DISSERTATION

ESSAYS ON TRADE LIBERALIZATION AND THE ENVIRONMENT

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ABSTRACT

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This dissertation explores the relationship between trade liberalization and the environment in several aspects. Chapter 2 first examines the existence of the Environmental Kuznets Curve for carbon dioxide emissions, in Vietnam and four other Southeast Asian countries: Thailand, Indonesia, Malaysia and Philippines. Then we include trade liberalization in the Environmental Kuznets Curve and investigate its determinants to further investigate the environmental impact of trade liberalization. We find evidence of a monotonically increasing linear relationship between per capita GDP and per capita carbon dioxide emissions for these five Southeast Asian countries in the period 1986-2010. The evidence supports the Pollution Haven Hypothesis that freer trade affects negatively the environment. Chapter 3 considers the issue of revealed comparative advantage in manufacturing industries in Vietnam, to examine whether Vietnam has become a "pollution haven" for pollution intensive industries as a result of the gap in environmental regulations between developed and developing countries. Then we examine how environmental stringency and factor intensities affect cross-industry trade specialization in Vietnam within a Heckscher-Ohlin framework. Our finding shows that serious environmental regulations have a negative impact on trade performance. Finally, Chapter 4 measures the pollution embodied in exports, the pollution embodied in imports, and the pollution content of Vietnam's international trade (for three air pollutants $C0_2$, SO_2, NO_x) in 2007 and 2012, using an Environmental Input-Output Analysis. Under the assumption of identical technology, the results show that Vietnam gained "environmentally" from trade liberalization

and expansion as of 2007, and gradually became the "pollution haven" as of 2012. The dissertation concludes with chapter 5.

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CHAPTER 1

INTRODUCTION

Trade liberalization, which is defined as a move towards freer trade through the reduction of trade barriers, is generally considered as a major force of economic growth. In spite of important benefits of trade liberalization (such as productive efficiency, efficient resource allocation, and economic growth), serious concerns have been raised about its negative impacts on the environment.

Vietnam's integration into the global economy has increased substantially during the process of trade liberalization. During the last four decades, Vietnam has pursued an outward-oriented policy to gradually reduce trade barriers. Vietnam's GDP per capita growth has been among the fastest in the world, and this rapid growth has remained almost unsurpassed by other developing countries. Exports have been growing by 20 percent (significantly faster than GDP). Due to low labor cost and preferential FDI policies for foreign enterprises, during the past three decades, Vietnam has been one of the largest FDI recipients among developing countries.

Along with the rapid economic growth, fears have also been raised for environmental problems in Vietnam. Certainly environmental degradation in Vietnam does not stem only from its opening-up process. However, there is evidence that Vietnam's rapid economic growth during trade liberalization process has resulted in a large deterioration in the environment.

As trade liberalization is indispensable to Vietnam's economic growth while environmental quality is a bottleneck for Vietnam's development, the relationship between trade liberalization and the environment has drawn much attention from economists, environmentalists and policy makers in Vietnam. Hence, this dissertation aims at examining and quantifying various aspects in the trade - environment relationship in Vietnam. Three essays in the dissertation consider (i) the environmental impact of trade liberalization; (ii) the role of factor intensities and environmental stringency on trade specialization; and (iii) the pollution content in Vietnam's trade.

Firstly, the next chapter discusses the environmental impact of trade liberalization in five Southeast Asian countries for the period 1986-2010. Different econometric models are employed to test the existence of the Environmental Kuznets Curve and evaluate the impacts of trade liberalization on the environment. The chapter investigates not only Vietnam but also four other Southeast Asian countries: Philippines, Thailand, Malaysia and Indonesia. These are newly-industrialized countries with large amounts of energy consumption and pollution generation. These five countries are selected to represent the Southeast Asia region, in which total emissions have increased significantly during the last decades. Southeast Asia has also emerged as an integrated part of the global economy. Globalization triggered by trade liberalization in this region has had a considerable impact on the economy and also led to various environmental concerns.

Together with worldwide decline in trade barriers, the role of environmental regulations has become increasingly important in countries' comparative advantage. This fact has raised the possibility that dirty production would shift from developed countries where environmental standards are taken seriously to developing ones where environmental regulations are more lenient. Over the last decades, the Vietnam economy has undergone significant reforms. One of the important economic reforms focuses on trade regime and trade structure. Trade specialization is believed to have links to the weak environmental regulations in Vietnam.

Chapter 3 therefore investigates the determinants of industrial trade patterns as well as identifying the role of environmental policy in Vietnam's trade patterns. Due to limited data, chapter 3 focuses on examining whether environmental stringency affects cross-industry trade specialization patterns in Vietnam. Our finding shows that serious environmental regulations have a negative impact on trade performance.

In the literature, there exist two important hypotheses about the trade-environment relationship: the Factor Endowment Hypothesis and the Pollution Haven Hypothesis. The Pollution Haven Hypothesis suggests that Vietnam would tend to specialize in pollution intensive products due to its relatively lenient environmental regulations. As Vietnam becomes more integrated into the world economy, concerns have been raised that the environment may have been degraded as a result of economic growth. On the other hand, due to Vietnam's relative scarcity in capital and abundance in labor compared to its major trading partners, the Factor Endowment Hypothesis predicts trade liberalization would lead to Vietnam's specialization in clean products (i.e. labor intensive ones). As one of the countries with rapid economic growth in Southeast Asia, Vietnam can be considered a good laboratory to test these two hypotheses.

Instead of testing the two hypotheses econometrically, chapter 4 employs Environmental Input-Output analysis to examine the overall pollution embodiment in exports and imports. We investigate the pollution embodiment in Vietnam's exports and imports to see whether Vietnam "exports" more pollution than it "imports" through trade in goods, as the Pollution Haven Hypothesis predicts.

This dissertation consists of five chapters. Except for the introduction and conclusion, each chapter is a self-contained study. Each study has its own introduction, literature review, methodology and results. The last chapter summarizes the main findings and features of this research, as well as highlighting the main policy implications and possible extensions for further research. Relevant references and appendices can be found at the end of the dissertation.

CHAPTER 2

ENVIRONMENTAL IMPACT OF TRADE LIBERALIZATION IN VIETNAM AND SOME SOUTHEAST ASIAN COUNTRIES

1. Introduction

The economic growth - environmental quality relationship has been a very controversial issue among economists and environmentalists during the past decades. On one hand, there has been a worldwide concern that economic growth results in environmental problems and ecological degradation. On the other hand, there is an optimistic viewpoint that as a consequence of economic growth and technological progress, the natural resource dependence could be lowered and a sustainable growth path could be ensured. In the literature there exist many theories with regards to this relationship, including, for example, the Factors Endowment Hypothesis, the Pollution Haven Hypothesis, the Environmental Kuznets Curve (EKC) hypothesis, the "race to the bottom" hypothesis and scale, composition and technique evaluation framework. The EKC hypothesis described an inverted-U shaped relationship between income levels and different environmental quality indicators, which indicates that at first environmental pressure rises as income increases, then starts declining at higher stages of development when income passes a turning point.

Nowadays, in the context of globalization, understanding the relationship between economic growth, trade liberalization and environmental quality is becoming increasingly important. For the Southeast Asia region, globalization triggered by trade liberalization has had a considerable impact on the economy. Southeast Asia has become as an important player in the international economy and has also been concerned with various environmental problems arising out of trade liberalization.

Since 1990s, numerous empirical studies have examined this relationship in different development stages. Different econometric methods have been employed using time series and cross-country data. Evidence on the environmental impacts of trade liberalization is mixed, especially for developing countries. To investigate this relationship further, this chapter discusses the environmental impact of trade liberalization in five Southeast Asian countries for the period 1986-2010. The models examine and evaluate the environmental impact of trade liberalization to see whether an EKC is observable.

The rest of this chapter is organized as follows. The next section reviews a rich body of the theoretical framework for the study. Then section 3 reviews the existing studies on economic development, trade liberalization and the environment. Section 4 and 5 present the data source, the model specification and the variable choices. In section 6, I discuss the estimation results, and summarize the findings.

2. Trade liberalization and the environment: a theoretical review

One of the trade and environment debates is whether trade liberalization harms or benefits the environment. Generally, trade liberalization has both negative and positive impacts on the environment.

The negative impacts of trade liberalization on the environment

Many environmental advocates claim that trade liberalization has considerable negative impacts on the local and/or global environment. Free trade harms the environment, both locally and globally; and trade liberalization is environmentally destructive. The negative impacts can be grouped as follows:

The destructive scale effect via economic growth

Environmentalists claim that trade liberalization exacerbates the existing environmental problems associated with economic activities. Opponents of trade liberalization are concerned that economic growth produces negative effects such as natural resource depletion, ecological destruction and environmental degradation. Climate change, deforestation, ozone depletion and global warming are examples of environmental problems that have resulted from economic growth. Especially for developing countries, various environmental problems are caused by rapid industrialization and trade liberalization.

Economic activities use environmental resources as factors of production. Trade liberalization increases the scale of economic activity, and this has an adverse impact on environmental quality. More material goods and by-products are produced, and the environment may become a dump for wastes as a result of growing economic activities. As Grossman and Krueger (1995) assert, if production methods and output composition are immutable, environmental damage will be unavoidably related to the scale of economic activity[1]. This effect is called the "scale effect": environmental quality can decline as the increase in trade volume potentially increases the overall size of economy, which in turn increases the level of pollution.[2]

Specialization in pollution-intensive industries

To examine the impact of trade on the environment, first we discuss trade theories applied to environmental considerations, such as the Factor Endowment Hypothesis, the

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[1] Grossman, G.M., Krueger, A.B. (1995). Economic growth and the environment. Q. J. Econ. 110, 353–377.
[2] Dinda (2004), EKC hypothesis: A survey, Ecol Econ 49: 431-455

Pollution Haven Hypothesis, and the Displacement Hypothesis. In general, trade theories predict that major gains from trade are based on comparative advantage and specialization. Environmentalists argue that seeking comparative advantage results in further environmental problems. Trade liberalization could lead pollution-intensive industries to concentrate on countries that have comparative advantage in producing dirty products, and the environment in these countries will suffer. This was attributed to the Displacement Hypothesis and the Pollution Haven Hypothesis. Basically they are the same regarding comparative advantage in international trade. The Displacement Hypothesis predicts that trade liberalization induces more dirty production in poor countries as rich countries enforce strict environmental regulations. The Pollution Haven Hypothesis (PHH) indicates that comparative advantage under trade liberalization shifts dirty production to developing countries, since multinational firms can take advantage of their low environmental standards. Gradually, developing countries tend to specialize in dirty production and become "pollution havens". Hence, in terms of environmental quality, developed economies benefit from international trade, while developing economies lose.

On the contrary, the Factor Endowment Hypothesis (FEH) suggests that it is the country's factors of production that determine its comparative advantage; environment monitoring does not have much effect on trade patterns. The FEH asserts that developed countries are relatively better endowed with capital than developing countries; hence they usually specialize in capital intensive products that are more contaminating than labor intensive ones. Consequently, this raises pollution in developed or capital abundant countries. On the contrary, pollution declines in developing countries (which are known as capital scarce countries) since their production of polluting industries has been contracted. Therefore, the overall environmental impact of trade depends on how comparative advantages are distributed.

`Race to the bottom' and Regulatory chill hypothesis

Advocates of environmental regulations usually assert that trade liberalization in the presence of environmental regulations provides the country that has the laxest environmental standards with a competitive advantage. They argue that high environmental standards are costly for firms to conform to. Hence, in order to be competitive, the government will not impose strict environmental standards. In other words, trade tends to adopt laxer environmental standards which cause environmental degradation. The “Race to the bottom” or “Regulatory chill” hypothesis claims that developing countries tend to lower the environmental regulations to protect their domestic industries under high pressure of international competition.

The positive impacts of trade liberalization on the environment

While arguments on the negative impacts of trade liberalization on the environment are reasonable, counter arguments from the optimists' side seem to be equally convincing. In the words of Antweiler: "Free trade is good for the environment."[3]

Efficient allocation of resources

The classic argument for global trade liberalization is that it is efficient for countries to specialize in the sectors that they have a comparative advantage over others. Hence, the first benefit of trade liberalization stems from the fact that countries are allowed to specialize to a greater extent in the industries that are produced relatively more efficiently. This viewpoint originates from Adam Smith and developed by David Ricardo with the principle of comparative advantage.

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[3] See Antweiler (2001)

Grossman and Krueger (1993) assert that when comparative advantage emerges from the differences in technology and factor abundance, resources will be shifted into the industries which can make intensive use of these factors. Hence, a liberalized global trade regime helps allocate resources to the production activities with least cost and highest return. This definitely indicates that natural resources are used efficiently, the required input per unit of output will be minimized, and waste will be kept to a minimum. Theoretically, this helps keep environmental stress to a minimum.

Environmental technology and management improvement

Advocates of trade liberalization claim that trade liberalization promotes the export of environment-friendly technology and standards from developed countries to developing ones. Without trade liberalization, firms tend to fix with their old technologies and do not have incentives to innovate. Trade liberalization fosters competition, and competition results in increasing innovation. Hence, through trade liberalization, companies try to innovate and develop better products, keeping prices low in order to increase their market share. Since a liberalized global trade regime allows technology and capital to flow more easily and freely, trade liberalization increases the adoption of environment-friendly technology and standards.

Another optimistic view[4]asserts that trade not only promotes the adoption of management practices and technologies but also increases the demand for higher environmental quality and more effective regulations. Technological innovation and management improvement is another environmental benefit of trade liberalization, although there have been some concerns about the risk of transferring obsolete technologies from developed countries to developing ones, which results in environmental deterioration in the developing world.

[4] For example, see Frankel (2003)

Income effect

This effect is associated with the gains-from-trade hypothesis which asserts trade liberalization raises real income. When income increases and basic needs are met, the demand for higher environmental quality also increases. This implies that if we consider the environment a luxury good, the government has to respond to the higher demand by raising environmental standards. Moreover, increasing incomes also provide countries with better resources to design, apply and enforce better environmental policies. As a result, production occurs in a more environment-friendly manner.

3. Literature review

The relationship between economic growth, trade liberalization and environmental quality is a very controversial issue in the literature.

Firstly, many attempts in the literature have been made to examine the environmental impact of economic growth. Grossman and Krueger (1991) conducted an empirical test of this relationship and found an inverted U-shaped relationship between income per capita and environmental quality (i.e. the Environmental Kuznets Curve (EKC)). Figure 2.1 illustrates an Environmental Kuznets Curve.

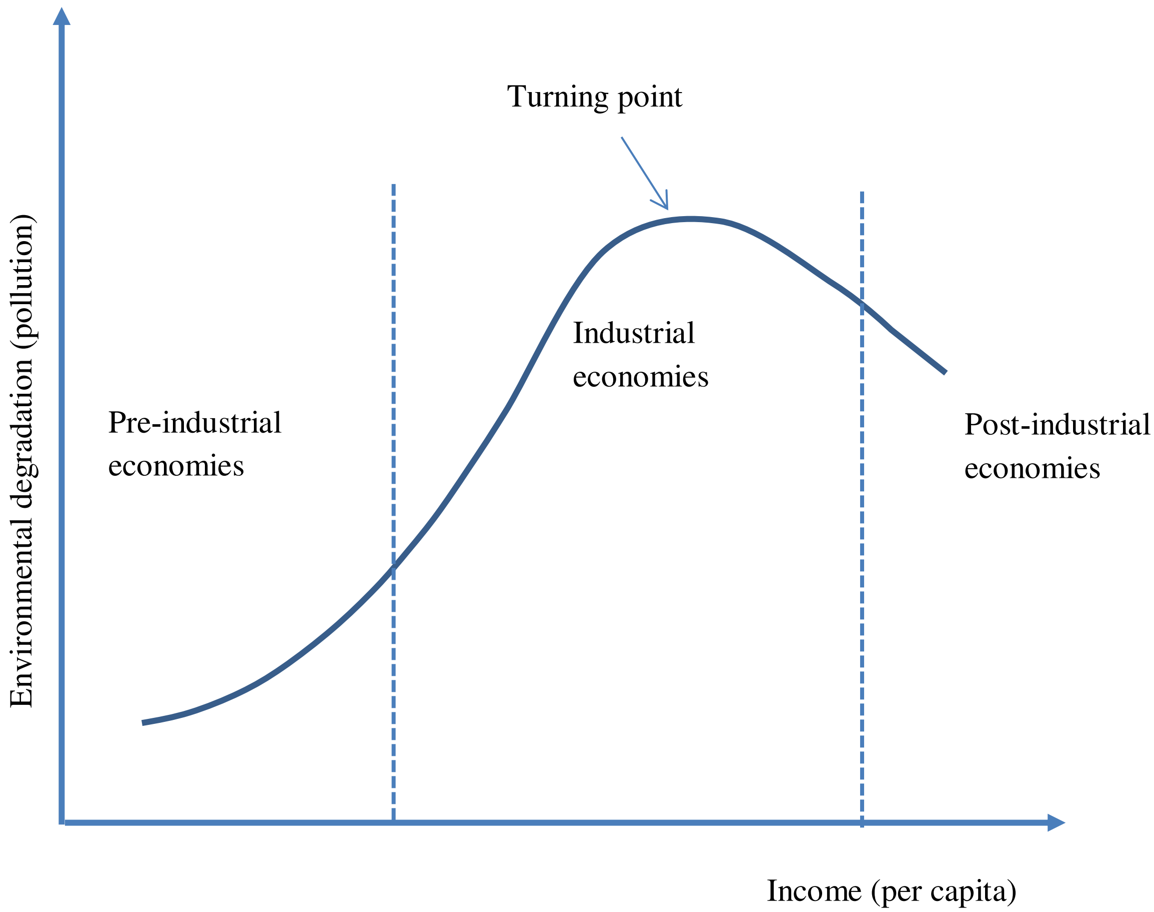

Figure 2.1. An Environmental Kuznets Curve (EKC)

Many other authors have attempted to test the EKC hypothesis such as Shafik and Bandyopadhyay (1992), Cropper and Griffith (1994), Selden and Song (1994), Holtz-Eakin and Selden (1995), Kaufmann, Davidsdottir, Garnham, and Pauly (1998), Suri and Chapman (1998), Agras and Chapman (1999), Dinda et al. (2000), Harbaugh et al. (2002), Begun and Eicher (2007). The results in terms of the estimated shape of the relationship between income and environmental quality are mixed. Moreover, if evidence of an EKC is found, the turning points of the EKC are also substantially different across studies. This is due to the absence of a single indicator for environmental degradation. In the economic literature, numerous environment indicators have been used and they are grouped into air quality indicators, water quality indicators and other indicators for environmental degradation.

Air quality indicators

In the literature there is a conventional distinction between local air pollutants and global air pollutants[5]. For local air quality pollutants (for example sulfur dioxide, nitrous oxides, and carbon monoxide), studies usually find an inverted U-shaped relationship between income and environmental quality (Selden and Song (1994), Holtz-Eakin and Selden (1995), Grossman (1995), Cole, Rayner, Bates (1997), Panayotou (1997)). However, these studies show largely different turning points across indicators.

For global pollutants that have very little direct effect on the population, empirical results often show no evidence of an EKC. Particularly, for global air pollutant carbon dioxide, the findings generally show that it monotonically increases with income.

Water quality indicators

Empirical results of an EKC for water quality indicators are even more mixed. Moreover, the turning points of the Environmental Kuznets Curve are generally higher than those for air quality indicators.

For some indicators such as chemical oxygen demand, biochemical oxygen demand, previous studies confirm the existence of the EKC but the results regarding its shape and peak are conflicting. Some results (Shafik (1992), Grossman and Krueger (1993), and Grossman (1995)) show that for some indicators, water pollution first rises as income grows, then it decreases and finally increases again. This is known as an N-shaped curve.

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[5] See Grossman (1995)

Other environmental quality indicators

Besides air quality indicators and water quality indicators, studies in the literature also have used many other indicators for environmental quality in examining the income-environment relationship (for examples, deforestation, access to urban sanitation and clean water, municipal solid wastes). In general, for most of these indicators, empirical results show little or no evidence of an EKC. For example, Shafik (1994) and Cole et al. (1997) show that for pollutants which have direct impacts on the population, environmental quality tends to improve along with economic growth. In contrast, for environmental pollutants that can be externalized, the shape of the curve does not go down at high levels of income. For deforestation, while Panayotou (1993) finds evidence of an EKC with the turning point at a low income level, Shafik (1994) concludes that income per capita doesn't have much impact on the rate of deforestation.

To sum up, empirical results regarding the EKC hypothesis are quite mixed. The indicators of environmental quality that are found to follow an EKC are mostly air quality ones. Studies in literature generally support the Environmental Kuznets Curve hypothesis for environmental pollutants that have direct impact on the population. More interestingly, whenever an EKC is empirically observed, the income levels of the turning points are different across studies.

Secondly, there has been extensive literature on the environmental impact of trade liberalization. Previous research usually examines the environmental effect of trade liberalization together with the environmental effect of economic growth that we discussed above[6]. Grossman and Krueger (1991, 1995) investigate the income-environment relationship using different environmental quality indicators (i.e. sulfur dioxide, dissolved oxygen, smoke,

[6] For examples, Kaufmann et al. (1998), Agras and Chapman (1999)

suspended particles, fecal coliform and biological oxygen demand). Then they attempt to test the hypothesis that trade liberalization results in lower environmental standards. For the air pollutant sulfur dioxide, they find that the level of SO_2 is considerably lower in countries that conduct an enormous amount of trade. This finding conflicts with their hypothesis. For other pollutants, their findings do not show a significant relationship with trade.

Studies in the literature also employ different methodological approaches to examine the relationship between trade and the environment[7]. The trade – environment relationship is multi-dimensional, and empirical results are influenced significantly by methodological factors such as research methods, samples, selection of data, and time of studies.

Some studies investigate the Factor Endowment Hypothesis vs the Pollution Haven Hypothesis. Many authors such as Mani and Wheeler (1998), Suri and Chapman (1998) examine the Pollution Haven Hypothesis. They suppose that environmental stringency between the North and the South is different. Through trade, pollution is shifted from the North to the South since the South specializes in pollution intensive products while the North specialized in clean products. Hence their findings support the Pollution Haven Hypothesis. In contrast, other studies find evidence against the Pollution Haven Hypothesis (Grossman and Krueger (1993), Gale and Mendez (1998)). They find evidence supporting the Factor Endowment Hypothesis.

Lucas, Wheeler and Hettige (1992) also investigate the relationship between trade and the environment by evaluating the impact of trade liberalization on the toxic intensity of output growth rate. Their findings show that trade liberalization has a positive impact on the

[7] Those research methods are discussed in the literature surveys by Dean (1992), Ulph (1994) and Van Beers and Van den Bergh (1996).

environment - an increase in trade openness results in a reduction in the growth rate of manufacturing toxic intensity.

Antweiler, Copeland and Taylor (2001) decompose the effect of trade on the environment into scale effect, technique effect, and composition effect. First, the scale effect influences environmental quality since a rise in economic activity increases the level of environmental degradation (i.e. increasing resource use and waste generation). The technique effect is described as increased income level raises the demand for higher environmental quality which leads to cleaner production processes. The estimated results of these two effects show a net reduction in pollution. The composition effect also has impact on environmental quality due to the differential pollution intensity of sectors in the economy. Their findings indicate that for poor countries, trade liberalization shifts output towards pollution intensive products, although the effect magnitude is small. The combination of these three effects suggests an amazing result: freer trade turns out to be good for the environment.

Judith M. Dean (2002) brings together the literature on the Environmental Kuznets Curve, economic growth and trade liberalization. She evaluates the environmental effect of trade liberalization in China using data on water pollution at provincial level. The findings show that trade liberalization exacerbates environmental problems through the terms of trade, but improves environment quality through the growth of income. A combination of the two effects yields the result that trade liberalization may have a positive impact on the environment in China.

Frankel and Rose (2005) also employ cross-country data and different environmental quality indicators to investigate the trade-environment relationship. Their findings show for local air pollutants (sulfur dioxide, nitrous oxides and suspended particulate matter), trade openness reduces air pollution. For the air quality indicator carbon dioxide, the trade openness estimate has a positive sign. For other measures of environmental quality (deforestation and energy depletion), their findings suggest that trade openness stops further deforestation and energy depletion. For rural clean water access, trade liberalization is beneficial to the environment.

To sum up, the relationship between trade and environment is multi-dimensional. Numerous studies in literature have attempted to investigate the income - environment relationship and/or the trade - environment relationship with different research methodologies.

The branch of the Environmental Kuznets Curve analysis investigating the environmental impact of trade that we discussed above has been criticized as lacking a solid theoretical grounding. As Kaufmann et al. (1998), Arrow et al. (1995), Grossman and Krueger (1995) emphasize, a more structural approach is needed to further investigate this complex relationship. However, no study in literature has empirically attempted such an approach. This reduced-form model is considered as a useful first step in exploring the environmental impact of income and trade liberalization. As Panayotou (1997) emphasizes, "this approach spares us the more difficult specification of structural equations and the more demanding data requirements of a more analytic approach"[8]. Moreover, this reduced-form approach also provides a comprehensive understanding of the impact of income as well as other factors on the environment.

Panayotou (1997) tries to decompose the economic structural factors affecting SO_2 emissions, a pollutant that often shows a U-inverted relationship with income. Since our interest here is to examine how trade liberalization affects the income-environment relationship in five Southeast Asian countries, we follow the approach developed by Panayotou to develop a basic model including per capita GDP, GDP growth rate and the variables of special interest.

[8] Theodore Panayotou, (1997), Demystifying the environmental Kuznets curve: turning a black box into a policy tool, Environment and Development Economics, 2, (4), 465-484

Particularly, we test the existence of the EKC and make a modest attempt at incorporating economic growth, trade intensity and foreign direct investment into the EKC to examine the impacts of trade liberalization on the environment.

4. Data and variables

4.1. Data

We use a balanced panel of time series and cross-section data. Our sample includes five Southeast Asian countries: Vietnam, Thailand, Malaysia, Indonesia and Philippines for the period 1986-2010. These are newly-industrialized countries with rapid economic growth. They consume a lot of energy and generate large amounts of pollution. These five countries are intended to represent the Southeast Asia region, in which total emissions have increased significantly during the last decades. Another reason for the choice of these five developing countries in Southeast Asia is that developing countries are underrepresented in the literature on the EKC. Most studies on the EKC include mainly developed countries. Few studies are carried out for the case of developing countries, such as Vincent (1997) who studies the EKC for Malaysia. Thus, for a comprehensive understanding of the evolution of the EKC, it is important to include developing countries.

In this chapter, we carry out the study for the period 1986-2010 since Vietnam - the main country of interest - launched an important economic and political reform in 1986 to facilitate the transition from a centralized economy to a market-oriented economy. Since then, Vietnam's integration into the global economy and liberalization of trade has increased significantly. This has significant impacts on the environment and natural resources.

4.2. Variables

This section discusses the selection of variables. First, we discuss the measurement of environmental quality. Next, we turn to the measurement of explanatory variables to capture the environmental impact of economic growth and trade liberalization.

4.2.1. Dependent environmental variable

It is difficult to quantify a comprehensive environmental quality variable. Grossman and Kruger (1995) emphasize that environmental quality has different dimensions, with each dimension responding to economic growth differently. Therefore, the study of trade liberalization – environmental quality relationship requires comprehensive environmental indicators.

In this study, the chosen environmental indicator is per capita carbon dioxide emissions (hereafter carbon dioxide, CO_2). Carbon dioxide is usually classified as a global pollutant since it has little direct impact on a local environment. In nature, it has a global impact and governments generally have fewer incentives to address carbon dioxide problems than other hazardous local environmental pollutants.

According to the *Survey of data and pollutants* (Ansuategi 2000), of all environmental quality indicators, the data situation for carbon dioxide CO_2 is the best since long time series data for many countries are available (Roberts and Grimes (1997), 192). Nevertheless, data is available for only CO_2 emissions. Due to the unavailability of long time-series data on environmental quality, researchers usually adopt a cross-country approach to address the income-environment relationship.

In this study, per capita carbon dioxide emissions are measured in metric tons per capita. The data source is World Data Bank. Descriptive statistics and data presentation are shown in Table 2.1.

4.2.2. Explanatory variables

In order to investigate the environmental impacts of trade liberalization, explanatory variables in this model include GDP per capita, the growth rate of GDP, the level of openness to international trade (or trade intensity) and foreign direct investment.

4.2.2.1. Per capita GDP

Per capita GDP is chosen as an income measure. This variable is measured in constant 2005 US Dollars and its data source is World Data Bank. A cubic functional form for the per capita GDP is employed to test the inverted-U shaped relationship between environmental degradation and explanatory variables (i.e. the Environmental Kuznets Curve).

4.2.2.2.The growth rate of GDP

In the previous literature of the EKC, there is no clear evidence of the direction that economic growth rate affects the relationship between income and the environment. Panayotou (1997) raises an issue that besides income variable, whether economic growth rate (i.e. "the speed that each income level is attained") also makes any difference to the relationship between income and the environment.

Social and environmental change rates are different. One of the reasons for the observed Environmental Kuznets Curve is the difference between economic and social change rates, as social change is often considered to take place at a slower rate than economic change. The faster economic growth rate (and corresponding environmental change) is, the bigger the gap between these two will be. Hence, economic growth rate is also an important factor that affects the relationship between income and environmental quality.

This variable is included to estimate the environmental impact of economic growth. The growth rate of GDP is measured in percentage change. Data on the growth rate of GDP comes from World Data Bank. Rapid economic growth is the most powerful instrument for reducing poverty and improving human well-being. Although rapid economic growth itself is necessary, it is not a sufficient condition for improving environmental quality. Economic and environmental protection policies must be coordinated for efficient economic growth, human well-being and environmental improvement. Figure A.2.6 depicts the relationship between carbon dioxide and the growth rate of per capita GDP.

4.2.2.3. Indicators of trade liberalization

It is difficult to define as well as to measure trade liberalization. In the literature, numerous indicators of trade liberalization have been employed with different strengths and limitations[9].

Trade liberalization is usually defined as a move towards freer trade through the reduction of trade barriers that restrain the free flow of products from one country to another. Specifically, Copeland and Taylor (2003) define trade liberalization as the removal of trade barriers that limit imports or restrict exports, to move domestic prices closer to world prices.

Tariffs and non-tariff barriers are often known as direct measures of trade liberalization. However, they have been criticized as biased measures of trade liberalization because of various intractable taxes, surcharges and subsidies.

[9] Different trade liberalization indicators are investigated in Edwards (1998) and Rodriguez and Rodrik (2001).

Indirect measures of trade liberalization include indices related to exchange rate distortions and price differences. For example, the Black market premium (BMP) index (Dean (1992; 2002)) is a measure of exchange rate distortion. It is defined as the percent of the currency traded on the black market over the official exchange rate. According to Rodriguez and Rodrik (2001), the main disadvantages of the BMP index is that it is related to various policy failures such as the effectiveness of laws and regulation enforcements. Another indirect measure of trade liberalization is the Dollar's price based indices. The Dollar's price based index has its flaw since it is determined by the nominal exchange rate movement and the Law of One Price hypothesis (Dollar (1992); Lucas, et. al (1993)).

In summary, each indicator has its own advantages and disadvantages in measuring trade liberalization[10]. In this study, we use trade intensity (Harrison (1996); Copeland and Taylor (2003)) as trade liberalization variable.

During the past decades, foreign direct investment has made an important contribution in economic growth and international economic integration for the five Southeast Asian countries. These five countries attract a large volume of FDI from multinational enterprises, owning to a growing regional market and rich natural resources. Therefore, FDI is also chosen as one variable to measure the environmental impact of trade liberalization in this study.

4.2.2.3.1. Trade intensity (or the level of openness). Another variable to capture the country's level of integration into the global economy is the level of openness (trade intensity). This indicator has been employed in the economic literature by many authors like Shafik and Bandyopadhyay (1992), Grossman and Krueger (1991), and Jean Agras and Duane Chapman (1999). Trade intensity or the level of openness is defined as the percentage of the total exports

[10] A comparison of different indicators of trade liberalization can be found in Edwards (1998), Harrison (1996).

(X) and imports (M) in GDP ((X+M)/GDP). Data on exports, imports and GDP to calculate trade intensity comes from the World Data Bank. Figure A.2.7 depicts the relationship between carbon dioxide emissions and trade intensity.

For developing countries, foreign trade plays a crucial role in economic development. International trade theories state that labor-abundant developing countries follow their comparative advantage to develop natural resource and labor intensive industries, whereas developed countries specialize in capital intensive ones. Therefore, through trade, dirty industries could be relocated from developed countries where environmental standards are taken seriously to developing ones where environmental regulations are relatively lenient. As a result, the environment seems to degrade in developing countries and be improved in developed countries.

Trade intensity or the level of openness variable captures either the Factor Endowments Hypothesis or the Pollution Haven Hypothesis. According to the Factor Endowments Hypothesis, trade intensity coefficient is expected to have a positive sign for developed countries (and negative for developing ones respectively), since developed countries are commonly known as capital abundant and polluting industries are considered capital intensive ones. On the contrary, the coefficient of trade intensity under the Pollution Haven Hypothesis is expected to be positive for developing countries (and negative for developed ones).

4.2.2.3.2. Foreign direct investment (FDI). Previous studies on the environmental impact of FDI often focus on two directions. The first one is that FDI leads to the reduction of CO_2 emissions per capita, as FDI is one of the sources of funding for environment-friendly production, or FDI promotes the transfer of technology from the source country to the recipient country that results in more investment in clean production. The second one is that FDI instead leads to more CO_2 emissions since it is one of the channels to shift dirty production to the FDI recipient country. In general, studies in the previous literature mostly focus on the impact of FDI on CO_2 emissions through the "direct" mechanism. There has been little attention to the issue whether FDI is also a function of CO_2 emissions. Following the literature, we also include FDI in our model as an explanatory variable.

This variable is used to estimate the impact of FDI on environmental quality in the process of trade liberalization. It is measured as the percentage of total net foreign direct investment (net inflows) in GDP (net FDI/ GDP). Data on FDI is collected from World Data Bank.

As environmental theory indicates, when competition becomes fierce between countries over a particular sector of trade and production, governments are given increased incentive to lower environmental standards and regulations. Therefore, through FDI developing countries with relatively lenient environmental standards become destinations for pollution intensive production. In addition, developing countries tend to compete for FDI as it is a source of economic development and employment. The intensity of the competition for FDI could result in the "race to the bottom" for environmental standards.

Figure A.2.8 depicts the relationship between CO_2 and FDI.

Table 2.1. Summary statistics of variables

Variables		Observations	Mean	Std. Dev	Minimum	Maximum
CO_2 (metric tons per capita)	Y	125	1.2851	1.9469	0.2703	7.8096
GDP p.c. ($1,000)	X	125	1.1969	1.5443	0.2687	6.3189
Growth rate of GDP p.c. ($100xGDP_t/GDP_{t-1}$)	G	125	596.0844	376.5774	-1312.6724	1328.8113
Trade intensity (or the level of openness)	P	125	94.6039	49.126	18.9505	220.4074
Foreign direct investment (% of GDP)	F	125	2.2442	2.5255	-2.7574	11.9395

5. Methodology

In literature the relationship between income and the environment is usually investigated by a functional form with quadratic or higher order terms that correlate pollution with income per capita and other explanatory variables. The reduced form model is commonly employed to estimate the relationship between emission level and income[11]:

$$y_{it} = \alpha_i + \beta_1 x_{it} + \beta_2 x^2_{it} + \beta_3 z_{it} + \varepsilon_{it}$$

in which:

y: environmental degradation,

[11] Dinda (2000), EKC hypothesis: A survey, Ecology Economics, vol. 49, issue 4, pp. 431-455

x: income,

z: a vector of other explanatory variables that have impact on environmental quality.

α is constant, β is the coefficient of the variables. The subscript i denotes country, t denotes time.

This reduced form model enables us to examine various forms of the income - environment relationship. Whether the equation takes the cubic, quadratic or linear form generally depends on the signs and the relative values of β_1, β_2, β_3. Appendix 1 presents the results of empirical studies on the income – environment relationship. As we can see, the results are mixed; and evidence of the EKC is found for some certain environmental indicators but not for others.

As trade liberalization is closely linked with economic growth, empirical studies in literature often include trade liberalization variables and interaction terms of trade liberalization variables with other variables in the EKC models. Hence, making use of existing studies in literature to test the EKC, in this chapter different trade liberalization variables are also included in the reduced form model.

In the literature, Panayotou (1997) tries to decompose the economic structural factors affecting SO_2 emissions, a pollutant that often shows a U-inverted relationship with income. Since our interest here is to examine how trade liberalization affects the income-environment relationship in five Southeast Asian countries, we develop a basic model including per capita GDP, GDP growth rate and the variables of special interest. We follow the approach developed by Panayotou. Particularly, we make a modest attempt at incorporating economic growth, trade intensity and foreign direct investment into the Environmental Kuznets Curve. In particular, we employ a quadratic functional form:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_3 G_{it} + \beta_4 G_{it} X_{it} + \beta_5 P_{it} + \beta_6 P_{it} X_{it} + \beta_7 F_{it} + \beta_8 F_{it} X_{it} + e_{it}$$

where: Y_{it} = CO_2 emissions in country i in year t

X_{it} = GDP per capita in country i in year t

G_{it} = GDP per capita growth rate in country i in year t

P_{it} = trade intensity (or the level of openness) in country i in year t

F_{it} = foreign direct investment in country i in year t

e_{it} = an error term

β_k = coefficient of variable *k*.

This model includes GDP growth rate and trade liberalization additively and multiplicatively with GDP per capita in order to test whether these variables have impact on the slope or intercept of the EKC or both. This model is built for an economy without interaction with the environment. This means we do not take into consideration the feedback of the environment to the economy in this model (i.e. the feedback is considered not significant). This is a limit of the approach because the environment is regarded as one of the economic production factors and it can have impact on the economy (either positive or negative). Moreover, concern has been raised in developing countries about the possibility that environmental pollution may limit growth. However, in this model we make an assumption that the effect is not significant, since CO_2 emission is only one component of environmental quality (and it is not necessarily correlated with the others).

We estimated five models. The first model just includes GDP per capita (X_{it}) as the independent variable. Then we consider 3 other models (model (2), (3) and (4)), which include one of the three variables, either GDP growth rate (G_{it}), or trade intensity (P_{it}), or FDI (F_{it}) as explanatory variable (additively or multiplicatively). This allows us to test the environmental impact of trade liberalization. In model (5), we include all explanatory variables at the same time.

$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + e_{it}$ (1)

$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_3 G_{it} + \beta_4 G_{it} X_{it} + e_{it}$ (2)

$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_5 P_{it} + \beta_6 P_{it} X_{it} + e_{it}$ (3)

$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_7 F_{it} + \beta_8 F_{it} X_{it} + e_{it}$ (4)

$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X^2_{it} + \beta_3 G_{it} + \beta_4 G_{it} X_{it} + \beta_5 P_{it} + \beta_6 P_{it} X_{it} + \beta_7 F_{it} + \beta_8 F_{it} X_{it} + e_{it}$ (5)

Equation (1) presents the basic Environmental Kuznets Curve. It estimates environmental quality as a function of income per capita. This approach is advantageous since it shows the net effect of income per capita on environmental quality.

We also estimate two versions of the five equations: fixed and random effects. The differences in the intercepts in the fixed effects version are treated as due to deterministic factors while they are treated as due to stochastic factors in the random effects version. Then the Hausman test (Hausman 1978) is used to determine the preferred model.

6. Estimation results

Panayotou (1997) notes that one of the potential problems in the data for EKC studies is multicollinearity. The combination of cross-section and time series is used to reduce this potential problem. We checked partial correlation coefficients and there was some collinearity between the same variables of different power (GDP per capita (X), GDP per capita square (X^2)), which we would normally expect with polynomial regressions. Also, there was some collinearity between GDP per capita (X) and trade intensity since the level of openness is computed as the share of total exports (X) and imports (M) in GDP ((X+M)/GDP). Otherwise, we observe no multicollinearity among our principal explanatory variables.

Table 2.2. Correlation coefficients of GDP per capita (X), GDP per capita square (X^2)

	X	X^2
X	1.0000	
X^2	0.9667	1.0000

Table 2.3. Correlation coefficients of explanatory variables: GDP per capita (X), GDP per capita growth rate (G), Trade intensity (P) and Foreign direct investment (F)

	X	G	P	F
X	1.0000			
G	-0.0333	1.0000		
P	0.8140	-0.0075	1.0000	
F	0.1624	0.2675	0.3645	1.0000

We use the Hausman test to determine which version is preferred. Specifically, we test the null hypothesis that the random effects are uncorrelated with year and region. Unless the null hypothesis is rejected at 5% significance level, the random effects random is preferred. The test results are shown in Table 2.4 below.

Table 2.4. Hausman test for fixed and random effects models

Hausman test	Model 1	Model 2	Model 3	Model 4	Model 5
Chi-squared statistics	51.68	92.03	113.54	83.94	82.41
p-value	0.0000	0.0000	0.0000	0.0000	0.0000
Null hypothesis	Ho: Random effects model is preferred				
Conclusion	Reject the null hypothesis				
	Fixed effects estimation is preferred				

Our test statistics favor the fixed effects estimation. Therefore, we report the results and focus our analysis on the fixed effects models.

The standard fixed (and also random effects models) do not take into account of autocorrelation and cross-sectional dependence. Since our sample includes only five countries, in the period of twenty-five years (total 125 observations), we do not need to test for cross-sectional dependence. To test for the presence of autocorrelation, we employ Wooldridge test (Wooldridge 2002 – Econometric Analysis of Cross Section and Panel Data, MIT Press) for first order serial correlation (AR1 auto correlation). Tabel 2.5 presents Wooldridge test results.

Table 2.5. Wooldridge test for first order autocorrelation

Wooldridge test	Model 1	Model 2	Model 3	Model 4	Model 5
F-statistics	1.726	1.968	1.408	5.050	4.575
p-value	0.2592	0.2333	0.3011	0.0879	0.0992
Null hypothesis	H_0: No serial autocorrelation				
Conclusion	Wooldridge test fails to reject the null hypothesis. Hence, the data does not have first-order autocorrelation.				

Table 2.6 presents the panel regression results for equations (1) – (5).

Table 2.6. Estimation results for CO_2 emissions: The role of economic growth, trade intensity and foreign direct investment variables.

		Model 1	Model 2	Model 3	Model 4	Model 5
Constant	Coefficient	-1.0258***	-0.8814***	-1.0541***	-0.9941***	-0.9267***
	t-statistics	-8.50	-6.35	-8.16	-8.09	-6.35
	standard errors	0.1207	0.1388	0.1293	0.1228	0.1459
GDP p.c	Coefficient	1.8472***	1.7855***	1.6643***	1.8034***	1.6019***
	t-statistics	18.52	17.22	12.33	16.92	11.64
	standard errors	0.0997	0.1037	0.1350	0.1066	0.1376
$(\text{GDP p.c})^2$	Coefficient	-0.0445***	-0.0410***	-0.0115	-0.0414***	-0.0046
	t-statistics	-3.53	-3.25	-0.66	-3.11	-0.26
	standard errors	0.0126	0.0126	0.0174	0.0133	0.0175
GDP growth rate	Coefficient		-0.0002**			-0.0002
	t-statistics		-2.04			-1.43

	standard errors		0.0001			0.0001
(GDP p.c) (growth)	Coefficient		0.0001			0.00003
	t-statistics		1.60			0.74
	standard errors		0.00004			0.00004
Openness	Coefficient			0.0036***		0.0039***
	t-statistics			2.74		2.83
	standard errors			0.0013		0.0014
(GDPp.c) (openness)	Coefficient			-0.0007		-0.0009*
	t-statistics			-1.55		-1.90
	standard errors			0.0005		0.00049
FDI	Coefficient				-0.0048	-0.0121
	t-statistics				-0.35	-0.78
	standard errors				0.0139	0.0156
(GDP p.c) (FDI)	Coefficient				0.0077	0.0088
	t-statistics				1.22	1.13
	standard errors				0.0063	0.0078
Test of the overall significance		0.0000	0.0000	0.0000	0.0000	0.0000
R^2		0.95	0.95	0.96	0.96	0.96
N		125	125	125	125	125

*** p<0.01, ** p<0.05, * p<0.1

F-test results show that all five models are overall significant.

First of all, we test model (1) which only includes GDP per capita as the explanatory variable to test the existence of the Environmental Kuznet Curve. The overall fit of model (1) is high, R^2 = 0.95. All variables in model (1) have the expected signs (positive for GDP per capita and negative for GDP per capita squared) and are statistically significant, which indicates a U-inverted relationship between CO_2 emissions and GDP per capita. However, it is important to note that, while the EKC reaches the turning point at approximately $20,000/habitant, our data range for GDP per capita just lies between $268.7 per capita to $6318.9 per capita. Hence, the result shows a monotonically increasing linear relationship between income per capita and CO_2 emissions. Also, we are not confident whether there would be a U-inverted relationship between CO_2 emissions and GDP per capita when GDP per capita increases and passes the level of $6318.9. This evidence supports the Pollution Haven Hypothesis, which asserts that if a country has lenient environmental standards, trade will affect the environment negatively. Figures 2.2.a and 2.2.b illustrate the results.

This result can be explained by the fact that the five selected countries are all developing countries, with the mean of GDP per capita for the period of 1986-2010 just $1196.9. At the beginning of economic development, trade has a negative impact on the environment, because the country will shift to the pollution-intensive production. This would raise concerns for the governments about the improvement of environmental protection.

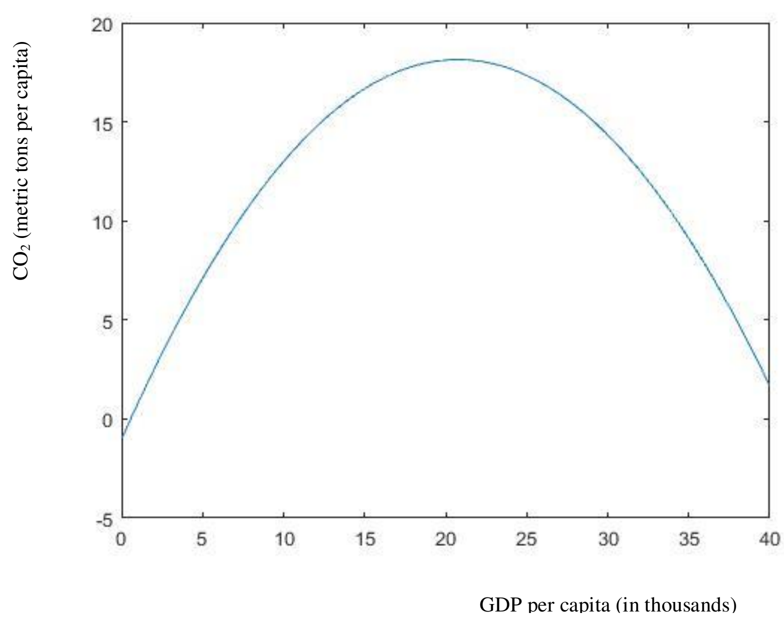

Figure 2.2.a. The Environmental Kuznets Curve

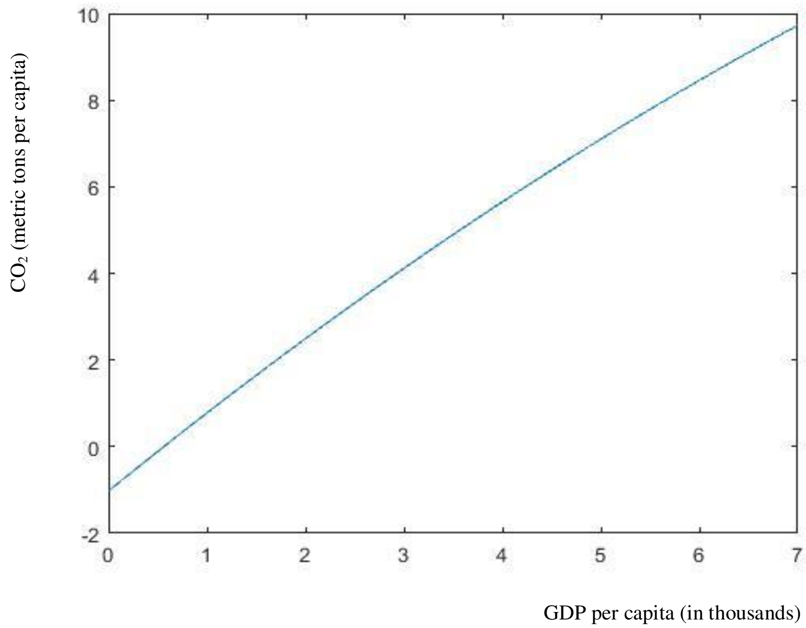

Figure 2.2.b. Monotonically increasing near-linear subsection over the range of the data.

In model (2), (3), (4), we introduce respectively three variables: GDP growth rate, the level of openness (trade intensity) and foreign direct investment to see the impacts of trade liberalization on the EKC. The overall fit of all the models increase, which implies that the explanatory variables do matter.

6.1. The impact of economic growth

The growth rate of GDP per capita of the five countries over the period 1986-2010 is introduced into the EKC model to capture the impact of economic growth on the EKC. The growth rate as additive term is statistically significant (t-statistic = 2.04). Economic growth affects both the EKC's intercept and slope, suggesting that its influence is not the same throughout the process of development. At low GDP per capita level, the economic growth rate enters with a negative sign for CO_2 emissions, which indicates that higher economic growth results in less CO_2 emissions. A percent increase in the growth rate leads to 0.02kg per capita reduction in the emission of CO_2. However, this impact does not remain the same in the process of development. As GDP per capita increases, due to the interaction with income, the positive effect of GDP growth rate on the EKC is gradually reduced and then becomes negative (i.e. higher economic growth results in more CO_2 emissions) after the income level of about \$2,500 per capita. Figure 2.3.a illustrates the effects of a higher economic growth on the EKC and Figure 2.3.b illustratres the subsection over the range of the data.

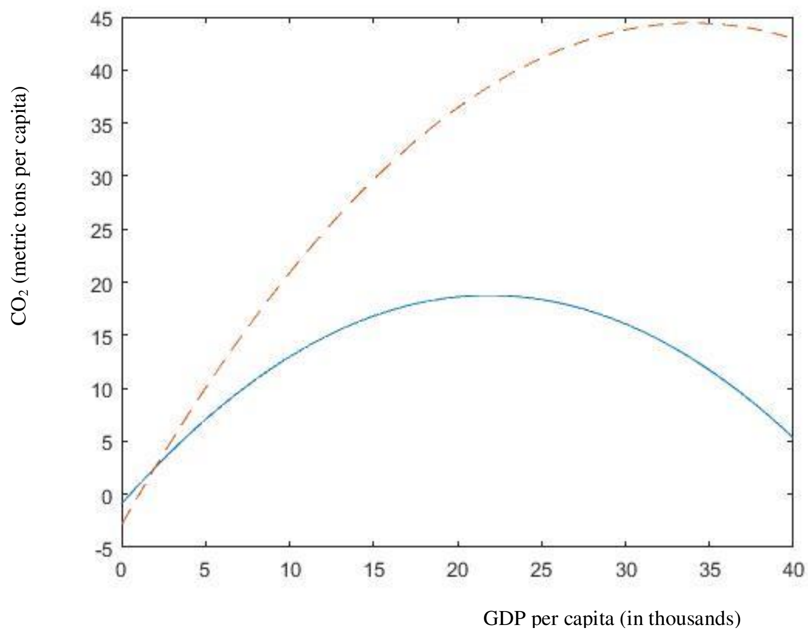

Figure 2.3.a. The impact of economic growth on EKC

g = 1%

g = 10%

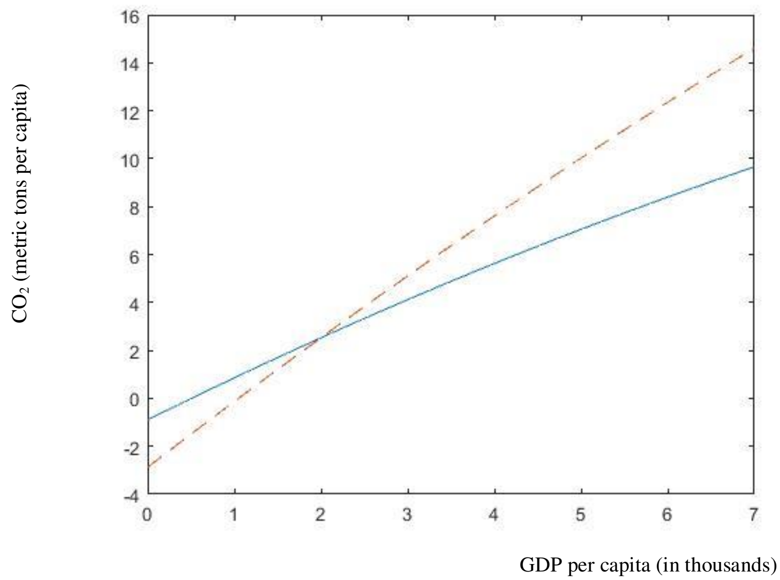

Figure 2.3.b. The impact of economic growth on EKC subsection over the range of the data

g = 1%

g = 10%

6.2. The impact of trade intensity on the EKC

The level of openness to international trade or trade intensity is introduced in model (3) to capture the impact of trade liberalization on the intercept and the slope of the EKC. The trade openness variable is statistically significant (t-statistics = 2.74) and have a positive sign. Figure 2.4.a and 2.4.b shows the impact of trade intensity on the EKC trajectories in the process of development. It can be seen that the effect of trade intensity at low level of income is not really considerable.

At low income levels, the effect of trade intensity is negative, which implies that the more open to international trade, the more CO_2 emissions. However, this negative impact for the five developing countries will disappear as GDP per capita increases. From the income level of about $10,000 per capita, the environmental impact of trade intensity becomes positive (i.e. more open to international trade leads to less CO_2 emissions). Figure 2.4.a illustrates the effects of more openness to international trade on the EKC and Figure 2.4.b illustratres the subsection over the range of the data.

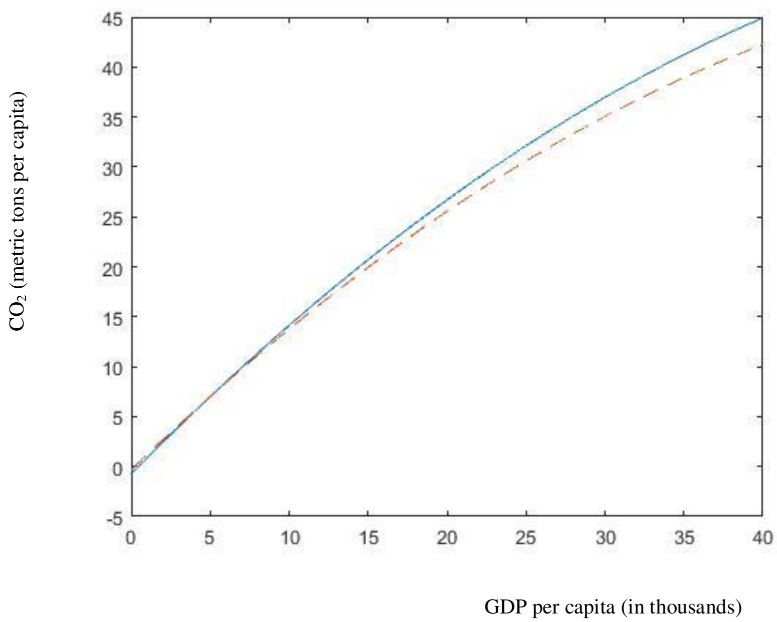

Figure 2.4.a. The impact of trade openness on EKC

P = 90

P = 200

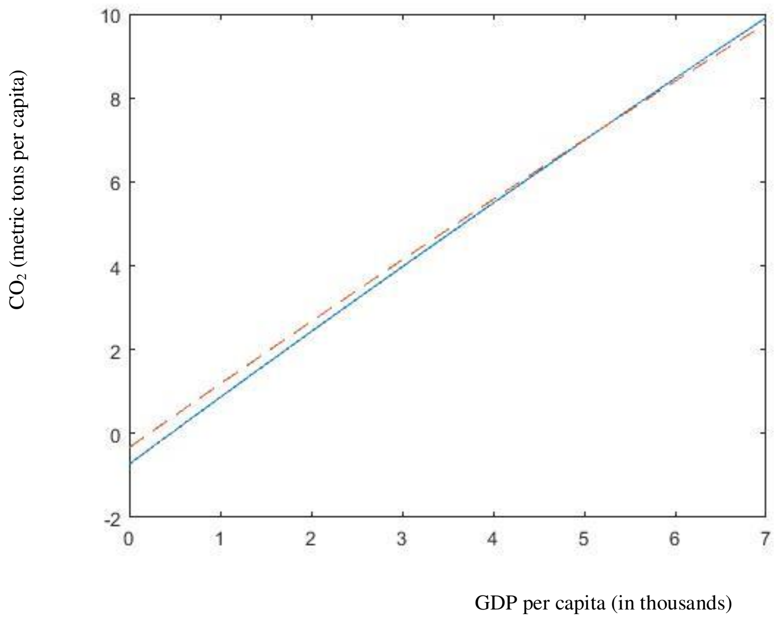

Figure 2.4.b. The impact of trade openness on EKC- Subsection over the range of the data

———— P = 90

------------ P = 200

6.3. The impact of FDI on the EKC

Foreign direct investment is introduced in model (4) to capture the impact of trade liberalization on the EKC's slope and intercept. As shown in Table 2.6, the additive and multiplicative terms of the FDI variable are statistically insignificant (t-statistic = 0.35 and 1.22 respectively for F and F.X variables). The effect of FDI at low levesl of income is not really considerable. However, the impact of more FDI to the economies at higher levels of income becomes increasingly impressive. After GDP per capita reaches a certain level, the impact of FDI on the EKC becomes negative (i.e. more FDI results in more CO_2 emissions). Figure 2.5.a illustrates the effects of more FDI on the EKC and Figure 2.5.b illustratres the subsection over the range of the data.

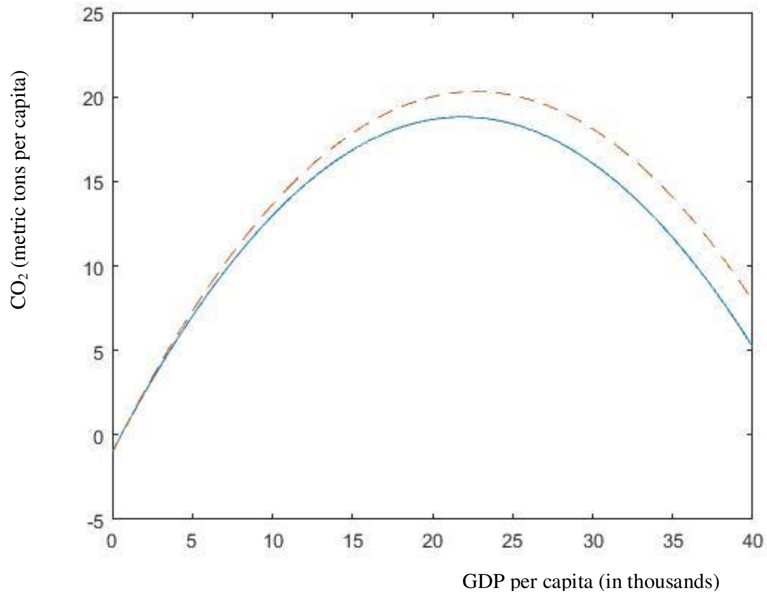

Figure 2.5.a. The impact of FDI on EKC

F = 1

F = 10

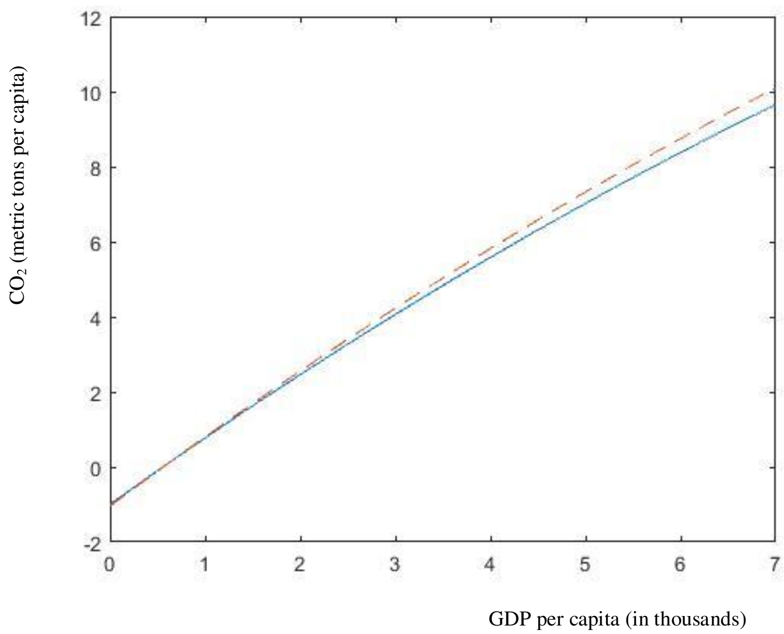

Figure 2.5.b. The impact of FDI on EKC – Subsection over the range of the data

F = 1

F = 10

6.4. The impact of economic growth and trade liberalization on the EKC

In model (5), we include all explanatory variables at the same time.

As shown in Table 2.6, explanatory variables as additive and multiplicative terms have different signs. Trade openness variable is stastically significant (t-statistic = 2.83) and has the positive sign. Economic growth and trade liberalization variables have impact on both the interception and the slope of the EKC, suggesting that its influence is not the same throughout the process of development. At low GDP per capita level, the impacts of economic growth and trade liberalization simultaneously on CO_2 emissions are modest. However, this impact is not constant during the process of development. As GDP per capita increases, due to the interaction with income (the multiplicative term is more significant than the additive term after a certain income level), the environmentally harmful effect of trade liberalization on the EKC gradually increases (i.e. higher level of trade liberalization results in more CO_2 emissions) after the income level of $7,000 per capita.

Figure 2.6.a depicts the impact of these three explanatory variables on the EKC simultaneously. Figure 2.6.b illustrates the subsection over the range of the data.

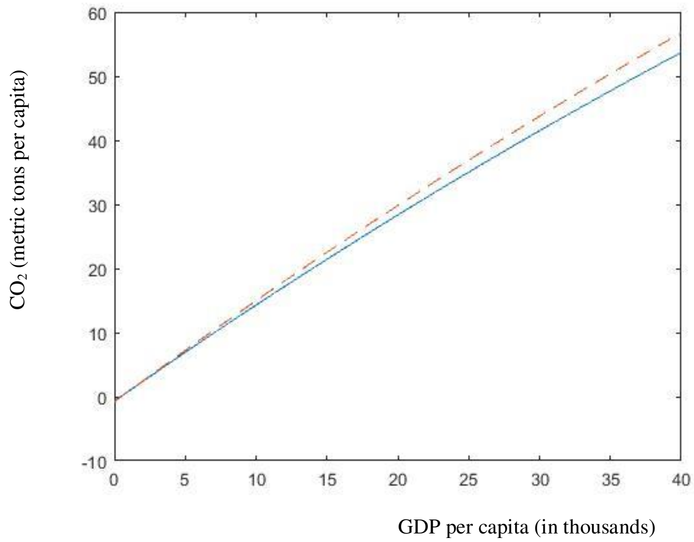

Figure 2.6.a. The impact of economic growth, trade intensity and foreign direct investment on EKC

G=1%, P = 90, F=1
G=10%, P = 200, F = 10

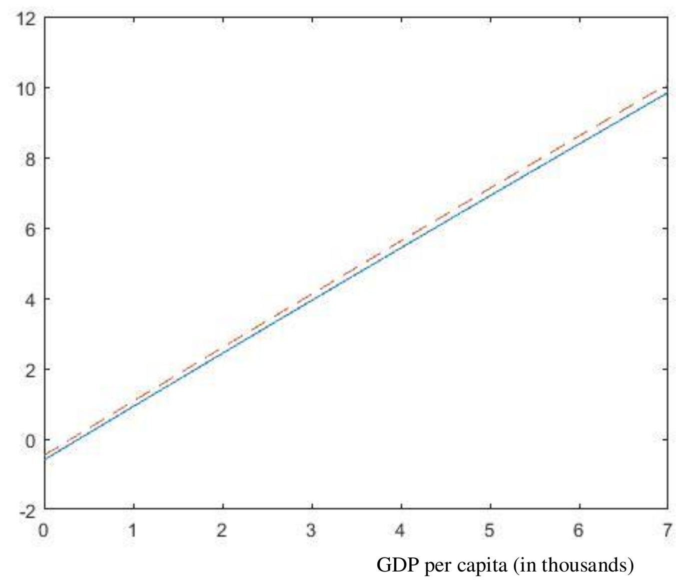

Figure 2.6.b. The impact of economic growth, trade intensity and foreign direct investment on EKC – Subsection over the range of the data

G=1%, P = 90, F=1
G=10%, P = 200, F = 10

As we can see, interestingly, the simultaneous impact of economic growth and trade liberalization on the EKC is moderate at low income levels. This result suggests that for the case of 5 Southeast Asia countries, at lower stage of development, trade liberalization has little impact on the environment. However, this impact does not remain the same in the process of development. As GDP per capita increases, the negative impact of freer trade on the EKC gradually increases after the income level of about $7,000 per capita (i.e. higher economic growth and more liberal trade lead to more CO_2 emissions). And of all the explanatory variables, the level of openness is the most important factor.

Our results are in line with other studies that investigate the existence of the EKC for global air quality indicator CO_2, since most studies in the literature generally show that global air pollutant carbon dioxide monotonically increases with income (See Appendix for more detail). For the impacts of trade liberalization on the EKC, our findings can also be compared with recent studies on developing countries. For example, Solarin et al. (2017) find that there is an evidence of EKC in Ghana, which implies that an inverted U-shaped relationship between economic growth and CO_2 emissions exists in the country. The PHH does exist in Ghana and the findings further revealed that there is positive impact of FDI and international trade on total emissions.

Both examining the case of China, Huang et al. (2019) and Zhou et al. (2018) confirm the existence of EKC hypothesis. Moreover, Huang et al. examine the impacts of foreign trade and FDI on CO_2 emissions and find that the total impacts of FDI and foreign trade on the environment are positive. Zhou et al. (2018) show that in the first stage, FDI has a negative impact on the environment. However, its impact would be positive in the lagged period through technological spillover.

For the case of a more developed country –Turkey, Haug and Ucal (2019) examine the impacts of FDI and foreign trade on carbon dioxide emissions in Turkey. They find that an EKC is present for both carbon dioxide emissions per capita and per unit of energy. Hence, increases in GDP per capita in Turkey have resulted in reduction in carbon dioxide emissions in at least the last decade.

7. Conclusion and policy implications

The reduced-form approach is known as a very useful first step in examining the relationship between economic growth and environmental quality.

This chapter makes a modest attempt to include trade liberalization into the Environmental Kuznets Curve model for a better understanding of this multidimensional income-environment relationship. In general, our findings confirm the existence of an EKC for carbon dioxide emissions. However, for the period 1986-2010, since income per capita of five Southeast Asian developing countries are all low, the results indicate an increasing linear relationship between per capita carbon dioxide emissions and per capita GDP. In other words, for the period 1986-2010, we find no evidence supporting the Factor Endowments Hypothesis which states that trade liberalization is beneficial to the environment. The evidence supports the Pollution Haven Hypothesis that freer trade negatively affects the environment.

According to Grossman and Krueger (1995), addressing environmental issues does not necessarily hurt economic growth in developing countries. However, weak institutional capacity in developing countries always hinders the governments from planning, making and enforcing strict and effective environmental protection policies. Higher level of openness and more attracted foreign direct investment would lead to higher environmental degradation in these countries. Therefore, the results also raise concerns about the "race to the bottom" for environmental standards.

The limitations of the study are the lack of available and reliable data for developing countries. Further research could be to broaden the model and include more developing economies or explanatory variables. Although some results in this study are found to be consistent with the empirical results of previous research, they do not indicate a unique relationship between economic growth, trade liberalization and the environment for all pollution indicators and countries. Further in depth studies are needed for a better understanding of this multi-dimensional relationship.

Understanding the trade liberalization – environmental quality relationship is important for policy makers on the planning, designing and implementation of economic and environmental policies. Oue results shed lights for governments in developing countries that are promoting foreign trade and attracting FDI vigorously. The results suggest that trade and environment policies need to be coordinated to control the negative impacts of trade liberalization on environmental quality.

For example, the government should strengthen its environmental laws. Since FDI inflows are considered a channel for environment-friendly technologies, the government should implement and enforce serious environmental regulations to attract clean FDI inflows. Pursuing green FDI will boost economic growth while having very limited impact on the environment.

Our findings also raise concerns for the "race to the bottom" in developing countries due to intensive competition for FDI. Governments of developing countries should strengthen their environmental standards and enhance environmental law enforcement.

Moreover, global pollution issues like carbon dioxide require effective international cooperation and special attention. At higher stages of development, the demand for environmental regulations and pollution abatement investment seems to increase. It is not clear whether or not developing world should follow developed countries' path to economic growth. However, there is no doubt that developing countries need effective economic and environmental policies to promote sustainable development.

CHAPTER 3

THE EFFECTS OF ENVIRONMENTAL STRINGENCY AND FACTOR INTENSITIES ON VIETNAM'S TRADE SPECIALIZATION

1. Introduction

Recent decades have experienced rapid economic growth, especially in countries with outward-oriented economic policies. Globalization and trade liberalization means that there is a worldwide trend of declining trade barriers. Therefore, the role of environmental standards has become more and more important in shaping comparative advantage among countries. Rising environmental awareness has also resulted in stricter pollution standards in developed countries. This fact, according to the Pollution Havens Hypothesis, results in the migration of polluting industries away from high-regulated countries (i.e. developed countries) toward less-regulated countries (i.e. developing ones).

Over the past decades, the Vietnam economy has undergone significant reforms. One important aspect of reforms lies in trade regime and trade structure. Trade specialization is believed to have links to the weak environmental regulations in Vietnam. There have been serious concerns that Vietnam has a comparative advantage and specialize in pollution intensive products. Hence, Vietnam may gradually become a "pollution haven" for pollution-intensive production from trade partners with tight environmental regulation (as the Pollution Haven Hypothesis suggests). However, the traditional Heckscher-Ohlin framework predicts that given Vietnam's labor endowment as well as physical and human capital scarcity, Vietnam will become more specialized in relatively clean industries (usually they are labor intensive ones) and less specialized in pollution intensive industries. In fact, the two effects may have simultaneous influence on different sectors in Vietnam. Therefore, the net impact of trade liberalization on Vietnam's trade specialization depends on which effect dominates the other.

In this regard, a huge body of research has been undertaken to empirically examine changes in trade patterns. Copeland and Taylor (2003) point out that although they are different, the pollution haven effect and the Pollution Haven Hypothesis are related. They assert that even when the pollution haven effect exists, if other factor intensities outweigh the pollution haven effect, then the Pollution Haven Hypothesis does not necessarily hold.

This chapter investigates the determinants of Vietnam's trade specialization, and the effect of environmental stringency on Vietnam's patterns of trade. Due to data limitations, we only focus on examining how environmental stringency and factor intensities affected cross-industry trade specialization in Vietnam in the period 2001-2008.

The rest of the chapter is structured as follows. Some basic information on trade reforms and the environmental regime in Vietnam will be presented in the next section. Then we briefly discuss the previous literature on the impacts of environmental stringency and other factor intensities on trade liberalization. Our data sources, variables and methodology are presented in section 4 and 5. Section 6 analyzes econometric results while section 7 presents the conclusions and further research questions.

2. Trade reforms and environmental regime in Vietnam

2.1. Trade reforms

The year 1986 is a key turning point in the history of the Vietnam economy when Vietnam announced its *doi moi* (renovation) policy, allowing the transition from a centralized economy to a largely market-oriented economy. Since the introduction of this renovation policy, there have been significant changes in trade policy regime in Vietnam. The key reform measures included[12] (i) removal of restrictions to establish foreign trading corporations; (ii) introduction of trade policy instruments (i.e. tariffs and quantitative restrictions), improvements in export incentives and gradual reduction in import barriers; and (iii) liberalization of foreign exchange regime. The objectives of these structural reforms were to remove the rigidities and plunge the Vietnam economy into the arena of globalization.

In the past decades, Vietnam has made great strides toward integration into the global economy. In 1995 Vietnam joined the Association of South East Asian Nations (ASEAN) and the ASEAN Free Trade Area (AFTA). In 1998, Vietnam became a member of the Asia Pacific Economic Cooperation (APEC) forum. On July 13th 2000, the United States and Vietnam officially signed the Vietnam–United States Bilateral Trading Agreement (VNUSBTA). This agreement came into force on December 10th 2002, facilitating Vietnam's further global integration.

In 2007, Vietnam joined as the 150th member of the World Trade Organization (WTO). The accession to WTO marked a key step in promoting Vietnam’s firmer integration into the global economy and gaining access to the world market on equal terms.

2.2. The environmental regime in Vietnam

In the past decades, Vietnam has made a great effort in establishing a command-and-control system of environmental protection, including standards, monitoring, and enforcement. In order to solve environmental problems in the context of economic integration and globalization, Vietnam has raised the importance of sustainable development in the national

[12] Auffret, P. (2003). Trade reform in Vietnam: Opportunities with emerging challenges (Vol. 3076). World Bank Publications.

dialogue. There have been dramatic changes in Vietnam's environmental institutions, policies and regulations in recent years.

2.2.1. Environmental institutions

Vietnam's Ministry of Science, Technology and Environment was established in 1992. The National Environment Agency was then established as a subsidiary under the Ministry. It is the first agency officially responsible for environmental protection and specializing in environmental issues. Vietnam's Ministry of Natural Resources and Environment was established in 2002. In each of Vietnam's 61 provinces and cities, the Department of Natural Resources and Environment is in charge of monitoring environmental protection activities and enforcing environmental laws and regulations.

Government agencies and organizations involved in environmental activities (i.e. policy planning, making and implementation in Vietnam) are described in Table 3.1 below; while the organizational structure on environmental management is illustrated in Figure 3.1.

Table 3.1. Government Agencies and Organizations Involved in Environmental Activities in Vietnam

Environmental Activities	Government Organizations
Policy Making	Communist Party of Vietnam Prime Minister National Assembly Provincial People's Councils National Environment Agency
Planning	Ministry of Planning and Investment Ministry of Finance Provincial Departments of Planning and Investment Planning Departments Ministry of Natural Resources and Environment Universities and Institutes
Supervision	Ministry of Natural Resources and Environment National Environment Agency Provincial People's Committees
Implementation	National Environment Agency Provincial Departments of Natural Resources and Environment Environment Departments

Source: *O'Rourke, D. (2002). Motivating a conflicted environmental state: community-driven regulation in Vietnam. In The environmental state under pressure (pp. 221-244). Emerald Group Publishing Limited.*

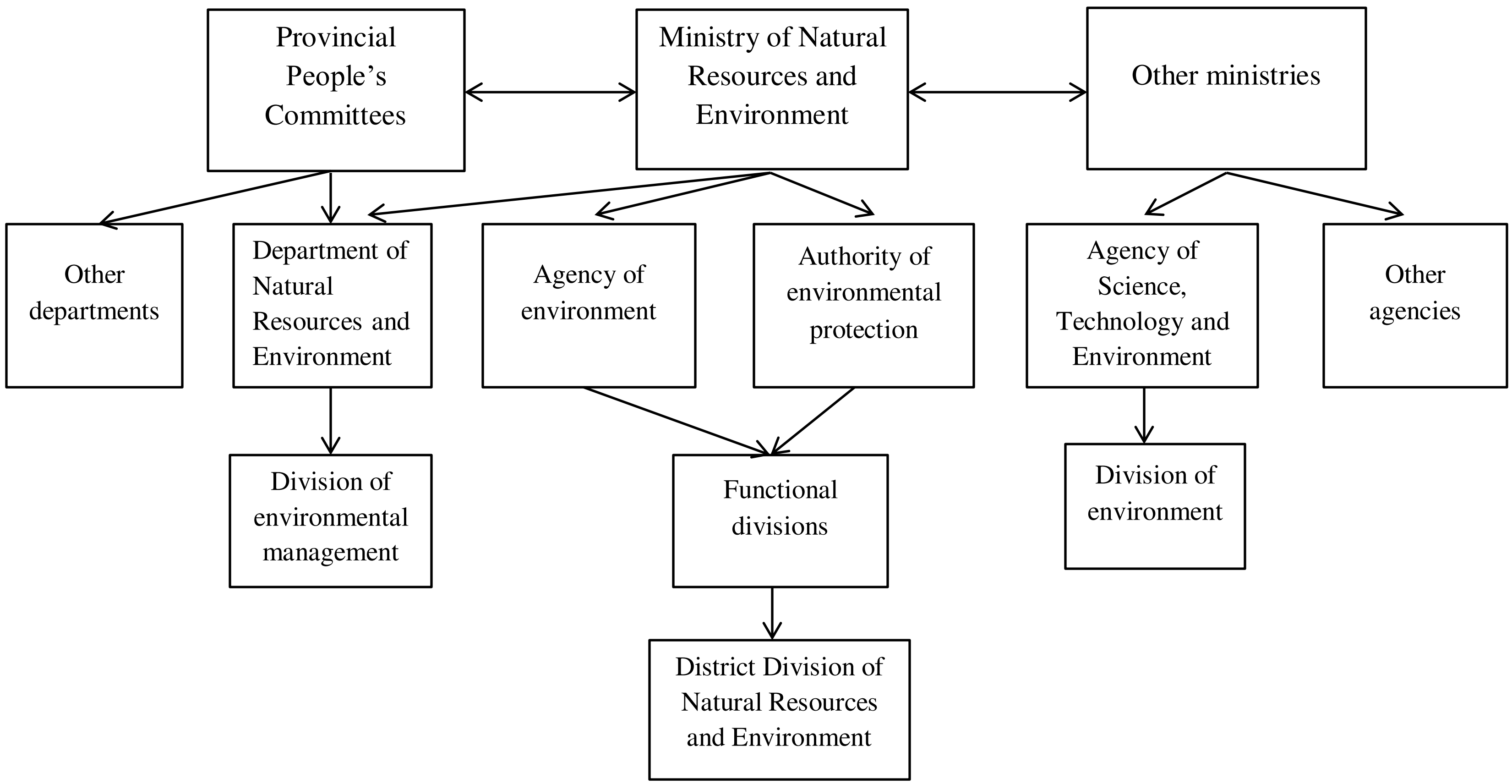

Figure 3.1. Vietnam's organizational structure on environmental management

Source*: Chinh The Nguyen. (2012). Environmental Economics and Management. Vietnam Education Publisher.*

As Figure 3.1 indicates, the government structure on environmental management has some disadvantages. One of them is the contradictions and overlapping responsibilities and duties among Government's ministries and agencies. Another problem is the insufficient cooperation between these ministries due to inappropriate division of tasks. This dispersal of responsibilities is very problematic in many areas of environmental management.

2.2.2. Environmental regulations

In Vietnam, the Law on Environmental Protection, which was enacted in 1993 and amended in 2005, is the key environmental legislation. The law not only provides a framework for environmental protection policies and measures but also regulates the rights, obligations and duties of individuals, households and organizations in protecting the environment. It also points out Government's responsibilities in national environmental protection, preventing pollution, avoiding the degradation of the environment, and rehabilitating degraded areas. Since the Law on Environmental Protection was promulgated, the government has issued various environmental regulations and standards classified as directives, decrees, circulars, instructions, action plans, programs and guides to ensure the implementation and enforcement of the Law on Environmental Protection.

In 1995, Vietnam's national environmental standards were officially issued by the Ministry of Science, Technology, and Environment. The standards focus on ambient air quality; surface water, coastal water and groundwater quality; pesticide residues; inorganic and organic industrial emissions; industrial wastewater discharge; and maximum permitted noise levels[13].

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[13] Dara O'Rourke (2003) Community-Driven Regulation: Balancing Development and the Environment in Vietnam (Urban and Industrial Environments). The MIT Press (page 152)

Vietnam's current environmental legislation also gives citizens the right to complain about and report environmental law violations, as well as to request compensation for environmental damage. This has created more opportunities and encouragement for people to participate in environmental protection.

In 2002, Vietnam ratified the Stockholm Convention on Persistent Organic Pollutants (a global environmental treaty that aims to restrict persistent organic pollutants). And up to now, Vietnam has become a member of about 20 international agreements on the environment.

In 2003, Vietnam's Prime Minister officially signed the National Strategy for Environmental Protection until 2010 and Vision toward 2020, which is an important guiding instrument for Vietnam's environmental protection in the context of global integration. In 2004, Vietnam raised the Environmental Impact Assessment requirements for new project approvals. In 2012, the Vietnam Sustainable Development Strategy for 2011-2020 was approved to promote sustainable development in the period of Vietnam industrialization and modernization.

3. Literature review

In this section, we will summarize and synthesize the methodologies and findings of previous studies on the impacts of environmental stringency and other factor intensities on trade liberalization.

First, a number of studies have concluded that environmental stringency has resulted in the migration of polluting industries from the developed countries to developing ones. This is because the stringency of environmental standards in developed countries has increased significantly together with the decrease in trade barriers; while environmental regulations in developing countries may be laxer. For example, the Kyoto Protocol climate change treaty excludes developing countries from internationally binding emissions reduction targets, which could lead to the loss of competitiveness in developed countries.

McGuire (1982) introduces an approach to incorporate environmental regulations into the theory of production, distribution, and trade. They conclude that if production factors are freely mobile across economies, the regulated industry will be entirely driven out from the more to the less regulated economy.

Chichilnisky (1994) considers a world economy with two regions – the North and the South - which represents developed countries and developing countries respectively. According to Chichilnisky, the South tends to specialize in products which deplete natural and environmental resources even if those countries are not well endowed with them.

Baumol and Oates (1988) also suggest that countries will voluntarily become the depository of the most polluting industries in the world if they do not restrict pollution emissions.

Second, many studies in literature have discussed the role of environmental regulations in shaping countries' comparative advantage. The debate has been prompted by concerns that in order to gain a comparative advantage in pollution intensive industries, developing countries could lower their environmental regulations.

Some research shows that environmental stringency does not affect countries' comparative advantage; some conclude that environmental regulations just have a temporary impact on countries' comparative advantage while others find evidence that it has influence on trade patterns.

- Environmental regulations do not affect countries' comparative advantage

Most empirical studies indicate that environmental regulations do not have an important influence on countries' comparative advantage and trade specialization, since environmental control cost is generally a tiny fraction of total production costs.

Among the research that finds no evidence on the impact of environmental regulations on countries' comparative advantage, Tobey (1990) uses the well-known Heckscher-Ohlin-Vanek (HOV) framework to examine the effect of environmental standards on trade specialization. After undertaking several empirical tests, he finds no systematic evidence of deviations in world trade patterns, because pollution controls are not very costly, even in heavily polluting industries.

Jaffe et al. (1995) assemble and assess the evidence on the hypothetical linkages between environmental regulations and competitiveness. Their findings show that the impact of environmental standards on competitiveness might be small and difficult to detect.

Harris et al (2002) find that when we consider the exporting and importing country specific effects together, the relationship between trade specialization and environmental stringency becomes statistically insignificant. Then, the authors conclude that environmental cost does not have a real effect on foreign trade, neither negative nor positive.

- Environmental regulations have a temporary impact on countries' comparative advantage

On the other hand, much research in literature finds that there exist temporary pollution havens. Mani and Wheeler (1998) find that the migration of pollution-intensive industries from developed countries to developing ones has not been a major issue. They conclude that pollution havens have apparently become temporary, since economic growth has created counterbalancing effects through improvements in clean production, regulations, and technical expertise.

- Environmental regulations influence countries' comparative advantage

Lucas et al (1992) examine pollution intensity in manufacturing industries in developed and developing countries. They develop time series estimates for the period 1960-1988. Their results show that the countries that experience the highest toxic intensity growth are the poorest ones.

Cole and Elliott (2003) argue that dirty industries are subject to competing forces of comparative advantage. The authors explain that polluting industries are considered capital intensive ones, and countries with lax environmental stringency are also capital scarce. They investigate whether pollution changes as a consequence of trade liberalization stem from the difference in environmental stringency or in capital-labor endowments.

Van Beers and Van den Bergh (1997) investigate bilateral trade flows among OECD countries. They also find that tight environmental standards have some negative impacts on trade patterns.

Third, a number of studies have focused on investigating why evidence of pollution haven pressures is mixed.

Some authors (such as Ederington and Minier (2003), and Levinson and Taylor (2004)) consider environmental regulations an endogenous factor since they are used as non-tariff trade barriers to protect domestic industries.

Ederington and Minier (2003) assert that the previous literature considered environmental regulation an exogenous factor. In other words, they implicitly excluded the role of trade considerations in environmental policy setting. Hence, these studies only estimate a part of the impacts of environmental standards on trade. Their findings show that if environmental regulations are considered endogenous, the impact on trade becomes more significant than previously reported. They also investigate whether environmental regulations have been used as one of the trade barriers to protect domestic industries. Given that environmental policy may be endogenous, they evaluate the effect of environmental standards on trade specialization. Their findings show that the impact of environmental standards on net import levels is significantly higher than previously reported.

Levinson and Taylor (2004) examine the impact of environmental standards on trade both theoretically and empirically. The paper aims to investigate "how unobserved heterogeneity, endogeneity and aggregation issues bias measurements of the relationship between regulatory costs and trade". The paper uses a large sample of 130 manufacturing industries in three countries (U.S., Canada, and Mexico) during a period of 9 years. The findings suggest that industries which increase most in pollution abatement costs also increase most in their net imports.

Neumayer (2001) reviews a number of factors to explain why clearer evidence on this has not been found. These include the fact that environmental protection cost only accounts for a small part of an entrepreneur's total cost; the fact that heavy industries depend a lot on their domestic market; and the fact that countries with relatively lenient environmental regulations may have certain characteristics such as corruption and poor infrastructure that prevent inward investment.

Cole et al. (2005) aim at explaining why environmental stringency does not appear to have had a widespread influence on US specialization. The authors examine different measures of specialization in the US. They show that although environmental regulations in the US are higher than in developing countries, its specialization in pollution-intensive industries is not lower than in other industries. They are even not increasing more slowly or reducing more quickly. Their discussion indicates that dirty industries are physical and human capital intensive. These factors are not abundant in developing countries; hence, developing countries are not attractive destinations for pollution-intensive industries. They illustrate econometrically that these factors are significant determinants of US specialization patterns and that the impacts of environmental stringency and factor intensities on trade specialization patterns are competing.

In this chapter, I will follow the method developed by Cole (2005). Particularly my study first employs different industrial specialization indices to examine whether low stringency of Vietnam's environmental regulations leads to increasing specialization in pollution-intensive production as the PHH predicts. Then we estimate econometrically the determinants of specialization, i.e. whether environmental standards affect cross-industry trade patterns in Vietnam.

4. Data and variables

4.1. Data

Our dataset is a balanced panel of cross industry and time series observations. Our sample includes 18 industries (Paper and Paper products, Coal, Leather, Plastic, Rubber, Wood, Printing, Textile, Apparel, Iron and steel, Non-metallic mineral products, Chemical, Food, Beverage, Tobacco, Machine, Transportation equipment, Furniture). Observations in our data set are for the period 2001-2008 since data on pollution abatement operating cost is not available in Vietnam for the years before 2001.

4.2. Variables

4.2.1. Trade specialization

Previous studies have employed many different measures of trade specialization to examine the relationship between environmental stringency and industrial competitiveness[14]. Cole et al. (2005) discuss three different trade specialization measures which are based around a country's net exports: revealed comparative advantage, net exports share in value added, and the Michaely index. He obtains consistent results that environmental regulations have negative impact on trade specialization. Following the literature, this chapter also employs various measures of specialization (the three measures of specialization as Cole discussed and one additional measure).

Revealed Symmetric Comparative Advantage (RSCA)

Balassa (1965, 1979 and 1986) first employed the index "Revealed comparative advantage (RCA)" in the study of international trade. Since then, it has been widely used in the literature on trade specialization.

The revealed comparative advantage index is defined as:

$$RCA_{it} = \left(\frac{\frac{X_i}{\sum_i Xi}}{\frac{X_{iw}}{\sum_i Xiw}} \right)_t$$

where:

X_i : country's exports from sector *i* in year *t*.

X_{iw} : world exports from sector *i* in year *t*.

[14] See Deardorff (1984)

In this formula, the numerator shows the percentage share of a sector in a country's total exports; while the denominator is the percentage share of that sector in the world's total exports. The value of RCA index equals one for a given sector can be interpreted that its percentage share equals the world's average. If the RCA value is greater than one for a given sector, the country has comparative advantage or specializes in that sector. Similarly, a lower than one value of an RCA implies that the country has comparative disadvantage or under-specializes in that sector.[15]

Revealed Symmetric Comparative Advantage (RSCA) is another transformation of the RCA index which is developed by Laursen (1998). It is defined as:

$$\text{RSCA} = \frac{RCA-1}{RCA+1}$$

The value of RSCA index ranges between -1 and 1.

Michaely index

The Michaely index was originally developed by Michaely (1962). It is defined as the difference of the percentage share of a country's exports from a sector in total exports and the percentage share of that country's imports from the same sector in total imports.

$$\text{MICHAELY}_{it} = \frac{X_{it}}{\sum_i X_{it}} - \frac{M_{it}}{\sum_i M_{it}}$$

where:

X_{it} : country's exports from sector *i* in year *t*.

M_{it} : country's imports from sector *i* in year *t*.

[15] Cole et al. (2005)

Its value also lies between -1 and 1. If a Michaely value is higher than zero, the country has comparative advantage or is specialized in that sector. Similarly, if a Michaely value is lower than zero, the country has comparative disadvantage or is under-specialized in that sector.

Net exports share in value added

Net exports share in value added is simply defined as the share of an industry's net exports in its value added.

$$NETXva_{it} = \frac{X_{it} - M_{it}}{VA_{it}}$$

where

X_{it} : country's exports from sector *i* in year *t*.

M_{it} : country's imports from sector *i* in year *t*.

VA_{it} : the value added of sector *i* in year *t*.

If the value of NETXva index increases, country's exports from the sector are increasing relative to country's imports from the sector or in other words, its specialization is increasing and vice versa.

Trade specialization index (TSI)

TSI is defined as the percentage share of a sector's net exports in total imports and exports volume.

$$TSI = \frac{X_{it} - M_{it}}{X_{it} + M_{it}}$$

Its value also lies between -1 and 1. A big value of TSI means the sector is more export specialized.

Although these measures of trade specialization appear to be similar and correlated, they are subtly different. As Cole (2005) emphasizes, the RCA index measures a sector's exports relative to other sectors' exports relative to other countries' exports from that sector. The Michaely index reports a sector's exports relative to that sector's imports, relative to total exports and imports. This index does not mention other countries' exports. Net exports per value added measures a sector's exports relative to its imports with no mention of other sectors or other countries. The trade specialization index shows the importance of a sector's net exports in its total trade. However, this index may overlook the differences in trade volume. For example, two sectors with different trade volumes (one industry with really high trade volume and the other with really small one) may have the same TSI index. Another example is that an industry's TSI index may remain the same no matter how its trade volume increases over time.

Previous studies in the literature usually use a wide range of industrial specialization indices (as discussed above) to descriptively examine whether high environmental stringency has led to decreasing specialization in pollution intensive industries in developed countries and lax environmental stringency has resulted in increasing specialization in pollution intensive industries in developing countries (as the Pollution Haven Hypothesis suggests).

Following the literature, in this chapter I also employ various measures of specialization (the three measures of specialization as Cole discussed and TSI index). Export and import data sources to calculate these measures of specialization are from UN Comtrade database.

Table 3.2. Average values of RCA, the Michaely, net exports and trade specialization index by industry (2001-2008)

Industry	RCA	Michaely	NETXva	TSI
Paper	0.3149	-0.0122	-0.0005	-0.6391
Coal	1.8238	0.0915	0.0022	0.1733
Leather	3.0163	0.0111	0.0002	0.9012
Plastic	0.4144	-0.0408	-0.0018	-0.6706
Rubber	2.6937	0.0157	0.0005	0.3318
Wood	0.8840	-0.0059	-0.0005	-0.3252
Printing	0.0951	-0.0006	0.0000	-0.5153
Textile	1.6962	0.0003	0.0216	0.3788
Apparel	6.4033	0.0830	0.0015	0.8142
Non-metallic mineral products	1.2872	0.0053	0.0001	0.3046
Iron and steel	0.2439	-0.0709	-0.0015	-0.8781
Chemical	0.1325	-0.0154	-0.0002	-0.8817
Food	4.2140	0.1704	0.0010	0.6307
Beverage	0.1557	0.0002	0.0001	0.0254
Tobacco	1.2657	-0.0006	-0.0001	-0.1576
Machine	0.2713	-0.1001	-0.0056	-0.6360
Transportation equipment	0.1316	-0.0320	-0.0005	-0.6079
Furniture	3.0632	0.0356	0.0008	0.8926

Table 3.2 illustrates the average values of RCA, Michaely, Net exports share in value added and TSI indices of 18 industries in Vietnam. A large variation in the indices can be seen across these industries. RCA index is found to be greater than 1 in nine of the 18 industries (Coal, Leather, Rubber, Textile, Apparel, Non-metallic mineral products, Food, Tobacco, Furniture), which indicates that Vietnam has a comparative advantage or specializes in these nine industries. The Michaely index has a positive value for nine industries (Coal, Leather, Rubber,

Textile, Apparel, Non-metallic mineral products, Food, Beverage, Furniture) which suggests that Vietnam is specialized in these nine sectors.

4.2.2. Environmental stringency variable

In the literature, various qualitative and quantitative measures of environmental stringency have been employed in examining the relationship between environmental regulations and trade patterns. Some studies use qualitative measures of environmental stringency. For example, Levinson (1996) develops the "monitoring employment" which measures the ability of states in enforcing statutes. Other qualitative measures of environmental stringency include countries' participation in global environmental treaties, and the quality of emissions standards (Smarzynska and Wei (2001)).

Other studies develop quantitative measures. For example, List and Co (1999) measure the estimated money spent by state's agencies to control solid waste disposal as well as air and water pollution. Tobey (1990) measures environmental stringency from one to seven degree, based on the 1976 UNCTAD survey, in which higher degree means stricter environmental standards. Levison (1996) develops different environmental stringency indices: the Conservation Foundation index that measures the ability of states in providing a quality environment; the Green index that evaluates the environmental statutes a state enforces; and the Fund for Renewable Energy and the Environment index that assesses the effectiveness of a state's environmental programs.

Besides these measures, many researchers have employed pollution abatement cost as a cost-based measure of environmental stringency. Annual pollution abatement operating cost is known as the annual expenditures on the operation of pollution treatment facilities. List and Co (1999) use pollution abatement operating cost relative to abating solid waste disposal and water and air pollution at firm level. Levinson (1996) uses industries' pollution abatement operating cost deflated by the number of workers. Another measure also developed by Levinson (1996) is industry abatement cost that measures the amount manufacturers have to pay for pollution abatement.

Following the literature, we also use the pollution abatement operating costs per unit of value added as a proxy for a country's environmental stringency. Data to calculate annual pollution abatement operating costs are collected from Vietnam's Annual Enterprise Survey, which is carried out by the General Statistics Office of Vietnam.

PAOCva = pollution abatement operating cost / value added

4.2.3. Measuring other control variables

Following previous studies in the literature, we define human capital intensity (HCI) as the share of value added paid to skilled workers[16]. Since data on unskilled and skilled wages for industries are not available in Vietnam, we employ the definition of HCI which was developed by Grossman and Kruger (1991,1994) and Cole et al. (2005):

HCI = $\frac{payroll}{VA} - \frac{unskilled\ wage*employment}{VA}$ in which unskilled wage is the wage of the textile industry

We also define physical capital intensity (PCI) as the non-wage share of value added[17].

PCI = 1 - $\frac{payroll}{VA}$

Tariffs mean import tariffs. In this study we calculate the average import tariffs. Data on non-tariff barriers is not available in Vietnam.

[16] See Cole et al. (2005).
[17] See Cole et al. (2005).

Data from the General Statistics Office of Vietnam enables us to calculate human capital and physical capital intensity. Import tariffs are collected from official documents regarding export and import tariffs in Vietnam from 2001 to 2008 (i.e. decrees, decisions, and circulars).

Table 3.3. Average values of PCI, HCI, tariff and environmental stringency by industry (2001-2008)

Industry	PCI	HCI	Tariff (%)	PAOCva
Paper	0.9352	0.0086	14.6468	0.0617
Coal	0.8067	0.1050	6.8375	0.0106
Leather	0.7940	0.0203	13.3429	0.0078
Plastic	0.9367	0.0126	8.6679	0.0015
Rubber	0.9367	0.0126	10.9418	0.0015
Wood	0.8967	0.0329	5.8087	0.0043
Printing	0.9013	0.0410	9.8182	0.0003
Textile	0.9196	0.0194	7.8889	0.0007
Apparel	0.7713	0.0117	19.3774	0.0048
Non-metallic mineral products	0.9184	0.0166	17.6485	0.0012
Iron and steel	0.9664	0.0144	7.0124	0.0216
Chemical	0.9443	0.0283	3.0000	0.0360
Food	0.9583	0.0048	15.5504	0.0014
Beverage	0.9583	0.0048	49.9167	0.0012
Tobacco	0.9444	0.0348	47.0690	0.0003
Machine	0.9170	0.0203	4.9135	0.0008
Transportation equipment	0.9542	0.0137	24.3185	0.0028
Furniture	0.8736	0.0018	18.3953	0.0010

5. Methodology

In the literature, most studies examining the impact of environmental stringency on competitiveness only focus on developed countries such as the US or OECD countries. In this chapter, we follow the approach developed by Cole (2005). In particular, we aim to identify and quantify the effect of environmental regulations together with factor intensities and tariffs in Vietnam's trade specialization at the industry level. Due to data limitations, I estimate the determinants of Vietnam's trade specialization index based on the following equation:

$$SPEC_{it} = \beta_0 + \beta_1 PAOCva_{it} + \beta_2 PCI_{it} + \beta_3 (PCI)^2 + \beta_4 HCI_{it} + \beta_5 (HCI_{it})^2 + \beta_6 tariff_{it} + e_{it}$$

(-) (-) (-) (+)

where,

$SPEC_{it}$: trade specialization index (RCA, RCSA, Michaely index, TSI)

$PAOCva_{it}$: pollution abatement operating costs per unit of value added

PCI_{it} : physical capital intensity

$PCI = 1 - \frac{payroll}{VA}$

HCI_{it}: human capital intensity

$HCI = \frac{payroll}{VA} - \frac{unskilled\ wage * employment}{VA}$ in which unskilled wage: wage of the textiles industry

tariff: import tariff

This equation allows us to examine the relationship between trade specialization and various independent variables including environmental stringency and traditional factor intensities. The environmental stringency coefficient is predicted to be negative (i.e. environmental stringency is a negative determinant of trade specialization). More stringent environmental standards in an industry indicate higher Government pollution taxes and more industry pollution abatement efforts which in turn, increase industry production costs. This comparative price disadvantage could lead to the contraction of domestic production and exports and the expansion of imports.

The sign of each coefficient of factor endowment indicates that factor is a source of country's comparative advantage or disadvantage. According to the H-O model, the relative abundance or scarcity of input factors determines country's comparative costs. A positive sign indicates that input factor is abundant within the country and vice versa. Cole et al. (2005) find that both human and physical capital intensity positively affect US specialization patterns. On the contrary, it is common belief that for Vietnam, physical capital and human capital are not sources of comparative cost advantage because of their relative scarcity. Therefore, HCI and PCI variables are predicted to be negative determinants of Vietnam's trade specialization.

The coefficient of import tariffs is expected to have a positive sign, since import tariffs are trade barriers which are used to restrict imports and protect domestic production.

6. Results and discussion

First, we calculate and present Vietnam's revealed comparative advantage at the three digit ISIC (International Standard Industrial Classification) levels. RCA indices are computed for the most pollution-intensive industries using industry aggregation data during the period 2001-2008. Figure 3.2 depicts RCA indices for the five most pollution-intensive industries (Paper, Coal, Leather, Iron and steel and Chemical). Our finding is that of the five most pollution-intensive sectors, two sectors have an RCA value greater than one which suggests that Vietnam has a revealed comparative advantage in these dirtiest sectors.

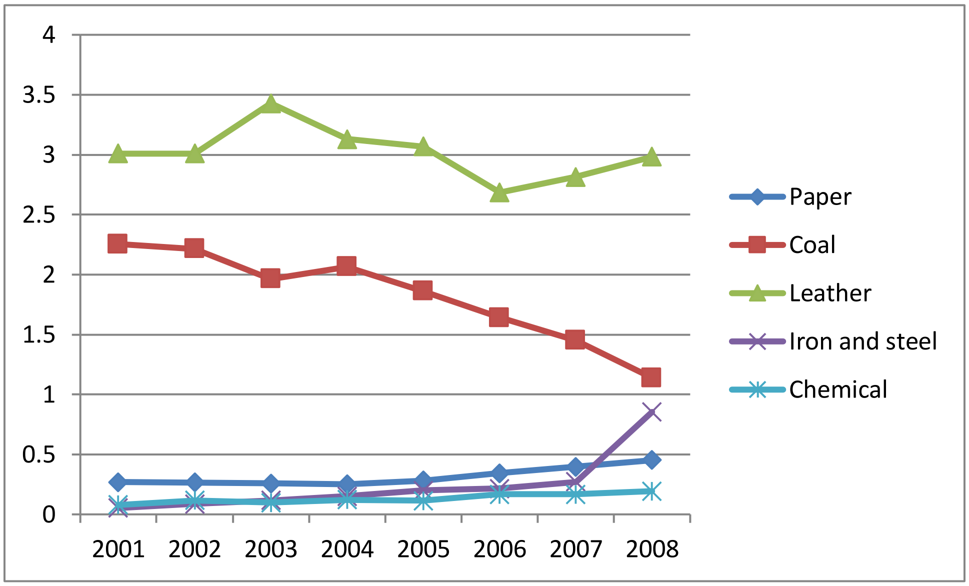

Figure 3.2. RCA Indices of Vietnam's "Dirty" Sectors

Table 3.4 records the changes in RCA, the Michaely, Net exports share in value added and TSI indices for the dirtiest sectors in 2001-2008. Table 3.4 considers the trade specialization indices (RCA, the Michaely, Net export and TSI) at a level of disaggregation. We report the trade specialization indices of the five dirtiest industries for the first and last years of the sample (i.e. 2001 and 2008). We find that the RCA, Net exports and TSI measures show an increasing trend for four out of five industries. The Michaely index records increases for three out of five industries. Therefore, the results suggest that Vietnam's trade specialization tends to increase in pollution-intensive industries.

Table 3.4. The changes in RCS, the Michaely index, Net exports share in value added and TSI index for the dirtiest industries in 2001-2008

Industry	RCA 2001	RCA 2008	Δ RCA	Mich. 2001	Mich. 2008	Δ Mich.	NetX 2001	NetX 2008	Δ netX	TSI 2001	TSI 2008	Δ TSI
Paper	0.269027	0.451657	+	-0.01367	-0.00819	+	-0.00062	-0.00036	+	-0.633937903	-0.54256	+
Coal	1.25411	2.13907	+	0.106142	0.048085	-	0.003591	0.000373	-	0.266596	0.009749949	-
Leather	3.010429	2.98396	-	0.012972	0.009417	-	0.000165	0.000185	+	0.868334	0.932055	+
Iron and steel	0.053342	0.85441	+	0.06131	0.06786	+	-0.0019	-0.00077	+	-0.96979	-0.6259026	+
Chemical	0.07843	0.19372	+	-0.01868	-0.01274	+	-0.00025	-0.00015	+	-0.93236	-0.8225637	+

Econometric analysis

We also estimate the determinants of Vietnam's trade specialization at the industry level (i.e. RsCA, the Michaely index, NETXva and TSI). For each trade specialization index, we do two sets of estimates – fixed effects and random effects. We see that the estimated coefficients vary across four measures of trade specialization in both their signs and magnitudes. For the Michaely and Net exports share in value added, we find most of the terms to be statistically insignificant. So we only focus our discussion on the estimation results for RSCA and TSI indices. Estimation results are presented in Table 3.5.

Table 3.5. The determinants of different trade specialization indices (RSCA, Michaely, Net Exports share in value added and TSI)

		RSCA		TSI	
		Fixed Effect	Random Effect	Fixed Effect	Random Effect
PAOCva	Coefficient	-1.296	-1.282	-1.03	-1.072
	t-statistics	-1.46	-1.43	-1.05	-1.10
	standard errors	0.8858	0.8956	0.98	0.977
PCI	Coefficient	-30.839***	-27.103**	-24.485**	-20.424*
	t-statistics	-2.76	-2.42	-1.98	-1.68
	standard errors	11.1847	11.1891	12.379	12.189
PCI^2	Coefficient	19.068***	16.243**	13.724*	10.810
	t-statistics	2.90	2.48	1.88	1.51
	standard errors	6.5789	6.5604	7.281	7.144
HCI	Coefficient	-.349	-.654	-.095	-.491

	t-statistics	-0.34	-0.64	-0.08	-0.44
	standard errors	1.0344	1.0228	1.145	1.112
HCI^2	Coefficient	1.397	.898	2.754	1.138
	t-statistics	0.15	0.10	0.26	0.11
	standard errors	9.4022	9.4273	10.406	10.274
tariff	Coefficient	-.002	-.002	.0034**	.00342**
	t-statistics	-1.18	-1.25	2.29	2.33
	standard errors	0.0013	0.0014	0.0015	0.0015
const	Coefficient	12.1596**	11.11156 **	10.7645**	9.496482*
	t-statistics	2.57	2.34	2.05	1.83
	standard errors	4.7393	4.7568	5.245	5.184
Test of the overall significance		F=3.88/ Prob>F = 0.0014	Wald chi2=18.08/ Prob>chi2=0.0060	F=2.31/ Prob>F = 0.0378	Wald chi2=16.83/ Prob>chi2=0.0099
R^2	0.2145		0.1255	0.1527	0.3382
N	144		144	144	144

*** p<0.01, ** p<0.05, * p<0.1

In all four estimations for RSCA and TSI indices, we find that the coefficients of all the important independent variables (PAOCva, PCI and HCI) have the expected signs. The environmental stringency variable (pollution abatement costs per value added) has a negative impact on the industry's trade specialization indices (RSCA or TSI). Moreover, human capital and physical capital intensities of a sector are also negative determinants of RSCA and TSI.

Therefore, the results support our hypothesis that environmental stringency as well as physical and human capital intensity are not sources of comparative advantage in Vietnam and negatively affect trade performance.

The coefficient of tariff has mixed signs. For TSI index, tariff is a statistically significant positive determinant of that industry's TSI.

The purpose of F-test and Wald test is to see whether all the coefficients in the model are different than zero. Our results show that two models with trade specialization indices RSCA and TSI are overall significant.

We use the Hausman test to determine which version is preferred. Our Hausman test results are reported in Table 3.6.

Table 3.6. Hausman test for fixed and random effects models

Hausman test	RSCA model	TSI model
Chi-squared statistics	13.11	13.12
p-value Prob>Chi2	0.0223	0.0223
Hypothesis testing	Ho: Random effects model is preferred	
Conclusion	Reject the null hypothesis. Fixed effects estimation is preferred.	

Our Hausman test results reject the null hypothesis. Hence, fixed effects estimation is preferred.

Elasticities

As Cole (2005) emphasizes, a statistical relationship soly cannot provide an adequate explanation for the increasing/ decreasing specialization in pollution intensive production. Therefore, the economic significance of the variables need to be considered. To evaluate the effects of each key independent variable (PAOCva, PCI, HCI) on trade specialization variable, we estimate elasticities. Estimated elasticities are used to examine the economic significance of the independent variables. Elasticities are calculated in STATA in the form of *d(lny)/d(lnx)* using the command *mfx* with option *eyex*. Table 3.7 presents the estimated elasticities for PAOCva, PCI and HCI.

Table 3.7. Estimated elasticities for PAOCva, PCI and HCI

Variable	Model	PAOCva	PCI	HCI
RSCA	Fixed effects	-1.878709	1.462079	-1.477584
	Random effects	-1.765346	.3210756	-1.604805
Michaely	Fixel effects	-.1168639	-.1417009	.1191206
	Random effects	-.1125406	-.1685801	.1196787
NETXva	Fixel effects	.0010878	-.0036837	.0025373
	Random effects	-.0003578	-.0048456	.004557
TSI	Fixel effects	-1.4598	-1.265203	-.9205545
	Random effects	-1.405579	-2.154215	-1.136813

The variety in our trade specialization measures and data set results in a wide range of values obtained for the estimated elasticities. As mentioned above that the coefficients in the case of the Michaely and Net exports share in value added are statistically insignificant, here we also find that the elasticity estimates for Michaely and Net exports share in value added appear to be the smallest in magnitude. Hence we only focus our discussion on the signs and magnitudes of the estimated elasticities for RSCA and TSI. Our findings show that a 1% increase in PAOCva would result in a reduction of 1.88% (for fixed effects) or 1.77% (for random effects) in RSCA and a reduction of 1.45% (for fixed effects) or 1.41% (for random effects) in TSI. A 1% increase in PCI would result in an increase of 1.46% (for fixed effects) or 0.32% (for random effects) in RSCA and a reduction of about 1.27% (for fixed effects) or 2.15% (for random effects) in TSI. A 1% increase in HCI would result in a reduction of about 1.48% (for fixed effects) or 1.60% (for random effects) in RSCA and a reduction of about 0.92% (for fixed effects) or 1.14% (for random effects) in TSI. So the effects of environmental stringency, physical and human capital intensities are not different very much in magnitude. This finding is in contradiction to Cole (2005) in which the estimated elasticities for physical and human capital intensities are notably bigger than for PAOCva.

It may be interesting to compare our resutls here with Cole (2005)'s findings. Cole (2005) investigates the competing impacts of factor intensities and environmental stringency on US specialization and finds that although US's environmental regulations are increasing and appear to be high compared with other developing countries, US specialization in dirty production is not decreasing. He demonstrates that dirty industries are typically physical and human capital intensive. PCI and HCI are significant determinants of US trade specialization, implying that environmental stringency and factor intensities have competing impacts on revealed comparative advantage. Whether estimating RSCA, the Michaely or NETXva, his findings show that PCI and HCI are statistically significant positive determinants of US trade patterns. For Vietnam, our results show that PCI and HCI are negative determinants of Vietnam's trade specialization. These results are definitely expected since the sign of factor endowment coefficients indicates that factor is a source of country's comparative advantage or disadvantage. A positive sign indicates that input factor is abundant within the country and vice versa. For estimated elasticities, our findings show that the effects of environmental stringency, physical and human capital intensities are not different very much in magnitude. This finding is in contradiction to Cole (2005) in which the estimated elasticities for PCI and HCI are notably bigger than thoses for PAOCva.

7. Conclusion and policy implications

With the increase in trade liberalization, fear has been raised about the adverse environmental consequences of trade liberalization in developing countries with laxer environmental policies (i.e. developing countries may shift their production, distribution, trade and FDI to more pollution-intensive industries). However, our literature review shows that there is relatively little empirical evidence on the impact of trade liberalization on the environment in developing countries, due to limitations of reliable data.

This chapter investigates the determination of Vietnam's trade specialization by using cross-industry regressions. Specifically, we employ the Heckscher-Olin factor endowments theory. In our model, the dependent variable (trade specialization) is measured by Revealed Symmetric Comparative Advantage (RSCA), the Michaely index, Net exports share in value added and Trade Specialization index. Pollution abatement cost per unit of value added is employed as a proxy for environmental stringency. Other independent variables include physical and human capital intensities (which are calculated based on pay roll) and import tariffs.

Our data set is a balanced panel of cross industry and time series observations. Based on data availability, our sample includes 18 industries for the period 2001-2008.

It is thought that Vietnam, like other developing countries, has comparative disadvantage in capital-intensive products and comparative advantage in labor-intensive products. Our results support the hypothesis. The coefficients of environmental stringency, human and physical capital intensity are negative as expected, which suggests that they are all negative determinants of trade performance (as for RSCA and TSI indices). Since Vietnam has comparative advantage in labor-intensive products and its environmental regulations are relatively lenient, Vietnam has a trend to develop pollution-intensive industries and become a "pollution haven", as the Pollution Haven Hypothesis suggests.

The impact of tariffs on trade specialization is inconclusive since it has different signs across different specifications.

From these results, several policies can be suggested.

First, our results indicate that environmental policies play an increasingly important role in developing countries like Vietnam. Although Vietnam's recent environmental standards are stricter than those in the past, they are still below developed countries' regulations. The tendency of Vietnam being a pollution haven is inevitable. Hence, Vietnamese Government should pay more attention to the environmental protection. Environmental policy should further be strengthened and enforced to help Vietnam produce environment-friendly goods as well as maintain natural resources and environment.

Second, since our findings support the hypothesis that Vietnam has comparative advantage in producing labor intensive goods, it is suggested that Vietnamese Government should put more proper emphasis on the production of labor intensive goods. This will create more employment opportunities, which in turn promotes economic development and reduce poverty in Vietnam.

Finally, the Government of Vietnam needs to realize the trade-off between the consequences of strict environmental regulations and comparative advantage, since too much emphasis on stringent environmental protection may result in the loss of comparative advantage.

CHAPTER 4

THE POLLUTION CONTENT IN VIETNAM'S TRADE

1. Introduction

The relationship between the environment and economic growth has long been a controversial subject. Some people see climate change, industrial pollution, species extinction and natural resource depletion as crucial current environmental problems. Others however see urban sanitation and improvements in air quality as environmental progress made by technological advances. Economic theories provide tools to clarify these conflicting points of view and to explore the relationship between environmental problems and the possibility of improvement.

For developing countries, trade liberalization is an important factor which contributes to economic growth. International trade benefits developing countries, promoting their economic growth. In turn, growth leads to increasing demand for a better environment. The complex trade – environment relationship has become one of the most challenging policy issues. The crucial question for developing countries is how to promote trade liberalization but still protect the environment and natural resources.

In the literature, the environment and environmental regulations have been considered factors of production as well as sources of comparative advantage. As we already discussed in Chapters Two and Three, there are two related hypotheses emerging from the trade – environment debate. According to the Pollution Haven Hypothesis (PHH), developing countries could have comparative advantage and specialize in pollution-intensive products due to their relatively lenient environmental standards. When the dirty industries are relocated, developing countries may become "pollution havens" for the world polluting industries. On the contrary, the Factor Endowment Hypothesis (FEH) suggests that developed countries could gain an advantage in producing dirty goods. This is because developed countries are known as capital abundant (i.e. relatively well endowed with capital). Since capital-intensive sectors tend to be polluting, developed countries will specialize in dirty products. Thus the manifestation of the PHH totally conflicts with the FEH. This debate has drawn much attention among economists and environmentalists.

Within this literature, there are numerous investigations of these two hypotheses (Grossman and Krueger (1992); Copeland and Taylor (2003); He (2006); and Falkowska (2018)). The empirical evidence has provided mixed results. However, Copeland and Taylor (2003) suggest that the two effects do not totally contradict each other. The remaining question is the weight of each effect and which one dominates the other.

As one of the countries with rapid economic growth in Southeast Asia, Vietnam can be considered a good laboratory to test these two hypotheses. On one hand, Vietnam has relatively more lax environmental regulations. Hence, Vietnam would have comparative advantage in dirty production, as the PHH predicts. As Vietnam participates more and more in global trade, it is suspected that Vietnam has a tendency to accommodate dirty industries and the environment is sacrificed for Vietnam's economic growth. On the other hand, Vietnam is considered to be capital scarce and labor abundant, as compared to Vietnam's main trading partners. So the FEH predicts that trade liberalization has resulted in Vietnam specializing in clean products.

This chapter does not aim to test the two hypotheses econometrically. Instead, we attempt to examine the pollution content of international trade in Vietnam. Using input-output analysis, we try to figure out whether Vietnam’s exports embody more pollution content than Vietnam’s imports.

2. Overview of Vietnam’s exports and imports

In recent years Vietnam is considered one of the fastest growing countries. The last decades have witnessed Vietnam’s annual growth rate of more than 7 percent. The average GDP growth rate of Vietnam during the period 2000 to 2015 was 6.15 percent[18].

Trade liberalization has definitely been an engine of this growth. Vietnam is ranked as the 33rd largest export economy[19]. The average annual growth rate of Vietnam’s exports and imports over the last decades was about 20 percent.

The average of Vietnam’s exports during the period 1990 to 2016 is 4781.76 million USD[20]. Vietnam's exports have doubled in the past five years due to huge foreign direct investment and low labor costs. Vietnam’s leading export products include broadcasting equipment, textiles, electronics, computers and components, shoes and footwear[21]. Vietnam’s main export partners are the United States, Japan, China, Korea and Germany.

The average of Vietnam’s imports during the period 1990 to 2016 is 5339.60 million USD[22]. Vietnam’s leading import products include machinery, transports and equipment, fuels, chemicals, manufactured goods, food and live animals. Vietnam’s main import partners are China, Korea, Asean and Japan.[23]

[18] Source: General Statistics Office of Vietnam
[19] http://atlas.media.mit.edu/en/profile/country/vnm/
[20] Source: General Statistics Office of Vietnam
[21] Source: General Statistics Office of Vietnam
[22] Source: General Statistics Office of Vietnam
[23] http://www.tradingeconomics.com/vietnam/imports

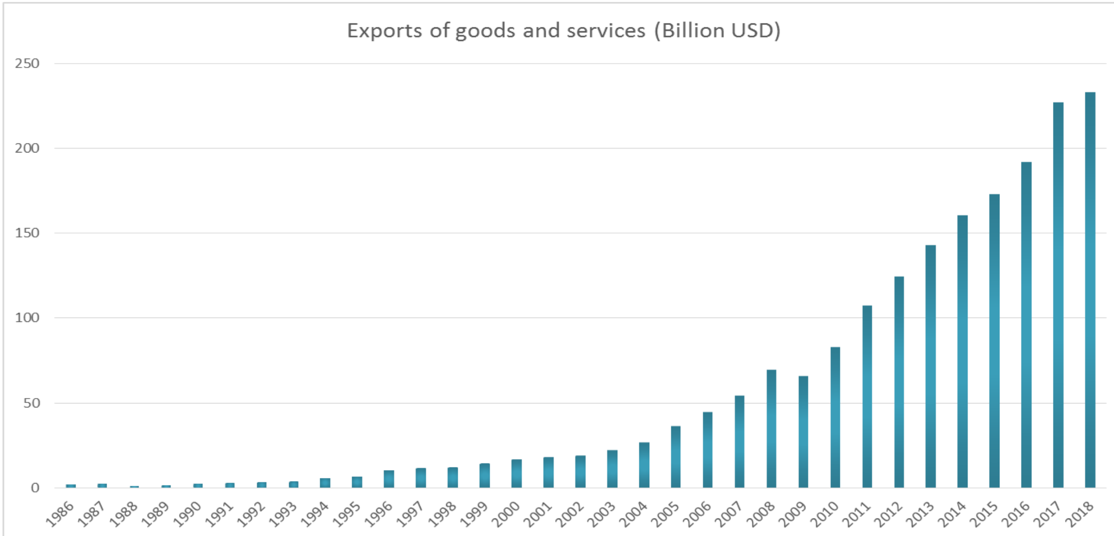

Figure 4.1. Vietnam's exports of goods and services from 1986 to 2018

(graph by author, data soure: World Data Bank)

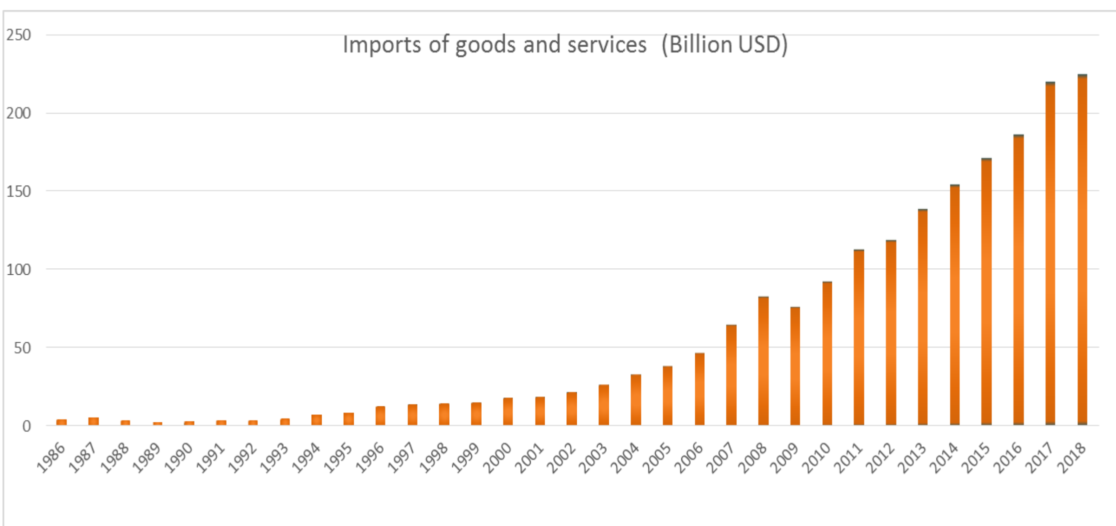

Figure 4.2. Vietnam's imports of goods and services from 1986 to 2018

((graph by author, data soure: World Data Bank)

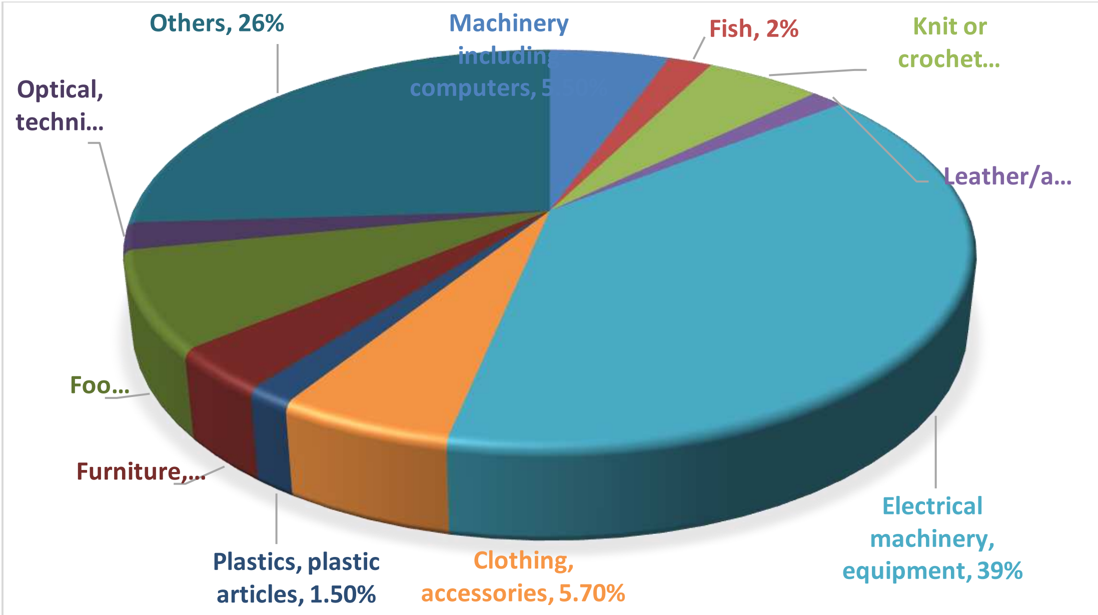

Figure 4.3. Vietnam's export products in 2018

(graph by author, data soure: General Department of Vietnam Customs)

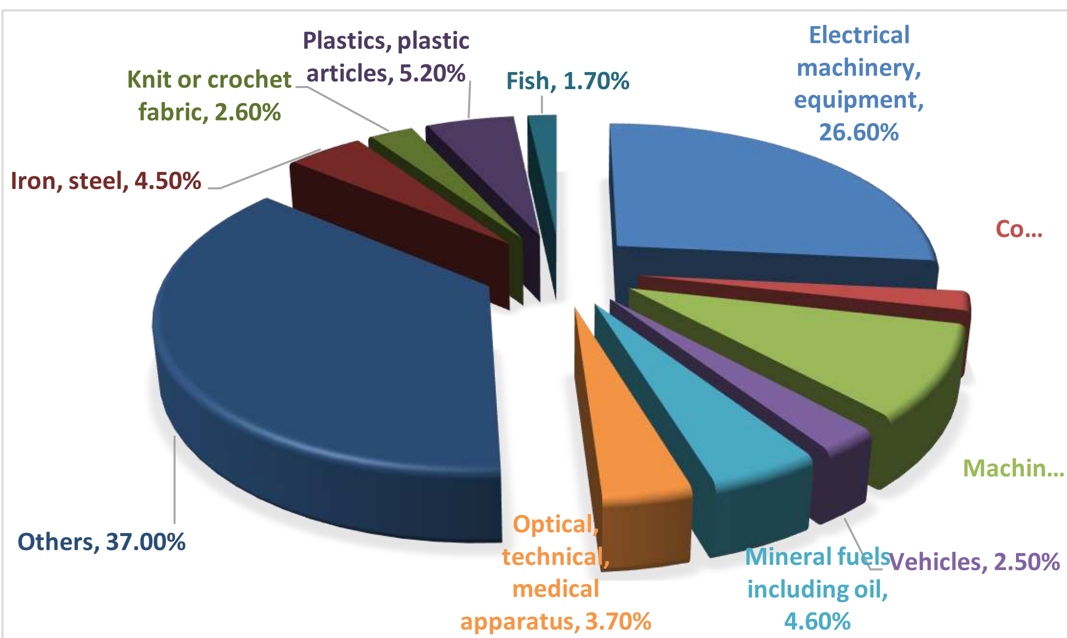

Figure 4.4. Vietnam's import products in 2018

(graph by author, data soure: General Department of Vietnam Customs)

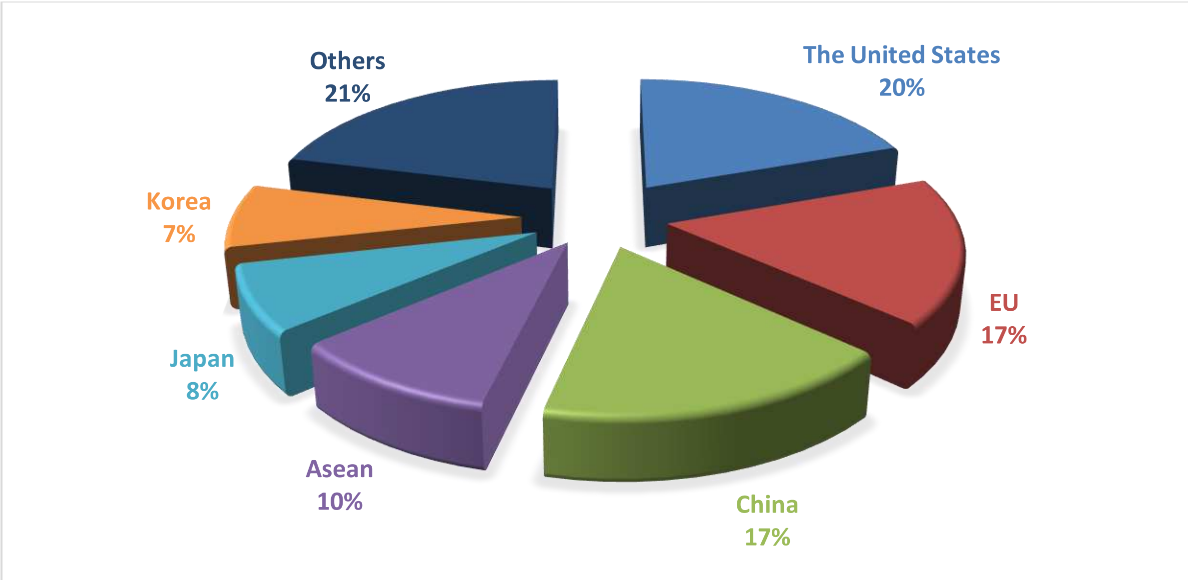

Figure 4.5. Vietnam's export partners in 2018

(graph by author, data soure: General Department of Vietnam Customs)

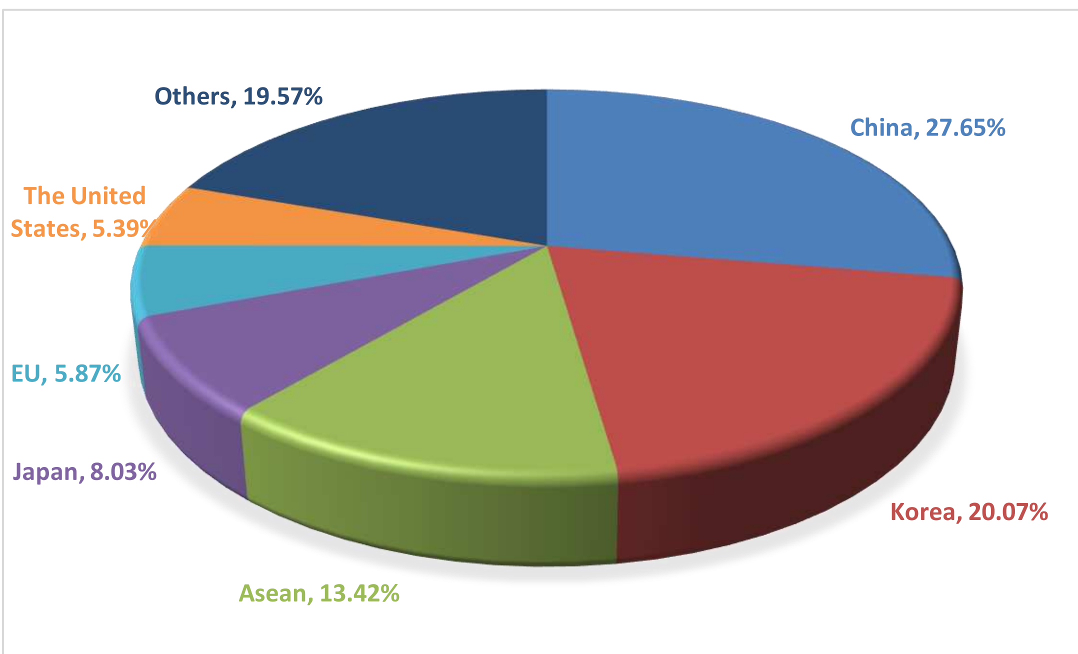

Figure 4.6. Vietnam's import partners in 2018

(graph by author, data soure: General Department of Vietnam Customs)

The Organization of Economic Cooperation and Development (OECD) is one of Vietnam's main import and export partners (i.e. accounting for about 52% of Vietnam's total exports and 40% of Vietnam's total imports)[24]. The main exports to the OECD include garment and textiles, rice, coffee, coal, crude oil, rubber, aquaculture and processed forest products while the main imports from the OECD include petroleum products, steel, machinery and equipment, fertilizer and electronics.

3. Literature review

Vanek (1968) was the first to introduce the "factor content of trade". The basic model is related to the concept of "integrated equilibrium" or international factor price equalization (Helpman and Krugman (1985)). With certain assumptions of goods and factor market competition and constant returns to scale technologies, unrestricted international trade in goods equalizes factor prices internationally, even though the factors cannot move across countries. Hence, a product contains a fixed amount of the factors of production, no matter where it is produced. Thus, one can describe international trade of goods as the exchange of production factor services embodied in goods[25].

The study of the factor content of trade is useful in answering the policy question of the impacts of trade liberalization on the economy.

In the context of integration and globalization, international trade has become a crucial determinant in shaping a country's economic structure. The more open a country's policies are, the more international trade has an influence on the country. Hence, the study of pollution embodiment in trade has drawn attention in this regard.

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[24] Source: viettrade.gov.vn

[25] Donald R. Davis and David E. Weinstein (2001). The Factor Content of Trade. NBER Working Paper No. 8637

The literature offers numerous methods that have been used to estimate the pollution embodiment in trade. Each method is different in the level of aggregation and accuracy. In general, they can be categorized as ***simple measurement*** and ***I-O techniques***.

Simple measurement

One quite simple measurement has been employed to determine the pollution content of trade, namely, the product of industrial emission intensity and its trade volume.

Muradian et al. (2001) calculate the pollution embodied in trade for eighteen industrialized countries. They define the concept of balance of embodied emissions in trade (BEET) as the amount of emissions embodied in imports minus the amount of emissions embodied in exports. A BEET higher than zero is considered a measurement of "environmental deficit" or "environmental load displacement". Then the index “environmental terms of trade” is simply defined as the proportion of emissions embodied in exports and emissions embodied in imports. The formulation is ETT= (EEPx/EEPm) x 100. If entailed pollution in exports increases at a higher rate than entailed pollution in imports across time, then one says the ETT "deteriorates". In the opposite case, they say the ETT "improves". For a given country, an ETT index value lower than 100 implies that pollution embodied in the country’s imports exceeds pollution embodied in its exports.

The authors choose five air pollutants with the emissions data from Industrial Pollution Projection System. Their findings show that during the last years of the analyzed period 1976 to 1994, the implied pollution in Japan, USA and Western Europe’s imports are generally larger than that of exports. The patterns of the balance of embodied emissions in trade (BEET) evolution are also different among industrialized countries. In Japan and Western Europe, it tends to have an inverted-U shape while in the US it seems to follow an N-shape.

Several studies have estimated the balance of emissions embodied in trade (BEET), following Muradian et al.'s approach. Grether et al. (2005) also use IPPS data to investigate the pollution content of imports for 16 different pollutants during the period 1986-1996 in more than 50 countries in a gravity framework. CO_2 emissions per dollar of GDP was used as a cost based measure for environmental stringency. The findings indicate the effects of both the Pollution Haven Hypothesis and the Factor Endowment Hypothesis on trade patterns.

I-O techniques

Another widely used method to estimate pollution embodiment is input-output techniques. Input-output analysis is a basic method of quantitative economics. Wassily Leontief is known as the founder of modern input-output analysis and as he emphasizes, the objective of the input-output analysis is to describe economic reality as closely as possible. Since 1941, Input-Output analysis has become popular and been applied in various economic studies.

Walter (1973) applied the Environmental Input-Output model to examine the US product profile and the pollution profile of exports and imports. The author defines pollution content as environmental control costs which include operating costs, capital cost, R&D costs and equipment appreciation. Using US imports and exports data during the period 1968-1970, he estimates the direct environmental management cost for each group of product. The results show that although the ratio of the average total environmental costs in exports to total exports is slightly bigger than the ratio of the average total environmental costs in imports to total imports, it is statistically insignificant.

In contrast to Walter (1973), numerous papers attempt to examine the pollution content of trade by measuring the physical flows of different emissions.

Wyckoff and Roop (1994) evaluate carbon embodiment in six largest OECD countries' imports of manufactured goods during 1984 to 1986. Their results show that the amount of carbon embodied in manufactured goods is substantial during this period. They suggest that many national policies that aim to control domestic greenhouse gas emissions might be ineffective if the contribution of imports in total domestic consumption is significant.

Antweiler (1996) was the first author to mention the concept of "pollution terms of trade". This notion originates from the idea that a country is considered to gain environmentally from trade if the pollution embodied in its imports exceeds that in its exports.

He sets up as an index the proportion of the pollution embodiment by unit of exports and the pollution embodiment by unit of imports. Using the US 1987 I-O table and pollution data at industrial level, under identical technologies assumption, he measures the index for 164 countries in 1987. His findings show that for industrialized countries, exports turn out to be more pollution intensive than imports; meanwhile, developing countries demonstrate an opposite pattern. Therefore, the environmental loads of trade in developed countries are bigger than in developing ones.

Hayami et al. (1997) build the Japan-China Input-Output Tables based on common industrial classifications for energy sources and air pollutants and apply onto 45 sectors. Using the I-O techniques, they compare the emissions of CO_2 between China and Japan in 1987. The results show that CO_2 emissions in China are double that in Japan, and SOx emissions in China are 20 times higher than those in Japan. As compared with the scale of these two countries' per capita income, this is a big difference. The findings reveal that regarding energy efficiency and removing pollutants, China is far behind Japan.

As global environmental issues such as climate change have increasingly drawn attention from economists and environmentalists, numerous research has been carried out to find a solution for sharing the burden of responsibility for GHG emissions reduction between producers and consumers. Proops et al. (1993), for example, carry out an input-output study of CO_2 emissions from the UK and Germany. Their results indicate carbon emissions of these countries may stabilize almost naturally overtime. And, at the end of the period 1970-1990 both countries still exported more embodied CO_2 than they imported.

Some studies also apply input-output analysis to developing countries. Machado et al (2001) investigate the impact of international trade on CO_2 emissions and energy use in Brazil. Using the commodity-by-industry input-output analysis in hybrid units, their results suggest that in 1995 carbon embodiment in Brazil's non-energy exports highly exceeds that in its imports.

Also utilizing the input-output models and IPCC guidelines, Mukhopadhyay and Chakraborty (2005) and Dietzenbacher and Mukhopadhyay (2007) evaluate the impacts of international trade on the environment in India. Their findings show that the country gained environmentally from foreign trade during the two periods 1991-1992 and 1996-1997.

Mukhopadhyay (2006) also uses the input-output techniques to examine the Factor Endowment Hypothesis and Pollution Haven Hypothesis for the bilateral trade between Thailand and OECD countries. He finds that in terms of the pollution content of trade, Thailand switched from being a net importer of pollution to a net exporter of pollution during the investigated years. More interestingly, the entailed pollution in Thailand's FDI-led exports represents over 80% of the pollution embodied in its total exports.

Milner and Xu (2009) also use the environmental Input-Output methodology to measure the pollution content of trade in China. Their findings suggest that in China, the pollution content in exports is less than in imports under the assumption of common technology. In other words, China has "saved" on local environmental resources or gained environmentally from the expansion of trade.

4. Methodology

4.1 Choice of pollutants

In order to evaluate the pollution content in Vietnam's trade, three air pollutants are selected in this chapter, including and Nitrous Oxides (NO), Sulphur Dioxide (SO_2) and Carbon Dioxide (CO_2). Gaseous fuels (natural gas), liquid fuels (oil) and solid fuels (coal) are primary energy commodities in the input-output table. The use of these energy commodities contributes to more than 90% of carbon emissions from fossil fuel combustion. Our assumption is that energy commodities are combusted when being used as an intermediate input producing greenhouse gases. We also assume that the energy combustion process produces the maximum amount of energy when a fuel is burned (i.e. highest efficiency), and delivers the maximum amount of air emissions (i.e. highest impact). The release of air pollutant emissions is affected by not only the combustion process but also abatement technologies. In this chapter, I only evaluate the emission generated from combustion; emission removal in the pollution abatement process is not examined.

4.2. Methodology: the Environmental I-0 Analysis

Since the late 1960s, many researchers have attempted to extend the input–output model, accounting for environmental pollution generation and abatement in association with inter-industry activities. The environmental input-output analysis (Leontief (1970)) that incorporates pollution into the traditional input-output framework is one of the key methodological extensions that have been widely applied.

Input-output analysis is known to have some major limitations:

First, the input-output analysis rests on Leontief's basic assumptions of constant returns to scale in producion, unchanged techniques of production and fixed input coefficients. These assumptions are unrealistic since the inter-industry analysis is not treated dynamically.

Second, the assumption that input coefficients are fixed completely ignores the possibility of factor substitution. In fact, it is possible for firms to substitute one production factor for another. Although the possibilities of substitutions in the short run are likely to be relatively smaller than those in the long run, they always exist.

Third, in the input-output analysis, final demand is taken as given and does not depend on the production sector.

Fourth, in the input-output analysis, outputs of one industry are related to inputs of the others through linear equations. This also sacrifices reality, since an increase in outputs does not necessarily require a proportional increase in inputs.

Lastly, price changes are ignored in the input-output analysis, which is also unrealistic. In reality, changes in input prices often result in input and output adjustments. This mechanism is not included, which makes the input-output analysis unrealistic.

Despite these limitations, the input-output method is still widely used in the literature to estimate pollution embodiment.

This study also employs the environmental input-output method introduced in Miller and Blair (1985), which is then employed in numerous papers such as Ahmad and Wyckoff (2003), Temurshoev (2006), and Mukhopadhyay and Dietzenbacher (2007). Specifically, I follow the model developed by Mukhopadhyay and Chakraborty (2005), Mukhopadhyay (2006), and

Milner and Xu (2009) to incorporate emission factors in the conventional input-output framework.

The input-output model is structured as follows:

For a given country, in a particular year, denote A as the $n \times n$ matrix of the domestic input-output coefficient (input-output table), in which each component a_{ij} represents the requirement of commodity i in monetary units per unit of commodity j, where n is the number of industries. Matrix A is called the Leontief matrix.

Denote X as the vector of domestic output and Y as the vector of final demand. The equilibrium condition is described as supply equals demand:

$$X=AX+Y \tag{4.1}$$

or

$$X= (I-A)^{-1}Y \tag{4.2}$$

$(I-A)^{-1}$ is also called "the Leontief domestic inverse matrix".

Now we formulate the emissions model through equation (4.2).

Assume all the energies in the economy are produced from 3 primary energy commodities Natural Gas, Crude Oil and Raw Coal.

Denote B as the energy requirement matrix. Hence b_{ij} represents the amount of energy commodity i (in monetary unit) required to produce one unit of the output of commodity j. Matrix B is extracted from matrix A.

Following IPCC guidelines, chemical emission factors are calculated by multiplying the fuel's net calorific values and the chemical content in net calorific values.

Matrix E is denoted as the emissions matrix per Standard Coal Equivalent (SCE) of fossil fuel combustion for the three air emissions.

Since the units of calculation of the coefficients in two matrices E and B are different (matrix B is calculated in monetary units while matrix E is calculated in physical units), before multiplying these two matrices, we need to reconcile them. We compare the physical and monetary units of each energy type in total energy output to have the ratio in producer price. The diagonal matrix of ratios is denoted as R.

The emission from fossil fuel combustion is now described as a function of the industry output:

$$F_{pd} = ERB(I - A)^{-1}Y \tag{4.3}$$

In this equation, ERB indicates only the direct fuel combustion in producing one unit of a good (i.e. the direct pollution intensity from industries). ERB $(I - A)^{-1}$ indicates the total emissions in producing one unit of a good (i.e. both the direct and indirect pollution intensity from industries).

In order to estimate the pollution content of exports and imports, we also follow previous literature to assume identical technology.

The pollution content of exports is defined as:

$$F_{pd}\ \text{exports} = ERB(I-A)^{-1}Y_X \tag{4.4}$$

Similarly, the pollution content of imports is defined as:

$$F_{pd}\ \text{imports} = ERB(I-A)^{-1}Y_M \tag{4.5}$$

Now the balance of emissions terms of trade (BETT) is simply calculated as the pollution embodiment in exports minus the pollution embodiment in imports:

$$BETT= ERB(I-A)^{-1}Y_X - ERB(I -A)^{-1}Y_M \quad (4.6)$$

$$\text{or } BETT= ERB(I- A)^{-1} (Y_X - Y_M) \quad (4.7)$$

BETT shows the net pollution embodiment in Vietnam's trade. With the assumption of identical technologies, BETT shows the difference between pollution generated from Vietnam's export activities and pollution avoided from Vietnam's import activities.

We derive the pollution terms of trade (PTOT) from equations (4.4) and (4.5). It is defined as the proportion of the pollution content of exports and the pollution content of imports:

$$PTOT = F_{pd} \text{ exports} / F_{pd} \text{ imports} = [ERB(I- A)^{-1} \; Yx] / [ERB(I- A)^{-1} \; Ym] \quad (4.8)$$

The pollution terms of trade represent the ratio of the pollution embodiment in one unit of a country's exports relative to the pollution embodiment in one unit of its imports. If the pollution embodiment in a country's imports exceeds that in its exports, that country is viewed as gaining environmentally from international trade. The value of this index smaller than one indicates that the country's imports have more pollution content than its exports.

5. Data

In Vietnam, there are five basic national input-output tables published for the years 1989, 1996, 2000, 2007 and 2012 at national level. In this study, we calculate the pollution content in Vietnam's trade using Vietnam 2007 and 2012 national input-output tables.

The Vietnam 2007 input-output table is the fourth one in Vietnam with the dimension of 138 products. Choosing 138 products is based on their importance in the economy and in service of economic analysis and statistics. To compile the Vietnam 2007 I-O table, the General

Statistics Office of Vietnam conducted a sample survey of producing units in all types of ownership which engage in production in Vietnam. Vietnam 2007 I-O table was constructed using concepts and definitions recommended by the United Nations in the System of National Account 1968 and 1993. The commodities used in Vietnam I-O table 2007 are reported in the Appendix.

The Vietnam 2012 I-O table is the latest one in Vietnam with the dimension of 164 products. The Vietnam 2012 I-O table was conducted using the national sample survey of producing units in all types of ownership in Vietnam in 2012. The commodities in Vietnam 2012 I-O table are also reported in the Appendix.

In this chapter, the Vietnam 2007 and 2012 input-output tables are used to calculate the pollution embodiment in Vietnam's trade. Following the previous literature, we typically assume identical technology to produce export and import goods. This assumption is also known as "if imports were made at home" (i.e. the country would have had to produce the goods if it had not imported them). This assumption is also common in the research of pollution embodiment in trade (Antweiler (1996), Mukhopadyay and Chakraborty (2005), Dietzenbacher and Mukhopadhyay (2007)).

Actual gas emissions from fuel combustion are different, depending on fuel types, combustion technology and pollution removal efficiency. However, according to IPCC guidelines, CO_2 emissions mainly depend on the fuel's carbon content, and are calculated on a highly aggregated level; while non-CO_2 gases from fuel combustion (SO_2 and NO_x emissions) are highly technology dependent and are calculated on a detail technology level. The calculation of the emission factors in detail is presented in the Appendix.

The components of matrix E - average emission factors - are shown in Table 4.1.

Table 4.1. Average Emission Factors (unit: ton/SCE)

	CO_2	SO_2	NOx
Raw coal	2.717	0.0225	0.0088
Crude oil	2.15	0.007	0.0059
Natural gas	1.872	0	0.0044

From the above table, it is easily seen that in all these fuels, the emission factor of CO_2 is much higher than those of SO_2 and NOx. Moreover, it is commonly known that raw coal is more contaminating than natural gas and crude oil. These average emission factors are also consistent with this scientific fact.

To construct matrix R, we use energy output data measured in monetary units from Vietnam input-output table which is published by General Statistics Office of Vietnam. Data in physical units of energy outputs are collected from the BP Statistical Review of World Energy, 63rd edition[26].

The diagonal of the matrix R is shown in Table 4.2.

[26] The BP Statistical Review of World Energy provides reliable data on the world energy market. The 63rd edition review is considered one of the most well-known publications in energy economics. It is widely used for reference by energy companies, academia and world governments.

Table 4.2. Diagonal matrix R (unit: 10^{-3} SCE/ dong)

	Coal	Crude oil	Natural Gas
2007	1.284212	0.177973*	0.177973*
2012	1.36008	3.14415	1.76783

*Since in the Vietnam 2007 I-O table, natural gas and crude oil are combined as one primary energy commodity, in this chapter we consider natural gas and crude oil have the same producer's price. In the Vietnam 2012 I-O table, crude oil and natural gas are reported separately as two different primary energy commodities.

Each component of the above matrix indicates the amount of energy that can be purchased per unit of Vietnam dong. In terms of energy content, crude oil and natural gas seem to be more expensive than raw coal in 2007 while in 2012 coal and natural gas appear to be more expensive than crude oil. These producer prices of energy are closely related to natural resource endowments in Vietnam.

6. Pollution content of Vietnam's trade

6.1. Pollution intensities

Firstly I present the pollution intensities of CO_2, SO_2 and NO_x in Vietnam using Vietnam 2007 and 2012 input-output tables. The pollution intensities of CO_2, SO_2 and NO_x at the sectoral level in 2007 are plotted in Figures 4.7, 4.8 and 4.9. Due to space limitation, we do not show industries' names in the graph.

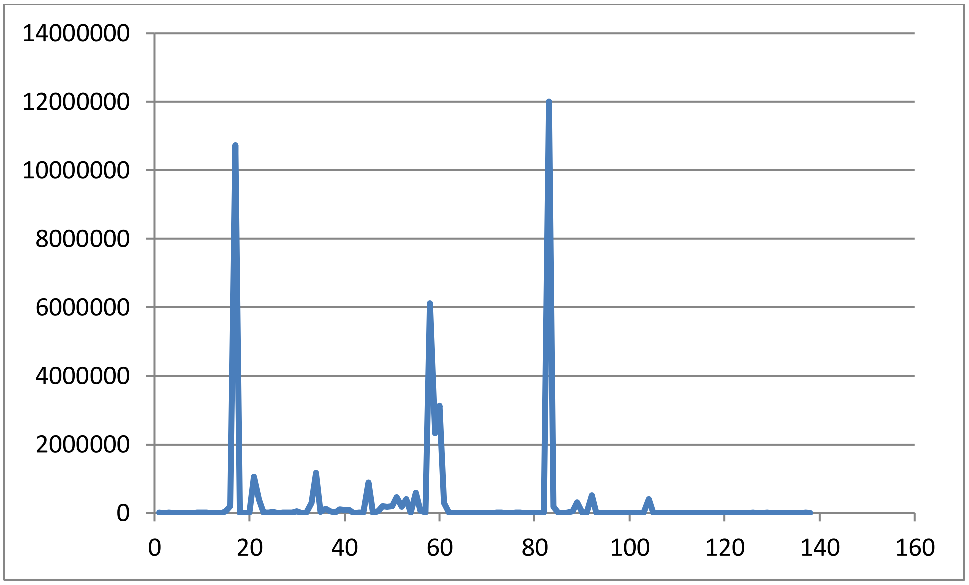

Figure 4.7. Sectoral Pollution Intensities of CO_2 in 2007

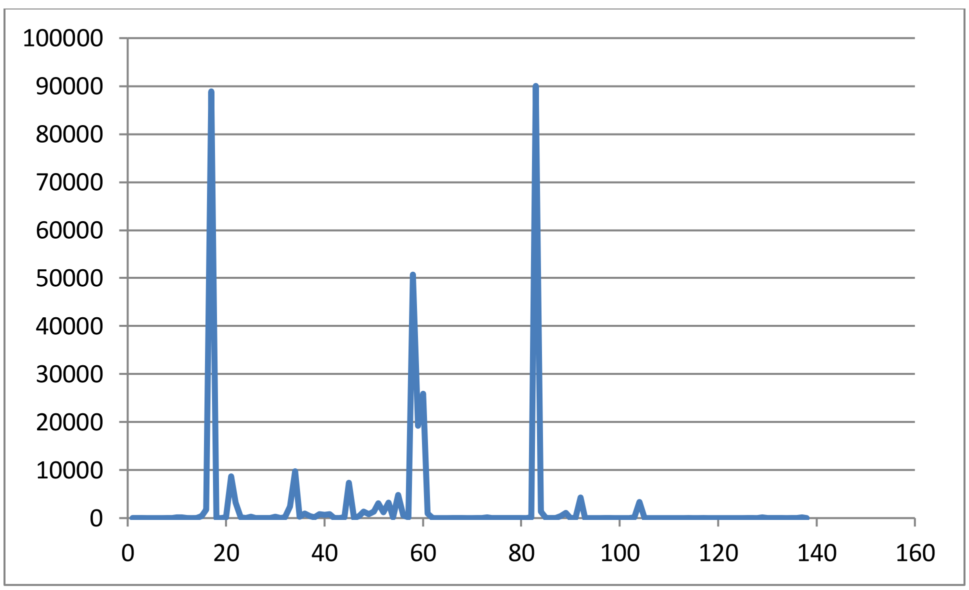

Figure 4.8. Sectoral Pollution Intensities of SO_2 in 2007

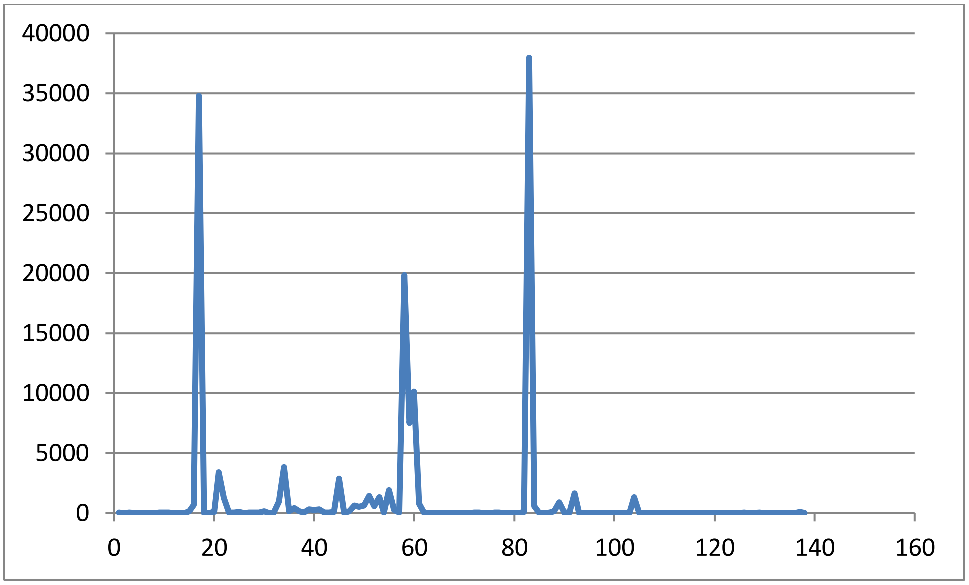

Figure 4.9. Sectoral Pollution Intensities of NO_X in 2007

As we can see from Figures 4.7, 4.8 and 4.9, all three pollution intensities vary dramatically across sectors in 2007. Heavy industries such as Iron and steel, Non-metallic products, Electricity, Chemicals, Coke and gas products are found to have a higher pollution intensity, since they pollute not only directly but also indirectly in the manufacture of their intermediate inputs.

Sectoral pollution intensity rankings for the three air pollutants in 2007 are relatively similar when we compare the three graphs. Industries that are carbon dioxide emissions intensive seem to be also sulfur dioxide and nitrogen oxides emissions intensive. The five cleanest (or least pollution-intensive) industries include Recycle, Tobacco, Financial services, Real estate and Tourism.

The pollution intensities of CO_2, SO_2 and NO_x at the sectoral level in 2012 are plotted in Figures 4.10, 4.11 and 4.12.

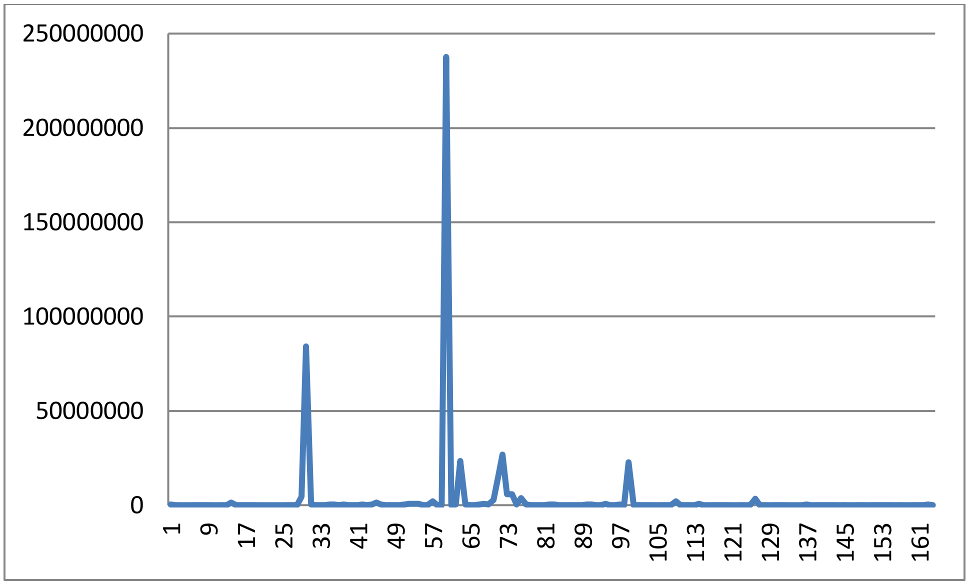

Figure 4.10. Sectoral Pollution Intensities of CO_2 in 2012

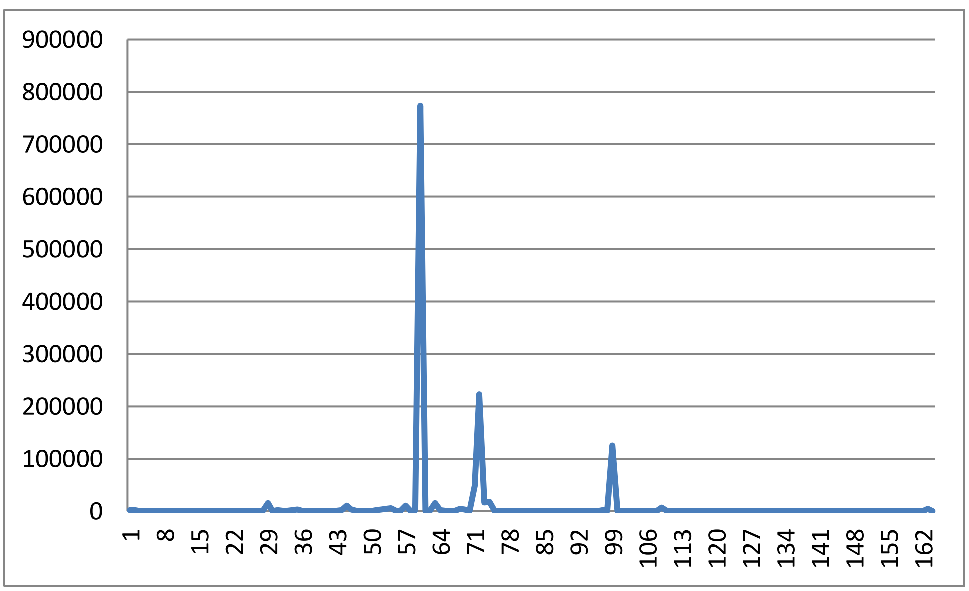

Figure 4.11. Sectoral Pollution Intensities of SO_2 in 2012

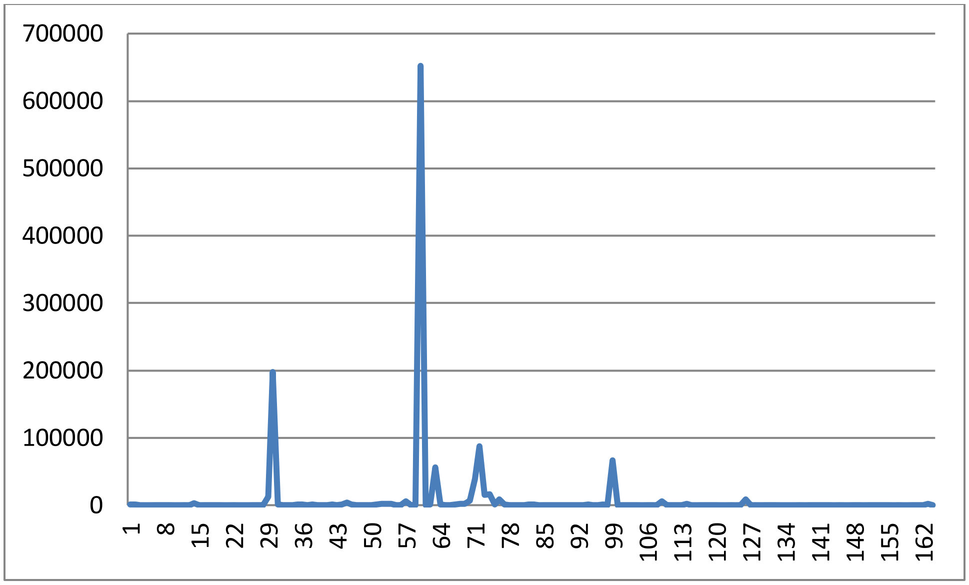

Figure 4.12. Sectoral Pollution Intensities of NOx in 2012

Figures 4.10, 4.11 and 4.12 also show that in 2012, all three pollution intensities vary dramatically across sectors, with higher pollution intensity found in heavy industries such as Iron and steel, Non-metallic products, Electricity, Chemicals, Coke and gas products. The five cleanest (or least pollution-intensive) industries include Recycle, Tobacco, Financial services, Real estate and Tourism.

Sectoral pollution intensity rankings for the three air pollutants in 2012 are relatively similar when we compare Figure 4.10, 4.11 and 4.12. Industries that are carbon dioxide emissions intensive seem to be also sulfur dioxide and nitrogen oxides emissions intensive.

More interestingly, when we compare sectoral pollution intensities of each of the three air pollutants between the years 2007 and 2012, we find that the pollution intensities have been increasing during the period for almost all industries.

6.2. Pollution Content of Vietnam's Trade

Using trade data from Vietnam 2007 and 2012 I-O tables, and assuming common technology (i.e. exports and imports are produced using Vietnamese technology), the basic results for pollution terms of trade, pollution embodied in exports, imports are calculated and reported in Table 4.3.

Table 4.3. Pollution embodied in exports, imports and PTOT of Vietnam with OECD countries for CO_2, SO_2 and NOx emissions in 2007

Pollutant	Pollution embodied in exports	Pollution embodied in imports	BETT	PTOT
CO_2	11798.39355	30132.36129	-18333.96774	0.39155224
SO_2	76.66889542	100.2230716	-23.55417616	0.764982496
NOx	35.95654755	98.73314323	-62.77659568	0.364179103

The BETT values in the above table indicate that Vietnam's pollution content in net exports are all negative for CO_2, SO_2, NO_x emissions in 2007. This absolute measure suggests that Vietnam has a "pollution deficit" relative to OECD from international trade (i.e. the pollution embodiment in Vietnam's imports is higher than in its exports). The average pollution content per unit of Vietnam's imports must be significantly higher than that of exports.

Similarly, the pollution terms of trade for all three air pollutants are less than unity, which implies that the average pollution content per unit of Vietnam's exports is smaller than that of its imports. As of the year 2007, Vietnam was not the "pollution haven" as the Pollution Haven

Hypothesis suggests; or in other words, it gained environmentally from trade. Since it is well endowed with labor, Vietnam has a comparative advantage in producing “cleaner” goods.

Table 4.4. Pollution embodied in exports, imports and PTOT of Vietnam with OECD countries for CO_2, SO_2 and NOx emissions in 2012

Pollutant	Pollution embodied in exports	Pollution embodied in imports	BETT	PTOT
CO_2	1710.770415	969.3889737	741.3814411	1.764792525
SO_2	12.17620632	9.446429366	2.729776949	1.288974473
NOx	5.327753468	2.392498501	2.935254967	2.226857599

The BETT values in the table show that in 2012, Vietnam’s pollution content in net exports are all positive for the three air pollutants. The average pollution content per unit of exports is higher than that of imports.

The PTOT index shows that for all three air pollutants, Vietnam’s imports embody less pollution content than its exports in 2012, since PTOT ratios are all bigger than 1. With the common technology assumption (assuming that the same Vietnamese technology is used to produce export and import goods), it seems that in 2012, Vietnam has become "pollution haven" for the world dirty industries.

My results may be compared with other studies. Milner and Xu (2009) provide mixed results. They explore the pollution content in China's trade for three air pollutants (CO_2, SO_2, NO_x). Under the common technology assumption, their findings show that the pollution content in China's exports is less than in its imports. Under heterogeneous technology assumption, their findings suggest that the pollution embodied in China's exports is greater than in its imports.

Mukhopadhyay (2005) also uses the input-output method to test both the pollution haven hypothesis and the factor endowment hypothesis for India's trade during the 1990s, considering three pollutants (CO2, SO2 and NOx). Their results show that the pollution content in India's import is much greater than the pollution content in its export, which is similar to the case of Vietnam in 2007. Their findings challenge the PHH and support the FEH, thus confirming that India gains from trade in terms of emissions.

Mukhopadhyay (2006) measures the pollution content of Thailand's trade with OECD using the input-output approach, for the period 1980 to 2000. Their findings suggest that as of 2000, Thailand became a "pollution haven", which is in line with our results of Vietnam in 2012. They show that these effects have been caused primarily by lax environmental regulations and the changes in Thailand's trade policies.

The above results show that from 2007 to 2012, Vietnam has switched from "pollution deficit" to being a "pollution haven". Some facts may help explain this change.

First, Vietnam's net exports have switched from being negative to positive from 2007 to 2012. In 2007, the value of exports of Vietnam reached 48.56 billion USD, increasing by 21.9 % compared with the previous year. The value of Vietnam's imports reached 62.7 billion USD, increasing by approximately 40%, compared with the previous year.[27] Hence, the net exports of Vietnam recorded a deficit of 14.14 billion USD. In 2012, the value of Vietnam's exports increased significantly by 18.2 percent to reach 114.5 billion USD, while its imports increased moderately by 6.6 percent to reach 113.8 billion USD. Net exports recorded a relatively small surplus of 748.7 million USD[28]. The change in Vietnam's net exports from negative to positive is one of the factors that made Vietnam becoming a pollution haven.

Second, there has been large growth in some dirty export sectors. Statistical data shows that exports of some dirty sectors experienced significant increases from 2007 to 2012, as shown in Table 4.5.

Table 4.5. Exports of some dirty industries between 2007 and 2012 (thousands USD)[29]

Industry	Export in 2007	Export in 2012	Percent increase
Machinery, boilers, nuclear reactors	1,067,365	3,512,712	229
Oils, mineral fuels, distillation products	5,347,645	3,512,712	-34
Miscellaneous chemical products	22,191	160,017	621
Inorganic chemicals, precious metal compound, isotopes	5,433	145,018	2569
Iron and steel	37,226	298,157	701
Articles of iron or steel	316,886	954,521	201
Copper and articles thereof	8,860	109,063	1131
Nickel and articles thereof	119	481	304

27 General Department of Vietnam Customs
28 Source: UN Comtrade and UN ServiceTrade
29 Source: General Department of Vietnam Customs

Aluminium and articles thereof	48,643	159,442	228
Lead and articles thereof	1,125	17,311	1439
Zinc and articles thereof	3,786	16,061	324
Tin and articles thereof	13,298	23,571	77
Other base metals, cermets, articles thereof	8,517	28,250	232
Miscellaneous articles of base metal	21,044	77,258	267

As we can see in the table, exports of most of the dirty industries increased significantly (by 3 or 4 times) between 2007 and 2012. Particularly, some dirty industries experienced great increases, such as exports of Copper and articles thereof increased by more than 12 times, exports of Lead and articles thereof increased by more than 15 times. Obviously, the significant increase in exports of these dirty industries is one important reason why Vietnam became a pollution haven.

Third, Vietnam's trade policies from 2007 to 2012 changed notably. The changes in Vietnam's trade policies after Vietnam became a WTO member in 2007 have had a big impact on the environment. For example, export duties on scrap metal have been reduced by approximately 50%, in accordance with Vietnam's WTO commitments. Moreover, Vietnam has recently joined the TPP (The Agreement on Trans-Pacific Partnership). To implement the commitments in TPP Agreement, Vietnam has to adjust and modify its legislation (laws and regulations). Since Vietnam's law is weak from the stage of drafting to promulgation and enforcement, the key challenge for Vietnam is to improve trade and trade-related policies within a stable, transparent, and predictable policy framework.

7. Conclusions and policy implications

The complex relationship between trade and the environment is highly debated. It has become the center of attention for economists, environmentalists and policy makers. This chapter contributes to previous research by analyzing the pollution content of Vietnam's trade in several ways. First, we use two latest Vietnam 2007 and 2012 input-output tables, allowing the measurement of the pollution embodiment in Vietnam's trade to be updated to reflect the characteristics of the Vietnam economy after joining WTO. Secondly, we utilize the input-output model to examine sectoral pollution intensities in Vietnam in terms of different important greenhouse gases (CO_2, SO_2, NOx). Lastly, we measure the pollution embodiment in Vietnam's exports, imports and most importantly, the pollution terms of trade. Under the assumption of identical technology, the results show that in 2007, Vietnam's exports were cleaner than its imports while in 2012, Vietnam's exports embody more pollution content than imports. Vietnam gained "environmentally" from trade liberalization and expansion as of 2007, and gradually became the "pollution haven" as of 2012.

From the results discussed above, I suggest several policies regarding the trade – environment relationship in Vietnam:

First, as the Vietnamese economy now highly depends on exports, it is important that the Vietnamese Government puts more emphasis on the environmental quality of exports. For example, the Government of Vietnam can adopt restrictive measures for pollution-intensive exports. The Government may consider export tariffs or taxes based on the effect of export production on the environment (i.e. eco-duties).

Second, instead of command-and-control policy, the Government may consider economic instruments to manage pollution (i.e. pollution management fees, fuel user charges, energy tax, and emission charges).

Third, the Government should pay attention to technological improvements. Since technological improvements in producing "green" products require a lot of entrepreneurs' research and development expenditures, the Government of Vietnam can provide entrepreneurs with financial incentives such as tax exemptions or tax rebates. In addition, most entrepreneurs involved in export activities in Vietnam are small and medium-sized ones. Most of them are less interested in applying environment-friendly technologies. Hence, the Government needs to take the initiative in promoting management techniques and technology development suitable for them.

Lastly, environmental problems in Vietnam are addressed by environmental policies; meanwhile trade-related issues are addressed by trade policies. Environmental policies and trade policies in Vietnam usaully do not express any concerns about the complex relationship between trade and the environment. Thus, our results suggest that environmental policies and trade policies in Vietnam should be integrated to harmonize trade expansion and environmental protection. For example, the Government may consider trade-related environmental measures and environment-related trade measures to maintain environmental protection while still realizing the gains from trade.

CHAPTER 5

CONCLUSION

This dissertation has explored the relationship between trade liberalization and the environment in different aspects: the environmental impact of trade liberalization and the trade pattern consequences of environmental regulations. Different methodologies and datasets are employed in three separate essays in order to examine the relationship between trade liberalization and the environment in Vietnam.

Chapter 2 investigates the environmental impact of trade liberalization econometrically following Panayotou's study (1997). We use the reduced form approach that includes only GDP per capita and the growth rate of GDP and the variables of special interest. The data set is a balanced panel of time series and cross-section observations. Our sample includes five countries in Southeast Asia: Vietnam, Thailand, Malaysia, Indonesia and Philippines, for the period 1986-2010.

We find evidence of a monotonically increasing linear relationship between per capita GDP and per capita carbon dioxide emissions for the case of five Southeast Asian countries in the period 1986-2010. The evidence does not indicate the existence of an EKC for carbon dioxide emissions. There is also no evidence supporting the Factor Endowments Hypothesis that freer trade is beneficial for the developing countries in Southeast Asia. On the contrary, the evidence supports the Pollution Haven Hypothesis that freer trade affects negatively the environment. Our findings also raise concerns on the potential "race to the bottom" because of the intense competition to attract FDI in developing countries.

Chapter 3 then examines and quantifies the effects of factor intensities and environmental stringency on Vietnam's trade specialization. Since comparable data on environmental stringency is not available internationally, we focus on cross-industry regression analysis for Vietnam only. We selected a cost-based measure to proxy environmental stringency (i.e. the pollution abatement operating costs per value added). Trade specialization is proxied by four different measures: a Trade Specialization Index (TSI), the Revealed Symmetric Comparative Advantage (RSCA), Michaely Index and Net Exports per value added (Netva). Our findings show that environmental stringency is a negative determinant of trade specialization. For other control variables, the effects of physical and human capital intensities on different trade specialization indices are less consistent.

In chapter 4, the Environmental Input-Output method is adopted to evaluate the general impact of international trade and investigate the pollution content of international trade in Vietnam. We use the two latest Vietnam input-output tables in 2007 and 2012, allowing the measurement of the pollution embodiment in Vietnam's trade to be updated to reflect the characteristics of the Vietnam economy after joining WTO. Under the assumption of identical technology, the results show that in 2007, Vietnam's exports are cleaner than its imports while in 2012, Vietnam's exports have larger pollution content than its imports. Vietnam gained "environmentally" from trade liberalization and expansion as of 2007, and gradually became the "pollution haven" as of 2012.

Future research on this trade-environment relationship in Vietnam could be extended in its content and research scope. On one hand, we can adopt more sophisticated econometric techniques and incorporate more recent and accurate data to extend the current discussion.

On the other hand, we can include variables measuring economic responses to environmental regulations at industrial level or firm level to further investigate the effects of environmental regulations on trade patterns. Furthermore, we can employ a more recent, up-to-date Vietnam I-O table (which is likely to be published in the near future) to examine the pollution content of trade.

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APPENDICES

Table A.2.1: Summary of the studies on EKC relationship between GDP per capita and environmental quality

Study	Environmental indicators	Explanatory indicators	Relation shape	Turning point (GDP/per)	Time period	Countries/ Cities
Holtz-Eakin & Selden (1992)	CO_2	GDP per capita (US$85)	Quadratic	35,400	uneven panel data, 1951-1986	130 countries
Shafik and Bandyopadhyay (1992)	SO_2	GDP per capita (US$90), locational dummies	Linear		1972–1988	47 cities in 31 countries
Kruger and Grossman (1993)	SO_2	GDP per capita (US$85), locational dummies, population density	Cubic	4107 14000	1977, 1982, 1988	52 cities in 32 countries
Panayotou (1993)	SO_2 NO_x Deforestation rate	GDP per capita (US$90)	Quadratic Quadratic Quadratic	3,137 5,500 1,200	1987–1988	55 developed and developing countries

Selden and Song (1994)	SO_2 SPM NO_x CO	GDP per capita (US$85), population density	Cubic Cubic Cubic Cubic	10,700 9,600 21,800 19,100	1979–1987	22 OECD and 8 developing countries
Holtz-Eakin and Selden (1995)	CO_2	GDP per capita (US$86)	Quadratic	35,428	1951-1986 panel data	130 countries
Carson et al. (1997)	CO_2	GDP per capita	Quadratic		1990 cross-sectional data	US states
Moomaw and Unruh (1997)	CO_2 (panel)	GDP per capita (US$85)	Cubic	12,813	1950-1992	16 countries in OECD
Bruyn, Bergh et Opschoor (1998)	CO_2 NO_x SO_2	Economic growth rate, energy price, income per capita	Linear Linear Linear	n/a	1960-1993	Netherlands, UK, USA, Germany

Suri and Chapman (1998)	Energy per capita consumption	GDP per capita, import-manufacturing ratio, export-manufacturing ratio, industry share	Quadratic	55,535 (model 1) 143,806 (model 2)	1971-1991	33 countries
Agras and Chapman (1999)	CO_2	GDP per capita, energy price (oil shock)	Linear		various years	34 countries
Galeotti and Lanza (1999)	CO_2	GDP per capita, population	Quadratic	10,800	1970-1996	110 countries
List and Gallet (1999)	SO_2	GDP per capita (US$90)	Quadratic	22,675	1929–1994	U.S. states
Borghesi (2000)	CO_2	GDP per capita, Income inequality	Linear		1988-1995	126 countries
Perrings and Ansuategi (2000)	CO_2	GDP per capita, share of agriculture in GDP	Linear		1990	114 countries
Panayotou et al. (2000)	CO_2	GDP per capita	Quadratic	$5,000	1870-1994 panel data and time series	17 developing countries

Azomahou and Nguyen Van Phu (2001)	CO_2	GDP per capita	Linear		1960-1996 panel data	100 countries
Stern and Common (2001)	SO_2	GDP per capita (US$90), time and country effects	Quadratic	101,166	1960–1990	73 developed and developing countries
Lindmark (2002)	CO_2	GDP per capita, technology, fuel prices	Quadratic		1870-1997	Sweden
Friedl and Getzner (2003)	CO_2	GDP per capita, share of tertiary sector in GDP	Cubic		1960-1999	Austria
Cole (2004)	CO_2	GDP per capita	Quadratic		1980-1997	21 countries
Azomahou et al, (2006)	CO_2	GDP per capita	Linear		1960-1996	100 countries
Richmond and Kaufmann (2006)	CO_2	GDP per capita, fuel mix	Linear		1973-1997	36 countries
Kunnas and Myllyntaous (2007)	CO_2	GDP per capita	Linear		1800-2003	Finland

Coondoo and Dinda (2008)	CO_2	GDP per capita, inter-country income inequality	Quadratic for only Europe; Linear for whole		1960-2000	88 countries
Lee et al. (2009)	CO_2	GDP per capita	Cubic for the whole panel; Quadratic for middle income, American and European countries		1960-2000	89 countries
Aslanidis and Iranzo (2009)	CO_2	GDP per capita	Linear		1971-1997	77 Non-OECD countries
Dutt (2009)	CO_2	GDP per capita, political institutions, socioeconomic conditions, education	Linear for 1960-1980; Quadratic for 1984-2002		1960-2002	124 countries
Halicioglu (2009)	CO_2	GDP per capita, energy consumption, foreign trade	Linear		1960-2005	Turkey

Jalil and Mahmud (2009)	CO_2	GDP per capita, energy consumption	Quadratic		1971-2005	China
Narayan (2010)	CO_2	GDP per capita	Quadratic		1980-2004	43 developing countries
Acaravci and Ozturk (2010)	CO_2	GDP per capita, energy consumption	Quadratic in 2 countries		1960-2005	19 European countries
Iwata et al. (2011)	CO_2	GDP per capita, nuclear power	Linear		1960-2003	28 countries (17 OECD, 11 Non-OECD)
Jaunky (2011)	CO_2	GDP per capita	Quadratic for 5 countries; Linear for whole panel		1980-2005	36 high-income countries

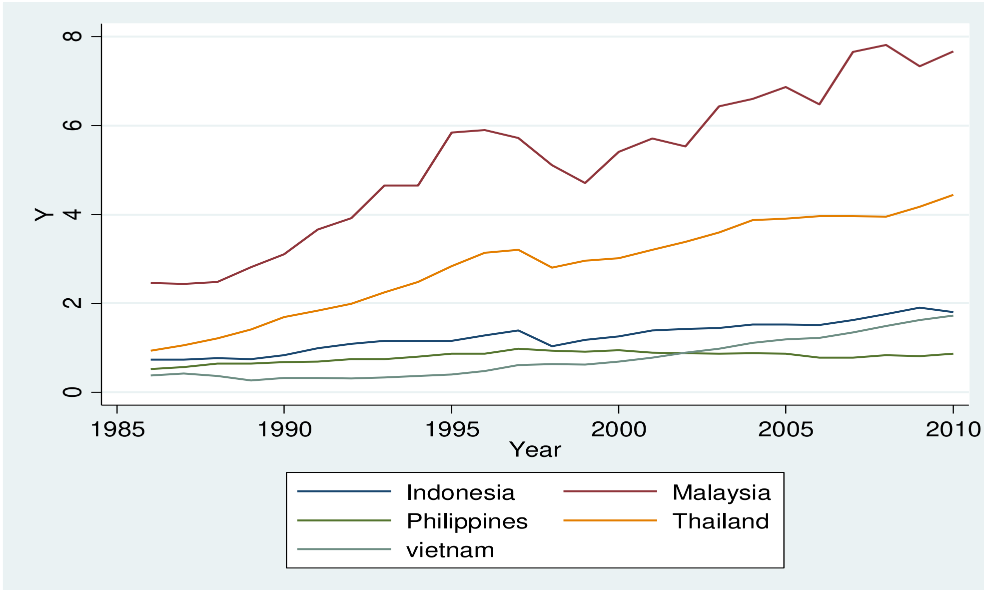

Figure A.2.1 CO_2 emission (Y) in five Southeast Asia countries (1986-2010)

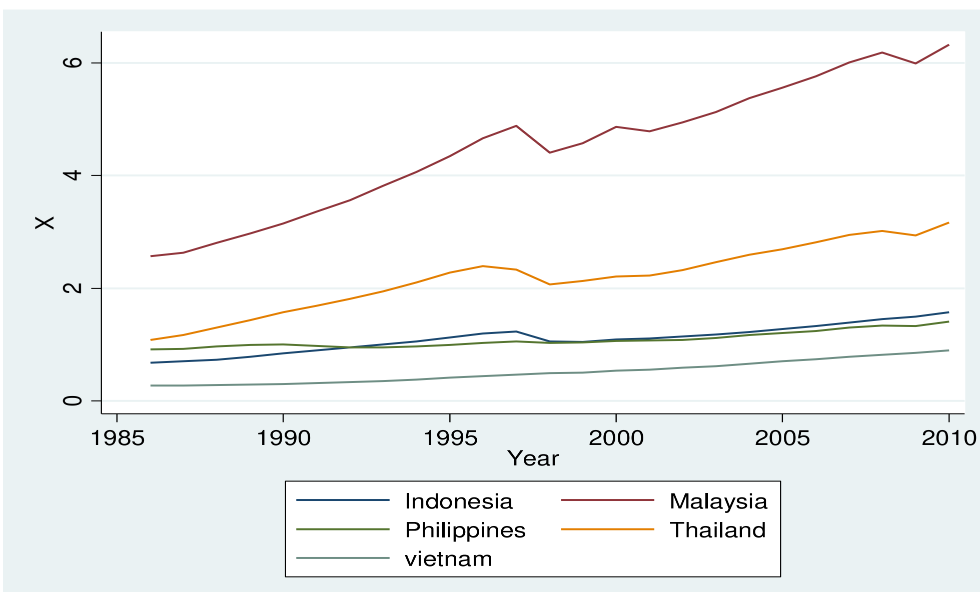

Figure A.2.2 GDP per capita (X) in five Southeast Asia countries (1986-2010)

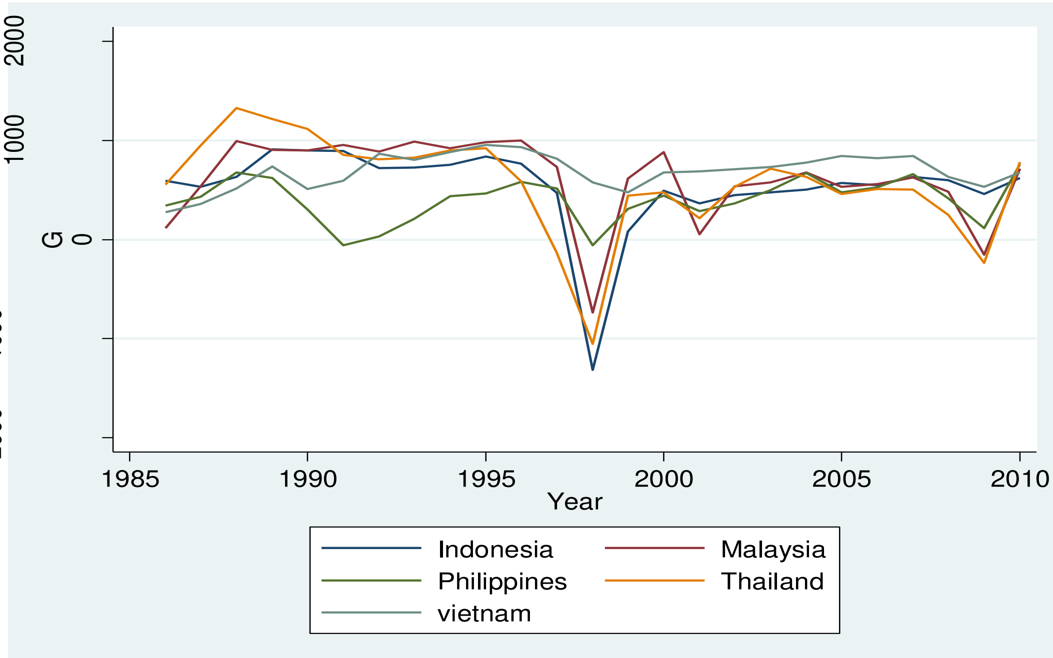

Figure A.2.3 The growth rate of GDP per capita (G) in five Southeast Asia countries (1986-2010)

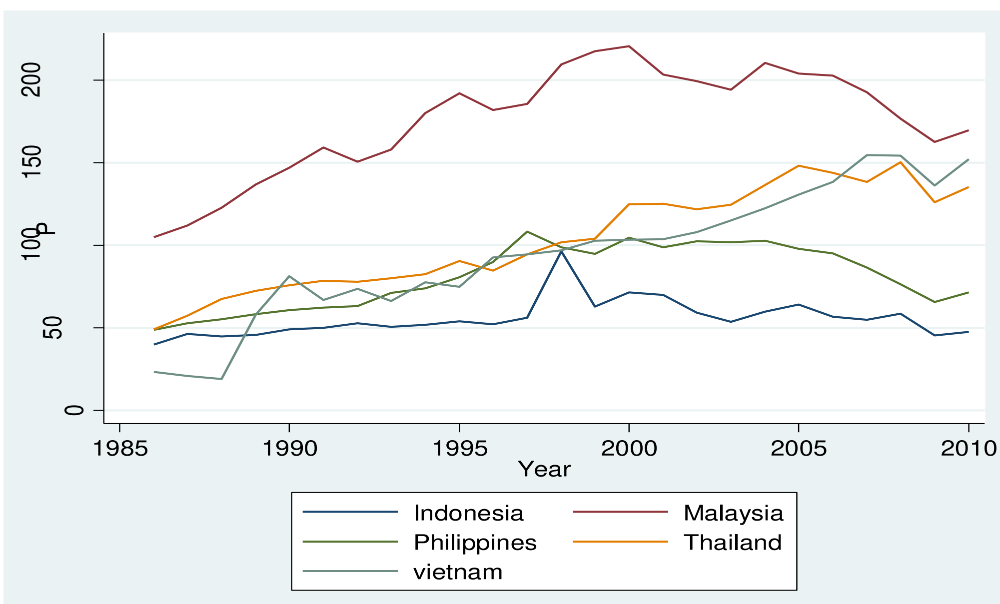

Figure A.2.4 Trade intensity (P) in five Southeast Asia countries (1986-2010)

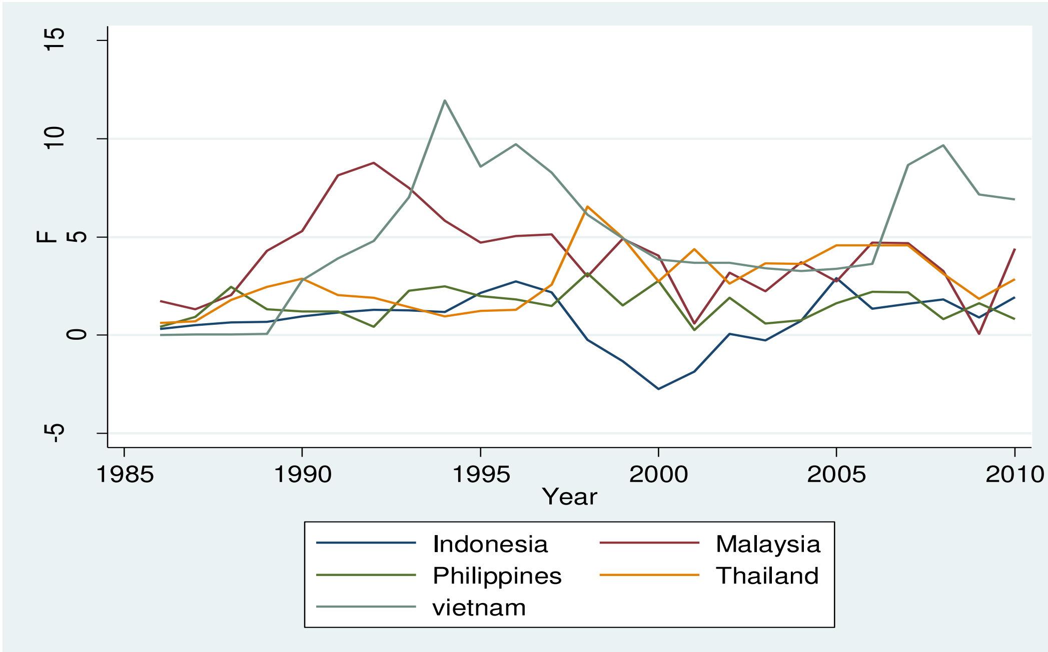

Figure A.2.5 Foreign direct investment (F) in five Southeast Asia countries (1986-2010)

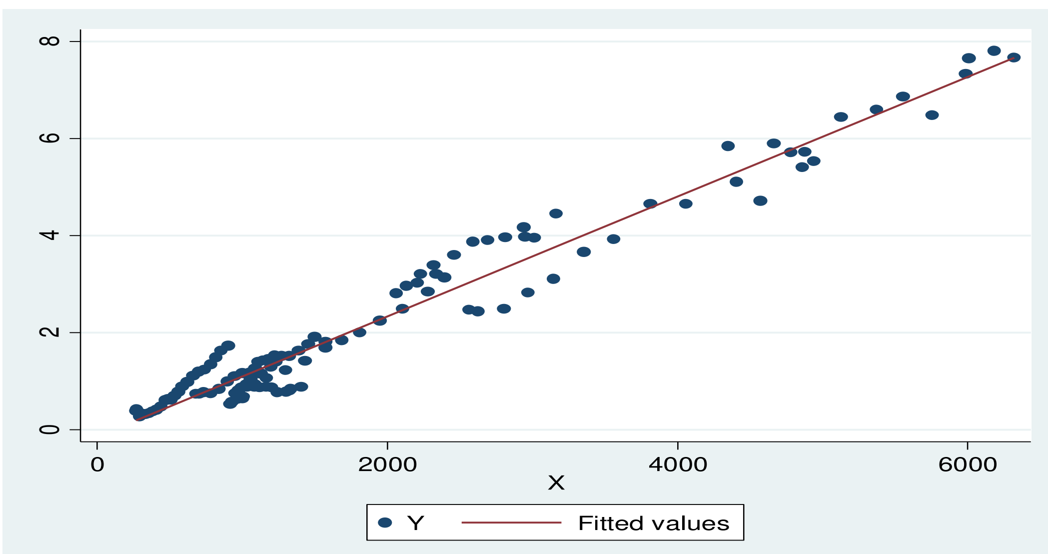

Figure A.2.6 The relation between carbon dioxide and per capita GDP (X)

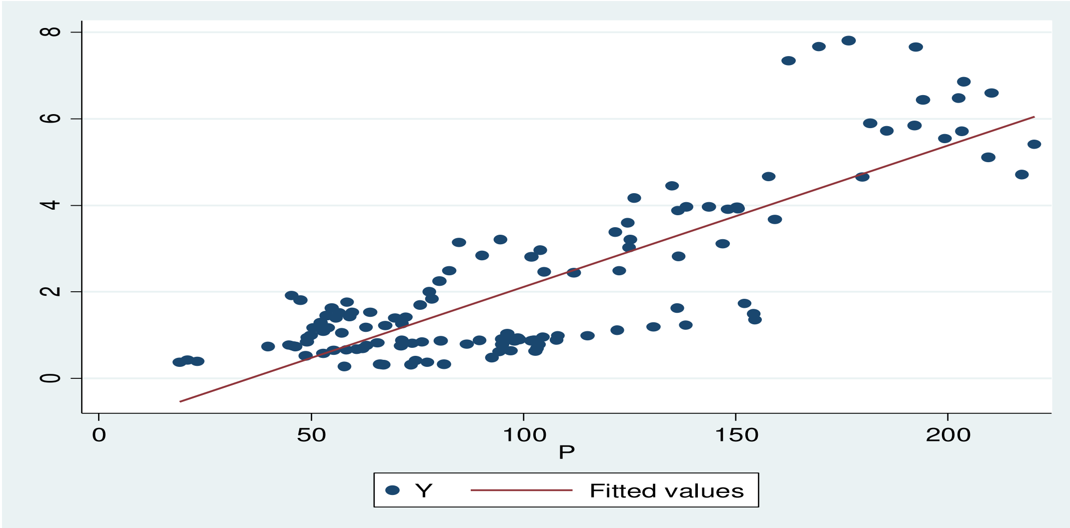

Figure A.2.7 The relation between carbon dioxide emissions and the level of openness (P)

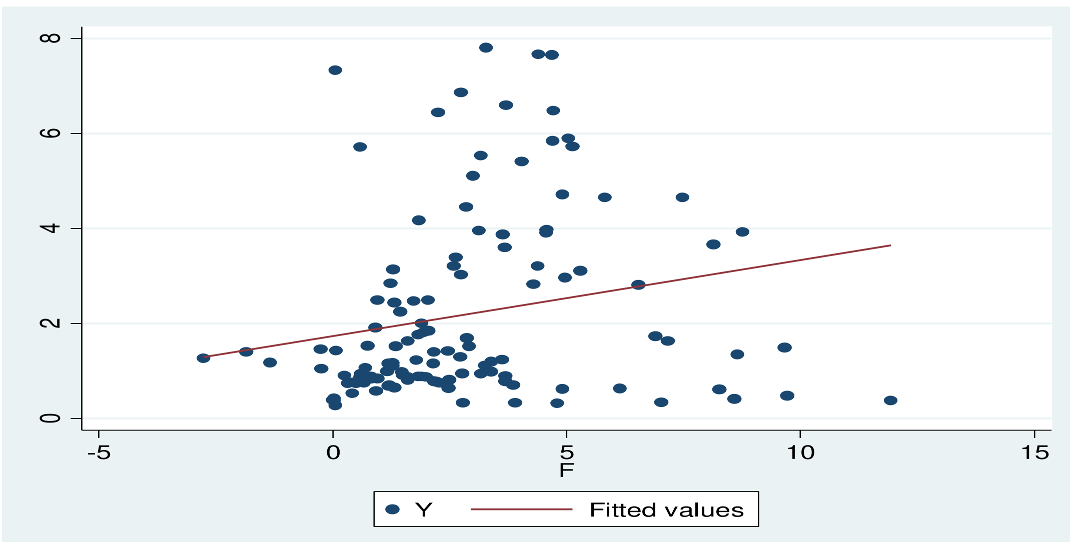

Figure A.2.8 The relation between carbon dioxide emissions and foreign direct investment (F)

Table A.3.1. Variable description and data sources

Variable	Description	Data source
RCA	Defined by equation (3.1)	UN Comtrade database
RSCA	Defined by equation (3.2)	UN Comtrade database
Michaely	Defined by equation (3.3)	UN Comtrade database
NetXva	Defined by equation (3.4)	UN Comtrade database
TSI	Defined by equation (3.5)	UN Comtrade database
PAOCva	Pollution abatement operating costs per unit of value added.	Annual Enterprise Survey – General Statistics Office Of Vietnam
PCI	The non-wage share of value added, as defined by equation (3.7)	General Statistics Office of Vietnam
HCI	The share of value added paid to skilled workers, as defined by equation (3.6)	General Statistics Office of Vietnam
Tariffs	Import duties per unit of imports	General Customs Office of Vietnam

Table A.3.2. Descriptive statistics

Variable	Observation	Mean	Standard deviation	Min	Max
RSCA	144	-0.012744503	0.545851779	-0.900134652	0.750725748
Michaely	144	0.000144867	0.060239009	-0.121770213	0.220609612
Netva	144	-8.82896E-07	0.005948476	-0.007997817	0.043737836
TSI	144	-0.02195021	0.616568241	-0.969794477	0.942555103
PAOCva	144	0.001686272	0.018671809	0.000122957	0.117270169
PCI	144	0.930483657	0.058365203	0.729170242	0.981293611
HCI	144	0.012661796	0.02953616	-0.080640325	0.125974394
Tariff	144	12.14235	17.02897429	3	100

Table A.3.3. Concordance between industry classifications

Industry	Vietnam's Standard Industrial Classification	International Standard Industrial Classification
Paper	170	341
Coal	051+052	051
Leather	151	323
Plastic	222	356
Rubber	221	355
Wood	161 +162	331
Printing	181	342
Textile	131	321
Apparel	141	322 +324
Non-metallic mineral products	239	361+362+369
Iron and steel	071 +072	371
Chemical	201	351+352
Food	101	311
Beverage	110	313
Tobacco	120	314
Machine	281	382
Transport equipment	291 +292	384
Furniture	310	332

Table A.4.1. List of product classification and definitions of codes in Vietnam 2007 and 2012 I-0 Tables

Product	Codes in 2007 I-O table	Codes in 2012 I-O table
Paddy (all kinds)	001	1
Corn	003	2
Nuts	003	3
Seeds	003	4
Sugarcane	002	5
Vegetable, beans	003	6
Flowers	003	7
Other annual plants	003	8
Fruits	007	9
Cashew	007	10
Pepper	007	11
Raw rubber	004	12
Coffee beans	005	13
Tea	006	14
Other perennial plants	007	15
Buffaloes, cows	008	16
Pigs	009	17
Poultry	010	18
Other livestock and poultry	011	19
Agricultural services and other agricultural products	012	20
Other agricultural products	012	21
Products from planting tree	014	22
Round timber	013	23

Other forestry products	014	24
Forestry service	014	25
Wild caught seafood products	015	26
Farm raised seafood products	016	27
Coal	017	28
Crude oil	018	29
Natural gas	019	30
Other none-metallic minerals	021	31
Stone, sand, gravel, clay	020	32
Other minerals	021	33
Supporting service for exploiting mine and ore	022	34
Processed meats and by-products	023	35
Processed fish and by-products	024	36
Processed preserved vegetables and fruit	025	37
Animal and vegetable oils and fats	026	38
Milk and diaries	027	39
Rice and flour	028 + 029	40
Sugar	030	41
Cocoa, chocolate and candy, cake	031	42
Processed coffee	032	43
Tea	033	44
Other remaining food (macaroni; spices, sauce, vinegar, ferment beer)	033	45
Animal feed	034	46
Alcohol	035	47

Beer	036	48
Non-alcohol water and soft drinks	037	49
Cigarettes	038	50
Fiber (all kinds)	039	51
Textile products (all kinds)	040	52
Costume (all kinds)	041	53
Leather, processed fur products (such as suitcase, bags, saddle ...)	042	54
Shoes, sandal (all kinds)	043	55
Processed wood and wood products	044	56
Paper and paper products	045	57
Products of printing activities	046	58
Coke coal and other by-product of cokes	047	59
Gasoline, lubricants	048	60
Other products extracted from oil, gas	049	61
Basic organic chemicals	050	62
Fertilizer and nitrogen compound	051	63
Plastic and synthetic rubber	052	64
Pesticide, other chemical products used in agriculture	053	65
Other chemical products; artificial fibers	053	66
Medicine, chemical prophylaxis and pharmacy	054	67
By-product of rubber	055	68
By-product of plastic	056	69
Glass and by-product of glass	057	70
Bricks	059	71
Cements	058	72

Other non-metallic mineral products	059	73
Iron, steel, iron	060	74
Precious metal products	061	75
Other metal products	061	76
Electronic device, computer and peripheral	062	77
Machinery and equipment used for information, televison and broadcasting activities.	063	78
Electrical household appliances	064	79
Other electronic products and optical products	065	80
Motor, electric generator, power transformers	066	81
Cell and battery	067	82
Electric conductor	068	83
Electric light equipment	069	84
Consumer electronics products (vacuum cleaner, washing machine, dishwasher, refrigerator)	070	85
Other electric equipment	071	86
General-purpose machinery	072	87
Special-purpose machinery	073	88
Cars (all kinds)	074	89
Car engines with tractor (except automotive)	075	90
Ships and boats	076	91
Motor vehicles, motorbikes	077	92
Other transport means	078	93
Bed, cabinet, tables, chairs	079	94
Jewelry, fake jewelry; musical instrument; sporting equipment; toys	080	95
Medical equipment (dentistry, orthopedic and rehabilitaion supplies	081	96

and equipment)		
Other industrial products	082	97
Machinery and equipment repair and maintenance services	082	98
Electric transmission services	083	99
Gas, fuel distribution by pipeline	084	100
Steam distributing, heating, air conditioning and ice making services	085	101
Natural water exploitation	086	102
Wastewater management services	087	103
Trash collection and recycling	087	104
Pollution management and other waste management	087	105
Housing construction	088	106
Other construction	088	107
Railway construction	089	108
Highway and road construction	089	109
Public works	089	110
Special-purpose construction	090	111
Cars, motorcycles and other car engines dealership services	091	112
Car and motorcycle repair and maintenance services	091	113
Wholesale and retail trade	092	114
Railway passenger transportation services	093	115
Railway freight transportation services	094	116
Bus and other road passenger transportation services	095	117
Road freight transportation services; pipeline transportation services	096	118
Water passenger transportation services	097	119

Water freight transportation services	098	120
Airline passenger transport services	099	121
Air freight transportation services	100	122
Parking services and supporting services for transportation	101	123
Postal and delivery	102	124
Residential services	103	125
Food services	104	126
Publishing services	105	127
Film, television, recording and music publishing	106	128
Radio, television	107	129
Telecommunication services	108	130
Computer programming services, consulting services	109	131
Other computer services	109	132
Financial services (except insurance and social insurance)	110	133
Life insurance, social insurance	111	134
Non-life insurance and re-insurance	112	135
Other financial services	113	136
Real estate business service	114	137
Legal services, accounting and audit	115	138
Office management services	116	139
Architectural services and technical services	117	140
Research and development	118	141
Advertising and market research services	119	142

Other professional, scientific and technological services	120	143
Veterinary services	121	144
Machinery and equipment rental services; personal and household appliances rental services	122	145
Labor and employment services	123	146
Travel agency services, other travel and tours services	124	147
Security services	125	148
Home and landscaping services	126	149
Office and administrative support services	127	150
Services of the Communist Party activities; political and social organizations, state management, national defense and compulsory social security	128	151
Education and training (except undergraduate and graduate education)	129	152
Undergraduate and graduate education services	130	153
Healthcare services	131	154
Care services, centralized nursing and social supporting services	132	155
Non-centralized social services	132	156
Arts and entertainment services	133	157
Library, conservation and museums services	133	158
Lottery, Bet and gamble	134	159
Sports; entertainment	135	160
Services of other organizations and foundations	136	161
Computer repair services; personal and home appliance repair services	137	162
Other personal services	137	163

Other home services	138	164

Summary of Emission Factors in previous studies

In order to construct emission matrix E, we need to calculate the chemical content in fuels (i.e. carbon, sulfur and nitrogen). In fact, different types of natural gas, coal and crude oil have different chemical contents in physical unit.

Emission factors are different, depending on fuel types as well as data sources. Emission factors are found in many energy resources in calorific terms, since it is less varied. The following table presents the average emission factors used in previous important papers on the pollution terms of trade.

Table A.4.2. Summary of Emission Factors in previous studies

Author(s)		Mukhodpadhyay (2002)	Mukhopadhyay and Chakroborty (2005)	Temurshoev (2006)	Dietzenbacher and Mukhopadhyay (2007)	Milner and Xu (2009)
Unit		mt/mt	mt/mt	mt/mtoe	mt/mtoe	ton/SCE
Carbon in	Raw coal	0.55	0.55	0.55	0.55	2.712
	Crude oil	0.77	0.79	0.77	NA	2.145
	Natural gas	0.67	NA	NA	NA	1.633
Sulfur in	Raw coal	NA	0.003	0.003	NA	0.0225
	Crude oil	NA	0.015	0.015	NA	0.0070
	Natural gas	NA	N/A	N/A	NA	0

Nitrogen in	Raw coal	NA	0.018	0.018	NA	0.0088
	Crude oil	NA	0.001	0.001	NA	0.0059
	Natural gas	NA	N/A	N/A	NA	0.0044

Notes:

mt/mtoe : million tonnes per million tonnes oil equivalent

mt/mt : million tonnes per million tonnes;

ton/SCE: tonnes per standard coal equivalent

Emission Factors Calculation

While CO_2 emissions mostly depend on the carbon content, the estimation of SO_2 and NOx, emissions not only depends on characteristics of the fuels but also requires information on many other factors, such as combustion conditions, technology, emission control policies... According to IPCC guidelines, SO_2 and NOx emissions are calculated based on technology level and applied activity.

In this chapter, we follow IPCC guidelines to calculate emission factors for CO_2, SO_2 and NOx.

CO_2 Emission factors calculation

Table A.4.3. Carbon Emission Factors and Oxidization factors

Fuel type	Raw Coal	Natural gas	Crude oil
Emission factor (TC/TJ)	25.8	15.3	20.2
Oxidization factor*	0.98	0.995	0.99

Source: IPCC guidelines.

* Oxidization factors range from 0.8 to 0.98 and are different among industries.

The molecular weight ratio of CO_2 to carbon is 3.66. After calculation, carbon dioxide emission factors are presented in the table below:

Table A.4.4. CO_2 Emission factors

Fuel type	Raw coal	Natural gas	Crude oil
CO_2(ton per SCE)	2.712	1.633	2.145

SO_2 Emission Factors calculation

In order to construct sulfur dioxide emission factors, we multiply the molecular weight ratio of SO_2 to sulfur by the fraction of sulfur oxidized and the sulfur content of the fuel.

Table A.4.5. Sulfur Content in Raw coal, Natural gas, and Crude oil (%)

Fuel	Raw coal	Natural gas	Crude oil
IPCC low	0.5	NA	1
IPCC medium	1.5	0	3
IPCC high	3	NA	4

In this study we follow CCCS to use sulfur retention ratio in ash 27%. We also use IPCC medium sulfur content values. We follow previous literature to assume that sulfur removal technology is not taken into consideration. To calculate sulfur dioxide emission factors, the molecular weight ratio of SO_2 to sulfur is 2.

Table A.4.6. SO_2 Emission Factors

Fuel type	Raw coal	Natural gas	Crude oil
SO_2 (ton per SCE)	0.0225	0	0.0070

Source: Peters et al. (2006)

NO_x Emission Factors calculation

NO_x from fuel combustion also highly depends on technology level. In this study we use default NO_x emission factors for the Industry, Energy and Construction sectors according to IPCC. Details are presented in the following table:

Table A.4.7. NO_x Emission Factors

Fuel type	NOx (t/SCE)	NOx (t/TOE)	NOx (t/T)	NOx (kg/TJ)
Raw coal	0.00879228	0.0125604	0.0062724	300
Natural gas	0.00439614	0.0062802	NA	150
Crude oil	0.00586152	0.0083736	0.0083632	200