haveman, Jon D.; Nair-Reichert, U. and Thursby, Jerry G. 2003. How Effective Are Trade Barriers? An Empirical Analysis of Trade Reduction, Diversion, and Compression. **The Review of Economics and Statistics.** 85 (May): 480-485.

Helpman, E. 1984. A Simple Theory of International Trade with Multinational Corporations. **Journal of Political Economy.** 92 (3): 451-471.

International Labour Organization. 2014. **Statistics and Database.** Retrieved December 30, 2014 from http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm

Jaffe, A. B. and Palmer, K. 1997. Environmental Regulation and Innovation: A Panel Data Study. **The Review of Economics and Statistics.** 79 (November): 610-619.

Keller, W. and Levinson, A. 2002. Pollution Abatement Costs and Foreign Direct Investment Inflow to U.S. States. **The Review of Economics and Statistic.** 84 (November): 691-703.

Kulnida Waewweerawong. 2014. **Distributional Impacts of Export, Foreign Direct Investment (FDI) and Foreign Portfolio Investment (FPI) in Thailand.** Submitted to Bank of Thailand. Retrieved November 3, 2015 from https://www.bot.or.th/Thai/Segmentation/Student/setthatat/DocLib_Settha_Paper_2557/M_Doc_Prize1_2557.pdf

Lee, Jong-Wha and Swagel, Phillip. 1997. Trade Barriers and Trade Flows Across Countries and Industries. **The Review of Economics and Statistics.** 79 (August): 372-382.

Leiter, Andrea M.; Parolini, Arno and Winner Hannes. 2011. Environmental Regulation and Investment: Evidence from European Industry Data. **Ecological Economics.** 70: 759-770.

Levin, J. 2006. **General Equilibrium.** Retrieved July 12, 2016 from https://web.stanford.edu/~jdlevin/Econ%20202/General%20Equilibrium.pdf.

Levinson, A. 1996. Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures. **Journal of Public Economics.** 62: 5-29.

Levinson, A. 2009. Technology, International Trade, and Pollution from US Manufacturing. **The American Economic Review.** 99 (December): 2177-2192.

Levinson, A. and Taylor, M. Scott. 2008. Unmasking the Pollution Heaven Effect. **International Economic Review.** 49 (February): 223-254.

List, John A. and Co, Catherine Y. 2000. The Effects of Environmental Regulations on Foreign Direct Investment. **Journal of Environmental Economics and Management.** 40: 1-20.

Lofgren, H.; Harris, R. L.; Robinson S.; Thomas M. and El-Said, M. 2002. **A Standard Computable General Equilibrium (CGE) Model in GAMS.** Washington D.C.: International Food Policy Research Institute.

Lofgren, H.; Robinson, S. and Thurlow, J. 2002. Quoted in Chadin Rochananonda. 2004. **Trade Liberalization and Government Finances in Thailand: A Computable General Equilibrium Analysis.** Doctoral dissertation, University of Kansas.

Markusen, J. R. 1984. Multinationals, Multi-Plant Economies, and the Gains from Trade. **Journal of International Economics.** 16 (May): 205-226.

Milner, C.; Reed G. and Pawin Talerngsri. 2004. Foreign Direct Investment and Vertical Integration of Production by Japanese Multinationals in Thailand. **Journal of Comparative Economics.** 32: 805-821.

Ministry of Industry. Department of Industrial Works. Public Information Center. 2014. **Industrial Environment Laws and Regulations.** Retrieved September 30, 2014 from http://www2.diw.go.th/PIC/law_01.html (In Thai)

Ministry of Natural Resources and Environment. Office of Natural Resources and Environmental Policy and Planning. 2014. **Ministerial Regulation.** Retrieved October 1, 2014 from http://www.onep.go.th/index.php?option=com_content&view=article&id=2754&Itemid=160 (In Thai)

Ministry of Natural Resources and Environment. Pollution Control Department. 2014. **Thai Environmental Regulations.** Retrieved December 21, 2014 from http://www.pcd.go.th/info_serv/en_regulation.html

Nuntaporn Methakunavut and Somchai Jitsuchon. 2002. Quoted in Chadin Rochananonda. 2004. **Trade Liberalization and Government Finances in Thailand: A Computable General Equilibrium Analysis.** Doctoral dissertation, University of Kansas.

Office of the National Economic and Social Development Board. 2016. **National Account.** Retrieved July 18, 2016 from http://www.nesdb.go.th/nesdb_en/main.php?filename=national_account

Parker, Jeffrey A. 2014. **Model for Pooled and Panel Data.** Retrieved June 25, 2015 from http://www.reed.edu/economics/parker/s11/312/notes/Notes13.pdf

Pearson, C. 1987. Quoted in Dean, J. M. 1992. **Trade and the Environment: A Survey of the Literature.** Working Paper. Worldbank.

Peng, A. 2009. **Introducing CGE Models to the Classroom Using EXCEL.** Retrieved February 9, 2015 from http://www.economics.ryerson.ca/workingpapers/wp103.pdf

Quazi, M. R. 2014. Effects of Corruption and Regulatory Environment on Foreign Direct Investment: A Case Study of Africa. **Global Journal of Business Research.** 84 (4): 51-60.

Smarzynska, B. K. and Wei, Shang-Jin. 2001. **Pollution Heavens and Foreign Direct Investment: Dirty Secret or Popular Myth?.** Working Paper. National Bureau of Economic Research.

Söderholm, Patrik. 2006. Environmental Taxation in the Natural Resource Extraction Sector: Is it a Good Idea?. **European Environment.** 16: 232-245.

Söderholm, Patrik. 2011. Taxing Virgin Natural Resources: Lessons from Aggregates Taxation in Europe. **Resources, Conservation and Recycling.** 55: 911-922.

Sompote Kunnoot. 2002. Developing a Standard Computable General Equilibrium (CGE) Model for Economic Analysis and Assessment. **Thai Journal of Development Administration.** 42 (2): 15-35. (In Thai)

Thailand Board of Investment. 2014. **Foreign Direct Investment: Annually Statistics.** Retrieved August 30, 2014 from http://www.boi.go.th/index.php?page=statistics_foreign_direct_investment

Thammasat University. Faculty of Economics. 2004. **The Computable General Equilibrium Model to Measure the Economic Impacts from Industrial Standard (NARAI 1 Model).** Submitted to The Office of Industrial Economics, Ministry of Industry. Retrieved March 23, 2015 from http://www.oie.go.th/academic/ (In Thai)

Torres-Reyna, O. 2007. **Panel Data Analysis Fixed and Random Effects Using Stata (V.4.2).** Retrieved April 15, 2015 from https://www.princeton.edu/~otorres/Panel101.pdf

Umaporn Wongwatanasin. 1999. **General Equilibrium Evaluation of Industrial Policies on Output, Trade Flows and Income Distribution in Thailand.** Doctoral dissertation, University of North Carolina.

United Nations Conference on Trade and Investment. 2015. **Foreign direct investment: Inward and outward flows and stock, annual, 1980-2014.** Retrieved May 19, 2015 from http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96740

United Nations Environment Programme. Environmental Law Branch. Division of Policy Development and Law. 2005. **Register of International Treaties and Other Agreements in the Field of the Environment.** Retrieved January 16, 2016 from http://www.unep.org/delc/Portals/119/publications/register_Int_treaties_contents.pdf

United State. Department of Commerce. Census Bureau. 2014. **Pollution Abatement Costs and Expenditures: 2005 Survey.** Retrieved July 19, 2014 from https://www.census.gov/econ/manufacturing.html

United State. Environmental Protection Agency. 2015. **Guide to Data Sources for Manufacturing from the U.S. Census Bureau.** Retrieved February 9, 2015 from https://www.epa.gov/environmental-economics/pollution-abatement-costs-and-expenditures-2005-survey

Wagner U. J. and Timmins C. D. 2009. Agglomeration Effects in Foreign Direct Investment and the Pollution Heaven Hypothesis. **Environmental and Resource Economics.** 43 (October): 231-256.

Warr, P. G. 1998. Quoted in Chadin Rochananonda. 2004. **Trade Liberalization and Government Finances in Thailand: A Computable General Equilibrium Analysis.** Doctoral dissertation, University of Kansas.

Wethang Phaungsap; Suthee Luangaramkul; Chanin Manopiniwes and Nattapong Puttanapong. 2008. **Computable general Equilibrium Capital Flow Model.** Submitted to Fiscal Policy Office, Ministry of Finance. Retrieved August 15, 2015 from http://www.fpo.go.th/FPO/pdf/capital_model_25aug51.pdf (In Thai).

Wilaiwan Sirirotjanaput. 2012. **Welfare Analysis of Household Demand for Vehicle Fuel.** Doctoral dissertation, National Institute of Development Administration.

Wisarn Pupphavesa; Santi Chaisrisawatsuk; Sasatra Sudsawasd and Sumet Ongkittikul. 2009. Competition Policy, Infrastructure, and Intellectual Property Rights. In **Realizing the ASEAN Economic Community A Comprehensive Assessment.** Michael G. Plummer and Chia Siow Yue, eds. Singapore: Institute of Southeast Asian Studies. Pp. 58-82.

World Bank. 2014. **World Development Indicators.** Retrieved July 23, 2014 from http://data.worldbank.org/data-catalog/world-development-indicators

World Economic Forum. 2014. **Global Competitive Report 2008-2009.** Retrieved August 30, 2014 from http://www.weforum.org/content/pages/competitiveness-library

Xing Y. and Kolstad C. D. 2002. Do Lax Environmental Regulations Attract Foreign Investment?. **Environmental and Resource Economics.** 21: 1-22.

Zarsky, Lyuba. 1999. Havens, Halos and Spaghetti: Untangling the Evidence about Foreign Direct Investment and the Environment. In **Foreign Direct Investment and the Environment.** Paris: OECD. Pp. 58-82.

Zeng, K. and Eastin J. 2012. Do Developing Countries Invest Up? The Environmental Effects of Foreign Direct Investment from Less-Developed Countries. **World Development.** 40 (11): 2221-2233.

APPENDICES

Appendix A

Country List in Pollution Heaven Reexamination

Country	Code	Region Group	Income Group	Country	Code	Region Group	Income Group	Country	Code	Region Group	Income Group
Afghanistan	AFG	6	5	Georgia	GEO	2	4	Northern Mariana Islands	MNP	1	2
Albania	ALB	2	3	Germany	DEU	2	1	Norway	NOR	2	1
Algeria	DZA	4	3	Ghana	GHA	7	4	Oman	OMN	4	2
American Samoa	ASM	1	3	Greece	GRC	2	1	Pakistan	PAK	6	4
Andorra	ADO	2	2	Greenland	GRL	2	2	Palau	PLW	1	3
Angola	AGO	7	3	Grenada	GRD	3	3	Panama	PAN	3	3
Antigua and Barbuda	ATG	3	2	Guam	GUM	1	2	Papua New Guinea	PNG	1	4
Argentina	ARG	3	3	Guatemala	GTM	3	4	Paraguay	PRY	3	4
Armenia	ARM	2	4	Guinea	GIN	7	5	Peru	PER	3	3
Aruba	ABW	3	2	Guinea-Bissau	GNB	7	5	Philippines	PHL	1	4
Australia	AUS	1	1	Guyana	GUY	3	4	Poland	POL	2	1
Austria	AUT	2	1	Haiti	HTI	3	5	Portugal	PRT	2	1
Azerbaijan	AZE	2	3	Honduras	HND	3	4	Qatar	QAT	4	2
Bahamas, The	BHS	3	2	Hong Kong	HKG	1	2	Romania	ROM	2	3
Bahrain	BHR	4	2	Hungary	HUN	2	3	Russia	RUS	2	2
Bangladesh	BGD	6	5	Iceland	ISL	2	1	Rwanda	RWA	7	5
Barbados	BRB	3	2	India	IND	6	4	Samoa	WSM	1	4
Belarus	BLR	2	3	Indonesia	IDN	1	4	San Marino	SMR	2	2
Belgium	BEL	2	1	Iran	IRN	4	3	Sao Tome and Principe	STP	7	4
Belize	BLZ	3	3	Iraq	IRQ	4	3	Saudi Arabia	SAU	4	2
Benin	BEN	7	5	Ireland	IRL	2	1	Senegal	SEN	7	4
Bermuda	BMU	5	2	Israel	ISR	4	1	Serbia	SRB	2	3
Bhutan	BTN	6	4	Italy	ITA	2	1	Seychelles	SYC	7	3
Bolivia	BOL	3	4	Jamaica	JAM	3	3	Sierra Leone	SLE	7	5
Bosnia and Herzegovina	BIH	2	3	Japan	JPN	1	1	Singapore	SGP	1	2
Botswana	BWA	7	3	Jordan	JOR	4	3	Saint Maarten (Dutch part)	SXM	3	2
Brazil	BRA	3	3	Kazakhstan	KAZ	2	3	Slovak Republic	SVK	2	1
Brunei	BRN	1	2	Kenya	KEN	7	5	Slovenia	SVN	2	1
Bulgaria	BGR	2	3	Kiribati	KIR	1	4	Solomon Islands	SLB	1	4
Burkina Faso	BFA	7	5	Korea	KOR	1	1	Somalia	SOM	7	5
Burundi	BDI	7	5	Korea, Dem. Rep.	PRK	1	5	South Africa	ZAF	7	3
Cambodia	KHM	1	5	Kuwait	KWT	4	2	South Sudan	SSD	7	4
Cameroon	CMR	7	4	Kyrgyz Republic	KGZ	2	4	Spain	ESP	2	1
Canada	CAN	5	1	Laos	LAO	1	4	Sri Lanka	LKA	6	4
Cayman Island	CYM	3	2	Latvia	LVA	2	2	Sudan	SDN	7	4
Central African Republic	CAF	7	5	Lebanon	LBN	4	3	Suriname	SUR	3	3
Chad	TCD	7	5	Lesotho	LSO	7	4	Swaziland	SWZ	7	4
Channel Islands	CHI	2	2	Liberia	LBR	7	5	Sweden	SWE	2	1
Chile	CHL	3	1	Libya	LBY	4	3	Switzerland	CHE	2	1
China	CHN	1	3	Lichtenstein	LIE	2	2	Syrian Arab Republic	SYR	4	4
Colombia	COL	3	3	Lithuania	LTU	2	2	Taiwan	TWN	1	2
Comoros	COM	7	5	Luxembourg	LUX	2	1	Tajikistan	TJK	2	5
Congo, Rep.	COG	7	4	Macao SAR, China	MAC	1	2	Tanzania	TZA	7	5
Costa Rica	CRI	3	3	Madagascar	MDG	7	5	Thailand	THA	1	3
Cote d'Ivoire	CIV	7	4	Malawi	MWI	7	5	Timor-Leste	TMP	1	4
Croatia	HRV	2	2	Malaysia	MYS	1	3	Togo	TGO	7	5
Cuba	CUB	3	3	Maldives	MDV	6	3	Tonga	TON	1	3
Curacao	CUW	3	2	Mali	MLI	7	5	Trinidad and Tobago	TTO	3	2
Cyprus	CYP	2	2	Malta	MLT	4	2	Tunisian Republic	TUN	4	3
Czech Republic	CZE	2	1	Marshall Islands	MHL	1	3	Turkey	TUR	2	3
Denmark	DNK	2	1	Mauritania	MRT	7	4	Turkmenistan	TKM	2	3
Djibouti	DJI	4	4	Mauritius	MUS	7	3	Turks and Caicos Islands	TCA	3	2
Dominica	DMA	3	3	Mexico	MEX	3	3	Tuvalu	TUV	1	3
Dominican Republic	DOM	3	3	Micronesia, Fed. Sts.	FSM	1	4	U.S.A.	USA	5	1
Ecuador	ECU	3	3	Moldova	MDA	2	4	Uganda	UGA	7	5
Egypt	EGY	4	4	Mongolia	MNG	1	4	Ukraine	UKR	2	4
El Salvador	SLV	3	4	Montenegro	MNE	2	3	United Arab Emirates	ARE	4	2
Equatorial Guinea	GNQ	7	2	Morocco	MAR	4	4	United Kingdom	GBR	2	1
Eritrea	ERI	7	5	Mozambique	MOZ	7	5	Uruguay	URY	3	2
Estonia	EST	2	1	Myanmar	MMR	1	5	Uzbekistan	UZB	2	4
Ethiopia	ETH	7	5	Namibia	NAM	7	3	Vanuatu	VUT	1	4
Faeroe Islands	FRO	2	2	Nepal	NPL	6	5	Venezuela, RB	VEN	3	3
Fiji	FJI	1	3	Netherlands	NLD	2	1	Vietnam	VNM	1	4
Finland	FIN	2	1	New Caledonia	NCL	1	2	Yemen, Rep.	YEM	4	4
France	FRA	2	1	New Zealand	NZL	1	1	Zambia	ZMB	7	4
French Polynesia	PYF	1	2	Nicaragua	NIC	3	4	Zimbabwe	ZWE	7	5
Gabon	GAB	7	3	Niger	NER	7	5				
Gambia	GMB	7	5	Nigeria	NGA	7	4				

Regional	**ID**
East Asia & Pacific	1
Europe & Central Asia	2
Latin America & Caribbean	3
Middle East & North Africa	4
North America	5
South Asia	6
Sub-Saharan Africa	7

Income group	**ID**
High income: OECD	1
High income: non-OECD	2
Upper middle income	3
Lower middle income	4
Low income	5

Appendix B

Equations and Definitions of the Variables

B.1 Variables of Pollution Heaven Reexamination

Notation	Description	Notation	Description
FDI	Net FDI inflow	RLAXPI	Relative Pollution Intensity Embed Laxity of country's pollution control
ILAX	Indexed Laxity of country's pollution control	RLAX	Relative Laxity of country's pollution control
IENVITAX,	Indexed Environmental tax	RENVITAX,	Relative Environmental tax
Ir	Indexed Capital price	Rr	Relative Capital price
Iw	Indexed Labor wage	Rw	Relative Labor wage
ITARIFF	Indexed Import tariff	RTARIFF	Relative Import tariff
IBUSET	Indexed Cost of business set up	RBUSET	Relative Cost of business set up
IEXCOST	Indexed Cost of export good	REXCOST	Relative Cost of export good
IMCOST	Indexed Cost of import good	RMCOST	Relative Cost of import good
IROAD	Indexed Road intensity	RROAD	Relative Road intensity
IENERGY	Indexed Energy abundant	RENERGY	Relative Energy abundant
IWATER	Indexed Water abundant	RWATER	Relative Water abundant
IGDP	Indexed GDP	RGDP	Relative GDP
REGIONID	Regional Dummy	YEAR	Year Dummy
INCOMEID	Income Group Dummy	CONID	Country Dummy
IND	Industrial Dummy		

B.2 Equations of Pollution Heaven Reexamination

Model 1: Pooled regression with time fixed effect for Global and ASEAN level

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \lambda_t YEAR_t + \sum_{t=2}^{T=6} \alpha_t ILAX_{it} \cdot YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \lambda_t YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{t=2}^{T=6} \alpha_t ILAX_{it} \cdot YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

Model 2: Pooled regression with regional dummy for Global and ASEAN level

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s REGIONID_s + \sum_{s=2}^{S=7} \gamma_s ILAX_{it} \cdot REGIONID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s REGIONID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=7} \gamma_s ILAX_{it} \cdot REGIONID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

Model 3: Pooled regression with income group of country dummy for Global and ASEAN level

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s INCOMEID_s + \sum_{s=2}^{S=5} \gamma_s ILAX_{it} \cdot INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

$$logFDI_{it} = c + \alpha_1 ILAX_{it} + \sum_{s=2}^{S=5} \gamma_s ILAX_{it} \cdot INCOMEID_s + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

Model 4: LSDV for Global and ASEAN level

$$logFDI_{it} = c_1 + \alpha_1 ILAX_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \boldsymbol{\beta_k}(\boldsymbol{IX}_{k,it}) + \varepsilon_{it}$$

Model 5: Time fixed effect for Thailand Level

$$logFDI_{it} = c + \alpha_1 RLAXPI_{it} + \sum_{t=2}^{T=5} \lambda_t YEAR_t + \boldsymbol{\beta_k}(\boldsymbol{RX}_{k,it}) + \varepsilon_{it}$$

Model 6: Time fixed effect with industrial dummies (concurrent regressions across industrial) for Thailand Level

$$logFDI_{it} = c + \alpha_1 RLAXPI_{it} + \sum_{t=2}^{T=5} \lambda_t YEAR_t + \sum_{s=2}^{S=6} \gamma_s RLAXPI_{it} \cdot IND_s + \boldsymbol{\beta_k}(\boldsymbol{RX}_{k,it}) + \varepsilon_{it}$$

Model 7: Country fixed effect for Thailand Level

$$logFDI_{it} = c_1 + \alpha_{it}RLAXPI_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \boldsymbol{\beta_k}(\boldsymbol{RX}_{k,it}) + \varepsilon_{it}$$

Model 8: Country fixed effect with industrial dummies (concurrent regressions across industrial) for Thailand Level

$$logFDI_{it} = c_1 + \alpha_{it}RLAXPI_{it} + \sum_{j=2}^{J=202} c_j CONID_{ji} + \sum_{s=2}^{S=6} \gamma_s RLAXPI_{it} \cdot IND_s + \boldsymbol{\beta_k}(\boldsymbol{RX}_{k,it}) + \varepsilon_{it}$$

B.3 Variables and Parameters for CGE

Endogenous Variables

$CH_{H,i}$	household H's consumption of commodity i
CHX_H	household H's consumption
D_i	quantity of domestic supply of commodity i
DD_i	domestic aggregate demand of commodity i
DDT_i	domestic aggregate demand less tax
E_i	quantity of export of commodity i
ER	exchange rate in local per foreign currency
IC	corporate's total income
$ICTAX_C$	corporate income tax spends to government
$ICTAX_H$	household H's income tax spends to government
IF_C	income from factor of corporate
IF_G	income from factor of government
IF_H	income from factors of household H
$IF_{H,K}$	income from capital factor of household H
$IF_{H,L}$	income from labor factor of household H
IG	government's total income
IH_H	household H's total income
INT_i	value of intermediate input of production for activity i
K_i	value of capital supply for activity i
KD_i	domestic capital supply quantity of activity i

KIN_i	capital from foreign quantity of activity i
L_i	value of labor supply for activity i
LD_i	Labor quantity supply for activity i
M_i	quantity of import of commodity i
NT_i	quantity of intermediate input for activity i
QD_i	composite demand of commodity i
ONT_i	value of intermediate output consumption of commodity i
OT_i	quantity of intermediate output consumption of commodity i
PD	price of domestic supply
PE	export price in local currency, Thai Baht
PK	capital price
PL	labor price
PM	import price in local currency, Thai Baht
PQ	composite commodity price
PX	output price
QS_i	quantity of composite supply
S	aggregate saving in the country
S_C	corporate saving
S_G	government saving
S_H	household H's saving
$TAXIC$	total tax on income that apply to household and corporate
$TAXP$	total tax on product that equal to $\sum_i TAXP_i$
$TAXP_i$	tax on production of commodity i
VA_i	value added as production input of activity i
X_i	quantity of output of commodity i
Z_i	investment consumption of commodity i

Exogenous Variables

$\overline{CAPI}$	foreign capital inflow endowment in local currency
$\overline{DFDI_i}$	shock of FDI inflow to activity i
$\overline{G_i}$	government consumption of commodity i

$\overline{INVO}$	investment abroad
$\overline{OTHF}$	other transaction according to the rest of the world
$\overline{S_O}$	other saving
$\overline{TRD\imath n_C}$	corporate received transfer from domestic institutions
$\overline{TRDIN_G}$	government received transfer from domestic institutions
$\overline{TRDIN_H}$	household H received transfer from domestic institutions
$\overline{TRDOUT_C}$	corporate spending transfer to domestic institutions
$\overline{TRDOUT_G}$	government spending transfer to domestic institutions
$\overline{TRDOUT_H}$	household H’s spending transfer to domestic institutions
$\overline{TRF\imath n_C}$	corporate received transfer from foreign
$\overline{TRFIN_G}$	government received transfer from foreign
$\overline{TRFIN_H}$	household H received transfer from foreign
$\overline{TRFOUT_C}$	corporate spending transfer to foreign
$\overline{TRFOUT_G}$	government spending transfer to foreign
$\overline{TRFOUT_H}$	household H’s spending transfer to foreign

Parameters

af_i	scale parameter for CES of value added of activity i
ak_C	capital factor share to corporate income
ak_G	capital factor share to government income
ak_H	capital factor share to household H’s income
al_H	labor factor share to household H’s income
aq_i	scale parameter for CES between import and domestic supply for commodity i
at_i	scale parameter for CET between export and domestic supply for commodity i
bf_i	share parameter for CES of value added of activity i
bq_i	share parameter for CES between import and domestic supply for commodity i

bt_i	share parameter for CET between export and domestic supply for commodity i
$cf_{H,i}$	consumption share factor of household H to consume commodity i
$cf_{Z,i}$	consumption share factor of the investment to consume commodity i
kp_i	proportion of Capital used in industry sector i
nvf_i	intermediate input per VA factor for Leontief production function
rf_i	rho parameter of substitution elasticity for CES of value added of activity i
rq_i	rho parameter for CES between import and domestic supply for commodity i
rt_i	rho parameter for CET between export and domestic supply for commodity i
sr_C	corporate saving rate
sr_G	government saving rate
sr_H	household H's saving rate
te	export tariff rate
ti_C	income tax rate applies to corporate
ti_H	income tax rate applies to household H
tm	import tariff rate
ts	average rate of tax on production
ts_i	tax rate on production of commodity i
we	world price of export
wm	world price of import

B.4 CGE Equations

Price Block

$$PM = ER \cdot wm \cdot (1 + tm)$$

$$PE = ER \cdot we \cdot (1 - te)$$

$$PX = (PE \cdot \sum_i E_i + PD \cdot \sum_i D_i)/\sum_i X_i$$

$$PQ = (PM \cdot \sum_i M_i + PX \cdot \sum_i X_i) \cdot (1 + ts)/\sum_i QS_i$$

Production and Trade

$$X_i = (1 + nvf_i) \cdot VA_i$$

$$VA_i = af_i \cdot \left(bf_i \cdot L_i^{-rf_i} + (1 - bf_i) \cdot K_i^{-rf_i}\right)^{\left(-\frac{1}{rf_i}\right)}$$

$$K_i = KD_i \cdot PK + KIN_i$$

$$KIN_i = (\overline{CAPI} \cdot kp_i \cdot PK) + \overline{DFDI_i} \cdot ER \cdot PK$$

$$L_i = LD_i \cdot PL$$

$$INT_i = NT_i \cdot PQ$$

$$ONT_i = OT_i \cdot PQ$$

$$QD_i = E_i \cdot PE + DD_i$$

$$QS_i = QD_i$$

$$D_i = DD_i - M_i \cdot PM - TAXP_i$$

$$DD_i = \left(\sum_H CH_{H,i} + Z_i + \overline{G_i}\right) \cdot PQ + ONT_i$$

$$DDT_i = DD_i - TAXP_i$$

$$X_i = at_i \cdot \left(bt_i \cdot E_i^{rt_i} + (1 - bt_i) \cdot D_i^{rt_i}\right)^{\left(\frac{1}{rt_i}\right)}$$

$$DDT_i = aq_i \cdot \left(bq_i \cdot M_i^{-rq_i} + (1 - bq_i) \cdot D_i^{-rq_i}\right)^{\left(-\frac{1}{rq_i}\right)}$$

$$E_i/D_i = \left[\left(\frac{PE}{PD}\right) \cdot \left(\frac{1 - bt_i}{bt_i}\right)\right]^{\left(\frac{1}{rt_i - 1}\right)}$$

$$M_i/D_i = \left[\left(\frac{PD}{PM}\right) \cdot \left(\frac{bq_i}{1 - bq_i}\right)\right]^{\left(\frac{1}{1 + rq_i}\right)}$$

Institution

$TAXP_i = (X_i \cdot PX + M_i \cdot PM) \cdot ts_i$

$TAXIC = \sum_H (ti_H \cdot IF_H) + (ti_C \cdot IF_C)$

$IF_H = al_H \cdot \sum_i L_i + ak_H \cdot \sum_i K_i$

$IF_C = ak_C \cdot \sum_i K_i$

$IF_G = ak_G \cdot \sum_i K_i$

$IH_H = IF_H + (\overline{TRDIN_H} + \overline{TRFIN_H} \cdot ER)$

$IC = IF_C + (\overline{TRDIN_C} + \overline{TRFIN_C} \cdot ER)$

$IG = IF_G + (\overline{TRDIN_G} + \overline{TRFIN_G} \cdot Er) + \sum_i TAXP_i + TAXIC$

$S_H = sr_H \cdot IH_H$

$S_C = sr_C \cdot IC$

$S_G = sr_G \cdot IG$

$S = \sum_H S_H + S_C + S_G + \overline{S_O}$

$ICTAX_H = ti_H \cdot IF_H$

$ICTAX_C = ti_C \cdot IF_C$

$CHX_H = \sum_i [IH_H - ICTAX_H - S_H - (\overline{TRDOUT_H} + \overline{TRFOUT_H} \cdot ER)] \cdot cf_{H,i} \cdot PQ$

$Z_i = cf_{Z,i} \cdot (S - \overline{S_O} - \overline{INVO} \cdot ER)$

System Constraint Block

$\sum_i INT_i = \sum_i ONT_i$

$\sum_i (VA_i + INT_i) = \sum_i X_i \cdot PX$

$\sum_i (X_i \cdot PX + M_i \cdot PM) \cdot (1 + ts_i) = \sum_i (OT_i + \sum_H CH_{H,i} + Z_i + \overline{G_i}) \cdot PQ$

$\sum_H (IF_{H,L}) = \sum_i L_i$

$\sum_H (IF_{H,K}) + IF_C + IF_G = \sum_i K_i$

$TAXP + TAXIC = \sum_i (X_i \cdot PX + M_i \cdot PM) \cdot ts_i + \sum_H (ti_H \cdot IF_H) + (ti_c \cdot IF_c)$

$CHX_H + ICTAX_H + S_H + (\overline{TRDOUT_H} + \overline{TRFOUT_H} \cdot ER) = IH_H$

$ICTAX_C + S_C + (\overline{TRDOUT_C} + \overline{TRFOUT_C} \cdot Er) = IC$

$\overline{G_i} + S_G + (\overline{TRDOUT_G} + \overline{TRFOUT_G} \cdot ER) = \mathrm{IG}$

$$\sum_i Z_i/PQ + \overline{INVO} \cdot ER + \overline{S_O} = S$$

$$(\sum_i E_i - \sum_i M_i) + [(\sum_H (\overline{TRFIN_H} \cdot ER) + \overline{TRFIN_C} \cdot ER + \overline{TRFIN_G} \cdot ER + \overline{OTHF} \cdot ER + \overline{DFDI} \cdot ER) - (\sum_H (\overline{TRFOUT_H} \cdot ER) + \overline{TRFOUT_C} \cdot ER + \overline{TRFOUT_G} \cdot ER + \overline{INVO} \cdot ER + \overline{OTHF} \cdot ER)] = 0$$

Appendix C

A Suggestion to Environmental Impact Evaluation

The important questions which would be asked is about the value of environmental impact if Thailand relax its relative laxity of pollution control enforcements (RLAX) for one point. The value of one point of RLAX can be evaluated to compare with the welfare value that were affected by the increasing of FDI inflows. This appendix will offer for the conceptual of environmental impact evaluation by using transfer cost analysis method.

C.1 Suggestion to Environmental Impact Evaluation

With regards to estimated results in Chapter 4, evaluation of environmental impact that were affected be the increasing of FDI inflows will fulfill the welfare investigation to improve pollution control enforcements in Thailand. Indirect measurements for the value of environmental impact is used in this study, average value of industrial Pollution Abatement Capital Expenditures (PACE) that was reported by the U.S. Environmental Protection Agency is applied in this evaluation. Because there is no exact data of industrial pollution abatement expenditures that had been collected for Thailand, therefore, a shadow prices method according to the Cost-Benefit Analysis (CBA) for developing country was applied to covert pollution abatement costs from the U.S. to Thailand. The results of indirect environmental impact measured by PACE is used in comparison with the results of welfare investigation from CGE analysis, it betrays total welfare impact to Thailand and would provide policy recommendations to the government in accordance with foreign investment promotions versus level of pollution controls to be enforced in Thailand.

Indirect measurement for the value of environmental impact begins with the U.S. PACE of the year 2005. Refer to table 4.6 in Chapter 4, there are three major industrial pollutants consisting of LAX[1] which is CO2 emissions in kg per 2005 US$ of GDP , LAX[2] which is Organic water pollutant (BOD) emissions in kg per day per worker, and LAX[3] which is PM2.5 for the dust content in ambient measured by mean annual exposure in micrograms per cubic meter ; and their PACE in year 2005 are 4,314.6 million US dollars, 6,725.2 million US dollars and 4,314.6 million US dollars respectively. Because examination of the impact of pollution control enforcements ends at year 2013, therefore, these PACE values in year 2005 are adjusted to the value of year 2013 by using the U.S. inflation rate as an adjustment factor. The U.S. inflation rates from the years 2006 to 2013 retrieved from WDI of the Worldbank are 3.07%, 2.67%, 1.93%, 0.79%, 1.23%, 2.06%, 1.80% and 1.49% respectively; by these numbers the adjustment factor is calculated to 1.16 which will be used in calculation for the PACE value of the year 2013. Finally, the adjusted PACE value for year 2013 are 5,006.6 million US dollars for CO2 emissions, 7.803.9 million US dollars for the organic water pollutant (BOD) emissions; and 5,006.6 million US dollars for PM2.5 of the dust content in ambient.

The concept of relative laxity of pollution control enforcements, RLAX, between Thailand and the U.S. is used in calculation for Thailand's PACE value in U.S. dollar for the year 2013 as per equation (C.1) where P = 1 is for CO2 abatement cost, P = 2 is for BOD abatement cost and P = 3 is for PM2.5 abatement cost. Sum value of $PACE[P]_{TH}^{2013}$ is total pollution abatement cost for Thailand in the year 2013, $PACE_{TH\_Before}^{2013}$, which will further be used in calculation for the PACE value after the country affected by an increase in laxity of pollution control enforcements as per equation (C.2).

$$PACE[P]_{TH}^{2013} = \left(\frac{LAX[P]_{TH}^{2013}}{LAX[P]_{US}^{2013}}\right) \cdot PACE[P]_{US}^{2013} = RLAX[P]_{US,TH}^{2013} \cdot PACE[P]_{US}^{2013} \qquad \text{(C.1)}$$

$$PACE_{TH\_After}^{2013} = \left(\frac{RLAX_{US,TH\_After}^{2013}}{RLAX_{US,TH\_Before}^{2013}}\right) \cdot PACE_{TH\_Before}^{2013} \qquad \text{(C.2)}$$

The RLAX value for the year 2013 when Thailand was the host country and the U.S. was the home country ($RLAX_{US,TH\_Before}^{2013}$) is equal to 1.8991, calculated by weighted method the same as what's described in section 4.2, and used as a base level in examination for the relation between pollution control enforcements and FDI inflows as aforesaid in Chapter 4. When the RLAX value increases for one point ($RLAX_{US,TH\_After}^{2013}$) equals to 2.8991, then the PACE value will be evaluated following the equation (C.2). Even though the pollution intensity (PI) in embedded into RLAX in the examination for the case of Thailand, it is however meaningless since PI values are offset from the numerator and its divisor in equation (C.2). The below table exhibits the calculation results for Thailand's PACE values for the base case before the country was affected by its laxity of pollution control enforcements and the value when the country had already been affected by laxity level and increased for one point.

Pollution Indicators	Pollution Abatement Capital Expenditures (million USD)		Laxity and Relative Laxity in Pollution Control Enforcement	
The U.S.				
CO2 emissions	$PACE[1]_{US}^{2013}$	5,006.6	$LAX[1]_{US}^{2013}$	0.3995
Organic water pollutant (BOD) emissions	$PACE[2]_{US}^{2013}$	7,803.9	$LAX[2]_{US}^{2013}$	0.1425
PM2.5 pollution, mean annual exposure	$PACE[3]_{US}^{2013}$	5,006.6	$LAX[3]_{US}^{2013}$	13.383
Thailand				
CO2 emissions	$PACE[1]_{TH}^{2013}$	17,614.0	$LAX[1]_{TH}^{2013}$	1.4055
Organic water pollutant (BOD) emissions	$PACE[2]_{TH}^{2013}$	8,335.1	$LAX[2]_{TH}^{2013}$	0.1522
PM2.5 pollution, mean annual exposure	$PACE[3]_{TH}^{2013}$	7,885.3	$LAX[3]_{TH}^{2013}$	21.078
	$PACE_{TH\_Befo}^{2013}$	**33,834.4**	$RLAX_{US,TH\_Befor}^{2013}$	1.8991
	$PACE_{TH\_After}^{2013}$	**51,650.4**	$RLAX_{US,TH\_After}^{2013}$	2.8991

The market price of environmental impact ($ENVIMPACT_M$) in billion Thai Baht, that is caused by the change of FDI inflows when Thailand's relative pollution control enforcements for industrial activities increased for one time when compared to home countries, is calculated following the equation (C.3); where average currency exchange rate in year 2013 is 30.73 Baht per U.S. Dollar (data from WDI report). By such equation, the environmental impact is valued at 547.5 billion Baht.

$$ENVIMPACT_M = \left(PACE_{TH\_After}^{2013} - PACE_{TH\_Before}^{2013}\right) \cdot EX^{2013}/1{,}000 \quad \text{(C.3)}$$

In addition, to evaluate the shadow price, which is often called accounting price, for the environmental impact; a standard conversion factor (SCF) is multiplied to the aforesaid market price and then transformed to the economic value. The reason for using shadow pricing is that Thailand is a developing country and their market price is much more distorted than developed countries. When applying PACE value from the U.S. to Thailand, all component prices which are included in PACE will be distorted by import controls, trade taxes and other tariffs. According to SCF, it is normally the ratio of all production at accounting prices to the value of all production at market price; and is used in computing the shadow price of minor component on nontrade goods. Equation (C.4) is a basic formula which has been widely used in estimation for the SCF.

$$SCF = (M + E)/[M \cdot (1 + tm - subsidy_m) + E \cdot (1 - te + subsidy_e)] \quad \text{(C.4)}$$

Where M is total value of imports in market price, E is total value of exports in market price, tm is import tariff rate, te is export tariff rate, $subsidy_m$ is subsidy rate of imports, and $subsidy_e$ is subsidy rate of exports. The values of these variables collected and calculated from Thailand's National Account for the year 2013; which M is 8,730.4 billion Baht, E is 8,396 billion Baht, total import tariff is 183.9 billion Baht and then tm is 0.0348, total export tariff is 0.22 billion baht and then te is 0.00, total import subsidy is 3.04 billion Baht and then $subsidy_m$ is 0.006, total export subsidy is 10.5 billion Baht and then $subsidy_e$ is 0.002. Finally, SCF for the year 2013 is equal to 0.982 which will further be used in calculation for the economic value of environmental impact, ($ENVIMPACT_E$), following to equation (C.5). Therefore, the economic value of environmental impact is equal to 537.6 billion Baht

$$ENVIMPACT_E = SCF \cdot ENVIMPACT_M \quad \text{(C.5)}$$

Similar to other impacts caused by laxity of pollution control enforcements that are reported in percentage of the GDP in order to be compared on the same basis, this economic value of environmental impact is divided by 12,901.5 billion Baht which is the GDP of the year 2013. Finally, the economic value of environmental impact is calculated to 4.17% of the GDP. Refer to the results of investigation for changes in institution's income and macroeconomic indicators, which was summarized in table 5.10 where their values are in percentage of the GDP, there are no better welfare gain when compared to economic values of environmental impact that is caused by the same laxity degree of pollution control enforcements in Thailand. The maximum household's welfare gain that was determined through aggregation of the total household income gained only 1.47% of the GDP in the major case of scenario one, while the environmental impact that is considered as the country's welfare loss is 4.17% of the GDP; that is 2.8 times the country's loss compared to the household's gain. In the same scenario, there are increases in export by 3.878% of the GDP and only 0.653% of the GDP improvements which are 1.1 times and 6.4 times less than the loss of environmental impact respectively. Although the aforementioned describes the focus in scenario one which is the most realistic case, notwithstanding evaluations for other scenarios still demonstrated similar results that no indicators have value of welfare gain better than the loss of environmental impact. Even in scenario four, where the assumption is quite hard to happen in the real world, there was positive changes in output, aggregate consumption and GDP; but those gains were still less than the loss at 2.0 times, 2.2 times and 4.4 times respectively. By these investigations, it obviously demonstrates that a relaxed pollution control enforcements that attracts more FDI inflows, in overview, will harm the country.

C.2 Restrictions of the Suggested Evaluation

There are some restrictions of this evaluation conceptual that should consider for future study. The purpose of PACE is to provide statistics on capital expenditures and operating cost that the private industry in the U.S. spend for both pollution prevention and treatment. By such original definition, it is not the cost for eliminating pollutions down to zero value but the use in preventing, treating and reducing pollution down to regulation limits. Since pollution regulations in the U.S. and Thailand have different limits, and then Thailand's PACE when compared with the U.S. is expected to be higher. In calculation for Thailand's PACE value according to equation (C.1), it uses relative laxity in pollution control enforcements as a transformation factor; however, such laxity is calculated from actual emissions not from regulation limits. With regard to increasing trend of emissions in Thailand while regulation limits mostly remain unchanged, as mention in Chapter 2, it is expected that emissions in the year 2013 in Thailand are higher than regulation limits. Therefore, using laxity index probably results in a higher PACE value for Thailand than using the proportions of Thailand's pollution regulation limits to the U.S. in same calculation. However, on the other hands, using proportions of regulation limits would lessen pollution abatement expenditures than actual value since it is not reflexed from actual emission levels. Weighing both two ways in calculation for Thailand' PACE value, using the relative laxity in pollution control enforcements is more appropriate since it reflects the cost of reducing actual emissions down to regulation limits. Moreover, the selected method is consistent with the use of the U.S. emissions as a benchmark for the indexed laxity in a worldwide comparison of pollution control enforcement levels, in a similar way, comparing and calculating for the PACE value of other countries shall also be benchmarked to the U.S. Therefore, PACE of high emission in Thailand is calculated in accordance with preventing, treating and reducing pollution down to the U.S. regulation limits.

The estimated environmental impact using this method is quite high when compared to the numbers of other focused welfare indicators. It would either be an over estimation in accordance with the methodologies described in previous paragraphs or underestimation if other kinds of social welfare impact other than PACE, such as the impact to people's health, are taken into account. However, this conceptual is just the one of various methods; other researchers who interest in similar topic could present alternative methods which would result in different value of environmental impact.

C.3 Cost to Implement Stringent Pollution Control Enforcements and its Effect

The cost to implement stringent pollution control enforcements is a major non-finding which excludes from scope of study but would be a future research topic. If Thailand do more stringent enforcement on pollution control and unacceptable industry the industry trends to follow environmental norms and adaptable regulations adhering to the conscience of planet at large and its people. That will take the country out of a low pollution control enforcements realm. Then the discussions about such implementation costs would be a part of the process as a whole when comparisons of results and the inter-consecutiveness to an overall system idea for major reshuffle in a move for global approach which can essentially be mapped in different orders to produce any variety of preconceived outcomes. The scope of this study cannot determine which of two costs, the ex-ante implementation cost or the pollution abatement cost is lower; however, there is an interesting point according to compassion in spending for both costs, and then this section will pursue with the normative discussions.

In general, the ex-ante implementation is expected including cost of pollutant prevention by change to new machines and the use of better technology in production, government expenditures used efficiently to promote, control and monitoring for pollution prevention activities. Government investment for infrastructure that supports emission prevention, costs of education and training to enhance conscious minds interested in an environmentally friendly future. General management costs must also be covered. We are able to say that those preventive actions would benefit the country in the long run as there will always be a need for continuous implementation and changes for a better future. Long term strategic considerations must be given such that the government shall plan for its log run budget in order to implement stringent pollution control policies in an acceptable way. Of course, when there is government expenditures injected into activities related to the country, GDP would boot up more or less; especially if such budget is spend to the activities like investing in infrastructure and sustainability. The government can impose incentives or subsidy to investors who replace old machines to the new ones showing more efficiency in lower emission as well as investing a in better production process adhering welfare. When there are new investments for new machines in the production process, the effects of such private investment also improve the country’s economy. By this normative scenario, there are not only direct benefits when making improvements for environmental care quality, but also the crowding out effect from government spending.

In a similar way, there would be a crowding out effect from spending of the pollution abatement costs as well. Since the activities to get rid of or to reduce the impact of pollutants that have to be spent for goods, labor and capital; therefore, such expenditures are either spent by the corporate and private factors or from the government, it is more or less injected to the economic system. However, there is one concern for both injected money from the ex-ante implementation cost and the pollution abatement costs; if both costs have to spend of the import goods and services with high amount, then the country will lose from trade balance in the case that imports dominate the exports. Lastly, both of the stringent implementation of environment regulations and the pollution abatement costs require deep analysis for their costs and benefits in order to provide policy recommendation; that is not an answer in this study and would be one of the potential research topics in the future.

BIOGRAPHY

NAME	Mr. Kanthasat Boontem
ACADEMIC BACKGROUND	Bachelor's Degree in Engineering (Mechanical Engineering) from Khon Kaen University, Khon Kaen Province, Thailand in 1997. Master's Degree in Economics (Business Economics) (Honors) with a major in Project Analysis from National Institute of Development Administration, Bangkok, Thailand in 2010.
PRESENT POSITION	Category Department Manager (Equipment and Spares), Corporate Procurement at Siam City Cement Public Company Limited.