TRADE AND THE ENVIRONMENT: AN EMPIRICAL ANALYSIS - THE CASE OF MALAYSIA

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AFTA	ASEAN Free Trade Agreement
AIRS	Aerometric Information Retrieval System
API	Air Pollution Index
ARI	Agriculture Resource Intensive
ASEAN	Association of South East Asian Nations
ASM	Annual Survey of Manufacturers
BOD	Biochemical Oxygen Demand
CEPT	Common Effective Preferential Tariff
CFCs	Chlorofluorocarbons
CITES	Convention of International Trade in Endangered Species of Wild Flora and Fauna
CM	Census of Manufactures
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPI	Corruption Perception Index
CTC	Carbon Tetrachloride
DOEM	Department of Environment Malaysia
DOSM	Department of Statistics Malaysia
EC	European Commission
EIA	Environmental Impact Assessment
EKC	Environmental Kuznets Curve
EMS	Environmental Management Systems
EPA	Environmental Protection Agency (USA)
EPI	Environmental Performance Index
EPU	Economic Planning Unit
EQA	Environment Quality Act
ETS	Emission Trading System
EU	European Union
FDI	Foreign Direct Investment
FEH	Factor Endowment Hypothesis
FIC	Factor Intensity Composition
FTZ	Free Trade Zones

GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GEMS	Global Environmental Monitoring System
GNI	Gross National Income
HCI	Human Capital Intensive
HDI	Human Development Index
HICOM	Heavy Industries Corporation of Malaysia
HHED	Human Health and Ecotoxity Database
HS Codes	Harmonized System Codes
IPPS	Industrial Pollution Projection System
ISIC	International Standard Industrial Classification
ISO	International Organization for Standardization
LNG	Liquid Natural Gas
LRD	Longitudinal Research Database
MIC	Malaysian Industrial Classification
MNCs	Multinational Companies
MSIC	Malaysian Standard Industrial Classification
NAFTA	North American Free Trade Agreement
NDP	National Development Policy
NDPES	National Pollutant Discharge Elimination System
NEW	New Economic Policy
NH3-N	Ammonia Nitrogen
NEP	New Economic Policy
NO2	Nitrogen Dioxide
NPI	Non pollution intensive
NVP	National Vision Policy
ODS	Ozone Depletion Substances
OECD	Organisation for Economic Co-operation and Development
PAC	Pollution Abatement Costs
PHH	Pollution Haven Hypothesis
PI	Pollution Intensive
PM	Particulate Matter
PTOT	Pollution Terms of Trade
R&D	Research and Development

SI	Specialization Index
SITC	Standard International Trade Classification
SO2	Sulphur Dioxide
SS	Suspended Solids
SPM	Suspended Particulate Matter
TI	Technology Intensive
TRI	Toxics Release Inventory
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations of Environment Program
UNSD	United Nations, Statistics Department
ULI	Unskilled Labour Intensive
WB	World Bank
WCO	World Customs Organisation
WTO	World Trade Organisation

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Abstract

International trade liberalization has taken place in Malaysia since the 1960s and it has significantly contributed to Malaysian socioeconomic and political stability. Much research focuses on the achievements of the Malaysian economy but not on the effects of trade liberalization on the environment. As many earlier researchers associated pollution with manufacturing factories, it is important for the impact of the trade-led expansion of this sector on the environment in the country to be measured.

This study covers the period from 1985 to 2006 using national and regional industrial panel data for four-digit ISIC Malaysian manufacturing sectors. During the period, the manufacturing and external sectors were the main engines of economic growth for the country. This study investigates the effect of international trade on the environment following three routes: regional level study, industrial level study and bilateral-trades study. Perhaps this three-route investigation of trade-environment relationships is the first in this area of study. Our results show no single peculiarity that either fully supports or contradicts the main body of literature. Despite popular beliefs that bilateral trade with developed countries will cause environmental degradation in Malaysia, this study has proven otherwise. As shown in the literature, the effects of trade on the environment are country specific and each country will show different results according to its own circumstances. Factors of production and countries' comparative advantage in resources appear to be relevant. The evidence to support the Pollution Haven Hypothesis has not found in Malaysia. The bilateral study shows that there is no overwhelming evidence for us to conclude that bilateral exports to developed countries cause more pollution emissions than bilateral exports to developing countries and neither that Malaysia is being used as a pollution haven nor other countries are being used by Malaysia as a pollution haven.

CHAPTER 1

Introduction

1. 1 Introduction

It is undeniable that economic benefits are an important outcome of international trade. There is a widespread consensus that international trade can contribute to the economic development of a nation. Countries participating in international trade are able to access a bigger spectrum of new products and technologies as well as able to attract foreign direct investment. International trade also creates opportunities for domestic producers to embark on mass production and achieve higher economies of scale. Furthermore trade can generate greater competition which can inspire innovation, creativity and enhance efficiency. In sum, trade can serve as a springboard to deliver economic prosperity to countries that are willing to open their economies to the rest of the world and its benefits range from contribution to poverty reduction, employment creation, per capita income expansion and achieving other macroeconomic goals. These benefits have led to a rise in the number of countries moving towards globalization and liberalising their economies. As such it is observed that policy makers are often overly focused on the benefits when deciding on national economic policies. International trade had always been used as an important strategy to expand the domestic economy in a bid by the government to improve people's standard of living and job opportunities which would ultimately free its people from poverty and inequality. However, despite the benefits that international trade brings, there is also a consensus that the by-product of economic activity expansion triggered mainly from the emissions of production process could dampen the environment standards and ultimately cause a social economic burden to its people.

Over the last few decades the impacts of environmental deterioration are becoming more profound with the frequent recurrence of environment disasters in many parts of the world. The environmental issues are becoming pertinent and have generated greater interests among academics, development analysts, and policymakers. Thus, besides the benefits, some economists begin to question the long term effect of trade liberalization on the environment. One well known report in this area, The Limits to Growth written by the Club of Rome (Meadows *et al.* 1972), says that trade liberalisation that leads to a higher economic growth is causing an expansion of economic activity as well as consumption. In exchange, this growth and expansion put more stress on the environment and often lead to excessive exploitation of natural resources. These ominous effects of trade painted by the trade liberalization's opponents are refuted by trade's proponents who believe that trade liberalization could play a vital role in spearheading the use of a more environment friendly technologies in the production process.

Malaysia is among many countries in the world where its socio-economic achievements are credited to its economic openness. Although the country is small in terms of size of the land and population as well as its geographic location far from the North American and European regions where the economic powerhouses are located other than Japan, the country has managed to put itself on the map of global trade and recognised as among the major trading countries in the world. There is no doubt that the country had succeeded in attaining the economic prosperity through years of efforts in pursuing trade expansion. The history of the country's involvement in international trade can be seen starting long decades ago before the country's independence. Prior to independence, the country was colonised by various advanced nations initially by Portugal then followed by Netherlands, Japan and Britain who all were mainly interested in exploiting the country's natural resources such as mining products and agriculture commodities.

In the next section I summarize the background of the research and this is followed by section 1.3 which deals with the objectives of the study and significance of the study. Section 1.4 discusses the statements of the problem. This is followed by the last two sections that outline the scope of the study and data sources, and organization of the study.

1.2 Background to the research

It has been noted extensively that in the early stages of development, most countries focused on economic progress and downplayed the importance of maintaining environmental standards. The economic development literature suggests that there are four priority goals to be achieved in the process of development. The most important goal is to achieve a higher rate of economic growth that would eventually translate into a higher per capita income, followed by a high employment rate; a fair distribution of income/wealth among the population; and finally a stable price level. However, in the later stage of development, the focus is shifted to other issues such as environment issues and sustainable development. As such, 'growth first and worry about the environment later' may be the right phrase to describe the conventional development process experienced by many nations especially the developing countries.

The world's present challenges are well beyond just the economic issues. At the turn of the 21st century, most countries in the world can no longer isolate themselves from facing the environment degradation caused by obsessive development. Despite the tremendous increase in per capita income in many countries in the world and numerous advances in life style in the world we live in today, there is still no guarantee that our living standards and quality of life have really improved. In fact there is still no definitive indicator to suggest that our living standards and quality of life have actually improved. There is a virtual consensus at the moment that pollution, environmental degradation and deforestation are among the major concerns in every part of the world. In certain places the increasing population experiences deterioration of living standards. Global warming, climate change calamities and depletion of the ozone layer are threatening the future of our living standards and all other inhabitants in the earth.

While we have no qualm that policy makers and researchers managed to reach a consensus on the role of trade liberalisation in raising income and prosperity, the debate on the environment relationship with trade liberalization still continues. Conservative environmentalists (or the hardliner environmentalists) are less tolerant and are consistently pointing fingers towards international trade as the main reason for the increase of pollution. They consistently bring forth the view that more trade and growth would mean more pollution. On the other hand, the moderate environmentalists who are seen as more tolerant are tirelessly promoting the concept of sustainable development and they express their concern over the possible negative impacts of trade liberalization on the environment. Trade liberalization proponents however argue that if the environment is a normal good, higher income induced by trade will raise demand for a cleaner environment. Simultaneously, increases in government financial strength as a result of trade will provide financial capacity for the government to expand its investment in environmental protection and cleaner production technologies.

Meanwhile, due to stricter environmental regulations imposed by developed economies, polluting industries may migrate to poorer countries where regulation is less stringent, which actually worsens the global environment. This scenario is referred to as the "pollution haven hypothesis" and is argued to have an adverse effect on the global environment. Moreover, this might also create unhealthy competition where countries compete to lower their environmental standards in order to attract investments. This is widely known as the "race to the bottom".

Malaysia's development progress over the years is not without its detrimental effect on the environment. In recent years, Malaysians have become less tolerant of the damaging effect produced by economic activity. Trade liberalization that contributes to expansion of economic activity has also contributed to the rise of air and water pollution. International trade also plays a major role in deforestation and soil degradation. Growth in trade has influenced the environment standards and quality of life. With the current emphasis on sustainable development, the effect of trade liberalization on the environment is becoming a major challenge to both the Malaysian government and producers.

International trade liberalization has taken place in Malaysia since it gained political independence in 1957. In the early 1980s, Malaysia embarked on an industrialization strategy with the implementation of an industrial master plan to guide the country. The main objective of the plan is to help the country to achieve a developed economy status. Given the small population that Malaysia has (13.8

million in 1980 and 25.3 million in 2005) and the limited purchasing power, expansion of international trade is needed in order to achieve a high rate of economic growth and a high level of per capita income. This over-dependence on international trade and economic expansion has put pressure on the environment.

The clearest detrimental effect of this over reliance on international trade is the continuous deterioration of environment quality due to air and water pollution as well as the increasing level of deforestation. Since the late 1980s, Malaysia has seen its average temperature rise continuously and the amount of rainfall decline. The rate of transformation in turning Malaysia into an industrial country has also caused many rivers to become polluted due to the improper management of industrial wastes. Most rivers and areas nearby an industrial site are more likely to be pollution prone than before. In 1999, it was reported that 65 per cent of 121 rivers in Peninsular Malaysia were severely polluted (OECD, 1999). This report seems to highlight the severity of the environmental deterioration which could result from heavily relying on international trade. This also raises questions concerning the long term sustainability of Malaysian economic progress.

Despite the unfavourable scenario portrayed by the report, the trade liberalization policy subscribed to by the government has continuously attracted a huge influx of foreign direct investment (FDI) into the Malaysian economy and has spurred industrial development. Many industrial zones that had been approved by the government to be set up are mostly in forestland and uninhabited areas in various places in states of Malaysia. As a result, many green areas had to be destroyed to accommodate the building of large industrial factories. The aggressive deforestation undertaken has led to the declining air quality and a rise in air pollution.

With the increased rates of deforestation and the poisonous gases that factories emitted, air quality has plummeted and likely would cause harm to the people, especially inhabitants in the surrounding area. This harmful effect of trade liberalization may also have long term consequences and would affect the socioeconomic stability of the country. With these conflicting agendas, both trade liberalization and maintaining high environment standards must be pursued with great prudence and closely monitored.

Globally, India and China experienced a high rate of environment degradation. Malaysia is a country with a population of nearly 29 million and land size of nearly 330,000 square kilometres. This is a far cry from China's 1.3 billion population and land size of 9.6 million square kilometres. In recent years it is without a doubt that China's growth in economic terms has been nothing less than a phenomenon. Aggressive economic expansion plan and rapid industrialisation have spawned economic growth in the past 2 decades. It is now known as one of the most industrialised nations in the world with many of the world's manufactured products being manufactured in China. In terms of local consumption, compare to Malaysia, China with nearly 45 times more population than Malaysia, have considerably more demand and combined with world manufacturing demand to cater for, a lot of industrial activities need to take place. Very little or almost no plan at all to handle the 'leftover' of industrialisation and years of accumulation of waste leads to the now ever increasing headache for the Chinese. Years of mismanagement causes pollution to skyrocket and is now becoming a major issue for the country. Pollution levels in China are so extensive that the World Bank report (2007) suggested that pollution in China is already causing 350,000 to 400,000 premature deaths a year. Compared to this, Malaysia's pollution problem is certainly is not as bad as China, and some may suggest that pollution is not really an issue for the country. Despite over two decades of economic expansion Malaysia's pollution is not as bad as other countries such as China's and this therefore gives rises to questions about the importance of this environment-trade's study.

Although pollution is not an issue in Malaysia as much as it is in China, this does not mean that there are no pollution problems in Malaysia. Malaysia, like many other developing countries has been blighted by pollution problems. Examples of such problems are the 2005 and 2006 haze which at its peak brought nearly the whole Malaysia to a standstill. The fact that the 2005 and 2006 haze managed to bring Malaysia to a standstill means that pollution is an issue in Malaysia. The haze does not only affect Malaysians in terms of health it also affects the governance of the country itself with many schools and government offices closed and business temporarily suspended on the advice of the federal government, asking residents to stay indoors. Though the 2005 and 2006 haze is not a daily recurrence (index measurements stay relatively low after the 2005 and 2006 event) this does not mean

Malaysia does not have pollution issues. Whilst problems regarding environment degradation are not as bad as China's this does not mean that Malaysia should be lax about it. There are indicators that suggest Malaysia would be in the same boat as China in the future if no extra steps are taken to curb pollution. Pollution in Malaysia especially in economic hotspots such as Kuala Lumpur and Shah Alam has slowly risen.

With the country continuing to pursue economic expansion there is a risk that not enough attention is given to the management of waste from industrialisation. As trade increase and the economy expands there are fears that these mismanagement will lead to much worse cases of pollution in Malaysia. Some environment degradations are permanent and therefore should be prevented before they happen. It is always better to prevent than to heal. Over the years as worldwide awareness of the good environment increases, activism relating to environment in Malaysia has increased. Many such cases of activism are fuelled by the belief that trade expansion relates to environment degradation. Recent protests by residents nationwide at plans to construct a highly toxic rare earth refinery (Lynast) near Kuantan, Pahang, Malaysia is a prime example of recently increased awareness amongst Malaysians. As Beghin and Portier (1997) point out, "congestion and environmental degradation may occur when environmental resources are fixed in supply and emissions are growing". Hence, with growing industrialisation led by trade, Malaysia may soon face a heightened pollution and environmental degradation that restrain future growth and prosperity.

Generally, the non-exporting sector constitutes the bulk of the economy in most developing countries (with the exports sector usually below 30 per cent of GDP) which implies low environment pressure. Instead in the case of Malaysia where the external sector constitutes about 200 per cent of GDP, this implies a high environmental pressure from the exporting sector.

This study may also show that the fact this country is deeply involved in international trade has not necessarily over-exposed the country towards environmental degradation. It challenged the argument that trade expansion does cause environmental degradation. Hence, as a trading nation, this study is very significant to evaluate how Malaysia is fetch on issue of the environment-trade relationship. This study may also be able to show how Malaysia benefited from trade due to technology transfers with a sizeable presence of MNCs in the country, i.e. trade leads towards more environmental-friendly products and processes.

1.3 Research objectives and significance of study

In light of the above discussion, the linkages between international trade and the environment particularly in the case of developing countries deserve our attention and this has been the main motivation of this thesis.

In recent years, environmental-trade issues have generated greater interests among researchers. Notably, a number of policy instruments have been taken by both developed and developing countries to incorporate environmental variables in their socio-economic development planning. In order for the nation to have the right policy and effective implementation, input and feedback / contributions from researchers both on theoretical aspects and empirical findings are important to be made available. Presently, the progress made in the field of economics and environment studies are not widespread. There are various challenges faced by researchers in this area of study especially in measuring the effect of international trade liberalization on the environment. Among the challenges are data availability, theoretical issues as well as methodology for empirical study. As such, most studies are mainly done for developed countries and focus on cross-section data analysis. The limited number of studies that involved developing countries is mainly due to the lack of data on the environment measurements. Despite the difficulties, it will be in the best interests of the country for the study to be made where a quantitative assessment of the effect can be used to measure the nation's overall gain from the international trade. Furthermore, explicit evidence would enable the government to make the right decisions on policies which may lead to adjustment of the existing economic policies where more balance and sustainable growth can be achieved. Only the right policy can ensure that the people's quality of life will be preserved and an increase in the overall welfare of the nation will be attainable.

Essentially, this research will determine the effect of international trade on the environment and assess the strength of the various effects which contribute to the past, current and future state of the environment. It will also shed some light on how policy instruments and institutions have played a major role in mitigating the negative effect of international trade on the environment. The study will also provide important lessons for policy makers and other related institutions in Malaysia.

To our knowledge, economic analysis of the relationship between trade and the environment in Malaysia is scarce. Drawing single-country development lessons from cross-country evidence is questionable. In general, the studies that attempt to analyse directly the effects of trade liberalization of the manufacturing sector on the environment for a single country particularly for developing countries are limited in number. Thus this study will shed light for the case a single country. We limit our attention in this study of trade liberalization on the environment to the case of manufacturing industry and air pollution.

It is acknowledged that the scope of environmental impact by trade liberalisation is wide including air pollution, water pollution, soil pollution and deforestation. This research, however, chose to focus on atmospheric pollution which is the subject most widely investigated in this area. It is also true that manufacturing activity is not solely the source of pollution in Malaysia. In 2007, the sector contributed to only 21 per cent of sulphur dioxide (SO2) emission, 25 per cent of particulate matter (PM) emission, 24 per cent of nitrogen oxides (NOX) emission and 1 per cent of carbon monoxides (CO) emission (DOE, 2007). However, the manufacturing sector has contributed massively to Malaysian exports contributing to a total of 85 per cent of total exports since 1990. It also consumed and stimulated other activities in the economy such as power generation and transport services. Both services had accounted for more than 40 per cent of the gas emissions. Despite all this, manufacturing also created demand for new settlements and urbanization. Thus more trees and forest need to be cleared to give way for the development. In sum, growth in trade not only led to an expansion of manufacturing activity but it also inevitably played a role in spearheading pollution in Malaysia.

1.4 Problem statement

In general, studies that attempted to analyse directly the effects of trade liberalization of the manufacturing sector on the environment for a single country particularly for a developing nation are limited in number. Another shortcoming is that most of the previous studies have focused on cross-country data. This is not surprising because in developed nations the voice of trade opponents and environmentalists are louder due their high preference towards environment standards.

In Malaysia, international trade has significantly contributed in shaping the landscape of Malaysian socioeconomic and political stability. However, research that relates the effects of trade liberalization on the environment in Malaysia is scarce and this study intends to fill the gap. This study will be using national, regional and industrial panel data for four-digit and three-digit ISIC manufacturing sectors. This period is chosen because during the period the Malaysian manufacturing sector and external trade was the main engine of economic growth for the country. Also, as many earlier researchers associated pollution with manufacturing factories, it is important for the impact of the trade led expansion of the sector on the environment in the country to be measured. Other than that, this period is chosen due to the availability of the data for the study.

In this thesis, we will investigate the effect of international trade on the environment following these three routes: regional/states level study, industrial level study and bilateral-trades study. These will form the three key chapters of my thesis. Firstly, for the regional/state level study, we will examine quantitatively the effect of trade on the environment that arises via three channels: the scale effect, the composition effect, and the technique effect using state level economic panel data[1]. Secondly, the study is focused on examining the effect of trade on the level of pollution emission using industry panel data. Thirdly, this study will examine the pollution haven effect hypothesis on the bilateral trade between Malaysia and its 41 main trading partners.

[1] Panel data model is explained in Chapter 4 (Literature Review).

The findings of this research can be used to enhance the existing policies related to international trade and the environment in Malaysia. This single country study which is rarely done will contribute to enhance the empirical studies in this area. Perhaps this three-route investigation of trade-environment relationships is the first in this area of study and the findings would help us to enhance our understanding of this area. The trade-environment relationship is basically a dynamic relationship. Therefore for this study, using panel data methods is obviously favourable as it takes into account both the time series and cross-sectional dimensions of the data.

This study contributes to the existing literature in the following ways. The study is unique in the sense that its three-route investigation is considered as a comprehensive approach which will provide evidence on the trade-environment relationship from three perspectives. While international trade has been recognized as an important engine for economic growth it is also associated with environmental degradation. However whether trade is significantly harmful to the environment is still not adequately answered and measured. The peculiarity and characteristics of trade and the environment of the country itself are largely considered as among the factors determining the validity of the findings of this study. To move forward as a successful nation, an understanding of the connection and assessment of the real impact of trade and economic growth on the environment in Malaysia is important in formulating pragmatic industrialization and environmental policies. To the best of our knowledge, no study has ever been done to investigate and measure the effects of trade liberalization on the environment in Malaysia using the three-route analysis.

1.5 Scope of study and data sources

In this study, for environmental examination we use industrial air pollution in Malaysia which focuses on four types of air pollutions namely, sulphur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and particulate matter (PM). In all empirical chapters the estimations are done for the four pollutants separately. As a measure of trade liberalization in the country we use data on the Malaysian manufacturing trade. Annual data from both the international trade statistics and manufacturing surveys are used extensively. This study covered the period 1985 to 2006.

To accomplish this study we use at least three types of statistics, these are environment statistics, international trade statistics and industrial statistics. All the statistics are from secondary sources. This study also uses industry pollution emission loads estimated using the Industrial Pollution Projection System (IPPS)[2] coefficients developed by the World Bank.

The main data providers for this study are the Department of Statistics Malaysia (DOSM) and the Department of Environment Malaysia (DOEM). Two types of data from DOSM are annual international trade statistics and data from the annual manufacturing survey (census). Both data sets are provided at a disaggregate level using two types of classification namely, the Malaysian Standard Industrial Classification (MSIC) and the Standard International Trade Classification (SITC). The environment statistics in the form of pollution ambient concentration is taken from the environment monitoring stations located across the states provided by DOEM. Unfortunately, all the data mentioned above are not directly in the format that we required. Thus data computation and transformation process had to be done before the analysis.

1.6 Organisation of the study

The present chapter has summarised the research problems and the background context to empirical research. Chapter Two and Chapter Three provide reviews on international trade and the state of environmental standards in Malaysia respectively.

Chapter Four is concerned with the literature review and conceptual framework. This chapter presents a detailed appraisal on both theoretical and

[2] The IPPS background is described in the Appendix 6.2. The more detailed IPPS is described in Hettige *et al.* (1995).

empirical aspects of the study into the effect of trade on the environment. The debate on the relationship is discussed and finally this chapter provides a review of the methodology.

Chapter Five, Chapter Six and Chapter Seven, the core of the research, provide the empirical analysis on trade and the environment linkages through the three routes. Chapter Five presents the empirical analysis on the linkages based on state (regional) level study. Chapter Six is focused on industrial level analysis. In Chapter Seven we extend our empirical analysis to the case of bilateral trade.

Finally Chapter Eight presents the discussion on the overall findings, discusses policy implications and the concluding remarks.

CHAPTER 2

The Malaysian International Trade

2. 1 Introduction

The significant role of international trade in determining national wellbeing has been well accepted and discussed throughout the economic literature. Nevertheless up until the early 19^{th} century, trade between nations was not as free flowing as it is now. High tariffs and lofty beliefs of Mercantilism between nations had restricted trade between nations to grow and to mature. Mercantilism is seen as a common practice in the 16^{th} to the 18^{th} century. Mercantilism is a doctrine that believes that government control of foreign trade is important to ensure a country or nation continues to thrive and prosper. It is done mainly to protect corrupting interests and has often been the cause of war and also used as a motive for colonisations. Amongst policies of Mercantilism are maximizing the use of domestic resources and exclusive trade to certain colonies. Mercantilism at its simplest can be seen as Bullionism which promotes the thinking of measuring one's wealth by the amount of precious metals owned. Therefore to avoid a decrease in wealth, exports of gold and silver are prohibited in Mercantilism policies. Mercantilism reached its low point in the early 19^{th} century as the free trade doctrine began its momentum in the United Kingdom. The free trade beliefs were spread around as the United Kingdom used its position as the world financial centre to advocate these beliefs. Since then international trade began to expand to all four corners of the world.

Consequently, for many countries, trade across international borders gradually increased and contributed to their Gross Domestic Product (GDP). Since the end of the Second World War, more measures were taken to promote free trade. The World Trade Organisation (WTO) and its predecessor General Agreement on Tariffs and Trade (GATT) then were established to formally promote and regulate international trade. Whilst the GATT and WTO regulate trade on a global scale, there are also several other regional agreements that promote free trade amongst member countries such as the North American Free Trade Agreement (NAFTA), the European Union (EU) and the ASEAN[3] Free Trade Agreement (AFTA). The agreements are served mainly to reduce trade barriers. This includes a time line for tariff reduction or elimination and facilitating free trade amongst member countries. The agreements also work as a complement to the free trade policy initiated by the individual country that may be difficult to implement individually. Hence, realising the importance of international trade, many countries are continuing to pursue regional/bilateral agreements to enhance their capacity and volume of trade.

Essentially, the role of international trade had grown significantly since the increasing belief of the free trade doctrine. Free trade that limits the protectionism policies (if not abolished) amongst nations has allowed goods, capital and labour to move more freely. For many countries, the economic reform via trade liberalization had enabled them to pull in foreign investment that was once scarce and often stifled by the trade barriers. This foreign investment along with the trade liberalization helped countries to achieve a decent economic growth and to participate actively in the globalisation. Many believe that free trade allows countries that have an abundance of natural resources yet lack the skills and technology, to efficiently cultivate their resources and become involved in international trade on a global scale. As such, foreign investment that creates job opportunities as well as spill-over effects in advancing social-economic systems would help countries to raise their living standards as well as globalising themselves. In medium or longer terms, technology transfer that often occurs through foreign investment would also help a country to transform its economic structure. As shown in many developing countries such as Malaysia, trade liberalization works as a catalyst in transforming an agriculture based economy to an industrial and service based economy.

This chapter proceeds with three sections. In the next section we provide a brief background of the country's economy. This is followed by a section on an overview of the Malaysian exports and imports compositions and its major trading partners and finally followed by a section of conclusions.

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[3] Association of South East Asian Nations consists of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

2.2 The Malaysian economy

The Malaysian economy is considered as one of the most progressive economies in its region and in the world. It was ranked the 3rd largest in Southeast Asia and the 29th largest in the world. With the economic growth of between 5 per cent and 7 per cent since 2007 Malaysia is now one of the fastest growing economies in the world. As of 2010, it is estimated that the country's Gross National Income (GNI) stands at RM 739,451 million (US$ 231,078 mill.) in nominal prices and the GNI per capita stands at RM 26,174 (US$ 8,179). As one of the countries that control the straits of Malacca[4], international trade is a key component of the country's growth. With an outward oriented and a very open economy, Malaysia is a member of several trade agreement both at regional and world levels. Malaysia is a participant of the General Agreement on Tariffs and Trade (GATT) and its successor World Trade Organisation (WTO). Both policy regimes are pivotal in the nation's trade and growth.

Malaysian international trade has grown greatly over the past 30 years. For example, in the ten year period of 2000 to 2010, Malaysian exports more than doubled from RM 373,270 million (US$ 116,647 mill.) in 2000 to RM 639,428 million (US$ 199,821 mill.) in 2010. The imports also follow the same trend during the period with an increase from RM 311,459 million (US$ 97,331 mill.) in 2000 to RM 529,195 million (US$ 165,373) in 2010. These figures are attributed to the initiatives taken by the government to support the export orientated industries by creating an investment friendly environment with various incentives and keeping close ties between the government and private businesses. The rapid growth of manufactured exports since 1980 was a commendable attainment of the trade liberalization policies. The government's decision to pursue an outward-looking development strategy is seen as the key to the path of sustained and vigorous growth of its economy. The external sector continues to be a major contributor to the country's revenue, accounting for more than 50 per cent of annual foreign exchange earnings over the decades. This however caused some concerns on the overall country wellbeing. The fact that the external sector constitutes the bulk of the

[4] The Strait of Malacca is a channel connecting the Indian Ocean and the South China Sea. This channel is heavily used by traders to ship their merchandise around the world.

Malaysian economy does imply the amount of pressure on the country's environmental standards. It's also worth mentioning that despite the government decision to make selective intervention to protect certain sectors of its economy, the trade barriers for the importation of goods and services are relatively few.

In terms of international trade policies, the government had embarked upon an open economy and trade liberalization from the early stages of development after gaining political independence. The key phases of Malaysian trade policy and its evaluations over time can be summarized in four phases. In phase I: Import substitution to encourage the growth of domestic industries that produced simple consumer goods (1957-1970). Very few quantitative restrictions were used to limit imports. In phase II: From 1970 to 1980, export-oriented industrialization was introduced. Free Trade Zones (FTZ) were established and tariffs were gradually reduced. Incentives were granted to encourage manufactured exports, partly linked to export performance. In phase III: From 1980 to 1985, Malaysia introduced a second round of import substitution measures for heavy industries, such as for automobiles, petrochemicals, iron and steel, and cements industries. Tariffs on a wide range of manufactured goods were substantially increased in the first half of the 1980s as part of the move towards heavy industrialization. Finally, in phase IV: From 1985 to present, further tariff reductions were introduced as part of the common effective preferential tariff (CEPT) of the ASEAN Free Trade Agreement (AFA) and a second round of export orientation through a cluster-based approach was initiated. This phase IV in particular has seen a substantial liberalization in Malaysia's international trade (EPU, 2005).

Despite the wide ranges of tariff/taxes reductions/exemptions on manufactured goods in response to liberalisation policy through various multilateral/regional/bilateral agreements, some tradable goods have still had a high tariff imposed such as automobiles. The common textbook argument of the necessity for a country to impose tariffs for goods is to protect the local producer, besides the additional sources of revenue. As such, the government believes that the national car producer (Proton) is still immature and in the process of developing their competitiveness. Hence, the automobile industry in the country requires various forms of assistance and protection from world producers. As a consequence, the consumers have to pay a penalty where to own a car in the country they need to spend more than their counterparts in other countries in the region. The government also legitimises the revenue generated to fund the investment towards modernisation of public transport as well as protecting the environment i.e. limiting the number of vehicles on the road that cause air pollution.

During the past decades, the Malaysian economy has experienced rapid structural changes. In the early years after independence, the economy was mainly made up of the agriculture and mining sectors, with both sectors contributing a combined 45 per cent of GDP and 66 per cent of employment. Also in that period, over three quarters of the country's exports earnings were derived from tin and rubber which put Malaysia as the largest exporter of tin and rubber in the world (Zakariah and Ahmad, 1999). Meanwhile, with the implementation of the New Economic Policy (NEP) between the years of 1970 and 1990, the Malaysian economy had an average GDP growth of 6.7 percent annually. In 1991 through to 2000 the National Development Policy (NDP), was implemented, with the same economic growth-oriented theme. It was then followed by the National Vision Policy (NVP). The policy incorporates key strategies of the NEP and NDP while at the same time includes new dimensions towards a more competitive, dynamic and resilient economy by the year 2010 (EPU, 2004). During the period, the Malaysian economy was moving progressively from a resource-based economy to a processing and industrial economy. As a result, the manufacturing sector grew from 13.4 per cent of GDP in 1970 to 30.1 per cent in 2007, while at the same time the share of agriculture dwindled from 30.8 per cent to 7.6 per cent of GDP. Essentially, the period had seen Malaysia become less reliant on the agriculture sector. The year 1988 is significant for the Malaysian manufacturing sector where during the year for first time the sector surpassed agriculture in terms of share in GDP. Overall, the country achieved a substantial increased Gross National Income (GNI) from RM 4,948 million in the year 1957 to RM 739,451 million in 2010. At present, relative to other countries in the world, Malaysia is ranked as an upper middle-income country (World Bank, 2009). As a step forward, the government has declared its long-term vision for Malaysia to become a fully developed nation by 2020. Table 2.1 below presents the contribution of each sector which shows that the economy has undergone a major transformation between 1960 to 2007.

Table 2.1: Sectoral share of Malaysia's Gross Domestic Product, 1960-2007(percentage)

	1960	1970	1980	1990	2000	2005	2007
Agriculture	37.9	30.8	22.9	16.3	8.6	8.6	7.6
Mining	5.9	6.3	10.1	9.4	7.3	6.9	8.4
Manufacturing	8.5	13.4	19.6	24.6	32.0	31.5	30.1
Construction	3.0	3.9	4.6	3.5	3.3	3.4	3.0
Services	44.6	45.6	42.8	46.8	48.8	49.6	50.8
Real GDP (RM million)	5,866	10,609	53,308	119,081	356,401	449,250	505,353

Source: Department of Statistics, Malaysia.

The country's movements from being a resource-based economy took a major step forward when the manufacturing sector began to see a rise in the case of providing employment. The manufacturing sector had seen a rise in employment with an increase from 15.8 percent in 1980 to 23.5 percent in year 2000. During the same period employment in the agriculture sector had shrunk from 38.6 percent in 1980 to 16.7 percent in 2000. The same period had also seen the mining sector's employment fall from 1.8 percent in 1980 to 0.3 percent in 2000. This employment distribution by economic activity also followed the same pattern of GDP structure. This is shown in Table 2.2 below. Reflecting the labour intensity of manufactured exports, it is without a doubt that the expansion of manufacturing exports is responsible for a substantial portion of the additional jobs created in the manufacturing sector during the recent periods.

Table 2.2: Employment by sector, 1980-2007(percentage)

	1980	1985	1990	1995	2000	2005	2007
Agriculture	38.6	30.4	26.0	20.0	16.7	14.6	14.7
Mining	1.8	0.8	0.6	0.4	0.3	0.4	0.4
Manufacturing	15.8	15.0	19.9	23.3	23.5	19.8	18.8
Construction	5.5	7.4	6.3	8.0	8.2	9.0	8.8
Services	38.3	46.4	47.2	48.3	51.3	56.2	56.7
Real GDP (RM million)	5.08	5.99	7.00	7.89	9.56	10.41	10.54

Source: Department of Statistics, Malaysia.

Mani and Wheeler (1999) have ranked the ten most pollution intensive industries, namely Iron and steel (371), Non-ferrous metal (372), Non-metallic mineral product (369), Miscellaneous petroleum and coal product (354), Pulp and paper (341), Petroleum refineries (353), Industrial chemical (351), Other chemical (352), Wood products (331) and Glass products (362). They also suggest that dirty industries share some characteristics, namely, a relative capital, land and energy intensity. Mani and Wheeler (1999) summarize; "...our evidence suggests that dirty industries are relatively intensive in capital, energy and land; their clean counterparts are relatively intensive in labour, although the difference is not striking". In Malaysia, the industry composition in the manufacturing sector is very much mixed. Even though all the ten industries are present in Malaysia, they do not represent a big portion of the total manufacturing sector. Instead the lion's share of the manufacturing sector in Malaysia is electrical and electronic which stays at 30 per cent of total manufacturing. However, in terms of the absolute number, production by the pollution industries is quite big and contributes significantly to export earnings.

2.3 Exports and imports compositions

The external sector is a major contributor towards the growth of the Malaysian economy. As shown earlier, the past several decades had seen an impressive growth in the export sector. For example the total value of exports has increased from RM 28,172 million in 1980 to RM 605,153 million in 2007, a more than twentyfold increase. During the mid 1980s, the key contributor to exports was the primary commodities, constituting about 61.5 to 78.5 per cent of the Malaysian exports. However as the economy began to move away from a resource based economy, the structure of the country's exports also started to change. Tin and rubber, which once had been a major source of income in 1960s to 1980s, have now been replaced as the highest source of income. In 1980 rubber and tin represented 16.4 percent and 8.9 per cent of exports respectively. As shown in Table 2.4, a steep decline followed in the years after when exports of rubber and tin fell to less than two per cent. Towards the end of the 1980s Malaysia had stopped exporting tin ore as local production was just sufficient to cater for domestic consumption. Petroleum and liquid natural gas (LNG) are now the top export earners for the mining sector, while palm oil has also replaced rubber as the main export for the agriculture sector. Moving forward, the performance of this sector has been crucial for sustaining high rates of growth in the economy. Hence, given a small size of population, the nation is blessed with a boom in export incomes which can be channelled for social-economic development. However, the strong push for the export sector also comes in the form of various incentives from the government to local and foreign companies.

During the 1970s and early 1980s, manufactured products had only contributed between 12 to 22 percent of total exports. However since experiencing the lacklustre performance of commodity prices which had led to several years of negative growth in 1980s, the government decided to make a significant shift in its policy by providing incentives to attract foreign direct investment (FDI) in industrial activities. As shown in Table 2.3, foreign investment has increased dramatically from less than RM one billion in 1980to about RM twenty billion in 2000. A bulk of the investment is invested in the manufacturing sector.

Table 2.3: Foreign investment in Malaysia (RM million)

Year	Total investment
1980	730
1985	959
1990	17,629
1995	9,144
2000	19,849
2005	17,883

Source: Department of Statistics, Malaysia.

With the vision to move away from being a resource based economy and the introduction of the various new policies to support this vision the numbers began to substantially change as shown in Table 2.4. At present manufactured products have become the backbone of Malaysia's exports. Malaysia's exports of manufactured product had massively increased from making up of only 21.7 percent of total exports in 1980 to 85.3 percent in 2005. In contrast, there has been a drastic fall in the share of commodity export earnings in total exports. The largest component of manufactured exports is electrical and electronic products. This product constituted more than 70 percent of Malaysia's total manufactured product exports. Malaysia is now one of the largest exporters of computer hard discs, audio and video components, semi conductor devices and room air conditioners. Besides that the country's surplus of labour has encouraged industrial activities to diversify including such as construction building materials, domestic electric equipments, electrical and electronics, transport equipment and other manufacturing products. Other than that, the country also exports resource based commodities such as petroleum, and liquefied gas, chemicals, palm oil, woods and wood products, rubber products and textiles. In the meantime, despite the aim being to move away from depending on exports commodities, Malaysia is still a leading exporter in some commodities. Some of the country's exported commodities are palm oil, rubber and cocoa. At present Malaysia is the largest palm oil producer in the world. With strong global demand from Europe and China, the production of palm oil has increased over the years. Palm oil plantations are becoming a prevalent feature of the Malaysian landscape and it is likely to increase with the growing global demand. Palm oil is used as an ingredient in cooking oil, cosmetics, soaps, bread, and chocolate.

Table 2.4: Gross exports of major commodities, 1980-2007(percentage)

	1980	1985	1990	1995	2000	2005	2007
Rubber	16.4	7.5	3.8	2.2	0.3	0.6	1.2
Saw logs and sawn timber	14.1	9.7	8.9	3.3	3.1	1.1	0.9
Palm oil	9.2	10.4	5.5	5.6	2.7	4.5	5.8
Tin	8.9	4.2	1.1	0.3	0.1	0.0	0.0
Crude petroleum	23.8	23.6	13.4	3.6	3.8	3.3	5.4
LNG	-	6.1	3.3	1.7	3.1	3.4	4.3
Manufactures products	21.7	32.1	58.8	79.6	85.2	85.3	79.8
Others	5.9	6.6	5.2	3.7	1.7	1.8	2.5
Total exports (RM mill.)	28,172	38,094	79,646	184, 987	373,270	334,420	605,153

Source: Ministry of Finance, Economic Report 2006/2007 and Department of Statistics, Malaysia.

The country's imports have also been increasing over the years. As shown in Table 2.5 below, imports have been increasing in value from RM 23,451 million in 1980 to RM 504, 814 in 2007. Throughout the period, intermediate goods had been by far the largest component of the imports. In 1980 they made up nearly half of the imports, and increased to 71.4 per cent in 2007. Over 85 percent of the imports were used to cater the manufacturing industry. Imports for consumption have generally been in decline since 1990 to its lowest in 2000 which stands at 5.4 per cent. However the figure rises in 2007 to just over a tenth of the total imports. Imports for investment goods had risen steadily since 1980, from 30.0 percent to reach its highest at 40.5 percent in year 1995. However the figure had fallen drastically since then to its lowest point in 2007 at 13.1 percent. The reason for the trend may be due to the major infrastructure and various private investments that have taken place between the late 1980s and early 2000s. During the period, about 20.0 per cent of the imports were machinery while metal products made up about 12 per cent. It is worth noting that, imported machinery and technology are significantly important in helping Malaysian pursuit of achieving industrial nation status.

Table 2.5: Gross imports by economic function, 1980-2007 (percentage)

	1980	1985	1990	1995	2000	2005	2007
Consumption goods	18.4	21.5	16.4	14.2	5.4	6.3	10.1
Investment goods	30.0	31.1	37.5	40.5	14.6	15.6	13.1
Intermediate goods	49.8	46.5	45.4	44.7	74.6	71.9	71.4
Imports for re-exports	1.7	0.9	0.7	0.5	5.4	6.2	5.3
Total imports (RM mill.)	23,451	30,438	79,119	194,345	311,459	280,691	504,814

Source: Ministry of Finance, Economic Report 2006/2007 and Department of Statistics, Malaysia.

The importance of international trade to the Malaysian economy can also be measured by computing the degree of economic openness. Brulhart and Thorpe (2000) proposed the following measure as a proxy for economic openness: Trade Exposure (TE) = (exports + imports) / GDP or total trade divided by the gross domestic product where all figures are evaluated at nominal prices. Table 2.6 below contains the estimates of trade exposure for the period of 1960 to 2007. As seen below, Malaysian economic openness has increased over the years. In 2000, the total value of exports and imports was double the size of its economy. This trend is expected to continue following the government policy to further liberalize the industrial and services sectors. In sum, a thriving and viable external sector is a great asset to the country, and will play an important role in achieving a developed nation status in the year 2020.

Table 2.6: Exports, Imports, GDP and Trade Exposure (TE)

	1960	1970	1980	1990	2000	2006	2007
Exports (RM bill.)	2.93	5.16	28.17	79.65	373.27	588.97	605.15
(percentage to GDP)	*(49.9%)*	*(43.6%)*	*(52.8%)*	*(66.9%)*	*(104.7%)*	*(102.7%)*	*(94.3%)*
Imports (RM bill.)	2.15	4.29	23.45	79.12	311.46	480.77	504.81
(percentage to GDP)	*(36.6%)*	*(36.3%)*	*(44.0%)*	*(66.4%)*	*(87.4%)*	*(83.8%)*	*(78.6%)*
GDP (RM bill.)	5.87	11.83	53.31	119.08	356.40	573.74	641.86
Trade exposure	**0.9**	**0.8**	**1.0**	**1.3**	**2.0**	**2.0**	**1.9**

Source: DOSM (various publications)

Historically, the United States has been Malaysia's largest trade partner. In 2007 Malaysia had exported 21.9 percent of its exports to U.S. The trade mainly focuses on assembled electrical products and manufactured electronics. In 2007 Malaysia was positioned in the top 15 nations that the U.S most trades with. As of 2010 the top ten of Malaysian export destinations were the Republic of Singapore, the People's Republic of China, the European Union (EU), Japan, the United States of America, Thailand, Hong Kong, the Republic of Korea, Australia, and India. The total exports to these countries amounted to RM 497.9 billion or 77.9 percent of Malaysia's total exports in 2010. On the other hand the top ten nations that Malaysia imports from during the same period were Japan, the People's Republic of China, the Republic of Singapore, the United States of America, the European Union, Thailand, the Republic of Indonesia, the Republic of Korea, Taiwan and Hong Kong. The total imports from these nations amounted to RM 491.2 billion or about 76.8 percent of Malaysia's total imports. In terms of total trade, Malaysia's top ten trading partners for the year 2010 were the People's Republic of China, the Republic of Singapore, Japan, the European Union (EU), the United States of America, Thailand, the Republic of Korea, the Republic of Indonesia, Hong Kong and Taiwan. These countries in total have contributed 79.0 percent or RM 922.7 billion of Malaysia's total trade in 2010. (EPU, 2010).

In term of Malaysian trade with the regions, in 2010, North East Asia was the top destination for the Malaysian goods. The total exports to North East Asia for the year 2010 were valued at RM 223.9 billion or 35.0 percent of the total exports. The main country destinations are Japan, the People's Republic of China and Hong Kong. Malaysia's exports to ASEAN countries came second with the total exports amounting to RM162.5 billion or 25.4 percent of the total exports for the year. The main country destinations are the Republic of Singapore, Thailand, Indonesia and Vietnam. Malaysia's exports to the European Union (EU) contributed RM68.7 billion or 10.7 percent of Malaysia's total exports. Germany, Netherlands and France are the main destinations for this region. Exports to North America were valued at RM64.1 billion or 10.0 percent of total exports. The two destinations from this region are the United States of America and Canada. (EPU, 2010).

2.4 Conclusion

Given that the Malaysian economy is heavily reliant on the external sector, the ability of the economy to finance the country's socioeconomic development is genuinely determined by the performance of the sector. As such the sector is a pillar for the country's development and it is essential the sector continues to grow and prosper. Thus it is possible that any negative impact of economic growth led by trade on the environment may not give much weight in the country's development policies, even though there was acknowledgement of the importance of sustainable development by the government. Therefore in the context of the broad strategy in maintaining exports competitiveness the government may not be in favour of enforcing a very strict environmental regulation. Especially it is unlikely that the government would impose stricter environmental regulations compared to other competitors especially the neighbouring countries which may dampen the country's competitiveness. Instead the government may well continuously pursue a business friendly environment.

CHAPTER 3

The Malaysian Environment

3. 1 Introduction

As discussed in the previous chapter, since achieving its independence in 1957, Malaysia has continuously made progressive steps to develop its economy. The aim of the government is to achieve a sustaining and competitive economy. As the country moves more aggressively towards an industrialisation economy and trade liberalization in order to attain the goal, the side effect of the expansion of the economy is beginning to show. Over the years by-products of the country's economic development such as industrial externalities and deforestation clearly take their toll on the country's environment. The environmental degradation as will be discussed later came in many forms for which its harmful consequences were in relation with the scale of the degradation. A large scale degradation may cause major environmental disasters or calamities and lead to a serious health epidemic. By and large the harmful effect is not only limited to the party that contributed to the problem but it may well spread to surrounding local areas from where the pollution was emitted. That is very much the case for local or domestic pollutants such as soil pollution, water pollution, and some air pollution such as SO2, CO, NO2 and PM emissions. While in the case of trans-boundary pollution such as carbon dioxide (CO2) its effect will be even more wide spread which may well spread to the whole region or involve multiple countries.

Besides that, despite the fact that pollution emissions will occur immediately or simultaneously when the economic or consumption activity has taken place, the environment effect may not be seen instantly. Instead the environmental degradation may take months or years to be seen or felt and it also depends on the scale of the pollution. As such, the environment standards will be worsening when the pollution emission is continued or accumulated. However, whilst it is commonly agreed that the effect of economic expansion on the environment is not instant, the residents can certainly feel it is happening. Falling levels of air quality, degradation of water sources as well as the effects of green house gases from the deforestation are among the environmental deteriorations affecting the everyday life of the Malaysian residents. Also, while the threat of environmental deterioration may not come immediately, it consequences to human life and other inhabitants can be enormous in the medium and long terms.

Globally, the phenomena of environment degradation can be seen across countries. The United Nations of Environment Program (1999) in its study of the environment and trade relationship shows some stylized facts that are worthwhile to mention here. The issues that were touched on in the report had some degree of relation with Malaysia. Firstly, the study stated that the consumption of energy had risen by nearly 70 per cent since 1971 and it will increase by 2 per cent annually for the next 15 years. The knock on effect of this is that the green house gas emission would rise by 50 per cent over the current levels. The study noted that a substantial effort is needed to increase energy efficiency and efforts must be made to move from being over reliant on fossil fuel. Secondly, the study also stated that since the signing to the 1987 Montreal protocol the usage of ozone layer depletion substances had gone down by 70 per cent. However, despite the encouraging figure, it would still take at least 50 years for the ozone layer to return to its normal level even if all countries live up to their commitment. Thirdly, the study showed that whilst the occurrence of acid rain is declining in many developed countries, the trend is in the opposite direction in the developing countries. The study found that stringent policy on usage of nitrogen oxide and sulphur dioxide and emission helps to reduce the amount of acid rain in developed nations. However the same cannot be said for developing countries. It is estimated that if the current trend of emission continues, the amount of sulphur dioxide discharged in Asia would be doubled by 2020. Fourthly, the study highlights the effect of excess nitrogen on the environment. Excess nitrogen coming from fertilizer, fossil fuel burning and human sewage has begun to overwhelm the nitrogen cycle. This in return would cause soil fertility to drop and can also cause over feeding of lakes, rivers and coastal waters. Given the current trend, it is expected that the amount of biological nitrogen will be doubled in 25 years.

Fifthly, with regards to deforestation which is the main concern the world is experiencing at the moment, the study found that there is no sign of abatement in deforestation. It shows that in the space of 30 years, between 1960 and 1990, 20 per cent of all tropical forest in the world was cleared. The study pointed out that the Amazons alone had seen 20000 square kilometres of it woodland cleared every year. The study also found that the government endorsement and the subsidies given had encouraged the transformation of forest land to large scale ranching and plantation at a more rapid pace. The study sees this as the main reason for the depletion of the natural tropical forest in developing countries. On the other hand, forest area for developed countries remains stable if not increasing slightly during the same time period. One knock on effect of deforestation is the endangerment of bio diversity. Habitat reduction caused by deforestation is one of the causes of the bio diversity equilibrium failing. Finally, global water consumption was also touched on in the study. With consumption increasing at an alarming rate, it is believed it will become one of the most pressing issues in the 21st century. A third of the global population is already experiencing moderate water shortages and it is estimated this can rise to two thirds in 30 years time if no serious water conservation measures are taken.

The immense deterioration to the environment quality which occurs worldwide as just shown may be contributed by many factors. But the overall verdict is all the major blows to the environment pin-point towards 'manmade'. To the trade opponents, they openly associate the environmental degradation as a result of the tremendous increase in the volume of international trade. By and large, it is difficult to dispute their accusation. Even though the rapid flow of goods and services worldwide is seen as a positive contribution to the economic convergence and increases welfare, its also come with hefty prices. Unless continuous effort and concerted actions are taken to mitigate the degradation that occurs beyond the individual country, the world risks major calamities.

Turning to the scenario of domestic environmental degradation, compared to other countries, Malaysia is very fortunate that generally it has not experienced any major environment disaster. Instead the country frequently faces a moderate scale of seasonal disasters including flood, drought and landslide. However the pollution caused by human activities especially economic activity is becoming a major concern. The government's outward policy is seen as instrumental in creating many industrial areas across the country. For many years especially for the last two decades the government has used the expansion of international trade to spur the economic growth. The growth of the country's economy would in turn help to increase the wealth of its people thus raising their standard of living. But as the economy begins to grow, the side effects began to be felt and people have slowly recognised the deteriorating of their quality of lives.

3. 2 Overview of the country climate and rainfall

Due to its proximity to the equator, Malaysia is a humid tropical country and its climate is characterized by maritime monsoon winds which are subject to interference by mountains in Peninsular Malaysia, Borneo and Sumatra. The annual rainfall is about 990 billion m3. Out of this, 360 billion m3 evaporates or transpires into the atmosphere. A further 566 billion m3 forms surface run-off whilst the remaining 64 million m3 constitutes groundwater recharge. The country's average annual rainfall is between 2420 to 2630 mm/yr. The monthly mean air temperature is 25'C to 28'C in the coastal lowlands and monthly relative humidity is between 75 to 90%.

3.3 Energy consumption and its trend

Energy is essential for economic development. However as is commonly known, use of fossil fuel (oil and natural gas), coal and coke for electricity generation, transportation and other industrial sectors can have adverse environmental effects. As shown in Table 3.1, Malaysia's largest energy resources are natural gas and coal, while hydroelectricity and oil comprise the other main sources of power. Crude oil and petroleum products which provided about 81 per cent of the total energy supply in 2000 are predicted to grow at 6.3 per cent per year. (DOEM, 2002). According to the 9th Malaysia Plan, the country's peak electricity demand is expected to increase at 7.8% per annum by the year 2010. Toward the sustainable development the country needs to increase energy efficiency and at the same time the use of energy that generates pollution implications needs to be curtailed. Perhaps it is time for the government to implement an environmental tax policy which could stimulate the use of clean technology to reduce the negative impact on the environment and at the same time does not dampen growth.

Table 3.1: Fuel Mix In Electricity Generation, 2000-2010

Year	Oil	Coal	Gas	Hydro	Others	Total
	% of Total					(GWh)
2000	4.2	8.8	77.0	10.0	0.0	6,928
2005	2.2	21.8	70.2	5.5	0.3	94,299
2010	0.2	36.5	55.9	5.6	1.8	137,909

Source: Tenaga National Berhad, Malaysia.

3.4 Environment policy and regulation

As the global community begins to realize the importance of conserving the environment more effort was put into place. Legislation and investments in improving the environment and preventing its degradation are now given a strong emphasis in national policies around the globe. The measures undertaken are not only restricted to national level but also across the globe. Essentially, an agreement needs to be agreed upon, on the steps needed to be taken to preserve the environment. The Kyoto Protocol is one such agreement. The Kyoto Protocol is basically an agreement between nations worldwide with the aim of achieving the "stabilization of greenhouse gas concentrations in the atmosphere".

In Malaysia, various laws and regulations are in place to protect the environment degradation. The main environmental regulation is the Environment Quality Act (EQA) which passed into legislation in 1974 and was amended in 1985. Basically this act enables the Malaysian Department of Environment to enforce the environmental related law which encompasses the prevention, abatement, and control of pollution. This act also enables it to act accordingly in order to enhance the quality of environment and for any other purpose that is related to improving the environment. Under this act, new projects that are put under the *high impact project* category will have to produce an Environmental Impact assessment (EIA).The act also makes it clear what is considered as pollution which includes, "any direct or indirect alteration of the physical, thermal, chemical, biological or radioactive properties of any part of the environment by discharging, emitting, or depositing wastes so as to affect any beneficial use adversely, to cause condition which is hazardous or potentially hazardous to public safety, or welfare, or to animal, birds, wildlife, fish or aquatic life, or to plants or to cause a contravention of any condition, limitation or restriction to which a licence under this act". (DOE, 2006). Hence, with the provision of the act, the DOEM acts as a main agency that is responsible for overall supervision of the Malaysian environment.

Other than the Environment Quality Act, there are also several other pieces of environmental related legislation. Amongst them are The Land Conservation Act that was passed in 1960, the 1934 Forest Enactment as well as the 1935 Forest Rule. The Water Enactment and The Mining Enactment were both passed in the same year, 1935. There is also the Street, Drainage and Building Act that was amended in 1978 and also the Provisions under Standard Logging Permits which concern logging permits and addressed Malaysia's deforestation issues. These pieces of legislation provide restrictions and give procedures one must undergo in order to use natural resources. These regulations enable the government and the authority control, to protect and limit any damage caused by human activities. Apart from the legislation that is already in place, the country blueprint of development plans such as the series of Malaysian five-year plans and the National Development Plan (NDP) have also re-enforced the need for good environment management and ecological protection for sustainable development.

The commitment given by the government to continue and enhance sustainable development has made Malaysia's environment standard relatively better than other developing countries. The realization of the importance of protecting the environment amongst the policy makers as well as the general public has raised the profile of the environment conservation and protection in the national development agenda. It is becoming apparent and acknowledged in the policy documents that the natural environment needs to be preserved, so it can continuously serve as the important provider of raw inputs in economic processes, ecological services and natural amenities. For example, this is strongly manifested in the policy thrusts of the Eighth Malaysia Plan and the country's latest long-run Outline Perspective Plan. Further to this, the National Environment Policy has also stated an explicit recognition of the importance of environmental variables to take into consideration in development planning at the macro and project levels.

This resulted in a more integrated and holistic management of the environment and natural resources. Regulatory framework and the institutional capacity were strengthened and new planning tools and different approaches to planning were introduced. Being a strong proponent of sustainable development, Malaysia's Green Strategies were recently created to endorse environmental related research and programmes. Various incentives such as pioneer status for investments, exemption of import duty and sales tax relating to energy conservation, energy efficiency, renewal energy, recycling and reduction of greenhouse gas emissions have been provided for companies going 'green'. The National Transport and National Energy Policy are put in place in a direct effort to reduce gas emissions from motor vehicles and industries.

Whilst passing new regulations and legislation in order to protect the environment, Malaysia also tries to abide by its commitment to international environment related agreements. Amongst those conventions is the Montreal Protocol. The protocol was signed in 1987 in a bid to protect the ozone layer. This is the first concrete step taken to protect the ozone layer from serious harmful substances such as chlorofluorocarbons (CFCs). In a bid to contribute to its commitment to the protocol, Malaysia has slowly begun to phase out Ozone Depletion Substances (ODS) and industries using CFCs. Earlier than that, Malaysia had jointed the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES), which was signed in 1977. Furthermore in an effort to improve its environment standard Malaysia had also became a member of the United Nations Conference on Environment and Development (UNCED). Actions by the government were recently praised and globally Malaysia is ranked 27th out of 133 nations in the 2008 Environment Performing Index in addressing its environmental issues, higher than countries like Australia, the United States and Netherlands.

In many countries, the key issue is effective enforcement of the regulations. Very often issues relating to pollution reduction and abatement rely heavily on the enforcement of already in place regulation. Many times countries have failed to uphold their environment pledge because of failure in enforcing their policy. As suggested in the literature, monitoring and enforcement are imperfect, i.e. legislative actions are not necessarily accompanied by actual implementations. There are many reasons for poor enforcement but one that always plagues the enforcement department is corruption. Countries in the north often suggest that corrupt and weak regional or national institutions are directly responsible for environment-degradation activities in developing countries. It is very hard to measure the absolute level of corruption. It is even harder to measure the level of corruption in a country to the enforcement of environmental law. However the level of perception of what people have towards their own government may help to give researchers an idea of the level of corruption in a country. The Corruption Perception Index (CPI) was first conducted and then published in 1995. The CPI is produced by Transparency International with an aim to rank countries according to the people's perception of corruption of a country based on several assessments.

One weakness of using the CPI as indicator is that the CPI represents the overall perception of corruption in a country. It does not accurately classify whether the CPI is related with enforcement of environmental law. However based on the CPI, one can generalise the level of corruption in practice when enforcing regulation within a country. For a government to fully utilise its resources, having less corruption is a must. In pursuit of developing a more developed economy, corruption practices are bound to happen. Cutting corners and misusing resources for individual gain are one of the many corrupted practices that can happen in a developing country. In terms of enforcement of the regulation, there is potential for enforcement officers to turn a blind eye to an incident involving enforcement of environmental regulation. Sometimes lack of enforcement takes the form of sacrificing the long term gain and country pledges in order to aggressively pursue the country's economic policy. For example in pursuing an industrialized economy status, factories not having the proper sewerage system are built to cater demands despite publicly commenting that it would not allow such construction to take place. It is very similar to the race to the bottom situation where nations in actual fact ignored the environmental aspect and went after economic prosperity. Only in this case the country did not make this circumstance public and instead paints a different portrait for the public.

In Malaysia, perhaps one of the most heavily linked corruption practices linked with the environment is illegal logging. Malaysia is home to one of the largest tropical rainforest in Southeast Asia. It is home to hundreds of species of rare wildlife as well as a breeding ground for high quality timber. Timber from Malaysia is well known to be used for furniture making due to its quality. In the past illegal loggers had illegally cut down woodlands in order to obtain such timber and sell it on the black market. Illegal logging affects Malaysia and its population in many ways. Illegal logging affects the environment in Malaysia in the way that it affects the water catchment areas. Water quality falls with silt and loose soil from unplanned logging entering local waterways. Illegal loggings also affect the country economically. In 2005, the government announced that illegal loggers could face jail sentences of up to 20 years in a crackdown on illegal logging activities. Despite the crackdown the fallout from these illegal activities is catching up with the present population. Landslides are now becoming much more common in Malaysia especially with areas close to steep hills or cliffs.

However, it is not very clear that corruption does affect the level of enforcement. Many programs were enacted in an attempt to stop corruptions. Segregation of duties is becoming popular in an effort to reduce chances of corruption. In many international companies in order to stop corruption and company secrets being exposed staff and company officials are being segregated. This is to stop one group of staff or personnel from having too much power or control. By limiting one's power and influence the chances of corruption and corporate espionage can be reduced. The same principal can be applied into government offices and officials in the sense that their power be limited and influence be restricted. Environment offices can segregate their officers and limit their influence over certain tasks. Other initiatives to combat corruption include increasing transparency and taking up initiatives to involve the public in evaluating or monitoring the enforcement of policy and regulation. In an attempt to involve the public in monitoring illegal loggings in Malaysia, Transparent International

Malaysia launched the Forest Watch Project. The project aims to make the public its eyes and ears and urges them to report any possible illegal logging practices. Such initiatives will help to reduce illegal logging activities and will reduce the chances of corruption amongst enforcement officers because they will be under more scrutiny by the public. Hence, the bigger challenge is how to promote a stronger work culture.

3.5 Type of pollution / environmental degradation

There are different types of environment pollutions, among others are air pollution, water pollution, soil pollution and deforestation (and off-shore pollution). Most of the pollutions are related to the human activity that occurred along with socioeconomic advancement. In the case of air pollution the source of the pollution can be from mobile or static sources. The mobile sources are mainly from transportation and open burning, while static sources are from industrial activities. The sources of the pollution can be generated by economic (businesses) activity or consumption activity. In the case of water and soil pollution the source is mainly from static sources including industrial, agriculture and the effect of deforestation.

3.5.1 Air pollution

With rapid economic growth and development, urbanization and industrialization has caused people to be highly mobile. A high demand for mobility and the excessive use of fossil fuel has contributed to falling air quality standards and is becoming a major problem for the Malaysian society. Air quality is reaching critical levels in a number of urban areas. The increasing numbers of cars and motorcycles on the roads is a major contributor to this problem. Because much of the traffic is mostly condensed to several specific urban areas, the standard of air quality tends be very poor. Some of these urban areas are Kuala Lumpur, Petaling Jaya, Prai and Johor Bharu.

Other than traffic, the manufacturing sector is also one of the major causes of air pollution. Industrial sites in Malaysia are often built on lands that once belonged to the tropical forest. However, due to the early government policy of achieving an industrialized economy and the goal of freeing the economy from being over reliant on the agriculture sector, much forest land was cleared to be made into industrial sites. Factories were built on the land in a bid to increase the country's manufacturing sector capacity. One industrial site that was set up on what was previously forest land is Shah Alam in the Selangor state. In these industrial areas, not only were trees cut down, thus decreasing the amount of oxygen available, but the burning of fossil fuel and the by-product fumes from the factories are causing the air quality to fall. Naturally as the site began to grow, many people would migrate to these industrial sites in search of better working opportunities and better living standards. Shah Alam is now considered as one of the most densely populated areas in Malaysia and through the use of motor vehicle increases for the purpose of mobility, it is one of the most polluted areas in the country.

Another issue that is faced by the Malaysians is the haze caused by the pollution. To be exact the haze was caused by the wildfire and open burning that occurred in neighbouring countries. The worst case of haze to have happened was in 2005 when smoke from forest burning in neighbouring country Indonesia caused severe visibility problems and respiratory issues. The problem nearly brought the central Peninsular Malaysia to a standstill. Smoke from the forest fires on the Indonesian island of Sumatra was identified as the main cause. Farmers commonly burn scrub and forest to clear land during the dry season for agricultural purposes. On August 10, 2005, air quality in Malaysia's capital was so poor to force health officials to advise residents to stay at home with doors closed. Some schools were closed to keep children from being exposed to the haze. A state of emergency was also given during the crisis to Port Klang and the district of Kuala Selangor as air pollution there had reached dangerous levels. Air quality later returned to normal as the smoke began to move northwards and visibility returned to normal.

A study in Europe in 1999 as shown in Table 3.2, suggests that the contribution of the three key sectors to air pollution varies depending on the type of pollutant. For example in the case of CO the main contributor is from the transport sector while in the case of SO_2 the energy sector is the key contributor to the emissions.

Table 3.2: Source of SO_2, CO and NO_2

	SO2	CO	NO2
% From transport	6.50%	53.70%	21.40%
% From industry	30.20%	17.50%	20.60%
% From energy transformation	51.20%	23.20%	42.40%
Atmospheric life	1-10 days	1 day	50-200 yrs
Resultant impact			
Local	Yes	Yes	No
Transboundary	Yes	Yes	No
Global	No	No	Yes

Source: Cole and Elliott (2003)

The report from DOEM (2005) showed that air pollution caused by motorized vehicles, was responsible for 98 percent of carbon dioxide (CO_2) emissions and 70 percent of nitrogen oxides emission. As nearly all carbon dioxide is caused by motorised vehicles the main focus of the government is to reduce emissions from these vehicles. One of the steps taken by the government is to introduce tax on import's vehicles. An exception and subsidies are given to gas driven trucks and busses. These measures are taken in the hope that there will be more gas driven vehicles rather than petroleum or diesel driven vehicles. In the 2009 budget, there were tax and duty exemptions for foreign hybrid cars. Furthermore the government had also already banned the practice of open burning in a bid to reduce poisonous fumes released to the air. The Environmental Quality Regulation had also been passed in 2003 where it will be used to regulate several environmental issues such as vehicle emissions and uncontrolled open burning. In the latest Ninth Malaysia Plan, the government aims to improve the standard of air quality by encouraging the use and development of cleaner technologies and by restricting the release of harmful gases. In order to achieve this, the Malaysian government decided that the sulphur content in diesel and petrol is to be reduced.

Issues regarding local and global pollutants and their abatement policies have been discussed for some time. In discussing policies and regulations, one has to first understand the characteristics and differences between these two types of pollutants. Local pollutants are called in such a way because the pollutants produced often stay around the area they originated from. In this study local pollutants are classed as staying locally or in the immediate vicinity of the country. Most local pollutants have a short life span thus the effect from local pollutant tends to stay locally and very rarely affects globally. In this study, examples of local pollutants are Sulphur Dioxide (SO2) whose atmospheric life often lasts between 1 to 10 days and Carbon Monoxide (CO) whose atmospheric life often lasts no more than a day. Most local pollutants affect the local population in term of health. Sulphur Dioxide (SO2) is well known as one of the causes of respiratory problems. Concentration of Sulphur Dioxide (SO2) in the atmosphere is also known to be able to influence the ecosystem for plant communities as well as animal life. Carbon Monoxide (CO) is the leading cause of poisoning through inhalation in many countries. Carbon Monoxide (CO) is a highly toxic gas which if inhaled in large quantities will often be fatal. Amongst common symptoms of Carbon Monoxide (CO) poisoning are light headedness, feeling weak, vomiting and fatigue.

Global pollutants on the other hand have a very long life span. Because of this, global pollutants tend to affect the population on a global scale. Examples of global pollutants are Carbon Dioxide (CO2) and Nitrogen Dioxide (NO2) whose atmospheric life often lasts between 50 to 200 years. Nitrogen Dioxide (NO2) is notoriously known as one of the components that give rise to acid rain. It is also known that Carbon Dioxide (CO2) is one of the components that contribute to greenhouse gases and ozone layer depletion. Empirical studies show that some evidence of Environmental Kuznets Curve (see Section 4.2) can be seen for most air pollutants except for Carbon Dioxide (C02). This is consistent with the fact that carbon emissions seem to increase globally. Hence, it is recognised that some environmental degradations are global in nature.

Based on a study as shown in Table 3.2, a large proportion of emissions of local and global pollutants are from energy transformation. It is important to this study to identify and classify these pollutants as it is important to recognise whether the pollutants in existence in Malaysia originated from within the country and due to economic change. For local pollutants it is easier for one to prove and limit the negative impact to the country of origin. Regulation and policy to address the local pollution are normally easier to implement by the national government. Less time is needed to pinpoint the origin of pollutants and resources can be coordinated more easily on effort to combat these pollutants. However the same cannot be said in the case of global pollutants.

The negative impact of global pollutants is spread all over the world. Because of the nature of global pollutants it is very hard for countries around the world to take individual measures without global support from other nations around the globe. Coordinated global movements are needed to prevent or reduce global pollution so that any abatement or prevention policy can be effective. Examples of such coordinated efforts are the Kyoto protocol, Montreal protocol and regional cooperation in OECD countries. It is observed that environmental cooperation among developed economies is more obvious compared to less developed economies. One may suggest this is due to a larger gap in economic structure and income level among the countries in the region, for example in the case of the East Asian region, making such environmental cooperation more difficult to take place. In the regions where the gap in income levels is narrowed, the similar cooperation on environment issues is much easier to be executed and sustained, such as in the OECD group.

The focus of this study is on local pollution i.e. the case of industrial and local pollution in Malaysia. In the case of local pollution, an individual country has more control in terms of abatement and prevention. In the case of prevention, this study tries to find whether globalisation and increasing international trade actually causes local pollution to increase.

3.5.2 Water pollution

Starting from around 1970, the construction of factories to manufacture agro-based products contributed in a major way to the pollution load in Malaysian rivers. Because more factories were hastily built in order to keep with to early government policy, the irrigation and disposal of by products from these factories was not properly induced. Waterways and rivers were used to dispose of such waste instead of a proper sewerage system. Water pollution in Malaysia originated from two sources. They are point sources and non-point sources. Among the sources that have been identified as point sources are manufacturing industries and sewage treatment plants. Animal farms are also included as point sources for water pollution. Non-point sources are mainly diffused ones such as agricultural activities and surface runoffs. A report published by the Department of Environment, Malaysia Environment Quality Report 2004, had stated that 17,991 water pollutions had been recorded to come from point sources. Most of the pollution comprises of mainly sewage treatment with 54 per cent, taking up over half of the total water pollution that came from point sources. Second highest was manufacturing industry with 38 percent. Animal farms came next with 5 per cent and agro-based industries with 3 percent.

In total, out of the 1064 water quality monitoring stations that are located within 146 river basins, 619 or 58 per cent were found to be clean, 34 per cent or 359 were categorized as slightly polluted and 86 or 8 per cent were polluted. In term of river basins 7 were categorized as polluted, 59 were slightly polluted and 80 river basins were clean. The report by the Department of Environment also found that the main contributors of water pollution were Biochemical Oxygen Demand (BOD), Ammonia Nitrogen (NH3-N) and Suspended Solids (SS). In the 2006 report, 22 river basins were found to be polluted by BOD, 41 river basins were contaminated by NH3-N and 42 river basins were by SS. It was found that a high proportion of High BOD mainly originated by untreated or partially treated sewage and discharges from manufacturing and agro-based industries. The main sources of NH3-N on the other hand were mainly from domestic sewage and livestock farming. And lastly sources for SS were mostly from earthworks and land clearing activities.

In terms of conserving and improving water qualities, the Malaysian government undertook several major measures. One of them is the adoption of the Water Services Industry Bill for the purpose of reforming the water industry. The bill was introduced to address issues faced by the government when the move to privatize the water industry had produced some negative side effects. The move to privatize the water industry led to a mixture of management systems which are deemed to have too many drawbacks. Some states have completely privatized their water industry whilst some are still in public hands. This mixture of management had resulted in some states not receiving enough investment for the industry. Consequently, due to the lack of investment, consumers' complaints due to supply shortage and poor water quality increased.

Both the Water Services Industry Bill and the later-introduced National Water Services Commission Bill transferred responsibility and control of the water industry from state level to the federal government level. This new regulation is hoped to give the country wide harmonization of the water industry.

3.5.3 Soil pollution and deforestation

Malaysia is blessed with many natural resources. Like many other countries in the region, the land in Malaysia is mostly covered by tropical rainforest. The total forest area in Malaysia is estimated to be around 19.93 million hectares, roughly 60.7 percent of total land area. Of this, just over 88 percent of total forest area or 17.56 million hectares are classified as Inland Dipterocarp forest, 1.56 million hectares are Peat Swamp Forest, 0.58 million hectares are Mangrove Swamp Forest and 0.23 million hectares are of Plantation Forest. Given the amount of areas covered by forestland, it is unsurprising to hear of woodland cleared to give way to industrialization. In order to utilise the land resource properly hectares of woodland were cleared. This woodland would be cleared so a new industrialised site or new township could be placed.

In order to cope with higher demand for palm oil more plantations are needed. Forest areas were cleared and huge plantations were built to cater for the demand. This intensive use of land has had a wide range of effects on the environment. Land development for agriculture interferes with soil formation. This causes the soil to be exposed to both water and land erosion. Soil erosion in some part of the country can be severe due to heavy rainstorms that can hit certain areas of the country. The eroded soil will end up as sediments in rivers and could end up as pollutant in the waterways. A report by DOEM (2005) shows that the majority of suspended solids in Malaysia's waterways are silts. Use of pesticides and fertilizers also poses problems to the soil as the accumulated residue of pesticide and fertilizers can cause soil fertility to deteriorate.

Other than for agriculture purposes, deterioration of forest areas is also due to excessive and uncontrolled as well as illegal logging. Malaysian rainforests are blessed with many different species and type of trees. Woods from these trees are extremely valuable and can fetch a high price especially in the black market. The consequences of uncontrolled and illegal loggings are now felt more than ever as more mudslides are occurring at an alarming rate.

3.6 International Comparisons

In the past two decades Malaysia's economy had grown at a rapid pace. With an aggressive economic blueprint it is easy to mismanage the waste produced. Table 3.3 below shows the amount of organic water pollutant from industrial activity for the period 1990 to 2004. It also shows the percentage of change between the years. It also provides comparison on how Malaysia fares compared to its Asian neighbours. From the table Malaysia produced nearly 105,000 kg of water pollutants per day in 1990. However in 2004 this number had increased by just over 75 per cent to 183,000 kg per day. In comparison, China, Asia's largest economy, had 33 times more water pollutant emitted from industrial activities in 2004. However relative to the year 1990, China's water pollutant emission had actually gone down by 13.5 per cent. Despite growing at a faster rate than Malaysia, China has actually managed to reduce its water pollutant by 13.5 per cent which is a stark contrast to Malaysia. The emission of BOD from industrial activity also increased in India and Indonesia but at much lower growth rate compared to Malaysia between the years.

Table 3.3: Emission of organic water pollutant (BOD) from industrial activity.

Thousands kg per day

	1990	2004	% of change
China	7038.1	6088.7	-13.5
Japan	1556.1	1184.7	-23.9
Korea	369.2	315.2	-14.6
Philippine	228.3	-	-
Cambodia	11.8	-	-
Thailand	291.6	-	-
Malaysia	104.7	183.8	75.5
Indonesia	495.6	733.0	47.9
India	1410.6	1519.8	7.7

Source: World Bank (2008)

Table 3.4 below shows the changes in forestland area between the 2000 and 2005. Between the period of 2000 to 2005, Malaysia has lost over 701,000 hectares of forestland which on average gives a 140,000 hectares reduction annually. However in comparison to its Asian neighbours Malaysia's loss of forestland is not the most. Indonesia recorded the largest area of lost forestland, with an annual average loss of 187,2000 hectares. The main reason for this loss is somewhat similar to Malaysia when it was still in its early years of economic expansion. Forestlands are cleared to make way for plantation and agricultural production purposes. Also illegal logging and increased agriculture exports such as palm oil causes deforestation to continue. In the past Malaysia also suffered from the same problems although stringent policy and regulation managed to reduce the rate of deforestation. Indonesia's deforestation does not only affect the country on its own but also causes problems to its neighbouring country. The manner how Indonesia's deforestation takes place also affects Malaysia. In the past farmers often decided to burn the forestland as a cheap and cost-saving way of clearing the land. The smoke from this burning often causes problem for neighbouring countries as it causes severe haze which on several occasions causes significant problems. Only recently an agreement between the nations managed to overcome this severe haze and open burning issue.

Table 3.4: Deforestation in Asia (thousands hectares)

	2000	2005	Annual change	Annual change rate (%)
China	177001	197290	4058	2.2
Japan	24876	24868	-2	-0.0
Korea	6300	6265	-7	-0.1
Philippines	7949	7162	-157	-2.1
Vietnam	11725	12931	241	2.0
Cambodia	11541	10447	-219	-2.0
Laos	16532	16142	-78	-0.5
Thailand	14814	14520	-59	-0.4
Malaysia	21591	20890	-140	-0.7
Indonesia	97852	88495	-1872	-2.0
India	67554	67701	29	0.0

Source: FAO Forest Resource Assessment 2005

Table 3.5: Environmental Performance Index (EPI), Human Development Index (HDI) and Per Capita GDP – A cross country view.

Country	EPI Score (2006)	HDI Score (2005)	Per Cap. GDP (PPP USD) (2005)
Bangladesh	43.5 (125)	0.547 (140)	2053
China	56.2 (94)	0.777 (81)	6757
India	47.7 (118)	0.619 (128)	3452
Indonesia	60.7 (79)	0.728 (107)	3843
Malaysia	83.3 (9)	0.811 (63)	10882
Myanmar	57.0 (88)	0.583 (132)	1027
Nepal	60.2 (81)	0.534 (142)	1550
Pakistan	41.1 (127)	0.551 (136)	2370
Philippines	69.4 (55)	0.771 (90)	5137
Sri Lanka	64.6 (67)	0.743 (99)	4595
Thailand	66.8 (61)	0.781 (78)	8677
Niger	25.7 (133)	0.374 (174)	781
New Zealand	88.0 (1)	0.943 (19)	24996

Figure in the parenthesis shows the rank of the country for the corresponding score.
Source: Esty, *et. al.*, (2006), UNDP (2007/2008)

Table 3.5 provides a comparison between Malaysia and several of its neighbours based on several indexes. The parentheses show the rank of the country for the corresponding score. The EPI statistics are obtained from Esty, et.al, (2006) who provide the EPI scores and its ranks. In comparison with its ASEAN neighbours, in 2006, Malaysia ranks the highest in the EPI score and sits at number

9 overall of 133 countries under review. The EPI reflects Malaysia performance in managing its environment and policy. However in the latest publication of EPI for the year 2012, Malaysia has fallen to number 25. The drop in ranking raises the question whether Malaysia is sacrificing its environment policy for economic growth. This is where this research comes in, where in regards to environment standard, this research tries to examine whether Malaysia is sacrificing its environment in exchange for trade expansion and is industrialization really the cause of environment degradation in Malaysia. Meanwhile, HDI and its scores are published in Human Development Report 2007/2008 (UNDP, 2007) which covers 177 countries. Overall, Table 3.5 shows Malaysia is ranked remarkably well in terms of EPI against the backdrop of a medium level of per capita GDP (US$ 10882) which is about the same level of per capita GDP as Thailand (US$ 8677). Despite per capita GDP for both countries being comparable, Malaysia is ranked number nine while Thailand is at number sixty-one in EPI.

3.7 Conclusion

Maintaining and protecting the environment is very important and it is a great challenge to achieve development without permanently damaging the environment for future generations. It is the duty of every citizen of the earth, particularly those at the helm of policy and decision-making to protect the environment. The government must ensure that development will take place in a balanced approach. A concerted effort and adequate law and regulation shall continue to be enforced and externalities from economic activities must be minimised. In Malaysia, as a result of the rapid economic growth in the country over the past four decades, the effort to mitigate the environmental degradation especially air and water pollution is become more challenging. Towards achieving developed-nation status, maintaining a good environment quality continues to be an important challenge faced by the country. Environmental degradation continues to be seen. If this is not addressed earlier it could derail the path of the country's development and may jeopardise all the long term development programs set by the government. Also, consequently, there is evidence showing that as the country becomes more developed, the cost of medical care especially inpatient hospital care has escalated tremendously. This will impose a significant burden on the country's economy.

The deterioration of environment standards in recent years is becoming an everyday issue of importance to the average Malaysian. There are many complex issues still remaining for policy-makers in the trade-offs between quantifiable economic benefits gained from natural resource utilization (or abuse) and the unquantifiable cost (or benefits) from doing so. Essentially, the common drawback of industrialisation experienced in many other countries is also hurting the country. As shown earlier, rapid expansion of economic activity especially industrial growth together with transportation is largely indentified as the main cause of the deterioration of air quality in the country. Overall, on the effort to ease environmental pressure, the government scrupulously acted by introducing gradually an environmental legal framework in monitoring the environment standards. Furthermore, a wise management of natural resources and the environment is imperative to ensure sustained economic growth and development. Finally, in its quest for developed-nation status, the right balance and sustainable development should be a key consideration in each policy formulation.

Appendix 3.1

Description of selected pollutants

Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless gas, arising from the incomplete burning of fossil fuels. Although carbon dioxide and carbon monoxide both arise from the combustion of fossil fuels, the contaminants exhibit different fates. Carbon dioxide persists in the atmosphere, whereas carbon monoxide remains in the atmosphere for an average of two months. Therefore, changes in emissions of carbon monoxide have a more rapid effect on atmospheric concentrations. Although carbon monoxide is odourless and colourless, its localized health effects (shortness of breath and dizziness, for example) make it a good candidate for a strong political economy effect.

Carbon dioxide

Carbon dioxide (CO2), like CO, is a colourless, odourless gas, released from fossil fuel combustion. As one of the primary culprits in global warming, CO2 is a pure "public bad" whose effects are not restricted by country boundaries. As such, it is subject to the international "free rider" problem.

Sulphur dioxide

Sulphur dioxide is a colourless gas with a pungent odour. It is formed when fuels containing sulphur (mainly coal and oil) are burned, and during various industrial processes, such as smelting. Short-term exposure to high levels of sulphur dioxide can be life-threatening. Long-term exposure to atmospheric sulphur dioxide can lead to or exacerbate asthma and other respiratory illnesses, and aggravate existing heart disease. In addition, sulphur dioxide is a precursor to acid rain, which leads to the corrosion of buildings, monuments, and other structures, and has adverse impacts on forests and aquatic ecosystems. Sulphur dioxide in the atmosphere is highly visible and can be transported long distances.

Source: U.S. Environmental Protection Agency, 2003.

CHAPTER 4

Review of Literature and Analytical Framework

4.1 Introduction

Since 1990, the average growth of the world international trade has exceeded 6 percent, while the world's merchandise output growth has averaged at only 3 per cent, confirming that international trade is continuing at a rapid pace (WTO, 1996). The liberalization of China's economy starting with its inception into the World Trade Organization (WTO) in 2001 has pushed the volume of world trade to a new level and the rates of expansion have continued to increase since then. The rapid expansion of world trade has also come at a time when evidence of environmental degradations across the globe has risen. This scenario has brought forth divided opinions on globalization and trade liberalization. The first is a group who are favourable to trade liberalization and the second group is of the opposite. The rise of various environmental issues such as global warming, climate change, ecological degradation and industrial pollution has made international trade liberalization policy to be strongly opposed by environmentalists.

In recent years, the trade liberalization opponents such as environmental activists have become more vocal and forceful in voicing their opposition towards the WTO and industrial nations. On many occasions protests and demonstrations have taken place during the WTO annual meetings. Whilst the globalization opposition have taken a harder stance and approach, in recent years in what we see as a more constructive and diplomatic approach, the environmentalists have lobbied and increased their pressure towards industrial countries and international authorities to further tighten the world commitments towards environmental issues such as steps to dictate the rates of air pollution emissions and the rates of deforestation in all nations. Persistent pressures by the trade opponents however hardly undermine the further trade liberalization across the globe since the group also faces strong resistance from the trade proponents both on domestic as well as international fronts. It is of no doubt that in recent years most countries in the world have stepped-up their participation in world trade and are eager to immediately exploit the potential benefits of international trade. In the past 15 years, international trade has expanded at almost twice the pace of global GDP (UNEP, 2000). Essentially, the proponents of trade liberalization back their arguments on the range of economic benefits brought about by trade while the group who are against the liberalization continue to claim that the speed of development and economic growth led by trade has magnified the environmental degradation.

Given the intense debate on the effect of the world trade expansion, the link between trade and the environment has generated a lot of interest especially among policy makers and researchers. Hence, while there is an extensive literature on the benefits of international trade to the world, the expansion of economic activities led by trade together with lax environmental regulation is often identified as among the key factors responsible for raising the level of pollution in many parts of the world especially in developing nations. However one could also suggest that, an increase in per capita income arising from trade-led economic growth significantly contributed to investment towards maintaining and controlling environment quality in the country. In other words, trade liberalisation that stimulates the flow of foreign direct investments (FDI) will also be able to improve a country's environment quality. Participation of foreign investors / firms in the local economy may work as catalysts to increase the host country's productivity and spearhead the use of environmentally-friendly technology which reduces energy consumption through increasing efficiency.

With increasing environmental concerns, many feel that continued discussions and debates on the effect of international trade on the environment are in need of more research and studies to further understand the effects. For the layperson, it seems that they are not equipped with appropriate knowledge to quell the pollution. Many have come to a simple conclusion that if one cannot see or smell the pollution then there is no need for one to worry about it, no matter how wealthy a nation is. Therefore it is important for researchers and policy-makers to play their role actively.

In this chapter we review the theoretical and empirical studies on the environment and trade relationship. This review of the literature continues with another five sections. The next section will review the main theories and hypotheses of the environment-trade relationship. This is followed by Section 4.3 which provides a review of selected empirical studies. Section 4.4 deals with a review of selected methodologies. In Section 4.5 we discuss issues related to data and pollution measurements. This is followed by the conclusion in Section 4.6.

4.2 A review of the main theories and hypotheses of the environment-trade relationship

The body of literature on the environment and trade relationship is growing. The initial investigations of the relationship can be traced back to the early 1970s and were stimulated by the first United Nations Conference on Human Environment in 1972. Some earlier studies include Baumol (1971), Blackhust (1977) and Pethig (1976). The more recent studies include Tobey(1990), Dean (1992) Lucas *et al.* (1992), Low and Yeates (1992), Grossman and Krueger (1991, 1993), Panoyotou (1993), Beghin *et al.* (1994), Mani and Wheeler (1998), Cole and Elliott (2001), Eskeland and Harrison, 2003; Copeland and Taylor, 2003; Cole *et al.* (2004); and Levinson (2008). Methods employed in these studies vary widely as do the results. Among others, CGE Models, I-O Models, Optimization Models, Econometric Models, Welfare Models, and International Trade Models (the Heckscher-Ohlin Model) are all used. A survey of literature in this area shows that the early studies started with some normative research. In the 1990s, it turned to positive research which started to develop to test hypotheses on trade policy and growth's impact on environmental outcomes. This is mainly engineered by the pioneering work by Grossman and Krueger (1993) on the effect of NAFTA on the environment in Mexico.

The existing literature reveals that there is a collection of diverse arguments on the theory as well as inconclusive evidence of the empirical studies. In the words of Copeland and Taylor (2004), "literature suggests that the empirical evidence is still far from clear". Factors surrounding the environment-trade linkages including the nation's trade and environment policies, the country's characteristics and the current state of development and environment standards of the country have contributed to the complexity of the relationship. Thus it is not surprising that many recent empirical studies and economists acknowledge that the net effect of trade on the environment is ambiguous and the findings from one study to another also vary given that there are broad differences in methodology and assumptions employed by researchers.

The classic argument for international trade mooted by the Heckscher-Ohlin theory urged that the main source in determining trade patterns lies in the comparative advantage of a country in its cost of production (Copeland, 2005). As the theory shows, it will be a better choice for countries to specialise in producing goods where they have a comparative advantage and then exchange their products for other goods. In other words, compared to an autarky scenario, the nation engaged in trading with other countries will reap optimum economic benefits from the used of limited resources. Therefore, based on the theory, factor endowments such as labour, capital and land play a major role in locating factories all over the world thus influencing the trade flows. Despite numerous support for this theory, many are still critical of the actual benefit of international trade to the world. This has made research in this area especially on trade and the environment relationship increasingly important. This theme of research is becoming popular and often sought by policy-makers and various international / local institutions involved with socio-economic planning and development.

It is a common view that while international trade will bring prosperity to the countries involved, it has also been blamed for causing a negative impact on the environment specifically in terms of polluting the soil, water and air in the process of production. In other words, on one hand, per capita income of a country would increase with international trade where the countries have experienced a bigger market share for their product and will earn more. On the other hand, an increase in production and consumption eventually would increase the level of pollution of countries, especially if the country's main exports come from the "dirty" industries. It is also argued that trade is one way for developed countries to stop producing environmentally sensitive products but continue consuming the products through imports of such products from developing countries. Besides the one way of trade-pollution casualty argument, there is also the trivial argument that the pollution hampers growth. The negative effects of trade on the environment in the form of externalities could contribute to sickness and less productive workers (Esty, 2001).

Despite the fact there are collusion goals between trade and environmental regulation, it also can be argued that if a country's environmental regulation is not too forceful against economic incentives or business profits reaped from growth, there would exist a harmony in the relationship between the needs of environment protection and the economic growth brought about by international trade liberalization. It is understood that, in the absence of the environmental regulation framework, it will be very difficult to confine / monitor the pollution produced by the expansion of economic activity as a result of trade liberalisation. Lack of regulation means there would be no incentive for producers to internalise the pollution. However, when the environmental regulation is in place, it will force "the polluter pays principle" and make the producers observe their obligations towards the environment standards.

In this review of the theoretical literature on the environment-trade linkages we continue with a detailed discussion of main theories / hypotheses on trade and the environment relationship. We start this with the mainstay contribution of Grossman and Krueger (1991, 1993) which suggests that the effect of trade on the environment arises from three effects, namely the scale effect, the composition effect and the technique effect. This will then be followed with other influential theories that contribute immensely to the body of literature. These include the environment Kuznets curve, the pollution havens hypothesis, the factor endowment hypothesis, a race to the bottom, a gain of trade theory and porter theory. Since this area of study is still evolving, there may also be duplication and interrelations in the arguments of the theories.

The scale effect

The scale effect takes place when trade increases economic activity which involves an expansion of production and consumption. If the method and technology of production stay the same while the scale of economic activity grows, pollution and resource depletion will rise. In other words, expansion of economic activity requires an increase of direct inputs such as raw materials and utilities consumption as well as indirect inputs including transportation services, logistics services, office space, commerce services, sewerage services and other services. Besides those, extra labour is required and further capital investments are also needed. The expansion of economic activity will spearhead demand for other upstream and downstream activities. In economic linkage terms, expansion in manufacturing activities will create demand for other activities (it can be a scenario where upstream activities stimulate downstream activities) such as power generation, construction (including infrastructure, non-residential building and residential building), agriculture and fishing, forestry and diverse types of service activities (transportation, communication, logistic, business services, real estate, hotel and restaurants, health, education and community services). Rates of employment that increase with the economic activity ultimately will stimulate final demand for household consumption expenditure. This will cause pollution to increase.

Regardless of pollution abatement expenditure, a rise in economic activity often means a rise in externalities. Furthermore, excessive 'consuming' of natural and non-renewable resources as well as deforestation will increase the level of environmental degradation. This would eventually erode nature's assimilative ability to absorb pollution emissions and other externalities. However, this harmful scale effect contention is more likely to occur when the expansion of economic activity is dominated by dirty industries (with the absence of a strong environment regulation in developing countries) together with a lack of environmental regulations and limited access to environmentally friendly technology. This potential scenario is not restricted to developing countries but also likely to take place elsewhere. A common argument is that for the benefit of domestic producers, a developed country would loosen their environmental regulations as part of their strategy to boost their competitiveness.

Despite all the arguments, the negative effect of trade on environmental quality that arises from scale effects would only happen if trade liberalization does not affect existing inefficient technology and no environment friendly-technology transfer takes place in the host countries.

The composition effect

The composition effect takes place when an economy experiences progress along with trade liberalization and goes through an evolution. If trade liberalization is the main source of the changes in the economy's composition, then it certainly has a significant role in shaping the environment. Expansion of the manufacturing sector stimulated by high demand in the external trade and mass production activity increases the presence and contribution of the manufacturing sector as a source of income and employment for a country. The process is stimulated by demand-driven effects that comprise both domestic consumption and external demand, supported by government policy.

It is observed that a country's economic activity goes through transformation along with the phases of development. Initially, at the early phase of development, many countries depend on primary commodities, such as agriculture commodities, saw log and mining and mineral commodities such as oil, gas, gold, copper, tin and other minerals as their main source of income. Then, with the opening of the economy to international trade, the countries begin to receive capital inflow from capitalist countries and the manufacturing sector starts to develop. Consequently, instead of exporting raw commodities, trade liberalization allows for the transformation of the commodities to semi-finished and finished products before being exported. This phase significantly reduces the contribution and the role of the agriculture sector and the manpower from the sector is diverted into the manufacturing sector. As the phase of development continues, demand for auxiliary activities of service industries increases and overtime it will play a major role in the economy and become a main source of employment due to the nature of the service sector which is a labour intensive industry.

The evolution of the economy certainly has an impact on the level and type of pollution in the domestic environment. A country experiences a low level pollution threat during the primary based economy period. This then shifts to a high pollution exposure when the manufacturing sector dominates the economy and finally the services sector which bring relief from excessive stress on the environment. In brief, economic structure will shift from non pollution intensive agriculture, to pollution intensive manufacturing to a finally less polluting service industry. Arrow, *et al.*(1995) stated, "the pattern reflects the natural progression of economic development, from clean agrarian economies to polluting industrial economies to clean service economies"[5]. This evolution of the economy certainly has an impact on the level and type of pollution in the domestic environment.

The technique effect

The technique effect is a crucial argument to determine whether trade liberalization benefits or harms the environment. If international trade brought a country to the technology frontier that provides a more efficient and environment-friendly production system, pollution intensity per unit of output will start to fall and this certainly will help to reduce the environment deterioration. The effect is deemed to be demand driven by many researchers. If one considers an environment standard as a normal good, increases in per capita income along with trade liberalization shift people's preferences towards a high quality environment. The intuition of this argument is that, for a country in the early stage of development with a low per capita income, environment qualities are not a focal point of discussion when policies and regulations were drawn up. Other factors such as employment and economic growth are at the forefront when making decisions. (Dasgupta *et al.*, 2002). At the later stage of development after a high income level has been achieved, the environmental standards begin to become a more important matter.

[5] This line of thinking is also found in many studies/papers such as Panayotou (1993).

Higher economic capability derived from trade expansion leads many to become more environmentally conscious. This implicitly suggests that there is a positive relationship between environment preferences and incomes. When environment standards become major talking points among the people, pressure will slowly increase for the government to implement more stringent environmental regulation. Higher per capita income also means that the government is more capable to maintain environment quality. Therefore the level of enforcement of environment jurisdiction will rise over time. In brief, one can safely conclude from this scenario, as per capita income continues to increase, the rate of pollution declines.

On the other front, external pressure put by importers from developed countries for efficient and environment-friendly production technology can also push for better environment standards. This voluntary/external pressure can be expected to become mandatory over time. In brief, over time, export market requirements can encourage producers to use the latest technology that is often cleaner than existing technologies. The access to new technologies provides a cleaner way of producing the goods. These will phase-out outdated and dilapidated technology which is hazardous to the environment. Consequently the technique effect will cause industrial changes that are likely to occur in two forms. First, the existing industry (factory) will opt for new technology which is relatively more environmentally-friendly. This will depend on the marginal cost of abatement and the long term commitment of the company. Some researchers said that "greener" technology will eventually increase the productivity of managers and employees (Esty, 2001). However, this can backfire as some suggest that expansion of economic activity through increasing capital can be harmful to the environment. The other form is that existing 'dirty industries' themselves will be phased out and substituted with "clean" industries which use more advanced technology. However these changes may not necessarily be smooth. There will be parties that hold some interests that do not wish for the transformation. In other words, the group is already comfortable with the existing status-quo of industry. This party will push for the industry to stay the same and may lobby for the factory to continue its operation. This may involve relocating some industries to new secluded designated areas and this will open more criticisms. Other than that, the environment abatement commitment will be an extra cost for the producers and the likelihood to internalise the cost will effect producer's commitment toward a more environmentally-friendly production system.

Meanwhile, Gallagher (2005) suggests that in the case of developed countries, the three effects of trade on the environment seem to be interacting. As income grows, the composition of industry shifted towards relatively less polluting-intensive economic activity with improvements in technology and environmental regulation taking place. Although the overall levels of growth have increased pollution (the scale effects), composition and technique effects have offset the pollution. However, one can argue that in the absence of the environmental regulation framework, it will be very difficult to condone the pollution produced by the expansion of economic activity as a result of trade liberalization. There would be no incentive for producers to internalise the pollution. Self regulation by the producers may be hard to come by. However, if the environmental regulation is in place, it will force "the polluter pays principle" among the producers where they will have to fulfil their obligations towards the environment standard.

Environmental Kuznets Curve (EKC) theory

Despite the important of the three effects, the literature has also focused on an Environmental Kuznets Curve (EKC) theory as the foundation to describe the environment-income relationship. The well known inverse U-shape relationship of income and inequality in the income distribution shown by Kuznets (1955) has been extended to describe the relationship between per capita income and pollution. If one assumes that the environment quality is a normal good then one can expect that demand for environmental standards will increase with income. The pioneering work on EKC started by Grossman and Krueger (1995) who find evidence to show that at lower levels of per capita income, environmental quality would fall with economic growth. However at a higher level of per capita income, environmental standards rise as the economy expands. Put simply, as per capita income increases along with trade liberalization, the effect on the environment would take the inverse U-shaped relationship. Hence, the connection of pollution and trade-led economic growth is hypothesized to be both positive and negative, depending on the level of per capita income and the stage of growth that the economy is going through. However one weakness to this model is that at which level of income per capita would the relationship of trade and environment standards switch from positive to negative. One can also question the suitability of this model across different countries, rather than for one country over time.

The World Bank (1992) has also concluded that international trade as such cannot be regarded as a cause of environmental degradation, but what causes this degradation is the absence of appropriate environmental protection policies. In contrast, Beckermen (1992), writes that, "in the end the best and probably the only way to attain a decent environment is to become rich". Thus, to some, GDP is both the cause and the cure of the environmental deterioration. Some suggest that when a study is done on a cross-country basis involving developed and developing countries, it is expected that developed countries (high income) possess a low pollution and developing countries (low income) possess a high pollution then the finding that postulates the inverse-U of EKC is just juxposition.

The other theory used in explaining the inverted-U curve is based on normal or natural process that take place in the economic progress. It relates to the broad phenomena where the structure of the economy tends to change with the development of the economy. As Panayotou (1993) suggests, environmental degradation tends to increase as the structure of the economy changes from rural to urban, and from agricultural to industrial. But pollution levels start to fall with the second structural change from energy-intensive heavy industry to services and technology-intensive industry. Finally, technological progress will lead to the substitution of obsolete and dirty technologies with cleaner technologies which improves the quality of the environment. This is the technology or technique effect. When the technology effect dominates the scale effect, the pollution levels would increase during the period of the first structural change of the economy and then decrease during the second stage of structural change. Therefore the inverted U curve artefact is again portrayed.

Essentially, as discussed earlier, there are two alternative theories used to explain the inverse-U relationship that is observed between pollutants and income per capita. One is based on the natural transition during economic development, the evolution from less pollution intensive agriculture, to pollution intensive manufacturing and finally to less polluting service industries. This is also known as the composition effect. The other theory relies on the scale and technique effects. The scale effect states that, to grow countries need to produce more. Ceteris paribus, the downside of producing more is the rise of externalities which implies a monotonous positive relationship between pollution and income. The technique effect assumes that environmental quality is a normal good. Therefore, the wealthier a country gets, the higher its demand for environmental regulations which leads it to reduce pollution per unit of output. Thus if the technique effect dominates after a certain point of income threshold, pollution will decrease.

There is however other recent research that has provided a positive critique of the EKC hypothesis. Some research seems to suggest that the level of the curve is actually dropping and shifting more to the left. As growth generates less pollution in the early stages of industrialization, pollution would begin to fall at lower income levels due to the technology overflow and economy globalization. Panayotou (1997) finds that better policies, such as more secure property rights and better enforcement of contracts and effective environmental regulations can help flatten the EKC and reduce the environmental price of economic growth.

In a comprehensive survey by Stern (1996), the author points out that only a subset of pollutants can apply the model of the inverted-U curve, such as sulphur dioxide and suspended particulates. In sum, while some economists seek to explain the inverted-U economic growth-pollution relationship, others cast doubt on the shape of the curve itself.

<u>The Factor Endowments Hypothesis (FEH) and Pollution Havens Hypothesis (PHH)</u>

Theory on the trade and environment relationship has also recognised two main factors that influence the pollution intensity of production and hence trade. The factors are known as factor endowments of production and stringency of environmental regulation. Both are described precisely in the Factor Endowments

Hypothesis (FEH) and Pollution Havens Hypothesis (PHH) respectively. As shown later, both hypotheses suggest that the more exposed a country to international trade, the more significant the role of trade on the country's composition of production, hence the intensity of pollution.

The Factor Endowments Hypothesis suggests that trade patterns are determined by the relative abundance of factor endowments in the country. Countries that possess relatively abundant capital are likely to specialize in producing capital-intensive goods while countries with labour abundance will produce labour-intensive goods. In general, the pollution intensive industries are relatively capital intensive (Antweiler *et al.*, 2001 and Cole and Elliott, 2003). Derived from the argument, a capital abundant developed country would have a comparative advantage in pollution intensive industries, even if it applies relatively tough environmental laws (Copeland and Taylor, 1996). This means pollution intensive products are likely to be produced in developed countries. This hypothesis is the foundation of the Heckscher-Ohlin theory of international trade. In regard to the trade-environment relationship, countries in the North which possess capital abundant factors are expected to export relatively more pollution intensive goods and countries in the South which possess labour abundant factors are expected to export labour intensive goods that are often regarded as less-pollution intensive goods. The hypothesis is in opposition to the PHH which states that trade patterns will be influenced by the stringency of environmental regulation. Other than labour and capital that formed the traditional factors of production, some believe that the environment should also be considered as a factor of production, using the same argument as in the case of labour and capital. Hence one can suggest that a country with environment abundance (natural absorptive capacity) will have comparative advantage in the production of pollution intensive industry. This is due to the environment abundance which implies that it cost less to pollute in the country.

The Pollution Haven Hypothesis's argument on the trade-environment linkage relies on the issue of environmental regulation. PHH theorizes that the choice of location for the manufacturing operation is significantly influenced by the stringency of environmental regulation enforced in the country. If the costs of compliance with environmental regulation differ across countries then ceteris peribus, one may expect relocation of pollution intensive industries to locations where the costs of compliance are lower (Kirkpatrick & Scrieciu, 2008). A country with less stringent environmental policy will attract more manufacturers to set up their factory which gives them the 'privilege' to emit pollution and other externalities. The insight of the PHH is that for poor countries, people are less concerned about environment standards compared to their desire for the benefit gained from economic activity expansion. Therefore for less developed countries, many expect that due to a lack of economic opportunity, the trade-led economic expansion is vital in improving living conditions and pursuing other macroeconomics goals. The policy-makers that subscribe to this hypothesis may also concur and collude with the EKC connotation that environment standards could be improved in due course when the fruits of economic benefits of trade have been fully reaped.

Most researchers maintain that developing countries have weaker environment regulation compared to developed countries. Thus, trade liberalization will encourage relocation of factories from developed countries to developing countries. However, as discussed earlier, trade liberalization would lead producers in the world towards convergence to a highly competitive market. This is the likely prelude to the argument that developed countries might also relax their environmental regulation in order to compete with developing countries. This is referred to as the regulatory effect. When the competition is not only confined to productivity but also non-economic factors such as regulation, it may create a scenario where some countries resort to having less stringent regulations to outdo others. Panayotou (1993) and some other researchers have named this scenario as the race to the bottom.

The PHH argument however has not been free from criticisms. One of criticisms levelled at the PHH argument is that, the PHH is too simplistic. The hypothesis implies that developed countries do not do anything to deal with the pollution in their own soil and instead merely export their pollution industries to developing countries. While at the same time, the developing countries are assumed voluntarily to become a home to pollution industries. These arguments show that it is very important to evaluate evidence provided by the empirical studies.

Despite the critics, there are some businesses/manufacturers' practices that may unintentionally seem to subscribe towards the PHH argument. For example, the phenomena of "unwanted' industries being moved out from developed countries to developing countries can easily be observed. The action can be related to macroeconomic theories. For instance, the theory of the product cycle suggests that at the maturing phase of the product cycle, the producers will make locational shifts of their operation closer to consumers. This may well involve the pollution industry as well. Perhaps the shift of pollution factories may be disguised for various reasons such as on the basics of the product cycle just discussed.

The other criticism towards the PHH is considered more substantiated. Critics urge that, there is empirical evidence to show that the cost of pollution abatement often does not exceed three per cent of the total production cost. According to available estimates, abatement costs in the North appear to be low, between 1 per cent and 3 per cent of total costs (OECD, 1993; Tobey, 1990; and Walter, 1973). Thus, it is less convincing to say that firms are willing to displace their operation to other countries due to the stringency of environment regulation, where they might incur a much higher cost of displacement. Therefore the cost of environmental compliance is outweighed by other factors affecting the company decision on location.

In another argument, the PHH effect is less likely because some factories are geographically immobile. According to Levinson *et al.* (2003), there are three potential determinants of geographic immobility: transportation costs in product markets, plant fixed costs, and agglomeration economies. Their research on the U.S manufacturing sector reveals that there are no uniform effects of possible relocation of manufacturing industries due to environmental costs. Their hypothesis is that an increase in environmental costs will have a greater effect on net imports in industries with low transport costs, low plant costs and small external economies. Thus the circumstances of the industry are important for whether there is mobility of firm due to regulatory differences.

A Race to the Bottom Hypothesis

This hypothesis is also widely discussed in the literature. Environmentalists and the opponents of trade liberalization are sceptical about the commitment and consistency of governments in defending environmental quality. They predict that further trade liberalization creates stiff competition among countries regardless of their nation status (developed or less developed). Developing countries look for new investment from developed countries as part of their development effort and focus on achieving growth as well as a high employment rate. At an early stage of development, the priority of the government of developing countries is more towards attracting investment and job creation which ultimately delivers economic growth and higher per capita income. Developed countries, on the other hand, have to maintain their growth path and thus often struggle to avoid capital outflows to developing countries. Developing countries with weak environment regulations will enjoy a comparative advantage in producing polluting products since the perceived price of the input 'environment' is lower than in developed countries with stringent regulations. The shifting of investment and manufacturing operation from developed countries to developing countries will put their employment and economic growth at risk. Thus, to avoid this, developed countries may adopt a strategy to sacrifice environmental standards in order to maintain economic growth to win the 'battle' with their economic growth path maintained. In sum developed countries that face stiff competition in the world market may induce a 'race to the bottom' in environmental regulations. Hence, trade liberalization will make the world economy more competitive and this can possibly cause changes in existing and future environment regulations for countries which are likely to have detrimental effects on environmental standards.

Frankel and Rose (2005) elaborate the difference between this hypothesis and PHH. They explain that the race-to-the-bottom hypothesis implies a negative effect on the overall world level of environmental regulation while PHH does not. PHH is based on environmental regulation differences between countries where certain countries (high income countries) choose to have strict environment regulations on their domestic production and import the pollution intensive products from other countries that allow the products to be produced under loose regulations.

Porter Hypothesis

In the words of Frankel and Rose (2005), "Porter Hypothesis claims that environmental regulation stimulates productivity- together with the positive effect of income on trade". Basically, the Porter Hypothesis argument depends on the technique effect of trade liberalization on the environment. Increased trade liberalization leads to stiff competition. This will push producers to enhance their research and development (R&D) capability which is geared towards high productivity. This competition ultimately makes the producers more innovative and willing to put significant amounts of expenditure into R&D. Furthermore, the presence of multinational companies in developed and developing countries will likely make an effort to have a high standard of environmental quality as a common agenda. Thus developing countries will benefit and push towards high productivity and greener technology which ultimately will be improving overall environment quality. Porter and van der Linde (1995) summarise that even though the common assumption is to relate environmental regulation to rising costs and risks to growth, it can be seen as a drive factor to stimulate innovation and productivity.

Gains-from-trade Hypothesis

Frankel and Rose (2005) suggest that there is the possibility of an effect in the opposite direction. Termed as the Gains-from-trade Hypothesis the authors urge that it is not unrealistic to expect that trade liberalization could bring a positive effect on the environmental quality even for a given level of GDP per capita. They support their argument by explaining that it is likely that trade liberalisation is able to spearhead good managerial and technological innovation that benefits the economy and the environment. This can happen especially through the role of multinational corporations. Trade liberalization enables the corporations to bring clean state-of-the-art production techniques from higher standard source countries of origin to host countries. Along with the openness, the heightened public awareness of environmental standards will push for stringent laws at an international level. The authors also emphasise that whether the race-to-the-bottom effect in practice dominates the gains from trade effect is an empirical question. On an optimistic note they suggest that even for a given level of GDP per capita, the environmental gains from trade will be apparent because the GDP measurement does not adequately capture the increase in welfare arising from enhanced variety of consumption.

Pollution Halo Hypothesis

In contrast to the main argument of the pollution haven hypothesis that trade liberalisation is likely to cause environmental degradation in developing countries (with weak environmental regulation), there is the other argument that suggests trade liberalisation and FDI benefit the environmental quality of a host country. Grossman and Krueger (1991), suggest that it is possible that pollution intensive industries relocating to developing countries can bring together a cleaner production technology than their local counterpart. The relocation of MNCs enables local firms to acquire a much better environmental technology from foreign firms (multinational corporations). In the long run, the presence of MNCs will have benefitted the local environment. This argument is best known as the pollution halo hypothesis.

In other words, the pollution halo hypothesis suggests that MNCs or foreign owned firms are able to provide emission-saving technologies, financial resources and managerial skills to the host country. As such, inwards FDI accompanying higher energy efficiency may improve the environment standards in developing countries. Echoing this hypothesis, Zarsky (1999) believes that MNCs will consistently use high standards and advance production technology regardless of the location of their operation. Hence, their involvement in a foreign country through foreign direct investment (FDI) is seen as "a vehicle working to diffuse best practice throughout the world". In other words, trade liberalisation via FDI of MNCs accelerates transfer of environmental technology. Zarsky (1999) also explains that "the pollution halo concept focuses not on industry location, but on the environmental performance of foreign owned firms relative to domestic firms. It suggests that what is important is not why a firm locates where it does, but how it performs once it gets there".

Consistent with the later argument, Albornoz *et al.*, (2009) suggest that overall the empirical literature shows that foreign owned firms are more likely to use cleaner production technologies than domestic firms and reemphasise that the presence of foreign owned companies works as a catalyst to encourage good environmental practice among the local firms. This is well summarised in Zarsky (1999), "the pollution halo hypothesis suggests that superior technology and management, as well as demands by "green consumers" at home, make OECD firms the vehicles for better performance. Learning and copying effects by domestic firms might also lift industry standards overall". Therefore, in Zarsky's opinion, international trade should generally help protect the environment, rather than harm it.

In sum, the pollution halo hypothesis suggests that MNCs or foreign ownership firms are able to provide emission-saving technologies, financial resources and managerial skills to the host country. MNCs work in transferring low carbon technology into developing economies will help to reduce marginal abatement cost. As suggested by Taylor (2005), "if the diffusion of clean technologies is accelerating as a result of globalization, this indirect impact of trade may well turn out to be the most important for environments in the developing world". Hence the pollution halo hypothesis intuition is that both trade and environmental protection can be advanced alongside globalisation. Despite this, I believe that a laissez-faire approach is not an option. The role of environmental regulation is still needed to support sustainable development. In other words, appropriate environmental regulations are needed to internalise the full environmental cost of production which implies reinforcement of the 'polluter pays' principle. Zarsky (1999) cautions that for the pollution halo effect to be seen in developing countries, the foreign firms may need to originate from countries that are more advanced in environmental regulation such as OECD-based firms. On the same point, Albonoz, *et al.*, (2009) suggest that the key assumption for the pollution halo effect is that foreign firms are cleaner than their domestic counterparts.

A number of authors have empirically tested the pollution halo hypotheses and the results have been inconclusive. The mixed evidence on the pollution halo hypothesis is reviewed in Zarsky (1999). Eskeland and Harrison (1997) find that foreign ownership is associated with cleaner and lower levels of energy use in the three countries of their sample (Mexico, Venezuela, Cote d'Ivoire). Blackman and Wu (1998) examine the electricity generation in China and find that foreign investment in electricity generation in China increased energy efficiency and reduced emissions which is consistent with the pollution halo hypothesis. Birdsall, *et al.*, (2001) also find support for the pollution halo hypothesis in the case of Chile. Similarly, Wang and Jin (2002) find evidence of a pollution halo effect in their analysis of firm level pollution discharge of 1000 firms in China. In contrast, Dasgupta *et al.* (1998) and Hettige *et al.* (1996) find no evidence to suggest that foreign ownership is significant in firm-level environmental performance as compared to domestic firms.

The recent empirical evidence on pollution halo effects is found in Albonoz, *et al.*, (2009). The authors study the relationship between FDI and the environmental performance of firms in terms of implemented environmental management systems (EMS) using Argentinean manufacturing firms (sample of 1,200 firms). In their paper, the authors find evidence of the existence of environmental spillovers. They elaborate several channels where the foreign firms work as a catalyst for exemplary environmental practice, these include: the courage of foreign firms in dissemination of environmental related knowledge and technologies, making a business deal with firms that act in an environmentally responsible way and allowing the movement of trained workers from foreign firms to domestic firms. To examine their argument, the authors include a range of spillover variables. This is done to assess whether foreign ownership benefits the local environment via positive environmental performance spillovers and whether the ownership structure of a firm has an influence on the number of EMS implemented per firm. Their main findings shows that foreign-owned firms are more likely to implement EMS than domestic firms and foreign ownership increases the number of types of EMS adopted. They offer two explanations to support their findings, "first is the standard leakage of technology and skills from one firm to another via the movement of labour and the second is that foreign customers and suppliers are directly encouraging other firms in their extended supply chain to implement EMS for their own benefit and a good corporate image".

Overall discussion on all the hypotheses

Sheldon (2006) highlights two main concerns raised by environmentalists. Firstly, with increased trade liberalization and economic integration, countries would be under more pressure to compete competitively. Governments would be more reluctant to impose tough environmental policies in order to protect their competitiveness. This argument is typically applied to developed countries where international competition is expected to hurt domestic industries. Local industries are more likely to be threatened by loss of market share or movement of industries from the countries with tough environmental policies to less developed countries with lax environmental policies. This relates to the popular argument that trade liberalization enhances competition and leads to a race to the bottom as discussed earlier. Secondly, any benefits from increased trade liberalization could be outweighed by damage caused to the environment which in certain cases may be irreparable. Furthermore, increases in purchasing power resulting from a higher per capita income as a result of trade-led growth may generate an unethical spending habit that produces more waste which causes more environmental degradation. Hence, together with a growing population, trade expansion that directly promotes the manufacturing of products where demand and consumption for new gadgets / appliances continues to rise over time has also contributed to the degradation.

Sheldon (2006) also discusses the scenarios where the trade-environment relationship is largely influenced by a nation's trade policy. Generally, if the pattern of economic activity across countries is affected by trade and this activity negatively impacts the environment, then trade expansion policy will also directly affect the environment. The author also explains that economic activities in one country may result in global environmental effects in the form of trans-boundary pollution. These can be acid rain, or other spill-over effects such as depletion of the ozone layer due to use of chlorofluorocarbons. As a consequence, trade policy may be used by the affected countries to reduce the damage they incur, if they trade with the offending country. Meanwhile, at international level, trade policy is also often formed part of a package of sanctions designed to enforce international environmental agreements. One example is CITES[6] which prohibits the import and export of endangered species, including trade with non-parties to the convention.

Neary (2006), describes the collusion between pursuing trade policy and environmental regulation among the policy-makers. The author explains that because of the widespread concern that trade liberalisation will increase pollution emissions, it raises the polemic whether environmental policy should be tightened to compensate for changes in trade policy. This dilemma shows with the author's words, that "increased environmental regulation in the EU has renewed fears that such measures could reduce competitiveness, leading to both deindustrialisation and 'carbon leakage' as pollution industries relocate internationally". The author also suggests that strengthened environmental regulation not only will shift the cost of environmental degradation but also will benefit the host country through the prospect of industrial agglomeration.

Liang (2006) explains the difficulty of finding the empirical evidence for the Pollution Haven Hypothesis and the Factor Endowment Hypothesis despite accepting the insight of both the hypotheses. He argues that there is problem with empirical tests for the two hypotheses. This is especially because normally the government of the country has not made trade and environmental policy separately. He added that there are many factors driving trade policy and environmental policies simultaneously. As such, capital abundant and strict pollution policies are often seen in rich countries. Poor countries are often the opposite. On the other issue, the author also does not support the use of cross-sectional country level data in empirical work.

Rock (1996) cited that several studies such as Low (1992); Birdsall and Wheeler (1992); and Wheeler and Martin (1992), have shown that the countries pursuing more open policies experienced lower growth rates in production of the pollution intensity products and tended to adopt cleaner and more environmentally sustainable industrial production than countries following import-substitution industrial policies. In his own study, Rock (1996) finds that during the period of

[6] CITES is acronym for Convention of International Trade in Endangered Species of Wild Flora and Fauna. It is set up under purview of the United Nations.

1973-1985, developing countries with outward-oriented policies have higher pollution intensities than those countries pursuing inward-oriented policies.

Despite a lack of evidence for a positive effect of trade liberalisation on the environment, Rock (1996) suggests some potential benefits of trade to the environment. The author's main argument is that with the comparative advantage in labour-intensive and comparative advantage in capital-intensive production attached to developing countries and developed countries respectively, trade liberalization should discourage production in dirtier capital-intensive sectors while encourage production in cleaner labour-intensive sectors. The next argument is that exporters to rich countries are increasingly pressurised to meet developed countrys' environmental standards. Additional to that, multinational corporations will use the same emission standards regardless of where they operate. Because the environmental standards of multinational corporations are likely to be more stringent than developing country standards, openness to trade and foreign investment should contribute to less pollution per dollar output. Other than that, openness and the competitive pressure generated should lead to increased investment in the latest technology which often is cleaner. Meanwhile, Beghin and Potier (1997), suggest that innovation and adoption of green technology tend to be regulation-driven. In their words, "without environment regulation, incentives to be 'greener' will be limited".

Apart from that, Rock (1996) offers two promising factors that trade could be a channel for a cleaner environment in poor countries in the future. The first factor is backing on the role of environmental groups in rich countries which regularly monitor production processes in the developing world, particularly those of multinational corporations (MNCs). The author goes on to suggest that if there were failures to adhere to the standard then green consumer boycotts will follow, thus increasing the cost of 'bad' environmental behaviour. For these reasons, MNCs are taking proactive measures to extend their environmental practices to subcontractors in developing countries. The second factor relates to the effort made by the International Standards Organizations (ISO) in Geneva which is currently focusing on environmental management business practice in a new standards series (ISO 14,000). Because access to developed country markets may be dependent on compliance of ISO 14,000, it is likely to influence producers to use better production systems to access the markets.

Rock's (1996) arguments are mainly in line with a number of earlier and recent researchers. Birdsall and Wheeler (1993); Lee and Roland-Holst (1997) and Jones and Rodolfo (1995), are among economists who have argued that trade is not the root cause of environmental degradation. Dinda (2004) describes that "free trade has the contradictory impacts on environment, both increasing pollution and motivating reductions in it". Hence, with the potential of positive effect of trade, it is possible that trade liberalisation that brings economic growth of a country can be part of the solution rather than the cause of environmental problem.

In light of the various hypotheses discussed, one may expect that the opponents of trade liberalization back the PHH to reject trade expansion especially into developing countries. In contrast, proponents of trade liberalization use the EKC theory to support their argument by suggesting that trade would eventually set high environment standards. The increasing national income resulting from a buoyant external sector will eventually generate an increased demand for environmental improvement. Also, trade-led growth enables governments to increase tax earnings and make more finance / resources available for environment-related expenditure including pollution abatement and the general protection of the environment. However, Winters (2004) argues that trade liberalisation by itself is unlikely to boost economic growth. The author urges that economic growth has to be accompanied by quality governance and improved macroeconomic policy making.

Liddle (2001) suggests that the PHH is verified if low environmental standards become a source of comparative advantage and therefore influence trade flows. On this ground the author makes a point that any empirical study to test the hypothesis must be based on the reflection that developed economies are relatively severe in environmental regulations with respect to developing economies. Meanwhile, Copeland and Taylor (1994) observe that the differences in regulation regimes and institutions help explain the heterogeneity across countries in response to trade and investment liberalisation. These arguments show that the stringency of the environmental regulation is also assumed to be associated with the level of development of nations.

The hypothesis that trade induces a 'race to the bottom' argues that there is the possibility that developed countries will relax their environmental regulations in order to compete with developing countries. This may be materialised if the "unconventional" comparative advantage that sourced from exploitation of natural resources and low environment standards are allowed to occur in developing countries. However, the FEH urges that factor abundance such as labour and land plays a major role in influencing comparative advantage and hence the trade patterns. Thus, it seems that the interrelated effects of the regulatory effect and the factor abundance effect (FEH) give an ambiguous effect of trade on the environment.

Levinson *et al.* (2003) suggest that some empirical studies do not find statistically significant evidence of the PHH because of three reasons. First, developed countries mostly trade among themselves. Thus they mainly have the same stringent environmental regulation. Second, some industries are less geographically mobile due to economic factors such as transportation costs, plant fixed costs and agglomeration economies. Thus it makes those industries insensitive to differences in regulatory stringency between countries. Third, environmental regulation represents only a small portion of total production costs. The environment abatement expenses incurred by producers do not differ significantly enough for them to relocate their operation to other places.

Besides the indirect effects, there are also direct effects of trade on the environment such as increases in transportation used to facilitate trade liberalization that harms the environment. An increase in international trade means fuel and energy consumption will be more and will affect the environment significantly. Merchandises are increasingly transported across borders and over larger distances. However, there has been relatively less attention given to this effect. According to a study done by a researcher in the World Bank (Hettige, 1998), transportation costs constitute a significant percentage of fuel consumption.

Overall discussion on the EKC hypothesis

Since the early work on EKC by Grossman and Krueger (1995), the EKC hypothesis continues to be used as a focal point in the study of trade and the environment. Its simple line of reasoning is easier to understand which makes it popular among policy-makers and trade proponents as well as among researchers in this area. In early research in this area, the focus was looking at the turning points of EKC. Copeland and Taylor (2004) reveal that there are mixed results on the EKC hypothesis. The authors suggest that "since different types of economic activity have different pollution intensities, it would be surprising to find a simple relationship between all possible realizations of income and pollution". On this basis, the authors predict that the shape of the relationship between income and pollution will be varying with the source of income growth. The authors also explain that sources of growth, income effects, threshold effects and increasing returns to abatement are the keys mechanism driving the results of empirical studies on the EKC.

However there are others that only partially agree with the EKC idea. Some believe that the process of decomposing economic development into components, and studying the bilateral relationship between pollution and each component is only partially right. Panayotou (1997) points out that,"...they focus only on the scale and industrialization effects and ignore the abatement effect of higher incomes". The author argues that conclusions from a model that only took account of economic growth variables and discarded other variables unconsciously can give misleading interpretations such as some countries can overcome their environmental problems without the establishment of conscious environmental policies.

Levinson (2000) states that by and large, the empirical research on EKC managed to find inverse-U-shaped patterns for most pollutants. Nevertheless, some pollutants failed to show the postulated EKC. The author gives the example of carbon emissions. The emissions seem to increase at ever decreasing rates with predicted peaks far outside reasonable income levels. The author explains that as a global pollutant involving cross-border externalities, no one country has sufficient incentive to regulate emissions. This certainly creates the free rider problem and this is very much more the case with carbon than any other pollutant.

The EKC hypothesis has also drawn many criticisms. Among the recent criticisms is from Gallagher (2005). The author maintained that even though over one hundred articles have been published since the milestone's study done by Grossman and Krueger (1993), the empirical evidence for the EKC hypothesis continues to be relatively weak and limited. His main argument is that evidence for the EKC is limited to a small number of pollutants. He backs up this argument by observing that most of the studies that have supported EKCs hypothesis are only limited to ambient concentrations of localised air pollutants in OECD countries (Grossman and Krueger 1993; Seldon 1994; Panayotou 1997). The author also highlights that the EKC evidence is hardly found for other forms of pollution such as water pollution, municipal waste, carbon dioxide and energy used, which made the EKC hypothesis questionable (World Bank 1992; Shafik 1994; Hettige 2000). Hence, the author reaffirms that despite a number of studies have shown that ambient concentrations for the selected pollutants may decline with income it also finds that the pollution emissions increase along with income. In sum, many researchers agreed that only a subset of pollutants can apply the model of inverted-U curve, such as sulphur dioxide and suspended particulates (Stern, 1996).

Another dispute on the EKC is that EKC studies have relatively small representation from developing countries (Gallagher, 2005). Stern (1998) also states that EKCs become more ambiguous as more developing countries are added to a sample. The issue of the EKC turning points that are much higher than original estimates is another important argument discussed in the literature. Gallagher (2005) has documented a number of studies that have found turning points ranging from $7,500 GDP per capita to $15,000 and higher (Seldon, 1994; Kaufmann, 1998; List, 1999). He goes on to argue "such evidence implies that pollution per capita may continue for decades before "turning" around". On another point, there is concern that the environmental damage that occurs during the initial stages of economic development prior to reaching any turning point can be irreversible such as deforestation (especially in old-growth forests), loss of biological and genetic diversity, loss of potable water, and deaths related to air pollution (Barbier 1994).

Apart from criticisms discussed earlier which fall within the EKC model itself, there are several other arguments that can also dispute the validity of the EKC hypothesis. Many suggest that there are other factors that contribute to an EKC. As shown in the literature, factors such as the degree of political freedom and democracy in a nation, population density, economic structure, and historical events such as the oil price shocks of the 1970s/1990s are among the factors that are correlated with reductions in pollution (Torras, 1996; Unruh, 1997).

The other argument is related to the nature of business in the globalization environment. Current business practice is involved with many outsourcing activities for which it is difficult to find the "financial border". Industrialized nations may have succeeded in cleaning up their own environment by simply exporting the dirtiest industries abroad. Hence, in a global context not much has changed and instead the impact of trade on pollution is simply shifted to another region. In brief, trade can displace pollution. Perhaps developed countries may have experienced EKCs partly because they now import pollution-intensive goods from less developed countries. However, it has been argued that many developing nations such as China may not have such luxury when there are no longer nations that can voluntarily be polluted (Lucas,1992; Suri,1998). As such, while some economists seek to explain the explanation of the inverted-U growth pollution relationship, others cast doubt on the shape of the curve itself.

Despite the importance of all the previous arguments that challenged the validity of the EKC hypothesis, there is one final argument discussed in the literature (such as in Gallagher, 2005) which specifically motivated this thesis. It is noticed that research as well as the empirical evidence for the EKC hypothesis in single-country cases is still very limited. The literature shows that the majority of early EKC studies have utilised cross-sectional or panel data to estimate the income-pollution relationship and are largely confined to developed countries. Gallagher (2005) suggests that "there is some evidence which shows that time-series applications to individual countries do not mimic cross-sectional trends". On this front, some researchers urge that extrapolating policy advice based on a cross-section of mostly developed countries to developing countries is fundamentally inappropriate especially because such an approach assumes that the development path of developed countries is easily replicable for the developing countries (Unruh, 1997). On this premises this thesis will give some contribution in the area of a single country analysis. Even though Vincent (1997) has also specifically made a single country study in the case of Malaysia this thesis will give more current findings and use different methodology. In particular, this study specifically addresses industrial pollution at an industrial level and regional level, as well as bilateral trade regional pollution led by trade.

4.3 A review of selected empirical studies

The continuing phenomena of environmental deterioration created worldwide concern over environmental issues and this has sparked diversified empirical studies in this area. Some suggest that at least 100 papers have been published since the release of the milestone paper by Grossman and Krueger (1993). Our review of previous studies shows that various empirical works on the environment-trade relationship are mainly focused on examining the main theories/hypotheses related to the relationship and basically can be grouped into three themes. The first theme is tests of the Pollution Haven Hypothesis and the Factor Endowment Hypothesis. The second theme is examining the validity of the EKC and the third theme is study related to the three well known effects of trade i.e. scale, composition and technique effects. Thus this review of empirical work will be done according to these groups as well as on the method used with emphasis given to the studies based on panel data analysis which will be the method use in our study.

Grossman and Kruger (1993) constitute the seminal work on the Environmental Kuznets Curve (EKC). Data for SO2, suspended particulate matter (SPM) and particulates (smoke) for 1977, 1982 and 1988 were analyzed. The data were from Global Environmental Monitoring System (GEMS), which monitors air quality in urban areas throughout the world. The authors estimate the regressions using both random and fixed effects models using a cubic function form. A linear time trend, a variable of openness and dummy variables of location were also included. The results show that concentrations of two of the three pollutants, SO2 and particulates, rise with per capita GDP at low levels of national income. The concentrations then fall as per capita GDP grows. The turning points for SO2 and particulates are $4,119 (1985 U.S. dollars) and $5,000 (1985 U.S. dollars) respectively. The estimated curves imply an inverted U shaped relationship. As for SPM, it was found to fall as per capita GDP rises at low levels of economic development. Then after GDP per capita reaches $9,000, economic growth has no further effect on the concentration of SPM. Grossman and Kruger argue that as a country's per capita income reaches a certain level ($4,000 to $5,000 1985 U.S. dollars) pollution problems tend to ease. They also predict that, because the free trade agreement between the U.S. and Canada would improve the economic growth of Mexico, whose per capita GDP was already $5,000 (1985 US dollars) at that time, this country would intensify its efforts to alleviate its environmental problems, so that its pollution level would decrease from that point on.

Apart from the work of Grossman and Krueger (1991,1993) that initiated the EKC and decomposition of the effect of trade on the environment, Antweiler, Copeland and Taylor (2001) and Copeland and Taylor (2003) represent an extensive body of theory and empirical research which explicitly focused on the effects of trade on the environment. Thus this review of literature will also give a special emphasis on work done by them. Early empirical research is mainly focused on testing different pollutant indicators of different countries with simple linear parametric models and trying to find evidence surrounding the EKC hypothesis. Most of researchers try to show the validity of the hypothesis by using various techniques which broadly categorize into cross-country (cross section) analysis and selected industries analysis. Both cross-sectional and panel data have been used in this research.

Baumol and Oates (1988) constructed a simple partial equilibrium model to explain the environmental implications of free trade between two countries (where one is rich and the other is poor) in a two goods world. One of the goods is produced through a dirty process and the other one is produced by a non-polluting process. The rich country adopts stringent environmental regulations while the poor country does not. Using partial equilibrium supply and demand curves for "dirty" goods in both countries, they demonstrate that the decision made by the poor country to use the most polluting production process to produce the "dirty" good will force the world price for that good below the socially optimal price. As a result, world demand for the "dirty" good is higher than socially optimal. With the demand rises, the poor country will produce more of the "dirty" good than is socially optimal because of a high demand from both domestic and foreign fronts. As a consequence, because of the poor country's failure to adopt a pollution control program, total world emissions of pollutants will be higher and in the long-run, the poor country that fails to undertake an environmental protection program when rich countries do, increases its comparative advantage in the production of "dirty" goods with the absence of offsetting subsidies. They conclude that less developed countries that choose uncontrolled domestic pollution as a means to improve their economic position will voluntarily be the repository of the world's dirty industries. It means that free trade when combined with differences in environmental practices between rich and poor countries should affect trade patterns and lead to pollution haven effects.

Antweiler, Copeland and Taylor, ACT (2001), suggest that trade liberalization is a determinant of pollution, where the direction of this effect will depend on a country's comparative advantage. Different to a number of studies, ACT (2001) allow comparative advantage to be driven by capital and labour endowments as well as differences in environmental regulation, with the latter determined by a country's income level. They conclude that, holding other determinants of emissions constant, trade liberalization does not have a unique relationship with emissions. The authors also stress that the effect of liberalization on the environment will be country specific and will depend crucially on a country's comparative advantage. In sum the effect should be different across countries.

Copeland and Taylor (2003), based on a study of sulphur dioxide concentrations in over 100 cities around the world from 1971 to 1996, reach a milestone conclusion that free trade can actually be good for the environment and find no evidence for the Pollution Haven Hypothesis. Their findings suggest that the expansion of trade leading to increases in the scale of economic activity by 1.0 percent work to raise SO_2 concentration by 0.25 percent to 0.50 percent via the scale channel, while increases accompanying the technique channel reduce the concentration by 1.25 percent to 1.50 percent. Thus the study finds that the overall effect of the liberalisation is beneficial. Therefore the authors conclude that since developed countries have a comparative advantage in capital-intensive polluting industries, the industries are likely to continue their operation in the countries even if environmental regulations are tighter. The authors also highlight that the right environmental policy in the form of regulations or taxes can lead to cleaner production methods through continuous improvement and innovation in the technology. In summary, the study reveals that trade liberalisation on balance is good for the environment. This study also provided a very important message to developing countries that the environmental problems can only be exacerbated if trade liberalization outpaces environmental policy. Hence, in balance the policy makers must consider an appropriate policy that works well for both trade and the environment.

Using a panel data analysis on industrial water pollution from twelve countries, Hettige, Mani, and Wheeler (2000) examine the composition and technique effects of income on pollution and evaluate how the effects vary with income. In this study, the pollution was measured by the manufacturing pollution intensity, the share of manufacturing in the economy and total output. The study then separately regressed firm level pollution intensities, the average pollution intensity in manufacturing and the manufacturing share of per capita income. The results find a hump-shape relation between the share of manufactures and per capita income. However, they find this composition effect is small in magnitude relative to the impact of scale effects. Conversely, the study finds a strong technique effect as shown by a high income elasticity of the pollution intensity which is estimated about 1. The overall finding of the study shows that industrial water pollution tends to initially rise with income and then flatten out. The authors conclude that the strong technique effect is responsible for offsetting the scale effect of the manufacturing (income) expansion.

In the study on environmental regulation and the competitiveness of US manufacturing, Jaffe *et al.* (1995) find relatively little evidence to support the hypothesis that the environmental regulations will dampen the competitiveness. The authors suggest that the result can be influenced by the severe limitation on the credibility of the data used in the study especially on the measurement of the relative stringency of environmental regulation. Evidence is also difficult to find because the cost of complying with the federal environmental regulation is a relatively small fraction of the total cost of production. The authors give the quote that according to EPA[7], the share for U.S industries on average is only about two percent with exception for some industries such as electricity producers, chemical manufacturers, petroleum refiners, and basic metal manufacturers. On these grounds, they suggest that instead of regulation cost there are other factors that are more influential in dictating competitiveness such as labour cost differentials, energy and raw material cost differentials, and infrastructure adequacy. The authors also argue that there are several other factors that have influenced the findings. They explain that even though the U.S environmental laws regulations are generally the most stringent in the world, the difference between U.S requirements and those in other western industrial democracies is not great. Even where there are substantial differences between environmental requirements in the U.S and elsewhere, the authors' opine that U.S. firms are reluctant to build less-than-state-of-the-art plants in foreign countries, thus even significant differences in regulatory stringency often are not exploited.

Levinson (2007), in his study on technology, international trade, and pollution in U.S. manufacturing finds that total pollution emitted by U.S. manufacturers declined over the past 30 years by about 60 percent, despite real manufacturing output having increased by 70 percent. The author provides two main findings to support the trend. First, the study finds that the decline in the total pollution emitted by U.S. manufacturers is mainly due to the changing of technology rather than due to changes in the mix of goods produced. However, the study shows that the pace of technological change has slowed over time. Second, increases in net imports of pollution-intensive goods are insignificant in explaining pollution reduction from the changing mix of goods produced in U.S. manufacturing. The author concludes that the two findings show that shifting polluting industries overseas does very little in the cleanup of U.S. manufacturing.

[7] EPA is acronym for Environment Program Authority (USA)

Beghin and Potier (1997), in their survey of literature make several arguments. Their main argument is that their survey shows that there is no strong empirical evidence for wholesale specialisation in dirty industries induced by trade liberalization. The authors also convince that trade liberalization does not necessarily imply a cleaner environment induced by specialisation in less pollution-intensive industries. As argued by many researchers, the authors suggest that for a given composition of aggregate output, the output expansion induced by trade liberalisation is harmful to the environment if proper environmental policies are not in place. They also noted that many environmental innovations were forced into existence by the presence of regulatory efforts of OECD countries. Meanwhile, Mani and Wheeler (1999) search for pollution havens by examining data on OECD countries and developing countries, and conclude that the " period of rapid increase in net exports of pollution intensive products from developing countries coincides with periods of increase in cost of pollution abatement in the OECD countries". Even though this evidence does not prove a causal effect between the regulatory efforts of the OECD and the rapid increase in net exports of pollution intensive products from developing countries, a potential causal effect is possible.

Tobey (1990) uses a Heckscher-Ohlin model and cross-country data to investigate whether environmental stringency is a determinant of net exports in pollution intensive industries, using a sample of 23 countries. Pollution intensive industries are defined as the five industries with the highest abatement cost in the US. In a first regression the author uses environmental stringency as an explanatory variable. In a second regression the author does not include the policy variable and applies the omitted variable test. Despite allowing for non-homothetic preferences, scale economies and product differentiation in the model, the study does not find evidence to show that the introduction of environmental control measures causes deviation of trade patterns from the H-O model. Meanwhile, Ederington, Levinson, and Minier (2005) further find that while the pollution haven effect does not impact U.S. imports for the average industry, high costs of pollution abatement are associated with increased imports for geographically footloose industries, in which relocation costs often are relatively low.

4.4 A review of selected methodologies

In a quantitative analysis of the trade and environment relationship, at least three techniques can be employed, including econometric techniques, economic modelling and simulation, and input-output techniques. In the case of econometric techniques, earlier research mainly uses aggregate cross-country data while in the more recent studies, a micro level of panel data analysis is becoming popular. However, using the econometric techniques has its limitations. Several limitations are well documented in the literature. For example, Kirkpatrick and Scrieciu (2008), explain that, as usual, the econometric approach has a standard problem of demonstrating causality. The authors admit that to show a statistically robust correlation between a change in trade policy and a change in measures of environmental quality is relatively simple but it is more difficult to 'prove' that the change in the policy is the cause of the change in environmental quality. Other limitations are related to the quality of data and the econometric specifications. The issue on data will be discussed specifically in a related section. Apart from that there are also issues about the assumptions and weak theoretical underpinnings which lead to considerable differences in the results as well as in the policy conclusions drawn from the findings.

In the case of economic modelling and the simulation approach, computable general equilibrium (CGE) models and partial equilibrium models are among the common approaches employed in the analysis of the trade and environment relationship. For CGE, most analyses are static and based on the simulation outcomes for a specific policy shock. According to Kirkpatrick and Scrieciu (2008) the main advantage of the model is, "it can isolate the impact of trade on the environment from other factors, whilst accounting for complex interrelations between economics sectors and the agents of an economy and macro-economic feedback". In spite of this advantage, CGE models have a significant limitation in interpreting the findings. This is because the results are simulated counterfactuals, do not measure actual outcomes, and are based on one-year datasets instead of historical time-series data incorporating key dynamics.

In the case of input-output models, the approach is based on one year datasets similar to the CGE. Input-output models describe and explain the production and consumption of each sector of a given economy in terms of its relationships to corresponding activities in all other sectors. The model is also able to track the commodity flow (goods and services) from one industry to another industry. Most studies that employ input-output models in the empirical analysis of the trade-environment linkages are using extended input-output models which include the interactions between the environment and the economy. Early environmental models are notable for augmenting the technical coefficient matrix with additional rows and columns to describe pollution generation and abatement activities. Typically, each pollutant appears as a row in the matrix and pollution produced in each sector is assumed to be a function of its output (Huang and Labys, 2001).

Despite various methods available for the empirical study of the environment-trade linkages, the econometric model is among the popular tools used to test the theoretical considerations. Most of the recent studies use panels of data and they typically pool time series and cross-section data. There are many recent contributions to this literature including three that are of particular interest to this study. Those are of Cole and Elliot (2003), Cole (2003) and Cole *et al.* (2005). The first two of these studies use a cross-country analysis. They had investigated the robustness of the Environmental Kuznets Curve (EKC) theory and environmental determinants with relation to the Pollution Haven Hypothesis and Factor Endowment theory. The study supported Antweiler *et al.* 's (hereafter ACT) (2001) theory that the environment-trade relationship is determined by the country characteristics.

The basic model of the relationship between international trade and environment pollution uses pooled cross-country and time-series data. This is the general model employed by many researchers such as Grossman and Krueger (1991), Shafik and Banyopadhyay (1992), Selden and Song (1994). The model is shown below.

$$Y_{it} = a_i + t_t + \beta_1 X_{it} + \beta_2 X_{it}^2 + \beta_3 X_{it}^3 + \beta_k Z_{kit} + e_{it}$$

where i is 1,.....N, countries or cities; t is 1,.....T, years, or time intervals; Y_{it} is the environmental stress variable; a_i is the country or site specific effect; t_t is a time specific effect; X_{it} is the real GDP per capita; Z_{kit} are the other variables that impact environmental quality and e_{it} is an error term.

Grossman and Krueger's (1995) initial estimations use reduced-form equations that relate the level of pollution in a location (air or water) to a flexible function of the current and lagged income per capita in the country and to other covariates. An alternative to their reduced-form is to model the structural equations relating environmental regulations, technology, and industrial composition to GDP. This is then linked with the level of pollution to the regulations, technology and industrial composition.

$$\gamma_{it} = G_{it}\beta_1 + G_{it}^2\beta_2 + G_{it}^3\beta_3 + \overline{G}_{it-}\beta_4 + \overline{G}_{it-}^2\beta_5 + \overline{G}_{it-}^3\beta_6 + X_{it}'\beta_7 + \varepsilon_{it}$$

Where γ_{it} is a measure of water or air pollution in station i in year t, G_{it} is GDP per capita in year t in the country in which station i is located, $\overline{G}_{it-}$ is the average GDP per capita over the prior three years, X_{it}' is a vector of other covariates, and ε_{it} is an error term. The β's are parameters to be estimated.

Cole *et al.* (2005) investigate the role of industrial characteristics and environmental regulation on air pollution using the UK manufacturing sector. Among the pollution determinants used in their study are energy use, factor intensities, firms' size in the industry, efficiency, level of research and development expenditure and stringency of environmental regulation. However they do not include trade-induced pollution as a pollution determinant in their study. Compared to the basic model, in this study the authors use more independent variables to explain the air pollution in UK manufacturing. The model used is shown below.

$$E_{it} = \alpha_i + \delta_t + \beta_1 N_{it} + \beta_2 PCI_{it} + \beta_3 HCI_{it} + \beta_4 SIZE_{it} + \beta_5 TFP_{it} + \beta_6 CAP_{it} + \beta_7 RD_{it} + \chi REG + \varepsilon_{it}$$

where the dependent variable, E_{it} is pollution emissions expressed per unit of value added. The variables α_i and δ_t denote industry and year specific effects, respectively. N_{it} denotes direct fossil fuel use per unit of value added, whilst PCI_{it} physical capital intensity, is measured as non-wage value added per worker. Human capital intensity, HCI_{it} is defined as the share of value added that is paid to skilled workers. S_{it}, is defined as value added per firm, within industry *i*. Total factor productivity, TFP_{it} is estimated using a Cobb-Douglas production function. The variable CAP_{it} is an industry's capital expenditure, scaled by value added and acts as a measure of the vintage of production processes. This is done under the assumption that the greater expenditure within an industry, the newer the industry's equipment and machinery is likely to be. Finally they use RD_{it} to measure research and development expenditure, scaled by value added, as an indication of innovation within an industry.

A study on the environmental impact of India's trade liberalization by Rabindran and Jha (2004), applied several sets of econometric models as shown below.

$$\ln(Y_{it}) = \ln(\alpha) + \beta_1 \ln(K_{it}) + \beta_2 \ln(L_{it}) + \beta_3 \ln(P_i) + \beta_4 (P_i * T_t) + \mu_i + \varepsilon_{it} \qquad (1)$$

where Y is the total output as a fraction of value added in manufacturing industry i for time period t measured at the 3 – digit NIC level (there are in total 186 3–digit NIC manufacturing industries); K is industry-wide capital productivity; L is industry-wise labour productivity; P is industry-wide pollution intensity; T is a liberalization dummy that takes the value 1 for post-1991 years and 0 otherwise; and μ represents industry fixed effects. Capital productivity is calculated by dividing the total stock of fixed capital by the net value added. The variables of interest are the interaction variables that capture the increase in production of dirty industries relative to clean industries during the liberalization period. If domestic production does not show an increase in the dirty industries relative to cleaner industries, we would find that $\beta_4 = 0$.

$$X_{it} = \delta + \gamma_1 X_{it-1} + \gamma_2 L_{it} + \gamma_3 K_{it} + \gamma_4 IIT_{it} + \gamma_5 P_i + \gamma_6 (P_i * T_t) + \eta_i + \omega_{it} \quad (2)$$

where X is the exports from industry i as a fraction of Indian value of shipment for time period t measured at the 3 – digit NIC level; K is industry-wide capital intensity; L is industry-wide labour intensity; P is industry-wide pollution intensity; T is the liberalization dummy that takes the value 1 for post 1991 years and 0 otherwise; η is industry fixed effects and ω is the error term. Labour intensity is calculated by dividing total payroll expenses in the industry by the value added. Capital intensity is calculated by dividing the value of fixed capital by the net value added. The variables of interest are the interaction variables that capture the increase in exports from dirty industries relative to clean industries during the liberalization period. If exports do not show an increase in dirty industries relative to cleaner industries, one would find that $\gamma_6 = 0$.

$$Z_i = \beta_1 P_i + \beta_2 L_i + \beta_3 K_i + \beta_4 Y_i + \varepsilon_i \quad (2.1)$$

Equation 2.1 estimates whether an industry is opened to FDI or not. In equation 2.1 , Z is a binary variable that takes value 1 if an industry is opened to FDI and 0 if it is not opened to FDI ; P is the pollution – intensity of an industry ; K measures capital-intensity; L is labour-intensity; Y measures whether it is an infrastructure industry; ε is the error term.

$$FDI_{it} = \gamma_1 I_{it} + \gamma_2 FDI_{it-1} + \gamma_3 P_i + \mu_i \quad (2.2)$$

Equation 2.2 estimates the amount of FDI inflow into manufacturing industry i in year t measured at the 3 – digit NIC level. I is the set of other industry level characteristics that may affect FDI inflows such as labour cost differentials across sectors in an economy and industry wide productivity. Labour market conditions are measured by manufacturing wages paid in a given industry. Industry wide productivity is measured by net value-added. The variable of interest is P which is the industry-wide pollution-intensity. If FDI does not show an increase in dirty industries, then $\gamma_3 = 0$.

Copeland and Taylor (2004) applied a simple analysis of the effect of trade liberalization on the environment. The manufacturing industries were first classified into dirty industries and clean industries. Then panel data on the dirty and the clean industries for output, value added, exports, employment and imports were computed. The basis of the categorization was drawn from Mani and Wheeler (1997). This categorization is based on U.S manufacturing industry. Copeland and Taylor (2004) urged that this method has its strength where generally the set of dirtiest manufacturing appears to be stable across both countries and pollutants. Several analyses can be used such as employing regression analysis to explore the sensitivity of the series to several potential determinants.

ACT (2001) examine three hypotheses in their study. First for a country with a comparative advantage in pollution-intensive output, trade liberalization will increase pollution emissions. As for a country with a comparative advantage in clean output, trade liberalisation will not contribute to an increase in pollution emission but in fact may reduce pollution. Second, the authors hypothesise that trade liberalisation is expected to increase pollution for countries with low per capita income and reduce pollution for those with higher per capita income. Third, countries possessing capital intensive industry contributes to a higher pollution. Their model allowed income and factor endowment differences to jointly determine the effect of trade on the environment

Cole (2003), in the examination on how robust is the environmental Kuznets curve, starts his estimations by using a basic equation, then expanded the model to include other explanatory variables and country characteristics. The reduced form function is similar to Antweiler *et al.*'s (2001) model. Hence their estimation of the EKC allows the impact of trade liberalization on pollution to depend on country characteristics. The key contribution of this paper is assessing the strength of the EKC critique. The models used in this study are shown in equation (1) to equation (7) below.

$$E_{it} = (\alpha + \beta_i F_i) + \delta Y_{it} + \phi (Y_{it})^2 + \varepsilon_{it} \qquad (1)$$

Where E denotes the environmental indicator, either in per capita form or in the form of concentrations, Y denotes per capita income, F denotes country–specific effects, and i and t refer to country and year, respectively.

$$p = \beta p^{w} \tag{2}$$

where

p is relative price of X, β denotes trade frictions and P^{w} is the common world relative price of X.

Antweiler *et. al* (2001) decompose pollution (z) into scale, composition, and technique effects;

$$\hat{z} = \hat{S} + \hat{\sigma} + \hat{e} \tag{3}$$

where

~ denotes percentage changes,

S is the scale effect

σ denotes the share of the pollution-intensive good X in total output, known as composition effect.

e represents the pollution intensity of dirty industries, known as the technique effect.

$$\hat{z} = \pi_1\hat{S} + \pi_2\hat{k} - \pi_3\hat{I} - \pi_4\hat{T} + \pi_5\hat{p}w + \pi_6\hat{\beta} \tag{4}$$

where all π_i are positive, k denotes the capital-labour ratio, I represent real per capita income, T represent 'country type' and all other variable are already defined.

The following basic equation is estimated for emissions of three air pollutants:

$$E_{it} = \gamma_i + \theta_t + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + \varepsilon_{it} \tag{5}$$

Where

E denotes per capita emissions, γ denotes country-specific intercepts, θ denotes time-specific intercepts, and Y represents per capita income.

The model is then expanded to test the trade considerations discussed in the previous section. Specifically, the following equation is estimated:

$$E_{it} = \gamma_i + \theta_t + \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 y_{it}^3 + \beta_4 KL + \beta_5 KL^2 + \beta_6 T_{it} + \beta_7 TRKL_{it} + \beta_8 T(RKL_{it})^2 + \beta_9 TRI_{it} + \beta_{10} T (RI_{it})^2 + \varepsilon_{it} \quad (6)$$

Where KL is the capital-labour ratio and T represents trade intensity, or openness. TRKL is an interaction of trade intensity with a country's relative capital-labour ratio, whilst TRI is an interaction of trade intensity with a country's relative income. E_{it} is environmental indicator either in per capita form or in the form of concentration and y denotes per capita income.

Antweiler *et. al* (2001) claim that the induced composition effect in country i (Ci) can be expressed as;

$$C_1 = \alpha_0 T_1 + \alpha_1 T_i RKL_i + \alpha_2 T_i (RKL_i)^2 + \alpha_3 T_i RI_i + \alpha_4 T_i (RI_i)^2 \quad (7)$$

Frankel and Rose (2005) take specific account of the endogeneity of trade in their estimations. They used instrumental variable to correct for simultaneity. The equation for the estimation is shown below.

$$EnvDam_i = \mu_0 + \mu_1 \ln(y/pop)_{90,i} + (\mu_2[\ln(y/pop)_{90,i}]^2 + \beta([X + M]/Y)_{90,i} + \mu_3(polity)_{90,i} + \mu_4 \ln(Land\ Area/pop)_{90,i} + e_i$$

Where;

EnvDam1 is one of three measures of environmental damage for country i

$\{\mu_1\}$ is a set of control coefficients

$\ln(y/pop)_{90,i}$ is the natural logarithm of 1990 real GDP per capita for country i

$([X + M]/Y)$ represents the ratio of nominal exports and imports to GDP

Polity is a measure of how democratic (versus autocratic) is the structure of the government.

Land Area/pop is a measure of per capita land area

e is a residual representing other causes of environmental damage

Cole (2000) addresses the econometric issues of the existence of autocorrelation in OLS residuals (that is the error terms are correlated over time) and the issue of heteroscedasticity (i.e. the variances of the error terms are not equal). Due to the existence of these features, the study adopted a generalised least squares approach which corrects for both autocorrelation and heteroscedasticity. Then the Box-Pierce and Durbin-Watson tests were used to indicate the existence of autocorrelation. Quadratic relationships, linear and log linear relationships are considered for two environmental indicators.

Quadratic in levels;

$$E_{it} = (\alpha + \mu_i F_i) + \beta Y_{it} + \gamma Y^2{}_{it} + \varphi X_{it} + e_{it} \qquad (1)$$

Quadratic in logs;

$$\ln E_{it} = (\lambda + \kappa_i F_i) + \eta \ln(Y_{it}) + \theta(\ln Y_{it})^2 + \omega X_{it} + e_{it} \qquad (2)$$

where;

E = environmental indicator in per capita form

Y = per capita income

F = region or country-specific fixed effects

X = exogenous factors

i = 1 ....n regions

t = 1.............T years.

Vincent (1997) has used Malaysia as a case study for examining the Environmental Kuznets Curves within a developing country. In the study he uses panel data analysis, estimated for both fixed-effects and random-effects specifications of the model. The reduced form used is shown below.

$$Q_{it} = \beta_{oi} + P_{it} \; x\,(\beta_p + \beta_y Y_{it} + \beta_{yy} Y_{it}^2 + \beta_{yyy} Y_{it}^3 + \beta_t t) + \varepsilon_{it}.$$

which can be rewritten as ;

$$Q_{it} = \beta_{oi} + \beta_p P_{it} + \beta_y P_{it} Y_{it} + \beta_{yy} P_{it} Y_{it}^2 + \beta_{yyy} P_{it} Y_{it}^3 + \beta_t P_{it} t + \varepsilon_{it}.$$

where

Q is pollution concentration, i indicates monitoring station/ administrative district/state (depending on the variable) t indicates year, Y is state-level per capita GDP and P is district-level population density. The author noted that "the time trend was a proxy for changes in per capita impacts over time due to factors not necessarily correlated with income (e.g. policy changes). He also stated "according to this model, population density by its own can affect air quality (if βp is statistically significant)". The finding shows that there is no evidence of EKC for many of the pollutants examined.

Cole (2004) examines trade-environment linkages as suggested by the Pollution Haven Hypothesis and the Environmental Kuznets Curve Hypothesis using the model as shown below for the case of a sample of OECD countries for the period 1980-1997. The estimations included ten air and water pollutants. The author clarified that the share of manufacturing in GNP is incorporated to show the extent to which structural change within the economy affects pollution.

$$
\begin{aligned}
LnE_{it} \quad = \quad & \gamma + F_i + K_t + \delta \ln Y_{it} + \phi(\ln Y_{it})^2 + \psi(\ln Y_{it})^3 + \sigma \ln M_{it} \\
& + \lambda \ln DX_{it} + \theta \ln DM_{it} + \eta \ln T_{it} + \varepsilon_{it}
\end{aligned}
$$

where

E is the pollutant

F is the country specific effects

K represents year specific effects

Y refer to per capita income

M represents the share of manufacturing in GNP

DX is the share of dirty exports to non-OECD countries in total exports

DM is the share of dirty imports from non-OECD countries in total imports

T is trade intensity

i and t represent country and year respectively.

Discussion

The review of empirical shows that many studies offer explanations on how trade liberalization will affect the environment. Variables such as changes to the scale of an economy, country characteristics, absorptive capacity and transfer of pollution abatement technology are several factors chosen to determine how trade will harm (improve) the environment. Some researchers admit that there is difficulty in assessing the empirical relationship between trade openness and environmental quality mainly because trade patterns, environmental quality, as well as income, may be jointly determined thus making causal inferences problematic. This shows that, the trade-environment relationship to a certain extent can be seen as a complex process which is difficult to use for econometric analysis.

Compared to the early studies, the recent research gives more emphasis to the functional form and econometric properties of data in the studies. In early studies, issues related to the econometric application such as endogeneity, omission bias, multicolinearty, non-stationarity, etc have not been addressed properly. Thus the legitimacy of the results of early empirical studies is disputable. As stated by Islam *et al.* (1999), the reduced form environment-income relationship gives the 'net effect' of income on the environment and documentation of this relationship is 'an important first step' in the study of the environment-income relationship. The primary reason for the reduced form approach is it is easy to apply.

In this present study, we focus the analysis using panel data analysis. Therefore, here we briefly describe the background and the advantages of the fixed effects model and random effects model.

Panel data analysis:

Panel data is a dataset in which the behaviour of the same entities is observed across time. This method of analysis is becoming a popular technique employed in the field of economic modelling[8]. Panel data allows us to control for variables we cannot observe or measure like cultural factors (when comparing countries or state within a country) or difference in business practices across companies. Panel data also help to control for unobservable variables that change over time but not across entities (i.e. national policies, federal regulations, international agreements, etc.).

[8] The overview of modeling technique depicted in this chapter draws mainly from the works of Verbeek (2004) and Greene (2003).

Hence, the main advantage of this technique is that the analysis takes into account both cross section and time series effects. This makes the analysis more comprehensive where it covers both dimensions. Panel data can be balanced data or unbalanced data. The panel is considered balanced if all observations are available across variables and time. If the complete datasets could not be obtained which is a common problem in panel data analysis, it can be corrected by using unbalanced panel estimation methods (Greene, 2003). Unbalanced panel estimation avoids losses in efficiency by using all available observations, including those for industries that are not observed in all years of the dataset. There are two techniques used to analyze panel data, fixed effects and random effects.

Fixed effects model (FE):

The rational behind FE is that it is used to control for differences across entities (ISIC) but not over time. The key insight is that if the unobserved variable does not change over time, then any changes in the dependent variable must be due to influences other than these fixed characteristics (Stock and Watson, 2003). In this model the slope parameters are basically estimated from the 'within' deviations because of the procedure involved, subtracting out the individual mean from the variables. This also involves the loss of a large number of degrees of freedom, equalling the number of individual units.

Random effects model (RE):

The rationale behind RE is that, unlike the FE model, the variation across entities is assumed to be random and uncorrelated with the independent variables included in the model. "..the crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not" (Greene, 2003). An advantage of RE is that we can include time invariant variables (i.e gender). In the FE model, these variables are absorbed by the intercept.

Typically, the Hausman test is used to decide which of these models to use. However, the Hausman test is actually a joint test of the specification of the model and the assumption that the individual effects are uncorrelated with the included regressors. This test does not reveal whether a rejection of the null hypothesis is caused by violation of the assumption of uncorrelatedness or by other kinds of misspecification of the model.

4.5 Issues related to data and pollution measurements

Data availability is still a major concern in this area of study. Using indirect estimations and proxies for the relevant data are norms in this area. Issues such as a lack of industry-specific pollution data (i.e. pollution per unit output) on a country by country basis are common in this area of study. If such data were available, one could first simulate changes in the country production and consumption patterns that take place as trade is liberalised and then use these results to calculate the associated changes in pollution. Shafik (1994) has pointed out that in the past this debate lacked empirical evidence to support one argument or the other, remaining on a purely theoretical basis for a long time. This is mainly due to, first, a lack of available environmental data for many years. Second, it also reflected the difficulty of defining how to measure environmental quality. In the absence of a single criterion of environmental quality, several indicators of environmental degradation have been used to measure the impact of economic growth on the environment. However, Shafik (1994) stressed that different indicators may yield different empirical results.

Many researchers agreed that, at present, the U.S is the only country that has collected pollution abatement cost data for a significant period of time. This causes researchers to have limited options for exploring the relationship between environmental regulations and competitiveness. Due to a lack of consistent cross-country pollution data, industries have often been classified as either clean or dirty with the classification typically being based on US data for either emission intensity, toxic intensity, or abatement costs as a fraction of value added (Sheldon, 2006).

Furthermore, there are various issues involved with measurement of the dependent variable of interest, namely, environmental quality. The first question whether it should be measured by pollution emission rates or ambient levels. Some researchers maintain that in order to capture the effects of the determinants, emission rates are appropriate and useful. However data on them are not easily available, at least in desirable form. This has led researchers to often use data on ambient levels. Ambient levels themselves however, have their own set of problems. Islam *et al.* (1999) suggest that the ambient pollution level in an area is influenced both by the pollution that is emitted in that area and by other natural factors such as location (the distance of a city or a site from the coast line), topography (a desert or a mountain range), weather patterns etc. In other words, there are other factors that influence ambient levels which are not directly linked to human activity. Besides that, the readings may be taken at different points of time or different intervals and using different devices. All these make capturing empirically the systematic relationship between environmental quality and its determinants even more difficult.

Meanwhile, in the absence of sectoral data for pollution intensities, various techniques have been used by researchers. For example, Cole (2000), has made estimations for nitrogen oxides, sulphur dioxide, carbon monoxide and suspended particulate matter using IPPS[9] coefficients. Multiplying the output change estimated for each sector by that sector's pollution intensity provides the change in air pollution for each country/region resulting from the change in the composition of output. In his approach, rather than applying US intensities to all other countries/regions, the US sectoral intensities have been scaled for each country/region according to the difference between the average total pollution intensity over the period 1970-90 (i.e total pollution/GDP) in the country compared to the US. He gives an example in the case of China, "if China's total sulphur dioxide intensity of GDP is, on average, 50% higher than total sulphur dioxide intensity in the US, then China's sectoral intensities will be estimated by increasing US sectoral intensities by 50%". The author admitted that despite the assumption that each country's sectoral intensities are uniformly higher or lower than those of the US, it is still a much better method compared to applying US sectoral intensities to other countries without modification. Another example is by Cole *et al.* (1998). The authors estimate the impact of the Uruguay Round on five air pollutants;

[9] IPPS is acronym for Industrial Pollution Projection System. It has a detailed explanation in the appendix of chapter (6).

nitrogen dioxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), suspended particulate matter (SPM), and carbon dioxide (CO2). In their study, they do not have sectoral pollution data for other countries. They also use the US coefficients with some scaled upward or downward to make the total emissions consistent with the data that are available.

The issues on data availability have been highlighted by many researchers. For example, Jaffe *et al.* (1995) raise several issues related to data and measurements. They explain that in many of the studies, differences in environmental regulation were measured by environmental regulation costs as a percentage of value-added, or some other measures that depends critically on accurate measurement of environmental spending. The authors also suggest that "even for the U.S where data on the environmental compliance costs are relatively good, compliance expenditure data are notoriously unreliable". Beghin and Potier (1997) state that the scarcity of data on pollution emissions by manufacturing activity outside the US imposes serious limitations on the evidence. Because of the shortcoming, most studies looking at pollution intensity of manufacturing activities rely directly or indirectly on the database constructed at the World Bank under the IPPS program with direction of David Wheeler. It shows that pollution intensity of US manufacturing varies greatly across activities and type of emission.

Besides that there is also issue of endogeneity in study of the environment-trade relationship. Theoretically, endogeneity problems arise when endogenous explanatory variables are included in the model of estimation. If this problem is to be ignored, it yields biased and inconsistent estimates. There are several arguments related to endogeneity in the trade and environment relationship. For instance, the EKC assumes unidirectional causality from GNP to emissions and allows no mechanism through which environmental degradation can affect income levels. It may be true that pollution emissions do not appear to be affecting per capita GNP. However it is possible to have a case where causality does appear to move from environment to GNP. As an example, land degradation in developing countries affects agricultural output. In other words, policies that alter pollution intensity can also affect income growth. This shows that countries may impose weaker environmental policies which simultaneously induce higher growth rates in pollution intensive industries and higher GDP growth rates. Hence national income may not be exogenous to pollution performance. In practice, few country governments are believed to make trade and environmental policy separately. There are many factors driving trade policy and environmental policies simultaneously. Therefore many researchers such as Copeland and Taylor (1994) suggest that income may endogenously lead to stricter environmental laws, which in turn define the structure of trade and domestic production. Millimet and Roy (2011) suggest that environmental regulation is considered to be endogenous where it may be correlated with unobserved determinants of location choice such as tax breaks or other firm-specific treatments, the provision of other public goods in addition to environmental quality (e.g., infrastructure), agglomeration, the stringency of other regulations such as occupational safety standards, corruption, local political activism and political institutions. They also suggest that "reverse causation may be an issue". This reiterates what has been said by Levinson (2010): "international trade has environmental consequences, and environmental policy can have international trade consequences".

In early empirical study of the environment-trade relationship, it seemed that the endogeneity problem was not widely discussed and therefore was not taken into account in the estimation. However, in the late 1990s a series of empirical studies started to take explicit account of the endogeneity of regulation. Recent studies such as Becker and Henderson (2000), Ederington and Minier (2003), Levinson and Taylor (2008), Cole and Elliot (2003), Keller and Levinson (2002), Cole and Elliott (2005), Ederington *et al.*,(2005), Cole *et al.*,(2006) and Wagner and Timmins(2008) using panel data in their examinations of the trade-environment relationship, indicated that it is important to control for unobserved heterogeneity and endogeneity. Empirical investigations that control for endogeneity of environmental policy tend to find more robust evidence of moderate pollution haven effects. Levinson (1999) points out that the endogeneity of environmental policy may be confounding estimates in the environment-trade relationship. The author studies the effects of taxes on hazardous waste on interstate trade in waste in the U.S. After correcting for endogeneity, he finds evidence that policy differences affect trade flows. Cole and Elliott (2003) in their study using the Heckscher-Ohlin-Samuelson (HOS) framework control for the potential endogeneity of environmental regulations. The other studies that have taken into account the endogeneity problem include Levinson and Taylor (2001) and Ederington and Minier (2001). In a recent study using state-level panel data on inbound U.S. FDI, Millimet and Roy (2011) stress that there are "significantly larger effects of environmental regulation once endogeneity is addressed".

Survey on the empirical literature shows several techniques have been employed to tackle (overcome) endogeneity problem such as fixed effects, instrumental variable estimators or matching estimators. For example, Levinson and Taylor (2001) used a Two-Stage Least Squares (2SLS) procedure with instruments to measure stringency of environmental regulations across states in the US, to capture the endogenous nature of the trade-environment relationship. Using this method they found that tighter environmental regulations are associated with larger net imports.

However, in the case of a single country study such as this study, we are in effect controlling for regulations. Thus while endogeneity issues do not go away, they are reduced compared to cross-country studies.

4.6 Conclusion

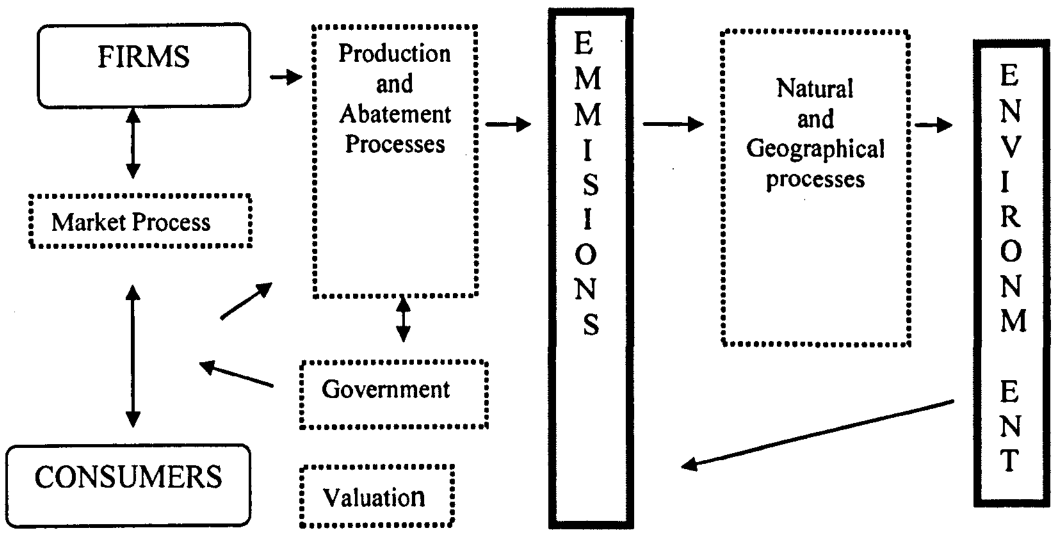
Theoretically, the effect of trade on the environment is not direct. The most explicit explanation offered in the literature is that trade liberalization can potentially contribute to economic growth of the country and hence increasing the country's per capita income which is measured by Gross Domestic Product (GDP) per capita or Gross National Income (GNI) per capita. Consequently, a higher economic growth stimulates expansion of economic activity and concurrs with increasing consumption. In turn, this puts more stress on the environment and leads to indiscriminate exploitation of natural resources. In spite of the gloomy effects on one hand, the trade liberalization on the other hand could also spearhead the evolution of more environmentally friendly technologies in the production process and thus prohibit further environment deterioration as well as a rehabilitation process. These processes are precisely highlighted by Dinda (2004), "the common point of all the studies is the assertation that environmental quality deteriorates in the early stage of economic development /growth and improves in later stages as an economy develops". However it is very naïve to believe that both the advantages and disadvantages of trade liberalization to the environment are automatic processes. Instead, as discussed at length earlier, the country characteristics such as factor endowments and possession of comparative advantage which determined the goods to be traded, level of per capita income and income distribution, and appropriate environment regulation in the country will influence the net effect of trade liberalisation. This present study completely subscribed to the main arguments in the literature especially ACT (2003) who strongly urge that it is the country's comparative advantages determined by the country's characteristics that influence the pattern of trade flows which ultimately affect the environment.

Essentially the body of literature shows that the effect of trade on the environment is theoretically ambiguous. As Kirkpatrick and Scrieciu (2008) suggest there are a lot of complex interdependencies that exist between trade, investment, regulation and environment quality. Different assumptions and possibilities in the theoretical literature suggest that the impact of trade liberalisation on environmental quality may not necessarily follow a uniform or unique pattern, and may depend on country specifics, the nature of the environmental problem under investigation, as well as policy and institutional measures accompanying the trade reform process. In the words of Frankel and Rose (2005), "....although the topic is the subject of a rapidly growing area of research, the answer is not settled. Indeed, the effect of trade on the environment is theoretically ambiguous".

Empirically, the review of previous studies shows that the methodologies employed to test the relationship are widely varied as are the results. Thus, how to adequately quantify the effect of trade on the environment is not a straightforward task. There are mixed arguments and empirical studies have shown no conclusive evidence. Variables such as changes to the scale of an economy, country characteristics, assimilative capacity and transfer of pollution abatement technology are several factors which determine how trade will affect the environment.

As highlighted and discussed in this literature, there is limited research that has been done on a single country. Therefore this present work is dedicated to improve our understanding of the complex and interdependent trade-environment relationship especially using the empirical evidence from a single country study. Malaysia is used as a case study given its rapid process of industrialisation and liberalisation.

Figure 1: Connection between processes, the economy's agents and the environment



Source: Carlo Perroni & Randall M. Wigle (1994)

Appendix 4.2

Table 4.1 Summary debates on the environment-trade relationship

Opponents of Trade	Proponents of Trade
1. Trade damages natural resources(stock and services)	1. Trade enhances economic development.
2. Trade allows environmentally harmful goods and processes to transfer to 'pollution haven countries' in exchange for economic gains.	2. Trade-devised income can fund improvement of environmental management and disseminate environmentally sound technology.
3. Trade under-cuts existing environmental pollution laws.	3. Trade provides incentives for environmental policy reform.
4. Trade affect international environmental agreements.	4. Trade enhances environmental harmonization among countries.
5. Any benefits from increased trade liberalization will be outweighed by damage caused to the environment.	5. Increased incomes resulting from trade liberalization will eventually generate an increased demand for environmental improvement.
6. Trade will increase production and consumption which is harmful to environment.	6. Free trade protects the environment by helping to generate the economic growth that both increases the demand for environmental protection and provides the resources necessary for it(GATT, 1992,pg. 19 – 20).
7. Governments will not set optimal environmental policies in view of global competition.	7. If commodities produced in an environmentally benign way are traded, trade may contribute to improving the environment as well as to development.(e.g. in Sweden,P.Ekins *et. al*,1994).
8. Trade competition will result in lobbying for less stringent environmental policies.	8. Protection can cause great environment damage as well as economic inefficiency(Repetto, 1985,1986,1988; Kosmo 1987).
9. Competition creates a race to the bottom or regulatory chill.	9. Trade enables pollution-fighting technologies available elsewhere to be imported. (Muradian *et.al*,2001)
10. Trade encourages 'ecological dumping'.	
11. If EKC is true, that the pollution problems are spread spatially or temporary, it does not yet appear to reach the downward – sloping part of the EKC in any country.	
12. Net negative environmental impacts rise if resources are mispriced(water, timber, oil, coal, fish, and open space are under price or over priced)	

13. Although the "free trade produces growth which benefits the environment" argument emerges as a theoretical possibility, it is not easily put into practice. 14. There is irreversible damage to the environment, with no scope for reparation(e.g. when species are made extinct) 15. A precondition for trade is transportation. Transportation requires fuel, normally fossil fuel. It has been estimated that international trade is responsible for one-eight of world oil consumption (Madeley, 1992,p.33). Thus trade contributes substantially to energy – related environmental damage, such as carbon dioxide emission and other oil pollution.	10. Freer trade can lead to better environmental outcomes also from a shift in the composition of production. (Muradian *et.al*,2001) 11. Inward-looking development policies may produce as serious environmental problems as the outward-looking strategies, along with significantly lower living standards.(Repetto, 1994)

Table 4.2: A summary of empirical studies of the environmental Kuznets curve (EKC) hypothesis[10]

Author and explanatory indicator I	Dependent variable II	Relation shape III	Turning point (GDP/per capita) IV	Remarks V
Shafik and Bandyopadhyay(1992) GDP/percapita $1985 PPP	Lack of clean water Lack of urban sanitation Level of particulate matters SO_2 Changes in forest area Annual rate of deforestation Dissolved oxygen in rivers Municipal waste per capita Carbon emissions per capita	Linear downward Linear downward Quadratic Quadratic U-inverted Quadratic Quadratic U-inverted Quadratic Quadratic Quadratic U-inverted	Declines monotonically Declines monotonically n.a. 3 000 n.a. 2 000 n.a. n.a. 4 000	Sample includes 149 countries for the period 1960- 1990
Hettige,Lucas and Wheeler (1992) GDP/ per capita $1985	Toxic intensity of GDP Toxic intensity of industrial output	Quadratic U-inverted Quadratic	12 790 n.a.	Global; toxic intensity of 80 countries ; logarithm.
Panayotou (1993) GDP/per capita $1985	SO_2 NO_X SPM Deforestation rate	Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted	3 000 5 500 4 500 1 200	Global; emissions per capita deforestation
Grossman and Kreuger (1993) GDP/per capita $1985 PPP	SO_2 SPM Smoke	Cubic N-normal Cubic N-normal Cubic N-normal	a) 4 107;b)14 000 Decreasing a)5 000 ; b)10 000	Global; GEMS data; urban concentration of pollutants
Shafik (1994) GDP/per capita $1985 PPP Time series	Lack of save water Lack of urban sanitation Annual deforestation Total deforestation Dissolved oxygen in rivers Fecal coliform in rivers Ambient SPM	Linear downward Linear downward Quadratic U-inverted Quadratic U-inverted Linear downward Cubic N-normal Quadratic U-inverted	n.a. n.a. n.a. a)1 375 ; b)11 500 3 280 3 670 n.a.	Global; World Bank data(World Development Report(WDR) 1992 environmental data appendix);linear, quadratic

[10] Source: Panayotou (2003)

	Ambient SO_2 Municipal waste per capita Carbon emission per capita	Quadratic U-inverted Linear upward Linear upward	n.a.	and cubic logarithm are tested
Selden and Song (1994) GDP/per capita $1985 Population density	Estimation by random effect: SO_2 SPM NO_X CO Estimation by fixed effect; SO_2 SPM NO_X CO	Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal	10 700 900 21 800 19 100 8 900 9 800 12 000 6 200	Global; data form World Resources Institute(WRI)World Resources 1990 – 1991 ; 30 countries in the sample
Cropper and Griffiths (1994) GDP/per capita $1985 Wood price Density of rural population	Deforestation rate	Quadratic, Africa, U-inverted Latin America, U-inverted Asia, n.a.	4 760 5 420 n.a.	Regional; 64 countries in the sample; deforestation observed during 1961 – 1991;FAO data
Holtz – Eakin and Selden (1995) GDP/per capita $1985	CO_2	Quadratic U-inverted Cubic N-normal	35 400 28 010	Global; emission per capita
Antle and Heidebrink (1995) GDP/ per capita $1985	Total area of parks and protected areas Deforestation Afforestation Total forest area	Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted	U-Shape pattern U-Shape pattern U-Shape pattern	Data from WDR 1987, environmental data appendix and from WRI World Resources 1990 - 1991
Grossman and Krueger (1995) GDP/per capita $1985	SO2 Smoke Heavy particles Dissolve oxygen Biological oxygen demand Chemical oxygen demand Concentration of nitrates Fecal coliform Total coliform Concentration of lead Cadmium Arsenic Mercury Nickel	Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal	a)4 053 ; b)14 000 6151 Decreasing 2 703 7 623 7 853 10 524 7 955 3 043 1 887 11 632 4 900 5 047 4 113	Global ; GEMS data : pollutant concentration in cities and rivers
Panayotou (1997) GDP/per capita $1985 PPP	SO_2	Cubic N-normal	a)5 000 ; b)15 000	The sample includes 30 developed and

Population density, industrial share; GDP growth; policy				developing countries for the period 1982 - 1994
Roberts and Grimes (1997) GDP/per capita $1987	CO_2	Quadratic U-inverted	n.a.	World Bank data and Carbon Dioxide Information and Analysis Center data
Cole, Rayner and Bates (1997)	NO_x SO_2 SPM CO NOx of transport sector SO_2 of transport sector SPM of transport sector Nitrates CO_2 Energy consumption CFCs and halons Methane (NH4) Municipal waste Transport energy use Traffic volume	Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted	15 100(14 700) 5 700(6 900) 8 100 (7 300) 10 100 (9 900) 15 100 (17600) 9 400 (9 800) 15 000 (18 000) 15 600 (25 000) 25 100 (62 700) 22 500 (34 700) 15 400 (12600) n.a n.a 400 000 (4 million) 108 200 (65 300)	Cross-country/regional data from OECD countries
Vincent(1997) GDP/ per capita Malaysian Ringgit 1978 Population density	SPM Biochemical oxygen demand Chemical oxygen demand Ammoniac nitrogen pH Solid particles in rivers	Cubic N-inverted Cubic N-inverted Cubic N-inverted Cubic, n.a. Cubic, n.a Cubic, n.a	n.a. (increasing) n.a. (decreasing) n.a. (increasing) n.a. (no form) n.a. (no form) n.a. (no form)	Malaysia ; used data set with observations from late 1970s to early 1990s
Hettige, Mani and Wheeler (1997)	Industrial water pollution	Linear upward	n.a.	Factor level data on industrial water pollution from 12 countries

Carson, Jeon and Mc Cubbin (1997) GDP/ per capita $1982	Greenhouse gasses Air toxic,1990 CO NO_x SO_2 Volatile organic carbon Particulate matter Air toxics,1988 - 1994	Linear downward Linear downward Linear downward Linear downward Linear downward Linear downward Linear downward Linear downward	Decreasing Decreasing Decreasing Decreasing Decreasing Decreasing Decreasing Decreasing	Data from 50 states of the United States
Moomaw and Unruh (1997) GDP/per capita $1985	CO_2(panel) CO_2 (for each country)	Cubic N-normal Linear downward	12 813; 18 333 n.a.	Oak Ridge National Laboratory data and Penn World Tables
Komen, Gerking and Folmer(1997) GDP / per capita $1991	Environment R&D	Linear upward	n.a.	19 countries of the OECD
Ravallion,Heil and Jalan (1997) GDP/per capita $1985 PPP	Carbon emission	Cubic N-normal	U-shape pattern	Data are from Oak Ridge National Laboratory and United Nations Statistical Division
Schmalensee, Stoker and Judson (1998) GDP/ per capita $1985 PPP	CO_2	Log linear	10 000	National level panel data set for 47 countries from 1950 to 1990
Torras and Boyce (1998) GDP/ per capita $1985PPP	SO_2 Smoke Heavy particles Dissolved oxygen Fecal coliform Access to safe water Access to sanitation	Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal Cubic N-normal	3 890 4 350 Decreasing Increasing Increasing 11 255 10 957	GEMS data cover the period 1977 - 1991
Unruh and Moomaw (1998) GDP/per capita $1985 PPP	CO_2 emissions	Cubic N-normal	n.a.	Data obtained from Summers and Heston (1991), for 16 countries
Suri and Chapman (1998) GDP/per capita $1985 PPP	Consumption of primary commercial energy per capita, expressed in terms of oil equivalents	Quadratic U-inverted	55 000	Data consist of observations of 33 countries over the period

				1971 – 1990; IEA data
de Bruyn, van den Bergh and Opschoor (1998) Economic growth rate	CO_2 NO_x SO_2	Linear logarithm Linear logarithm Linear logarithm	n.a n.a n.a	Data from the Netherlands, United Kingdom, United States and West Germany for various time intervals between 1960 and 1993
Rothman (1998) GDP/per capita $1985 PPP	Food, beverage and tobacco Garment and footwear Gross rent, fuel and power Medical care and services Other commodities	Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted	12 889 35 263 23 278 47 171	United Nation International Comparison Programme data
Kaufman,Davidsdottir,Pauly and Garnham (1998) GDP/per capita $1985 PPP	SO_2 (cross-section) SO_2(fixed effects) SO_2(random effects)	Quadratic U-inverted Quadratic U-inverted Quadratic U-inverted	11 577 12 500 12 175	United Nations Statistical Yearbook 1993 data ; panel of international data for 23 countries
Chaudhuri and Pfaff (1998)	Indoor air pollution	Quadratic U-inverted	n.a.	Micro data from Pakistan Integrated Household survey 1991
Kahn (1998)	Vehicle hydrocarbon emissions	Quadratic U-inverted	35 000	Data from the Random Roadside Test, created by the California Department of Consumer Affairs, Bureau of Automotive Repairs.
Islam, Vincent and Panayotou(1999)	SPM	Quadratic U-inverted	n.a.	GEMS data on suspended particulate matter; data contain 901 observations from 23 countries

				from the period 1977 - 1988
Sachs, Panayotou and Peterson (1999) GDP/per capita $1985 PPP	CO_2	Quadratic U-inverted	12 000	The study combined time series and cross-section national level data to construct a panel with 3,869 observations for the period 1960 - 1992
Galeotti and Lanza (1999)	CO_2	Quadratic U-inverted	13 260	New data set developed by IEA that covers the period between 1960 – 1995
Bhatttarai and Hamming (2000) GDP/ per capita $1985 PPP	Deforestation	Quadratic U-inverted	6 800	Data from FAO, WRI, and UNEP for 1980,1990 and 1995. National income, exchange rates and trade data taken from Penn World Tables, Summer and Heston(1991)

Table 4.3a. Selected empirical papers on the environmental Kuznets curve[11]

Paper	Pollutants	Data	Specification	Finding
Grossman and Krueger (1991)	SO2,TSP, water quality.	Various countries, years	Cubic in logs, random effects, with lagged GDP	Most pollutants peak before GDP/capital reaches $8000.
Shafik and Bandyopadhyay (1994)	SPM, SO2, fecal coliforms in rivers, sanitation, municipal waste, carbon emission, deforestation.	149 countries 1960-1990	Panel regression based on OLS log linear, quadratic, cubic	Water and sanitation pollution peak earliest. Urban air pollution peaks for middle income countries.
Sleden and Song (1994)	Panel of NOxCOSPM SO2	30 countries, three periods (1973-1975, 1979 – 1981, 1982 – 1984)	Pooled x – section, fixed effects, random effects.	Substantial support for the inverted – U hypothesis, but with turning points at higher incomes.
Holtz-Eakin and Selden(1995)	CO2	Uneven panel of data on 130 countries 1951 – 1986	Quadratic in levels and natural logs	Concave emissions-income path, but no peak within reasonable range of incomes.
Roberts and Grimes(1997)	CO2	US for 1962 – 1991	OLS with linear and curvilinear effects of level of economic development on CO2 emissions	Concavity of carbon emissions-income curve due to a relatively small number of wealthy countries becoming more efficient. No peak emission at reasonable income levels.
Hilton and Levinson(1997)	Automotive lead emissions	48 countries. Leaded gasoline data from Octel	Quadratic in levels and logs, splines	Predicted peak lead emissions is sensitive to functional form

[11] Source: Levinson (2000).

				and time period. Decomposes scale and technique effects.
Kahn (1998)	Automotive hydrocarbon emissions	1993 California, USA	OLS	Find inverted-U-shaped emissions/income relation peaking at $25,000.
Wang, *et al.* (1998)	Exposure to toxic waste.	Cross section of US counties in 1990.	Tobit estimation	Inverted-U-shaped relationship between toxic waste and county income.
Chaudhuri and Pfaff (1998)	Indoor air pollution	Household level data in Pakistan.	Tobit estimation of fuel use, translated into air quality.	Inverted-U-shape relationship between household income and indoor air quality.
Milimet and Stengos (1999)	Toxic releases from TRI.	US states 1988-1996.	Semi parametric partially linear log.	N-shaped path, turning up at high incomes($30,000 per capita).
Arora and Cason(1999)	Toxic releases from TRI.	0993 cross section of 30,000 zip codes.	2 – stage maximum likelihood sample selection model where the first stage estimates a probit model.	Variables that proxy for collective action significantly reduce local releases.
Harbaugh *et al.*(2000)	SO2 , , TSP	Various years and countries.	Fixed effects, panel, with polynomials in GDP and lagged GDP.	Grossman and Krueger's(1995) finding are sensitive to countries studied, year covered, functional form, and econometric specification. Confidence bands

				around the pollution-income path render its shape uncertain.
Taskin and Zaim (2000)	CO2 emissions (millions of tons)	Cross-section data on 52 countries 1975 – 1990	Nonparametric kernel regression technique.	Improved environmental quality at the initial phases of growth (up to GDP/capital of $5000), followed by a phase of deterioration(up to $12,000), and then improvement again.
Bradford, *et al.*(2000)	13 different air and water pollutants.	Various years and countries.	New variant on cubic function with fixed effects.	Similar to Grossman and Krueger: some pollutants exhibit inverse-U's, others do not.

Table 4.3b. Selected theoretical models of growth and environment[12]

Paper	Model	Cause of non-monotonicity	Results
John and Pecchnino (1994)	Overlapping generations model. Environmental quality is a stock resource that degrades over time unless maintained by investment in the environment.	An economic that begins at the corner solution of zero environmental investment degrades its environment with economic growth until positive environmental investment is desired. Then environmental quality begins improving.	Inverse –V shaped, peaking when the dynamic equilibrium switches from a corner solution of zero environmental investment to an interior optimum with positive investment.
Stokey (1998)	Static model, choice of production technologies with varying degrees of pollution.	Blow a threshold level of economic activity, only the dirtiest technology can be used. With economic growth, pollution increases linearly with income until the threshold is passed and cleaner technologies can be used.	Inverse –V –shaped pollution-income path, with a sharp peak at the point where a continuum of cleaner technologies becomes available.
Jones and Manuelli (2000)	Overlapping generations model, with endogenous formation of political institution.	Economy needs threshold income to establish institutions for correcting externalities.	Monotonic increasing pollution, inverted-U, or "sideways mirrored S"
Andreoni and evinson (2001)	Robinson Crusoe model (static, one good, one person, one period).	Returns to scale in pollution abatement technology.	Pollution increases or decreases with income.

[12] Source: Levinson (2000).

CHAPTER 5

The Effect of International Trade on the Environment: The Case of Industrial Trade and Air Pollution Concentrations in Malaysian States

5.1 Introduction

This chapter will examine the empirical evidence on the trade and environment relationship using sub-national data which is the first of three routes undertaken by this research. Specifically, we will analyse the effect of international trade liberalization of the manufacturing sector on the air pollution in the states of Malaysia that arises via three channels: the scale effects, the composition effects, and the technique effects. This empirical analysis will also evaluate the characteristics of industries in the regions where one may hypothesise that trade causes environmental degradation. We believe that this 'micro investigation' will provide a new perspective that will enhance our current understanding of the relationship.

Malaysia is a federation country consisting of thirteen states which geographically are split into two parts, Malaysian Peninsular and Malaysian Borneo. Apart from the thirteen states, there are also two federal territories (FT) which are controlled directly by the federal government. The total land area is approximately 329,960 square kilometres. The thirteen states and two federal territories (FT) are namely: Perak, Johor, Pahang, Selangor, Terengganu, Kedah, Kelantan, Negeri Sembilan, Melaka, Pulau Pinang, Perlis, Sabah, Sarawak, FT Kuala Lumpur and FT Labuan. The states of Sabah, Sarawak and Labuan are situated in Malaysian Borneo and the other states are located in Malaysian Peninsular. The map of the states is shown on the last page of this thesis. The total population of Malaysia was 26.6 million in 2006, comprising a multi ethnic society. Table 5.1 below provides a comparison of land area, population and the economic strength (GDP) between the states.

Table 5.1: States of Malaysia, Land Area, Population and Real GDP (2006)

States	Land area (sq.km)			Population ('000)			GDP (RM mill.)			
		%	rank		%	rank		%	rank	Percap.
Johor	18987	5.8	5	3171	11.9	2	46498	9.8	3	14664
Kedah	9425	2.9	8	1882	7.1	6	16632	3.5	10	8837
Kelantan	15105	4.6	6	1531	5.7	8	7985	1.7	13	5216
Kuala Lumpur	243	0.1	14	1580	5.9	7	63931	13.4	2	40463
Labuan	92	0.0	15	85	0.3	15	2191	0.5	15	25776
Melaka	1652	0.5	11	725	2.7	13	13072	2.7	12	18030
Negeri Sembilan	6657	2.0	10	962	3.6	12	17695	3.7	9	18394
Pahang	35965	10.9	3	1455	5.5	10	22080	4.6	8	15175
Perak	21005	6.4	4	2283	8.6	5	25503	5.4	7	11171
Perlis	795	0.2	13	228	0.9	14	2615	0.5	14	11469
Pulau Pinang	1030	0.3	12	1492	5.6	9	41516	8.7	5	27826
Sabah	73620	22.3	2	2997	11.3	3	26647	5.6	6	8891
Sarawak	124450	37.7	1	2358	8.9	4	45560	9.6	4	19321
Selangor	7979	2.4	9	4850	18.2	1	100884	21.2	1	20801
Terengganu	12955	3.9	7	1042	3.9	11	13258	2.8	11	12724
Malaysia	329960			26640			475526			17850

Source: Department of Statistics, Malaysia (compilation from various publications)

The table shows that there are heterogeneities in all three statistics between the states. Kuala Lumpur, Labuan, Selangor and Melaka recorded a higher population density, 6,502 persons per square kilometre, 924 persons per square kilometre, 608 persons per square kilometre and 439 persons per square kilometre respectively. On the basis of real GDP, the states of Selangor, Kuala Lumpur, Johor, Sarawak and Pulau Pinang are considered as well ahead of the other states. The economic activity in those states is expanding at a more aggressive rate and the industrialisation process contributes massively to the local economy (except Sarawak). The five states are also equipped with more advanced infrastructure and facilities such as a well integrated transportation hub, world class sea-port facilities and a modern communication networking service. Other than that, the existence of upstream and downstream activities as well as economic agglomeration causes industrialisation and commerce activities to expand more rapidly in some states, particularly in the five states which are considered as developed in relation to the other states. The disparity in economic opportunities and other socio-economic factors such as accessibility to better amenities and facilities encourages population mobility between the states. This led to certain states being more populated than other states.

The 15 states of Malaysia are administered together as a sovereign country under a federal constitution. The constitution which is the higher law in the country provides the list of matters controlled by federal government and the list of matters that are under the states' jurisdiction. Under this federalism system, most of the important matters such as public security, economy and social policies are governed by the law determined by the federal government, while the matters related to land and natural resources are under the jurisdiction of states' legislative. Therefore in terms of monitoring and maintaining the environment quality, the federal authorities have to work together with the states authorities. However, despite having similar regulations to regulate producers across the states, in practice not all manufacturer / companies strictly adhere to the regulations' requirements.

Generally, there is an increasing concern among people especially in the relatively more developed states about the actual socio-economic benefits of the industrial activity expansion led by international trade. This suggests that, despite the fact that most of the states have benefited from the success of the economic liberalisation policy implemented by the Malaysian government, it also comes with harmful consequences. The industrialisation's externalities which caused deterioration in local air quality are among their main concerns. However, at present there is no scientific evidence to confirm that the industrialisation led by trade is the main cause of the deterioration. This study aims to find any statistical evidence to support the claim or otherwise.

The next section will describe the problem statement and significance of the study. This is followed by another 4 sections of this chapter namely, theoretical considerations and methodology, data preparation, results of estimations and discussion on the findings and finally conclusions in sections 5.3 to 5.6 respectively.

5.2 Problem statement and significance of study

Given different levels of development and economic achievements as well as geographic heterogeneity across states, this study will examine how trade liberalization affects the environment. Specifically, this study aims to examine the trade and environment linkages using state level data with regards to well known theoretical arguments that trade affects the environment through three effects[13], namely the scale effects, the composition effects and the technique effects. In particular, this study will examine the ACT (2001) hypothesis that any environmental degradation that may caused by trade is determined by the characteristics of the industry in the regions. Firstly, for a state with a comparative advantage in pollution-intensive outputs, trade liberalization will increase air pollution and for a state with a comparative advantage in clean output, trade liberalisation will not contribute to a rise in air pollution or even possibly reduce air pollution. Secondly, trade liberalisation is expected to increase air pollution for states with low per capita income and reduce air pollution for those with higher per capita income. This study will also examine whether the results of ACT (2001) and Cole and Elliot (2003) hold for different types of pollutants. Hence, the estimations and examinations will be made separately on four type of air pollutants, namely sulphur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and particulate matter (PM). The aggregated air pollutant in the form of the Air Pollution Index (API) is also examined[14].

This study is considered unique as instead of using the air pollution and industrial export statistics at the national level which represents the whole country in examining the trade and environment relationship, we will examine the relationship using the statistics of air pollution ambient concentrations, production, capital-labour ratio, exports and other statistics at a sub-national level. By pursuing this disaggregated level examination, the study aims to make a comparison of the

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[13] As discussed in the literature chapter, the three effects that influence the patterns of trade-environment relationship are pioneered by Grossman and Krueger (1993). They argue that the scale effects have negative consequences, the composition effects have ambiguous consequences and the technique effects have positive consequences. This gives the overall consequences depending on the strength of each effect.

[14] API is a quantitative measure that describes ambient air quality. The index is obtained by combining figures for various air pollutants into a single measurement.

evidence from the industrial level analysis in the next chapter with this regional level analysis in the current chapter. Other than that, this study also expands the use of pollutant concentrations measured at the overall level of each state to the pollutant concentrations by location of monitoring stations, namely urban area, sub-urban area and industrial area. The approach just described is believed to be the first in this area of research especially in the case of Malaysia. Hence, this single country study at the state (regional) level which is rarely done will contribute to enhance the empirical studies in this area. The period chosen for this study is 1996 to 2006 which is largely driven by availability of the data.

This study is based on sub-national level data which comprised 15 states in Malaysia. Every state has limited executive and legislative power whereby most of the regulations and policies are determined by the federal government. Note that characteristics at the sub-national level in one country will not be comparable with the characteristics in other country especially in terms of governance and jurisdiction of the state. For example, in the case of the sub-national level in the U.S., the numbers of states is 50 states and every state has independence of jurisdictions in enforcing law related to the environment and this is not the case for Malaysia.

There are some advantages to using panel data at a sub-national level compared to cross-country data. Firstly, using panel data from a single country ensures a consistent measurement of pollution and other variables used in the analysis. Secondly, as the focus is on a single country, there is less concern over the omissions and differences of potential determinants such as levels of bureaucracy, socio-economic freedom, legal institutions, cultural norms and corruption. Furthermore, one can be assured that the regulation regime and the national institutions related to trade and the environment remained constant across the states at any point in time. Finally, using panel data allows the study to control for time invariant and unobserved determinants of pollution across the states.

5.3 Theoretical consideration and methodology

The analysis on the trade-environment relationship usually begins with the reduced form econometric function which shows the relationship between the dependent variable measured by the pollution indicator and the explanatory variable measured by income per capita. The basic function used for cross-country analysis is shown as below.

$$E_{it} = \gamma_i + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + \varepsilon_{it} \qquad (1)$$

For year *t* and country *i*, E_{it} denotes the environmental indicator, γ denotes country-specific effects, and Y_{it} represents income per capita. This reduced form function is initially used by Grossman and Krueger (1995) along with their famous submission that the environment and income relationship postulates the Environment Kuznets Curve (EKC). The cubic function is used because the connection of pollution and trade-led economic growth is hypothesized to be both positive and negative, depending on the level of per capita income and the stage of growth that the economy is going through.

For this study, the initial investigation will be done by using the basic equation and then including other explanatory variables which namely are the capital-labour ratio and trade intensity. The three variables; income per capita, capital-labour ratio and trade intensity are identified as the important determining factors in the trade-environment relationship's literature. Income per capita and the capital-labour ratio are variables used to examine the characteristics associated with the pollution effect of trade in this regional study. The trade intensity is the key variable in this study where it is used to examine the evidence of trade-induced pollution in the environment-trade relationship. Considering that the present study is a single country analysis and its focus is on the manufacturing (industry) sector, we have replaced the variables used in a cross-country study with appropriate variables in this study. In the case of income per capita we substituted it with the state's industry output per capita and for the country's capital-labour ratio we replaced it with the state's industry capital-labour ratio. For trade intensity, it is normally measured by the country's total exports and imports divided by the country GDP in the case of a cross-country analysis. However, in this study, trade intensity is measured by dividing the state's exports from the industry sector by the state's output of the industry sector. Hence we only use exports to measure openness. This is different to ACT (2001) and others in their cross-country study where overall trade is included (exports plus imports) as a proxy for openness. Since this study is a case of a single country, we may not expect that the dependent variable (pollutant) is influenced by imports. By excluding imports in the openness computation, the model is not measuring the pollution contents of imported products by Malaysia (states) which have been produced in the producer's country (i.e. the pollution emitted in the home country (outside Malaysia)). Instead the focus is only on the effect of production undertaken in Malaysia. For the environment indicator to be examined, this study uses the state's air pollution ambient concentrations. The function to be estimated is shown below;

$$E_{kt} = \alpha_0 + \alpha_1 kl_{kt} + \alpha_2 (kl_{kt})^2 + \alpha_3 icpct_{kt-1} + \alpha_4 (icpct_{kt-1})^2 + \alpha_5 eors_{kt} + \alpha_6 tm + \varepsilon_{kt} \quad (2)$$

For the year t and state k, E_{kt}, refers to air pollution ambient concentrations, kl_{kt} denotes the capital-labour ratio, $icpct_{kt-1}$ is one period lagged constant price manufacturing output per capita (measures income), $eors_{kt}$ is the ratio of exports to output in manufacturing (measures trade intensity), tm denotes a linear time trend and ε_{kt} is the error term.

The function then is extended to include interactions among the explanatory variables. According to ACT (2001), Cole (2003) and Cole and Elliot (2003), the relationship between trade liberalization and pollution can be modelled as followed;

$$\begin{aligned} E_{it} = {} & \alpha_0 + \alpha_1 RKL_{it} + \alpha_2 (RKL_{it})^2 + \alpha_3 RY_{it-1} + \alpha_4 (RY_{it-1})^2 + \alpha_5 RKL_{it} Y_{it-1} + \alpha_6 O_{it} + \alpha_7 O_{it} RKL_{it} \\ & + \alpha_8 O_{it} (RKL_{it})^2 + \alpha_9 O_{it} RY_{it-1} + \alpha_{10} O_{it} (RY_{it-1})^2 + \alpha_{11} O_{it} RKL_{it} RY_{it-1} + \alpha_{12} T + \varepsilon_{it} \end{aligned} \quad (3)$$

Where for the year t, E_{it} refers to per capita emissions in country i, RKL_{it} denotes the relative capital-labour ratio, RY_{it-1} is one period lagged relative per capita income, $RKL_{it}RY_{it-1}$ is the cross product of RKL and RY, O_{it} measures trade intensity (the ratio of imports plus exports to GDP), $O_{it}RKL_{it}$ is an interaction of trade intensity with a country's relative capital-labour ratio and $O_{it}RY_{it-1}$ is an interaction of trade intensity with country i's relative income, $O_{it}RKL_{it}RY_{it-1}$ represents the interaction of trade intensity, relative capital-labour ratio and relative income. T denotes a linear time trend and ε_{it} is the error term. The term 'relative' is referred to as the average of the sample.

In the present study which is a single country study, the national institutions related to trade and the environment remain constant across states. Hence, compared to the cross-country studies that have encountered an endogeneity problem, this study treats institutions as exogenous in the model specification. Through this model, we will be able to obtain the information on the indirect impact of trade on pollution emission going through the two economic determinants, i.e. composition effects and technique effects. In the equation, the trade intensity has been interacted with a country's determinants of comparative advantage. Trade intensity is interacted with a country's relative capital-labour (KL) ratio to capture the factor endowment argument and with a country's relative per capita income to test the environmental regulations of the pollution haven argument. A squared term is included for both capital-labour ratio and income variables to allow a diminishing effect at the margin. A quadratic term is also included for both interacted variables. According to ACT (2001), with the two conflicting forces of comparative advantage, the theory does not tell at which point further increases in the capital-labour ratio raise pollution (via composition effects) or when increases in per capita income led by trade finally lower pollution (technique effects).

Thus, with regards to an interaction term of trade intensity with a quadratic capital-labour ratio, the FEH suggests that an increase in trade intensity would be associated with rising pollution for a country with a high capital-labour ratio and the opposite effect for a low capital-labour ratio. Therefore, assuming that the other characteristics or determinants of trade remain constant, if the capital-labour ratio in a state is sufficiently lower in respect to their trading partners, it will have a comparative advantage in labour intensive industry and hence export less polluting goods. Alternatively, if the capital-labour ratio is not low enough, it is more likely to export pollution intensive goods which often is encouraged by lax or moderate levels of environmental regulations. On the interaction term of trade intensity with quadratic per capita income, the PHH suggests that trade liberalization will increase pollution for countries with low per capita incomes (low regulations) and reduce pollution for those with high incomes (high regulations). The detailed argument on this was discussed in the literature review chapter.

Compared to developed countries, states in Malaysia possesses an abundance of labour with mixed levels of capital endowments and practise a less rigorous pollution control. Some states have ample natural resources and agricultural land to support the growth of the industry sector especially in resources and agriculture-based industries. Following the reasoning of Copeland and Taylor (1995), we can expect, on one hand, owing to the factor endowments of Malaysia's state comparative advantages, it is supposed to orientate its specialization towards labour-intensive industries which often produce less pollution intensive products. On the other hand, its less stringent environmental regulations may also facilitate its specialization towards some pollution-intensive sectors. Thus, this suggests that trade liberalisation is either causing a positive or negative consequence on environmental quality across the states, depending on the pollution propensity of the expanding industrial activities. In sum, the aggregate effects of trade on the environment therefore consist of both, the comparative advantages that arises from the condition of factor endowments in the states and also the comparative advantages caused by a relatively less strict environmental regulation.

Following the ACT (2001) model specification, this study has modified the specification to take into account that the scope is narrowed to the trade-environment relationship in the case of states in a single country. This study uses one period lagged constant price industry output per capita instead of one period lagged income per capita and the ratio of industry exports to industry output as a measure for trade intensity. This study also uses state-level industry capital-labour ratio and constant price industry output per capita in the trade-related multiplicative terms. The variables just mentioned are used based on the consideration that this study is interested in international trade of Malaysian states with the rest of the world. Other than that, the ratio of exports to industry output (instead of ratio of total trade to industry output) as a measure of trade intensity is used in the present study. This is done in order to strengthen the fact that PHH argument is interested in the part of local production that is not used domestically. Hence, the modified version of the model is shown as follows;

$$\begin{aligned} E_{kt} = &\alpha_0 + \alpha_1 kl_{kt} + \alpha_2 (kl_{kt})^2 + \alpha_3 icpct_{kt-1} + \alpha_4 (icpct_{kt-1})^2 + \alpha_5 kl_{kt} icpct_{kt-1} \\ &+ \alpha_6 eors_{kt} + \alpha_7 eors_{kt} kl_{kt} + \alpha_8 eors_{kt} (kl_{kt})^2 + \alpha_9 eors_{kt} icpct_{kt-1} \\ &+ \alpha_{10} eors_{kt} (icpct_{kt-1})^2 + \alpha_{11} eors_{kt} kl_{kt} icpct_{kt-1} + \alpha_{12} tm + \varepsilon_{kt} \end{aligned} \quad (4)$$

For the year t and state k, E_{kt}, refers to air pollution ambient concentration, kl_{kt} denotes the state's industry sector capital-labour ratio, $icpct_{kt-1}$ is one period lagged constant price manufacturing output per capita (as measures of income), $kl_{kt}\ icpct_{kt-1}$ is the cross product of kl ratio and $icpct$, $eors_{kt}$ is the ratio of exports to output manufacturing (as a measure of trade intensity), $eors_{kt}\ kl_{kt}$ is an interaction of trade intensity with a state's capital-labour ratio and $eors_{kt}\ icpct_{kt}$ is an interaction of trade intensity with a state's industry output. $eors_{kt}\ kl_{kt}\ icpct_{kt-1}$ represents the interaction of trade intensity, kl ratio and $icpct$. tm denotes a linear time trend and ε_{kt} is the error term. In this model, the quadratic one period lagged constant price manufacturing output per capita is representing the EKC submission which suggests that the environmental degradation is increasing with income before it is decreasing. Because it is difficult to find direct measures of environmental stringency, per capita output (income) is used as a proxy. Capital-labour ratio is used to examine the FEH argument and trade intensity which is the key variable in this study is used as a proxy for trade liberalisation.

Cole and Elliot (2003) argue that compared to pollution emission data, the pollution concentrations data can be influenced by site-specific effects such as average temperature of the site, type of measuring equipment used, the level of rainfall of the site and nature of the observation around the site. Thus this requires the inclusion of dummy variables in the model to control for such site-specific effects. However, since this study is not a cross-country study and the pollution concentrations data are only sub-national, we have decided that the model does not need to control for the site-specific effects. Instead, additional estimations were made where models using data that clustered according to the areas of monitoring stations were employed. The areas are classified as industrial areas, urban areas and sub-urban areas, thus holding constant type of area. It is noted that whilst all states have data that represents industrial areas, some states do not have data for urban area and sub-urban area. Thus the number of observations is reduced slightly for the urban and sub-urban estimations. We believe that disregarding the site-specific effects is appropriate in the case of a single country study and the country is small such as Malaysia where the atmosphere and temperature is not much different from one place to the others. We can also safely say that the absorptive capacity on average is about similar. The absorptive capacity is related to environmental abundance which may be used to absorb or neutralise the pollution caused by economic activity without incurring any cost. A sizeable increase (reduction) in forestry and natural areas may increase (decrease) absorptive capacity. Furthermore the country has only one season. The model also includes regional fixed effects to control for unobserved characteristics of the area that remain constant over time. The only difference is the size of land area between states but we cannot see this as a reason that warrants including site-specific effects in the model. However, in cross country analysis (or for a single country analysis in which the size of the country is large such as the U.S, Australia and Germany, where some countries may allow each region/area to have autonomy to set their own environmental standards/regulations) including the site-specific effects in the model is very important. The site-specific effects not only arise from geographic conditions but are also influenced by apparatus / equipment use, method of measurement such as time interval of observations, different skills and experience of the workforce, different regulations that govern the authorities to carry out the works (as well as jurisdiction power), different levels of capital investment spent on the infrastructure, machinery and equipment (some may use digital other may still use analogue equipment which may affect the accuracy of the concentrations reading) as well as the strength of institution which usually is constrained by financial capability and the current state of the pollution that the country is confronted with.

5.4 Data Preparation

In this study, extensive amounts of data are required from various sources. The sources are mainly based on secondary data in the form of published and unpublished material provided by the Malaysian authorities. Three different types of statistics provide the variables to be used in the model. These are environment statistics, international trade statistics and industrial statistics. The data on pollution ambient concentrations which will be used as the dependent variable in the model are compiled from each environment monitoring station located across the states provided by the Department of Environment, Malaysia (DOEM). The DOEM reports pollution ambient concentration of four types of air pollutants namely, sulphur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and particulate matter (PM) concentrations. The estimations of the effect of trade on the environment will be done using the four concentrations separately. For data on total manufacturing output and the output for each industry as well as all products manufactured in each industry, published and unpublished data from the Department of Statistics, Malaysia (DOSM) were used. These data are mainly derived from the Annual Manufacturing Survey/Census conducted by DOSM. Finally, for data on international trade, this study uses the data on export and import goods declared by exporters and importers to the Department of Custom, Malaysia. These data are also under the custody of DOSM. In this area of study it is noted that the lack of availability and comprehensiveness of the data are the common constraints faced by many other researchers. Hence we foresee it as a main challenge that we have to overcome in this study.

<u>Data on pollution ambient concentration</u>

The environment statistics are broadly collected under the jurisdiction of DOEM which is governed by the Environmental Quality Act (EQA) 1974 (amended in 1985 and 1995). The act provides for the control and prevention of pollution, as well as the protection and enhancement of environmental quality in all segments of the environment, including air, water and land. When the act and other laws pertaining to the environment were first being enforced, only a limited air quality monitoring had been carried out by the department. Therefore a nominal amount of environmental statistics had been published. The compilations of the pollution ambient concentration statistics did not start until 1991 when the resources and expertise were made available to the department. As such, data prior to 1991 for much longer time series statistics were not available. However, in the early stage, the compilations began with very few monitoring stations, which have increased steadily over the years. Thus, for this study we were only able to begin the period of study from 1996 onwards. Currently there are 52 environment monitoring stations used to monitor the air quality continuously throughout the country. The list of stations is shown in Table 5.2 in Appendix 5.1 In terms of the location of the stations, this has been categorised into three areas, namely: industrial areas, urban areas and sub-urban areas[15]. The process of compilation of the pollution concentrations in Malaysia is based on Recommended Malaysian Air Quality Guidelines. It is worthwhile to highlight that there are some criticisms levelled towards the method of data collection especially in terms of the basic choice for the location of monitoring stations. The critics urge that the choice for locations of monitoring stations is very subjective with no scientific basis and could render statistical bias in the data compilation. Hence, the distribution of monitoring stations could easily dictate the overall mean of the concentration compilations[16] which may give misleading outcomes.

The correct measures for environmental standards that provide the right indicators for the state of pollution is another key issue raised by some of the research. The pollutants are broadly distinguished into two categories of measurement, namely, emission of pollutants and environmental ambient concentration of pollutants. Pollution emission measures the amount of pollutants (tons) generated by economic activities for a period of time regardless of the size of

[15] Industrial areas are the areas gazetted for purpose of industrial activity, while urban areas are areas with population of 10, 000 or more and sub-urban areas are the areas surrounding the urban areas which mainly serve as major housing areas and commuter towns.

[16] In this study, for each pollutant we firstly computed the annual average based on the monthly average of each station. Then for the pollutant by areas and by states we use the simple average of all monitoring stations located in the areas and states respectively.

the area into which pollutants were emitted while the pollution concentration measures the quality of pollutants per unit area (ug/m^3) without regard to the activity that emitted them (Kaufman *et al.,* 1998). Both measurements have advantages and disadvantages. In terms of advantages, pollution emission (tons) provides a specific implication of the operation of production and consumption activities on the air pollution. However the amount of emission cannot be measured directly, instead it needs to be calculated indirectly based on a certain sets of procedures and assumptions used by the data compilers. The key information needed for the calculation is the amount of energy and intermediate input consumption in the production process. However, this method has its shortcomings particularly as there is no standard guideline to be followed by the researchers and data compilers. In the absence of clear guidelines from the international agencies, it led to deferments in the compilation process used by national authorities as well as across countries.

Other than that, there is a popular practice where the amount of pollution emissions (tons) can be estimated grossly by using conversion factors of fossil energy consumption as provided by the United Nations Environment Program (UNEP). This practice is normally used to estimate the emission of carbon dioxide (CO2). The key assumption is that air pollution emission from industrial activities is a result of fossil energy consumption during the production process. However, some air pollution emissions are produced from a variety of industrial production processes such as chemically or physically transforming materials from one stage of process to another stage of process which are not necessarily related to fossil energy consumption.

Despite the weaknesses, pollution concentration is widely used as an official measurement of air pollution especially by policy makers and international agencies. Using this method, the current state of pollution for the selected areas is measured at frequent intervals throughout the year. In order to complete the task, environment monitoring stations which are equipped with scientific equipments operated by the environmental authority are normally used to calibrate the level of air pollution concentration at designated time intervals. Currently, the types of air pollution concentrations measured by the stations include SO2, CO, NO2 and PM concentrations. As mentioned earlier, the location of stations which is determined by the authorities is also subject to arguments. Therefore it is possible to dispute the reliability of the statistics. Apart from that, it is also noted that the measurements are not able to distinguish industrial air pollution from the other sources of air pollution such as transportations air pollution and other activities where some of the pollutants have travelled from one place to other places. Furthermore, the air quality and the pollution composition in the atmosphere are also influenced by geographical factors such as climate and wind as well as absorption capacity.

Other than that, it could be observed that ambient concentrations vary from place to place within the country/state which led some to argue that aggregating data across cities to form an air quality index for a country may not be appropriate. However, despite the limitations, there is not much can be done. At least for this single country study the overall climate and geography conditions are about the same. The issues are normally down played by many researchers and they are obliged to take the data as given. Essentially, the limited accessibility and other shortcomings surrounding the environment statistics are the norm in many parts of the world especially in the case of developing countries. Lack of funding and less focus on environment issues by the government and the public are among the reasons. However, in general this has gradually changed in recent years. Hence, the very fact is that the availability of the environment statistics itself is quite limited especially among less developed countries.[17]

In Malaysia, the air quality parameters are measured as averages of time periods. SO_2 and PM are reported on twenty hour moving averages, CO on eight hour moving averages and NO_2 on one hour moving averages (DOEM, 2007). The pollution concentrations are used in the regional study (Chapter 5) and pollution emissions are used in industrial level analysis (Chapter 6). In ACT, they used pollution emissions, hence similar with our industrial level study (Chapter 6). We did match their specification with some modification as explained in the chapter.

[17] Furthermore measurement error in the dependent variable will only increase the standard errors but does not bias the estimation coefficients.

Data on industrial statistics

The compilation of economic statistics is one of the key tasks of DOSM which provides an important input in the economic monitoring process and national socio-economic policies formation for the nation. In preparing industrial statistics we have explored the data from the Annual Manufacturing Survey which is conducted every year by DOSM. This is a sample survey and the reporting unit is an establishment. The number of establishments covered every year varies and is determined by the size of turnover and the result of sampling techniques employed by the department. Other than that, in every five years instead of a survey, the Manufacturing Census is conducted which covers all manufacturing establishments that are in operation across states regardless of the size of turnover. The data collected in the census years are used by the Department as a benchmark for data extrapolation, sampling techniques and other statistical procedures which are required for conducting the annual survey (for non-census years). The survey (census) provides us with the principal industrial statistics for each industry in the manufacturing sector such as output, intermediate input consumption, capital expenditure, wages and number of employees. In terms of the methodology and procedures used in the survey (census), the Department has complied with the recommendations and guidelines provided by the United Nations, Statistics Department (UNSD). It is important that all the countries in the world follow the same guideline for international comparison of the statistics.

In carrying out the survey (census), each establishment is classified according to the Malaysian Standard Industrial Classification (MSIC) based on its principal economic activity. Generally the classification is used to group each economic activity with regards to the production technology employed by the establishments into their relevant industry groups as defined in the MSIC. Hence, every establishment in the particular industry should have similar characteristics in terms of technology and to a certain extent the use of the same composition/types of intermediate input in their production process. The MSIC classification is the national version of the International Standard Industrial Classification (ISIC) produced by the UNSD. Under the system of classification, the classification has gone through a series of revisions. The updating or revision carried out by UNSD takes into account the evolving technology and the invention of new products over the years. Thus when revisions occurred in the ISIC, the MSIC has also been revised accordingly by the DOSM. Basically both classifications are compatible with each other. However compared to ISIC, the MSIC provides a more disaggregate level of industry classification. This is to serve the needs of the government to formulate economic policies for selected industries. By using the classification, each industry can easily be identified by the government where specific policies such as taxes and incentives towards the selected/targeted industry can be implemented and monitored. In this process of preparing the data, this study has encountered two versions of MSIC. The survey/census conducted before years 2000 used the early version of MSIC 1968 while the survey/census carried out for the years 2000 onwards used the latest version of MSIC 2000. Thus, in the process of preparing the industrial statistics data for the period of this study, we encountered two versions of the classification. In order to combine the two series of statistics that use different classifications, we employ the concordance table provided by the data compiler, DOSM. Using the concordance table, the data series for year 2000 onwards have been reclassified to the MSIC 68 classification. The main reason for this step is because in the latest version of MSIC 2000, the industries are more disaggregated, which make it easier to recombine the industry according to the MSIC 68 classification.

Data on international trade statistics

The trade statistics are compiled by the DOSM through the custom declaration documents provided by exporters and importers to the Department of Custom, Malaysia. The general system of recording is adopted in compiling Malaysian external trade statistics. Under this system, the national boundary of the country is used for the frontier (exit/entry) for all exports and imports. All goods entering or leaving the country are recorded, whether or not such goods are subject to custom clearance for taxes. All goods crossing the territory frontier inward and outward need to be declared using a specific form where the standardised commodity code is assigned for every product. The code is unique for every product. This enables the process of identifying the products exported and imported for various purposes such as for tax rates and trade agreements to be done easily. The code system is known as the Harmonized System Codes (HS Codes) which is a standard product classification issued by the World Customs Organization (WCO) to unify the classification of the goods for taxes purposes. Under this classification, goods or articles are grouped according to the materials of which they are made. Currently, the HS uses six digit codes for identifying different products across the world. The country using these HS Codes can suffix additional digits to the existing six digits according to national needs. In the case of Malaysia, the codes are extended up to nine digits. Traditionally the HS Codes are used internationally as a basis for the customs tariff. However, for the purpose of collection and computation of international trade statistics, the National Statistical Office in every country is using the Standard International Trade Classification (SITC) recommended by the United Nations, Statistics Department (UNSD). These statistics' compilation is facilitated through a converter table that harmonises SITC codes with HS Codes which are provided by the UNSD. As was the case with ISIC, the HS Codes and SITC codes have also been updated from time to time very much for the same reason.

Process of constructing and integrating the data

Because this studies using the air pollution concentrations, we could not ascertain the contribution of each industry to the level of air pollution concentration. Instead as mentioned earlier each industry's contribution to air pollution can only be established through estimation of the volume of pollutant emission emitted by each industry in the country (state). However this route of investigation will be discussed in the next chapter of this thesis. This current study uses the state as the unit of observation whereby all the industry level and international trade data as well as air pollutant statistics have to be computed according to the states. Due to the nature of the official statistics that overly focus at a national level, the data available are not directly catered for state level analysis. Thus, in this study a significant amount of time is focused on constructing a regional data set for the fifteen states to be used in the model. The process of constructing and integrating the data involved some steps as follows.

As stated earlier the data providers use various types/versions of classifications in their statistics compilations. Therefore, firstly we need to address this issue. In the case of industrial statistics, the data series were classified by the data compiler (DOSM) according to MSIC 1968 and MSIC 2000 which is Malaysia's version of International Standard Industrial Classification (ISIC) rev. 3 and ISIC rev. 4. For trade statistics, the compilation is based on Standard International Trade Classification (SITC) rev. 2 and SITC rev. 3. Because both compilations are using different types of classifications, both data have to go through the matching process which means that we need to use one common classification. For this, ISIC rev. 3 has been chosen as a common classification to bring together both the international trade and industry statistics.

Secondly, by using results of the Annual Manufacturing Survey, we have identified and selected the required variables such as output (products), intermediate consumption, capital expenditure, employment and compensation of employees (wages and other remunerations in-kind and cash). These data are made available by the DOSM. These variables originally have been arranged according to MSIC 1968 for the data series from 1996 to 1999 and by MSIC 2000 for the data series from 2000 to 2006. These data computations are done for each state as well as for the national level (aggregated) for the period of the study which is 1996 to 2006. The number of industries in existence varies across states and years. However there is no clear volatility shown in the time series. At the national level, the total number of industries available in Malaysia ranged from 138 to 197 according to five-digit level MSIC 1968/2000 classifications. Generally the number of industries shows an increasing trend over the years parallel with an increasing number of new products in the market. Thirdly, on completing the computation, then these data series have been reclassified according to the ISIC rev.3 at the four-digit level which is the common classification we had chosen. The four-digit level industry grouping enables the data to have a more compatible correspondence with the export and import data. Later, for the analysis we have aggregated the data at four-digit into three-digit ISIC. At the four-digit ISIC the total number of industry groups is 79 while at the three-digit ISIC the industry groups have been reduced to 28.

Fourthly, when these data are ready, the next task is to integrate/match the data series of industrial variables with data on international trade in order to associate the exports and imports for each product into their respective industries and by states for each year. As mentioned earlier, the official compilation of international trade data uses the SITC classification where for the series before 1988, the products are classified using SITC rev. 2 while the series from 1988 onwards is classified using SITC rev. 3. Therefore to match both data sets we have constructed a concordance table to link all the classifications. By using this procedure we have managed to bring together the international trade data and the industrial data for the model. Upon completing this step it provided this study with the time series of industrial and international trade statistics which we required according to the four-digit ISIC rev. 3. However, at this stage we have only matched the international trade data and industrial data at national or aggregate level. Attempts to extend the same technique for the state level are constrained by the data limitations. As described earlier, the way international trade statistics have been compiled, where no custom declaration is made for the movement of goods and services across states (except for Sabah and Sarawak), it is not possible to have the data on exports and imports by states being compiled directly.

Fifthly, in the absence of export and import statistics by industry at the state level, the data need to be computed indirectly. We have resolved this by using the national level data as a proxy. Using data at the national level, we have constructed the profile of each product's exports and imports together with their respective output for each industry grouping of the four-digit ISIC. Based on this information, national export-output ratios and import-output ratios annually for each industry at the national level are calculated. Then the ratios to the industry output produced in each state for each industry were applied. This approach assumes that the export and import ratios for each industry are the same for all states. In spite of that, the estimations of exports and imports for each industry in every state will still vary according to different profiles of output produced. The data for each state are therefore based on the data of the industries in that state.

Sixthly, at this stage the variables which we are interested in such as output, intermediate input consumption and wages are all valued in nominal terms. Therefore to remove the effect of price volatility, the nominal values have to be deflated with a price deflator to arrive at the real value. For this process, we employed the manufacturing GDP price deflators[18] for the 79-industry group of four-digit ISIC. This choice may not be fully appropriate but it is believed that it is enough to serve the purpose of eliminating the influence of price volatility. A more appropriate method of deflating the nominal output into real terms requires volumes of the product-specific price deflators. This method should be considered if the movement of prices of goods in the industry group are very different across industries, which means that the price of each individual industry is substantially different from the average price of each 79-industry group. In the process of this computation, it is observed that some industries experienced substantial prices volatility such as in the electrical and electronics industry and resource-based industry. With this final step, we have completed the data computation process for 79 four-digit industries of ISIC over the period 1996-2006 at the national level. For the state level, we have access to the data for 15 states over the period 1996-2006 where we are using states as a unit of observation. The former series will also be used in the next chapter while the later series are mainly applied in this current chapter.

Table 5.3 to Table 5.5 below present selected summary statistics related to this study. Table 5.3 shows the composition of GDP for each state in 2006. As can be seen only three states including Kelantan, Kuala Lumpur and Sabah recorded a contribution of the manufacturing sector that is less than 10 per cent of GDP. For the other states, the share of manufacturing is much higher, between 12.9 per cent and 54.5 per cent. Eight states recorded a more than 30 per cent contribution of the manufacturing sector in their GDP.

[18] The price deflators for each 79-industry-group of ISIC are computed from unpublished material of National Account Statistics, DOSM.

Table 5.3: Composition of gross domestic products (GDP), 2006.

	Agriculture	Mining	Construction	Manufacturing	Services
Johor	10.3	0.1	3.4	39.4	45.3
Kedah	9.1	0.1	2.9	38.3	48.8
Kelantan	19.2	0.2	2.0	5.1	73.4
Kuala Lumpur	0.1	0.0	3.7	7.3	87.9
Labuan	3.1	0.0	0.8	21.8	73.7
Melaka	3.6	0.1	2.3	50.9	43.1
Negeri Sembilan	6.8	0.1	2.3	52.4	38.0
Pahang	19.1	0.2	2.2	31.0	47.5
Perak	15.1	0.3	2.5	19.8	62.3
Perlis	24.6	0.7	2.8	12.9	52.5
Pulau Pinang	1.9	0.0	1.8	54.5	41.1
Sabah	29.4	10.7	2.1	9.5	47.9
Sarawak	17.4	20.4	2.1	28.1	31.8
Selangor	1.4	0.2	4.9	39.0	50.4
Terengganu	9.3	0.2	3.0	32.6	54.8
Malaysia	7.9	9.4	3.0	29.2	49.1

Source: Department of Statistics, Malaysia (2008)

Table 5.4 shows that except for Labuan, more than 43 per cent of manufacturing goods are exported to the world market. Johor, Kedah, Pulau Pinang and Selangor recorded exports-output ratios that exceeded the ratio at the national level (68.1 per cent). The high ratios show that almost all the states are highly involved in international trade. Thus, expansion in trade certainly led industry to growth.

Table 5.4: Average manufacturing output and exports, 1996-2006 (RM million)

	Output		Exports		Exp./Out.
	Value	%	Value	%	(%)
Johor	78847	17.3	55536	17.9	70.4
Kedah	17540	3.8	13452	4.3	76.7
Kelantan	1595	0.3	1019	0.3	63.9
Kuala Lumpur	10495	2.3	4702	1.5	44.8
Labuan	1073	0.2	394	0.1	36.8
Melaka	29016	6.4	18345	5.9	63.2
Negeri Sembilan	26959	5.9	17954	5.8	66.6
Pahang	11444	2.5	5381	1.7	47.0
Perak	16548	3.6	10551	3.4	63.8
Perlis	825	0.2	367	0.1	44.5
Pulau Pinang	79315	17.4	70168	22.6	88.5
Sabah	14678	3.2	6380	2.1	43.5
Sarawak	27593	6.0	12969	4.2	47.0
Selangor	127707	28.0	87411	28.1	68.4
Terengganu	12558	2.8	6021	1.9	47.9
Malaysia	456193	100.0	310649	100.0	68.1

Source: Author's calculation based on data from DOSM.

Table 5.5a and Table 5.5b show the average concentration for four pollutants and API during the period of study. Graphs that show the trend over the years for selected concentrations are shown in Appendix 5.2. States that are considered more developed such as Johor, Pulau Pinang, Selangor and Kuala Lumpur as well as Negeri Sembilan are seen to have recorded high concentrations of SO2 and NO2 compared to other states, while in the case of CO and PM most states experienced high level of concentrations. Except for PM concentrations, all the concentrations levels are generally high in industry areas as shown in Table 5.5b compared to the data shown for the overall area (Table 5.5a). This pattern is common in almost all the states.

Table 5.5a: Average of concentrations (overall area), 1996-2006.

	SO2	CO	NO2	PM	API
Johor	8.5	803.8	12.5	50.0	85.0
Kedah	2.5	634.7	6.8	41.8	72.2
Kelantan	2.0	938.9	6.0	39.8	58.5
Kuala Lumpur	5.8	1863.8	23.3	66.3	119.3
Labuan	0.6	533.4	2.9	34.4	53.9
Melaka	4.8	622.3	8.3	62.9	87.8
Negeri Sembilan	6.8	740.4	10.0	54.0	105.1
Pahang	2.0	342.0	3.5	40.2	61.0
Perak	3.3	614.4	8.1	48.6	78.3
Perlis	1.2	706.1	5.1	40.2	57.8
Pulau Pinang	12.1	855.6	12.8	58.7	94.2
Sabah	1.5	465.9	3.0	49.1	66.7
Sarawak	2.5	635.8	6.1	43.3	69.7
Selangor	6.0	1198.1	20.5	59.4	109.7
Terengganu	1.7	441.3	3.0	43.0	63.3

Note: Data for SO2, CO and NO2 are multiplied by 1000.
Source: Author's calculation based on data from DOEM.

Table 5.5b: Average of concentrations (industry area), 1996-2006.

	SO2	CO	NO2	PM	API
Johor	9.9	820.9	13.3	45.9	84.0
Kedah	3.6	753.9	7.8	49.3	75.2
Kelantan	1.9	938.9	5.4	40.4	58.5
Kuala Lumpur	5.8	1863.8	23.3	66.3	119.3
Labuan	0.6	533.4	2.9	34.4	53.9
Melaka	5.5	596.3	8.4	72.3	87.9
Negeri Sembilan	7.4	757.0	11.0	58.2	107.6
Pahang	2.7	342.0	4.7	54.4	67.2
Perak	3.5	682.7	8.7	47.4	78.2
Perlis	1.2	706.1	5.1	40.2	57.8
Pulau Pinang	18.3	697.2	13.1	67.4	101.5
Sabah	1.5	465.9	3.0	49.1	66.7
Sarawak	3.1	661.2	6.2	42.0	68.9
Selangor	8.8	2450.6	31.6	58.8	91.0
Terengganu	1.9	352.2	2.3	39.9	61.8

Note: Data for SO2, CO and NO2 are multiplied by 1000.
Source: Author's calculation based on data from DOEM.

Table 5.6 below shows the dependent variables and explanatory variables and their unit of measurement used in the estimations. As described earlier, all the variables are computed from secondary data.

Table 5.6: Variables and unit of measurement

Variables	Unit of measurement
Dependent variables:	
i. SO2 Concentrations (overall, industrial, urban, sub- urban)	ppm
ii. CO Concentrations (overall, industrial, urban, sub- urban)	ppm
iii. NO2 Concentrations (overall, industrial, urban, sub- urban)	ppm
iv. PM Concentrations (overall, industrial, urban, sub- urban)	ug/m^3
v. Air Pollution Index (overall, industrial, urban, sub- urban)	Index number
Explanatory variables:	
i. Ratio of capital expenditure to wages of labour in manufacturing sector (kl)	Numbers
ii. One period lagged of constant price per capita output of the manufacturing sector (icpct)	000' Ringgit Malaysia (RM)
iii. Ratio of manufacturing exports to output of manufacturing (eors)	Numbers
iv. A linear time trend (tm)	1= 1996, 2= 1997........, 11= 2006

Note: ppm- parts per million measures of the concentrations of pollutants in air
: ug/m^3- microgram per cubic metre.

5.5 Results of estimations and discussion

This section will present results of estimations for the fixed effect models. The discussion on the fixed effect models can be referred to the literature review in Chapter 4. The results of estimations of the basic equation (2) are shown in Table 5.7a to Table 5.7d. The results of estimations for four pollutants and API are presented according to areas, starting with overall areas followed by industrial areas, urban areas and sub-urban areas respectively.

Table 5.7a shows the results of estimations using equation (2) in the case of the overall areas. As can be seen, there is statistical evidence showing that an increase in the capital-labour ratio causes PM concentrations to decrease but at a decreasing rate. However there is no statistical evidence of such a relationship for other pollutants and API. In term of output (income) per capita, an increase in state output per capita causes pollution concentrations to decrease but at a decreasing rate for the case of CO, NO2 and PM concentrations whilst the opposite pattern for SO2 concentrations and API is seen. However, only for SO2, CO and NO2 coefficients are statistically significant. Turning to the trade intensity explanatory variable, it shows that states' trade liberalization causes air pollution concentrations to decrease for all four pollutants and API albeit only PM concentrations are statistically significant. Finally, the time trend shows that pollution has gone up over time in the case of CO and NO2, and decreased in the case of SO2 concentrations. It shows no relationship in the case of PM concentrations and API.

Table 5.7a: The determinants of pollution concentration- **overall** area (basic equation)

Variable	SO2	CO	NO2	PM	API
a_1kl	0.199	0.226	-0.041	-0.612**	-0.209
	(0.205)	(0.279)	(0.144)	(0.310)	(0.268)
a_2klsq	0.028	-0.164	0.001	0.493**	0.145
	(0.155)	(0.211)	(0.109)	(0.235)	(0.203)
a_3icpct	0.159	-1.149**	-0.555**	-0.694	0.070
	(0.363)	(0.494)	(0.255)	(0.548)	(0.474)
$a_4icpctsq$	-0.943***	0.614*	0.329*	0.174	-0.283
	(0.255)	(0.348)	(0.180)	(0.386)	(0.333)
a_5eors	-0.076	-0.069	-0.058	-0.312***	-0.098
	(0.069)	(0.095)	(0.049)	(0.105)	(0.091)
a_6timey	-0.418***	0.281***	0.163***	0.073	0.002
	(0.048)	(0.066)	(0.034)	(0.073)	(0.063)
cons	0.125***	0.005	-0.028	0.076	0.045
	(0.038)	(0.052)	(0.027)	(0.057)	(0.049)
R^2(within)	0.578	0.131	0.148	0.112	0.041
R^2(between)	0.703	0.011	0.131	0.268	0.171
R^2(overall)	0.061	0.000	0.070	0.088	0.067
corr	-0.781	-0.606	-0.534	-0.820	-0.548
observations	165	165	165	165	165

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

Table 5.7b below presents the results of estimations based on concentration data attained from industrial areas. In general, the coefficient patterns are similar to the patterns for the overall area. This suggests that pollution concentrations that are measured from industrial areas are well represented in the overall base estimations. However in the case of PM concentrations the number of coefficients that are statistically significant is less in comparison to the estimations based on urban areas

(Table 5.7c) and sub-urban areas (Table 5.7d). This implies that PM concentrations may be less caused by industrial activities. It also shows that the size of SO2 coefficients have increased in the case of industrial area estimations compared to overall area estimations.

Table 5.7b: The determinants of pollution concentration industrial area (basic equation)

Variable	SO2	CO	NO2	PM	API
a_1kl	0.238	0.141	-0.017	-0.272	-0.202
	(0.172)	(0.209)	(0.121)	(0.287)	(0.300)
a_2klsq	-0.022	-0.099	-0.034	0.304	0.171
	(0.130)	(0.158)	(0.092)	(0.217)	(0.228)
a_3icpct	0.444	-0.704*	-0.538**	-0.824	0.133
	(0.304)	(0.369)	(0.214)	(0.507)	(0.531)
$a_4icpctsq$	-0.975***	0.392	0.369**	0.546	-0.369
	(0.214)	(0.260)	(0.151)	(0.357)	(0.373)
a_5eors	-0.061	-0.043	-0.032	-0.281***	-0.146
	(0.058)	(0.071)	(0.041)	(0.097)	(0.102)
a_6timey	-0.364***	0.148***	0.151***	0.059	0.023
	(0.040)	(0.049)	(0.029)	(0.068)	(0.071)
cons	0.118***	0.023	-0.029	0.057	0.029
	(0.032)	(0.039)	(0.022)	(0.053)	(0.055)
R^2(within)	0.569	0.073	0.184	0.089	0.041
R^2(between)	0.711	0.054	0.160	0.321	0.247
R^2(overall)	0.097	0.025	0.082	0.125	0.091
corr	-0.732	-0.511	-0.513	-0.776	-0.639
observations	165	165	165	165	165

Table 5.7c and Table 5.7d present the results of estimations based on data of pollution concentrations from urban areas and sub-urban areas respectively. As can be seen in both areas, we find a higher number of coefficients are statistically significant in the case of CO, PM and API. Table 5.7c shows that there is statistical evidence that increases in trade are associated with lower CO concentrations. Also, compared to estimations based on overall and industrial areas, it is only estimations using urban and sub-urban areas that show statistical evidence for some of explanatory variables. In urban area-based estimations (Table 5.7c), an increase in industry output per capita causes API to increase at a diminishing rate, while in sub-urban area-based estimations (Table 5.7d), an increase in the capital-labour ratio causes API to decrease, at a decreasing rate. It is worthwhile to note that, for estimations in sub-urban areas in the case of SO2, the estimates show that a state's trade liberalisation causes concentrations to increase, albeit the coefficient is

statistically insignificant. This is the only case of a positive relationship between trade intensity and concentration.

Table 5.7c: The determinants of pollution concentration urban area (basic equation)

Variable	SO2	CO	NO2	PM	API
$a_1 kl$	0.014	-0.194	0.282	-1.036**	0.343
	(0.385)	(0.321)	(0.283)	(0.506)	(0.405)
$a_2 klsq$	0.156	0.182	-0.166	0.868**	-0.206
	(0.282)	(0.235)	(0.207)	(0.371)	(0.297)
$a_3 icpct$	0.241	-1.203***	-0.927***	-0.354	0.871*
	(0.461)	(0.384)	(0.339)	(0.606)	(0.485)
$a_4 icpctsq$	-0.248	0.881***	0.475*	0.413	-0.843**
	(0.371)	(0.309)	(0.273)	(0.488)	(0.390)
$a_5 eors$	-0.121	-0.218***	-0.034	-0.301***	-0.036
	(0.078)	(0.065)	(0.057)	(0.103)	(0.082)
$a_6 timey$	-0.379***	0.092*	0.176***	0.121	0.071
	(0.060)	(0.050)	(0.044)	(0.079)	(0.063)
cons	0.158***	0.123***	-0.028	0.139**	-0.005
	(0.051)	(0.042)	(0.038)	(0.068)	(0.054)
R^2(within)	0.360	0.189	0.190	0.170	0.127
R^2(between)	0.004	0.053	0.082	0.058	0.105
R^2(overall)	0.065	0.062	0.046	0.083	0.109
corr	-0.076	-0.334	-0.592	-0.228	-0.036
observations	110	110	110	110	110

Table 5.7d: The determinants of pollution concentration sub-urban area (basic equation)

Variable	SO2	CO	NO2	PM	API
$a_1 kl$	0.027	-0.270	-0.392**	-1.218***	-1.137***
	(0.273)	(0.232)	(0.158)	(0.350)	(0.404)
$a_2 klsq$	0.057	0.102	0.183	0.557**	0.601**
	(0.201)	(0.170)	(0.116)	(0.257)	(0.297)
$a_3 icpct$	0.603	1.184**	0.433	0.184	-0.287
	(0.550)	(0.465)	(0.317)	(0.685)	(0.791)
$a_4 icpctsq$	-1.587***	-1.232***	-0.527**	-0.960**	-0.345
	(0.376)	(0.318)	(0.217)	(0.478)	(0.552)
$a_5 eors$	0.164	-0.086	-0.007	-0.075	-0.181
	(0.103)	(0.087)	(0.059)	(0.129)	(0.149)
$a_6 timey$	-0.263***	0.315***	0.147***	0.432***	0.385***
	(0.063)	(0.053)	(0.036)	(0.074)	(0.085)
cons	0.084	0.017	-0.063	-0.163**	-0.181**
	(0.068)	(0.058)	(0.039)	(0.073)	(0.084)
R^2(within)	0.533	0.412	0.255	0.369	0.248
R^2(between)	0.829	0.117	0.088	0.222	0.443
R^2(overall)	0.168	0.002	0.013	0.007	0.048
corr	-0.859	-0.365	-0.332	-0.749	-0.795
observations	99	99	99	110	110

In sum, the results of the basic estimations for overall areas as well as all sub-areas for all pollutants except in of case SO2 (sub-urban areas) show a negative but mostly insignificant effect of trade on pollution concentration. While the estimations using the basic model have been done, we proceed the analysis by introducing interactions in the model to study the trade effect in more detail.

Using equation (4), we have estimated the model using both fixed effects and random effects. In this section we presents the results of the estimations using the fixed effects model as shown in Table 5.8a to Table 5.8d below. Similar to the previous discussion, the results of estimations for each pollutant and API are presented according to areas of the monitoring stations. Table 5.8a shows the results of estimations of the model for SO2, CO, NO2, PM and API using data on the overall areas, then followed by Tables 5.8b, Table 5.8c and Table 5.8d which provides the results of estimations for air pollution concentrations and API using data from industrial, urban and sub-urban areas respectively. The Hausman specification test suggests that there is some correlation between the explanatory variables and the error terms. Thus the random effects model may not be consistent. The Hausman simultaneity test also accepts the null of exogeneity in the models suggesting that simultaneity bias is not present.

Table 5.8a below shows results of estimations based on all areas (overall). In terms of an interaction term of trade intensity and capital-labour ratio, there is statistical evidence that the effect of trade on concentrations increases with the level of the KL ratio, at least up to some turning point, consistent with the FEH, in case of SO2, NO2 and API. There is no statistical evidence of such a relationship in the case of CO and PM concentrations. Meanwhile, for the interaction terms of trade intensity and industry output per capita, none of the coefficients are statistically significant.

Table 5.8a: The determinants of pollution concentration- **overall** area

Variable	SO2	CO	NO2	PM	API
a_1kl	-1.963***	0.144	-1.280**	-1.997*	-2.402**
	(0.643)	(1.078)	(0.533)	(1.177)	(0.998)
a_2klsq	1.156***	0.268	0.702**	0.874	1.401**
	(0.359)	(0.602)	(0.298)	(0.657)	(0.557)
a_3icpct	0.053	-1.426	-0.118	0.824	0.998
	(0.672)	(1.127)	(0.557)	(1.231)	(1.043)
$a_4icpctsq$	-1.442**	1.037	0.250	-0.847	-0.858
	(0.567)	(0.951)	(0.470)	(1.039)	(0.880)
$a_5klicpct$	0.598	-1.181	-0.409	0.525	-0.574
	(0.679)	(1.139)	(0.563)	(1.243)	(1.053)
a_6eors	-0.055	-0.031	-0.076	-0.168	-0.105
	(0.144)	(0.242)	(0.120)	(0.264)	(0.224)
$a_7eorskl$	1.759***	0.059	1.109**	1.033	1.965**
	(0.631)	(1.058)	(0.523)	(1.155)	(0.979)
$a_8eorsklsq$	-1.388***	-0.490	-0.728**	-0.379	-1.393**
	(0.391)	(0.655)	(0.324)	(0.715)	(0.606)
$a_9eorsicpct$	-0.251	-0.037	-0.880	-2.070	-1.724
	(0.894)	(1.498)	(0.741)	(1.636)	(1.386)
$a_{10}eorsicpctsq$	-0.010	-0.314	0.176	0.967	0.621
	(0.500)	(0.838)	(0.415)	(0.915)	(0.776)
$a_{11}eorsklicpct$	0.345	1.317	0.618	-0.084	1.131
	(0.645)	(1.081)	(0.534)	(1.180)	(0.999)
$a_{12}timey$	-0.367***	0.293***	0.204***	0.129*	0.065
	(0.042)	(0.070)	(0.035)	(0.077)	(0.065)
cons	0.098***	0.012	-0.014	0.091	0.056
	(.036)	(0.061)	(0.030)	(0.067)	(0.056)
R^2*(within)*	0.7277	0.1502	0.2375	0.1598	0.1272
R^2*(between)*	0.6369	0.0066	0.1095	0.2509	0.1176
R^2*(overall)*	0.091	0.0004	0.0614	0.0845	0.0457
Corr.	-0.8621	-0.6256	-0.6333	-0.8775	-0.7398
Observations	165	165	165	165	165

Table 5.8b shows results of estimations in the case of industrial areas. For the interaction terms of trade intensity and capital-labour ratio it shows a similar pattern as in the case of the overall area, except for CO concentrations where an increase in the KL ratio decreases the impact of trade on pollution, albeit the coefficient is statistically insignificant. In the case of the interaction term of trade intensity and industry output per capita, there is statistical evidence that an increase in trade caused SO2 concentrations to decrease at high levels of industry output per capita. The other coefficients of the interaction terms are statistically insignificant.

Table 5.8b: The determinants of pollution concentration industrial area

Variable	SO2	CO	NO2	PM	API
$\alpha_1 kl$	-0.895*	0.450	-1.025**	-0.957	-2.548**
	(0.519)	(0.811)	(0.448)	(1.088)	(1.115)
$\alpha_2 klsq$	0.573**	-0.005	0.417*	0.966	1.507**
	(0.290)	(0.452)	(0.250)	(0.607)	(0.623)
$\alpha_3 icpct$	-0.437	-1.077	-0.353	0.329	0.833
	(0.543)	(0.848)	(0.468)	(1.137)	(1.166)
$\alpha_4 icpctsq$	-0.682	0.954	0.217	1.083	-0.527
	(0.458)	(0.715)	(0.395)	(0.959)	(0.984)
$\alpha_5 klicpct$	0.529	-0.807	0.124	-1.575	-0.682
	(0.549)	(0.856)	(0.473)	(1.148)	(1.178)
$\alpha_6 eors$	-0.029	-0.015	-0.065	-0.066	-0.171
	(0.117)	(0.182)	(0.100)	(0.244)	(0.250)
$\alpha_7 eorskl$	0.764	-0.292	0.868**	0.522	2.073*
	(0.510)	(0.796)	(0.439)	(1.067)	(1.095)
$\alpha_8 eorsklsq$	-0.731**	-0.074	-0.483*	-0.504	-1.413**
	(0.316)	(0.493)	(0.272)	(0.661)	(0.678)
$\alpha_9 eorsicpct$	0.877	0.264	-0.364	-2.208	-1.501
	(0.722)	(1.127)	(0.622)	(1.511)	(1.550)
$\alpha_{10} eorsicpctsq$	-0.778*	-0.427	0.072	0.190	0.266
	(0.404)	(0.631)	(0.348)	(0.845)	(0.867)
$\alpha_{11} eorsklicpct$	0.102	0.736	0.103	1.450	1.155
	(0.520)	(0.813)	(0.449)	(1.090)	(1.118)
$\alpha_{12} timey$	-0.329***	0.150***	0.181***	0.122*	0.099
	(0.034)	(0.053)	(0.029)	(0.071)	(0.073)
cons	0.097***	0.032	-0.028	0.126**	0.049
	(0.029)	(0.046)	(0.025)	(0.062)	(0.063)
R^2*(within)*	0.7406	0.0837	0.269	0.1411	0.131
R^2*(between)*	0.6594	0.0419	0.1177	0.3094	0.1416
R^2*(overall)*	0.1058	0.0151	0.0633	0.1185	0.0434
Corr.	-0.7861	-0.46	-0.5675	-0.831	-0.7664
Observations	165	165	165	165	165

Results of estimations for urban areas are shown in Table 5.8c below. For the interaction terms of trade intensity and capital-labour ratio, there is statistical evidence that the trade effect on SO2 concentrations is decreasing with the size of the capital-labour ratio (eorskl) though at a decreasing rate (eorsklsq). A similar pattern is also seen for PM concentrations and API but all the coefficients are statistically insignificant. In the case of CO and NO2 concentrations, the effect of trade on pollution falls continuously with the size of the KL ratio, albeit all the coefficients are statistically insignificant. In terms of the interactions between trade intensity and industry output per capita, an increase in trade caused pollution concentrations to increase more as industry output per capita rises, up to a point for

CO, NO2, PM and API, while for SO2 the trade effect increases continuously with industry output per capita. However none of the interaction term coefficients are statistically significant.

Table 5.8c: The determinants of pollution concentration urban area

Variable	SO2	CO	NO2	PM	API
a_1kl	2.685**	0.846	1.395	0.799	1.325
	(1.189)	(0.958)	(0.857)	(1.602)	(1.296)
a_2klsq	-0.879	1.041	0.719	0.955	-0.533
	(0.813)	(0.656)	(0.586)	(1.096)	(0.887)
a_3icpct	-0.843	-3.846***	-3.500***	-4.288*	-1.730
	(1.771)	(1.428)	(1.277)	(2.386)	(1.931)
$a_4icpctsq$	1.346	3.756***	3.797***	4.698**	0.918
	(1.711)	(1.379)	(1.234)	(2.305)	(1.865)
$a_5klicpct$	-0.637	-2.576**	-2.808***	-2.861	-0.806
	(1.418)	(1.143)	(1.022)	(1.910)	(1.545)
a_6eors	0.077	-0.365**	-0.110	-0.571*	-0.305
	(0.218)	(0.176)	(0.157)	(0.294)	(0.238)
$a_7eorskl$	-2.361**	-0.582	-0.754	-1.568	-0.734
	(1.008)	(0.813)	(0.727)	(1.358)	(1.099)
$a_8eorsklsq$	1.375**	-0.347	-0.250	0.549	0.275
	(0.606)	(0.489)	(0.437)	(0.817)	(0.661)
$a_9eorsicpct$	0.416	1.505	1.674	4.488	3.551
	(2.294)	(1.849)	(1.654)	(3.090)	(2.501)
$a_{10}eorsicpctsq$	0.229	-1.162	-2.071	-4.740	-3.018
	(2.301)	(1.854)	(1.659)	(3.099)	(2.508)
$a_{11}eorsklicpct$	-0.256	1.589*	1.706**	1.709	0.623
	(1.088)	(0.877)	(0.785)	(1.466)	(1.186)
$a_{12}timey$	-0.395***	0.116**	0.201***	0.126	0.052
	(0.064)	(0.052)	(0.046)	(0.086)	(0.070)
cons	0.442**	0.321**	0.100	0.077	-0.164
	(0.176)	(0.142)	(0.127)	(0.237)	(0.191)
R^2*(within)*	0.4244	0.3163	0.2974	0.215	0.1552
R^2*(between)*	0.0011	0.0381	0.0614	0.205	0.1475
R^2*(overall)*	0.0747	0.0503	0.0335	0.2072	0.1475
Corr.	-0.152	-0.5672	-0.6906	-0.0701	-0.1211
Observations	110	110	110	110	110

Table 5.8d below shows the results of estimations based on data from sub-urban areas. For the interaction term of trade intensity and capital-labour ratio, the trade effect on pollution increases with the level of the capital-labour ratio up to a point, except for CO concentrations where the effect size continuously rises with the KL ratio. However all the coefficients are statistically insignificant except for API. Meanwhile for the interaction term of trade intensity and industry output per capita,

the trade effect on pollution increases continuously with the level of output per capita in the case of SO2, PM and API and falls continuously for NO2 concentrations. For CO concentrations the trade effect increases with industry output per capita but at a decreasing rate. However all the coefficients are statistically insignificant.

Table 5.8d: The determinants of pollution concentration sub-urban area

Variable	SO2	CO	NO2	PM	API
a_1kl	-1.277	-0.757	-1.062	-4.169**	-6.343***
	(1.172)	(1.085)	(0.698)	(1.641)	(1.855)
a_2klsq	0.319	-0.699	1.241	1.182	2.342
	(1.308)	(1.210)	(0.779)	(1.816)	(2.054)
a_3icpct	0.383	-1.027	0.275	-0.250	-1.382
	(1.505)	(1.393)	(0.897)	(2.016)	(2.280)
$a_4icpctsq$	-2.945***	-0.436	0.934	-1.218	-0.382
	(1.013)	(0.938)	(0.630)	(1.360)	(1.538)
$a_5klicpct$	-0.507	3.307	-2.960	4.146	4.730
	(4.066)	(3.764)	(2.422)	(5.594)	(6.325)
a_6eors	-0.110	-0.390*	-0.049	-0.425	-0.858**
	(0.237)	(0.219)	(0.141)	(0.325)	(0.368)
$a_7eorskl$	1.067	0.174	0.974	2.962	5.367**
	(1.320)	(1.222)	(0.786)	(1.847)	(2.089)
$a_8eorsklsq$	-1.081	0.580	-1.155	-0.763	-2.247
	(1.377)	(1.275)	(0.820)	(1.911)	(2.160)
$a_9eorsicpct$	0.090	2.941	-0.459	0.423	1.064
	(1.982)	(1.835)	(1.181)	(2.556)	(2.890)
$a_{10}eorsicpctsq$	0.655	-1.183	-0.747	0.321	0.098
	(0.914)	(0.846)	(0.545)	(1.180)	(1.334)
$a_{11}eorsklicpct$	4.022	-1.734	2.566	-4.106	-4.090
	(3.572)	(3.307)	(2.128)	(4.888)	(5.527)
$a_{12}timey$	-0.349***	0.244***	0.165***	0.444***	0.374***
	(0.068)	(0.063)	(0.041)	(0.086)	(0.097)
cons	0.567**	0.250	0.041	-0.187	-0.093
	(0.237)	(0.219)	(0.141)	(0.341)	(0.386)
R^2*(within)*	0.636	0.450	0.38	0.404	0.3192
R^2*(between)*	0.835	0.309	0.274	0.316	0.5458
R^2*(overall)*	0.136	0.339	0.0583	0.028	0.0717
Corr.	-0.846	0.098	-0.0137	-0.822	-0.848
Observations	99	99	99	110	110

Overall discussion

The results of the basic equations for all type of pollutants generally do not provide a common pattern to describe the environment-international trade relationship. This is consistent with a priori expectation because trade by itself could not be considered as the main determinant factor of environmental degradation. Instead the production (output) and consumption led by trade are widely seen as the causes of the degradation. Therefore using equation (4) the effect of the trade intensity on the pollution concentrations is measured through the scale, technique and composition effects of trade. As shown in the equation, the trade intensity has been interacted with capital-labour ratio and income to represent the effects. Hence, using equation (4) allows us to correctly examine the environment-international trade relationship as suggested in the literature. This method is mainly attributed to ACT (2001) and Cole and Elliot (2003).

In the case of air pollution concentrations of overall areas (Table 5.8a), the results of estimations have shown that the pure composition effect resembled a U-shape for SO2. Initially pollution declines with the capital-labour ratio and then it increases. This concurs with prior expectations. It is similar for NO2, PM and API, albeit the PM capital-labour ratio square (klsq) coefficient is not statistically significant. However, CO coefficients are not statistically significant and 'incorrectly' signed. In the model, for the industry output per capita terms (icpct) which captured scale and techniques effects, the study finds mixed evidence across pollutants. For SO2 concentrations, we find that the pollution concentration increases with industry output per capita at a decreasing rate. It implies that at a high industry output per capita, increases in output will reduce SO2 concentrations. The same trend is experienced in the case of PM concentrations and API but the opposite trend shows in the case of CO and NO2 concentrations. However, except SO2 concentrations, we find no statistically significant relationship for all the pollutants.

Turning to trade variables, the results show that the trade intensity variable (eors) has a negative sign for SO2 concentrations and all others pollutants. All the coefficients are statistically insignificant. This shows the hypothetical effect of trade at zero levels of capital-labour ratio and output. However with regards to the trade interaction terms, the estimations have provided evidence that the capital-labour ratio influences pollution but no evidence for an effect of income. Thus, the interaction terms between trade and the capital-labour ratio show that the effect of trade on pollution increases with the level of the capital-labour ratio, at least up to some point, for SO2, NO2 and the overall API. However the coefficients on the interaction terms between trade and output per capita are not statistically significant.

In regard to the time trend, we find a statistically significant negative time trend for SO2 concentrations, implying that factors which are common to all states, but which change over time, are reducing emissions. However, all the other pollutants have a positive time trend even though NO2 concentrations and API are not statistically significant. The cause of a positive time trend may presumably be from increasing transportation and power generation which play an important role in supporting manufacturing activities. It is worthwhile noting that in cross-country studies the results show no conclusive evidence for the effect of technological change on air pollution emission. Thus the sign of the coefficient on the time trend cannot a priori be predicted. These effects are observed for the overall areas, and when areas are sub-divided by location, for industrial areas in particular as opposed to urban and sub-urban areas.

The estimation results in Table 5.8b, 5.8c and 5.8d provide us with mixed findings. For SO2, NO2 and the overall API, there is evidence of the factor endowment effect in industrial areas (as for overall areas in Table 5.8a) as well as in sub-urban areas for the overall API only. The fact that the trade effect on pollution, via the factor endowment hypothesis is observed strongest in industrial areas is not surprising because SO2 concentration, in particular, is widely associated with industrial activity and also identified as a local pollution. The concentration is considered a local pollution because it may not able to travel for a long distance due to its short life-span. The overall pattern is consistent with underlying findings in cross-country studies. However, few of the interactions between trade and output per capita are significant in any area.

Compared to SO2 concentrations, other pollutants examined in this study do not provide conclusive evidence and most of the coefficients are not statistically significant. However, it is worthwhile to highlight that, evidence of a pollution haven effect is found for CO and NO2 concentrations in urban areas as shown by industry output per capita (as measures of income) coefficients (icpct and icpctsq). However, this should not be implied as the evidence of trade-environment relationships, instead it is believed that a large pollution emission from transportation activity could be the bigger contribution of air pollution in urban/city areas.

To evaluate further the effect of trade liberalization on the concentrations we examine the effect according to different levels of output per capita and capital-labour ratio. This is important because it is believed that the environment-trade relation is a dynamic process with the pattern of relationship being influenced by the level of output (income) and capital-labour ratio in the states. Therefore using the results of estimations and assume all the other factors remain constant we calculate the overall effect of the trade expansion on concentrations at three percentiles of capital-labour ratio and income per capita (i.e. 25th per25th percentile, 50th percentile and 75th percentile). Such an analysis makes the effect of the capital-labour ratio and output levels on the pollution effect clearer than in Table 5.8, where this relationship was perhaps hidden by quadratic terms and interactions. We can also see more clearly where quadratic relationships reach their turning point.

In this study, the marginal effect is computed to evaluate the effect of a unit of trade expansion at various levels (25^{th}, 50^{th} and 75^{th} percentiles) of income and capital-labour ratio. For example, as shown in Table 5.9a, say the economy is in the lower quartile (25^{th} percentile) of capital labour ratio and income, as trade increases (by RM one million) SO2 concentration goes up by 0.0013 ppm (parts per million measures). The country's annual average value of exports in recent years is around RM 500 billion and the average SO2 concentration recorded in the industrial area was 18.3 ppm.

If the economy in a situation where both capital labour ratio and income are at the 75^{th} percentile, as trade increases SO2 concentration goes up by 0.0028 ppm.

This may suggest that during the period of study, the capital-labour ratio effect (factor endowment) is more dominant than the income effect (regulatory effect). Overall, except in the case of PM, trade expansion that occurs at a high level of capital labour ratio causes more pollution as compared to the expansion at a low level of capital labour ration. In contrast, trade expansion that occurs at a high level of income causes less pollution as compared to the expansion at a low level of income. The results of the marginal computations also show that the pollution concentration increases with trade expansion for most of the range of the capital-labour ratio, for all pollutants except in the case of PM. As shown in Table 5.8a which is the basis for this marginal effect analysis, among the four pollutants, SO2 coefficients are mainly significant. Hence, the marginal effects for other concentrations may not appropriate or less meaningful to be highlighted.

As shown in Table 5.9a, evaluating the effect of trade expansion on SO2 concentrations for overall areas at the 25th percentile, 50th percentile and 75th percentile of capital-labour ratio and income per capita, we find that at all three band percentiles, while an increase in trade will increase SO2 concentrations, its effect dwindled as the states become richer (i.e. as income (output) per capita moves from 25th percentile towards 75th percentile). Since the industry output per capita term captures the technique effects of trade on the environment, the results shown that there is evidence of negative technique effects of trade on the environment for SO2 concentrations and the negative effect is slowed at a high output per capita.

Table 5.9a: Evaluate the trade marginal effect at 25th, 50th and 75th percentiles (SO2)

SO2		Capital-labour ratio effect (kl)		
Output Percapita Effect		25th percentile	50th percentile	75th percentile
	25th percentile	1.343	1.961	4.046
	50th percentile	1.129	1.747	3.832
	75th percentile	0.101	0.719	2.804

Meanwhile, examining at the three levels of industry output per capita (i.e. 25th, 50th and 75th percentiles), while trade expansion causes an increase in SO2 concentration, its effect is increasing as the capital-labour ratio goes up from the 25th towards the 75th percentile for all the industry output per capita levels. Since the capital-labour ratio term captures the composition effects of trade on the environment, thus there is evidence of positive composition effects of trade on the environment for SO2 concentrations which means that at a higher capital-labour ratio, trade led to a high composition of pollution intensive industry which causes more pollution concentrations.

The results of the trade marginal effect for CO, NO2 and PM concentrations are shown in Table 5.9b to Table 5.9d below accordingly. It seems that even though the calculations of marginal effects of the three pollutants may not show exactly the same pattern, the general pattern shows a similar trend in the case of evaluating the marginal effect at various level of per capita income (rows). As can be seen, as the output per capita moves from a low percentile (25^{th}) to a high percentile (75^{th}), the effect of trade expansion on the air quality is less harmful as shown by low or negative CO, NO2 and PM effects at a high percentile of output per capita compared to at a low percentile of output per capita as shown in the Tables 5.9b to Table 5.9d. Hence we may safely say that the negative effect of trade to the environment is reduced as the states become richer or produce more output as shown by marginal effect analysis for the pollution concentrations.

Table 5.9b to Table 5.9d also show the trade marginal effects at various percentiles of the capital-labour ratio (columns) for CO, NO2 and PM concentrations, again calculated using the estimated coefficients in Table 5.8a. As can be seen, except for PM, the marginal trade effects of the concentrations have the same pattern as in the case of SO2 concentrations where the trade liberalization cause more pollution concentrations at a high capital-labour ratio compared to at a low capital-labour ratio. Hence, this suggests that there is evidence of positive composition effects of trade on the environment for CO and NO2 concentrations.

Table 5.9b: Evaluate the trade marginal effect at 25th, 50th and 75th percentiles

CO		Capital-labour ratio effect (kl)		
Output Percapita Effect		25th percentile	50th percentile	75th percentile
	25th percentile	-9.245	58.161	169.377
	50th percentile	-17.491	49.914	161.130
	75th percentile	-101.308	-33.902	77.313

Table 5.9c: Evaluate the trade marginal effect at 25th, 50th and 75th percentiles

NO2		Capital-labour ratio effect (kl)		
Output Percapita Effect		25th percentile	50th percentile	75th percentile
	25th percentile	-0.099	0.693	3.304
	50th percentile	-1.261	-0.469	2.142
	75th percentile	-6.415	-5.623	-3.012

Table 5.9d: Evaluate the trade marginal effect at 25th, 50th and 75th percentiles

PM		Capital-labour ratio effect (kl)		
Output Percapita Effect		25th percentile	50th percentile	75th percentile
	25th percentile	-6.691	-7.201	-4.834
	50th percentile	-11.724	-12.235	-9.867
	75th percentile	-31.800	-32.310	-29.943

5.6 Conclusion

The magnitude and sign of all of the effects considered in this chapter vary by pollutant and method of measurement. Thus it makes a big difference what pollutants/methods of measurements were used as well as the location of monitoring stations. Our results for SO2 concentrations generally support those of ACT (2001) and Cole and Elliot (2003) based on international experience. We find statistical evidence that the pollution effect of trade varies with the capital-labour ratio for SO2, NO2 and the overall API, but no evidence that income determines pollution or affects the size of the trade effect in the case of any pollutant based on the overall area results. Despite that, we find weak statistical evidence that the pollution effect of trade varies with income in the case of SO2 concentrations in industrial areas.

However, analysis of trade marginal effects provides a clearer picture for evaluating whether the pollution effect of trade varies with the regional characteristics. In fact, the results show that the pollution effect of trade varies with the capital-labour ratio and with income as seen in case of SO2, CO and NO2. It means that the overall findings support the argument that different levels of output (income) and factor endowments (capital-labour ratio) of the country (states) have a significant influence on determining the trade-environment relationship. Essentially this confirms the importance of the state/country's characteristics in determining the relationship as argued by ACT (2001) and Cole and Elliot (2003).

This study finds that there is no simple relationship between trade and the environment, since it depends on the level of capital-labour abundance and income per capita which behave in contradicting terms with trade liberalization. It therefore might be difficult to find robust evidence of the pollution effect of trade that varies with the capital-labour ratio and with income. This suggests that both characteristics are in operation and tend to cancel each other out. Also, at any point in time, environmental quality is the outcome of the interplay between pollution-generating activities on the one hand, and pollution abatement on the other. Furthermore, the role of absorptive capacity (nature) should be taken into account. It is possible that a higher absorptive capacity in less developed states has softened the effect of trade-led economic activity compared to regions/states with a lower absorptive capacity.

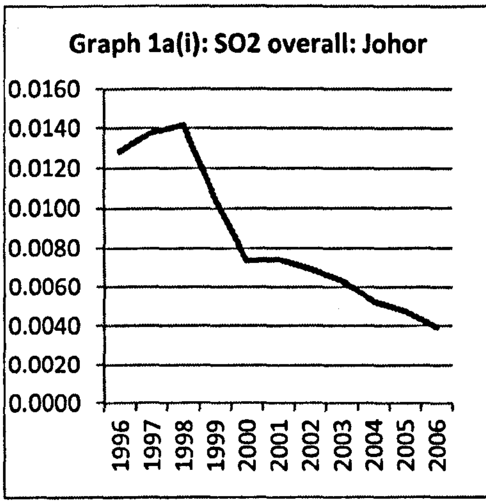
The evidence that trade liberalization increases pollution of SO2 concentrations implies that the capital-labour ratio in Malaysian states is not sufficiently lower than its trading partners, thus the country experienced the comparative advantage in exporting polluting goods given the moderate level of environmental regulation. When capital-labour abundance is low enough, the effect of trade liberalization contributes to a reduction of SO2 concentrations where industries that are less capital intensive will be the major export contributors. Given that Malaysia is ranked as a middle income country, this key finding is perhaps associated with the dilemma between expecting more FDI inflow to generate national income with the needs for more critical policies on protecting the environment.

Finally, Malaysia's desire to achieve the status of a developed nation by 2020 will require rapid economic growth and expansion, especially in the urban, industrial and commercial sectors. Economic growth needs to be guided by the principles of sustainable development. The extent to which sustainable development is achieved will ultimately depend on the ability of the country to monitor and manage the impacts of economic activities on the environment. Therefore, it is believed that these findings will provide a platform for improved planning of resource and environmental policies, better collection of physical and environmental data and the development of appropriate conceptual analytical frameworks. Malaysia's pursuit of rapid economic growth should be achieved through a clean and healthy environment. In this connection, pursuing sustainable development, promoting environmentally sound technologies via trade-led economic and legislative mechanisms needs to be integrated to the planning and development efforts of nation, at federal, state and local levels.

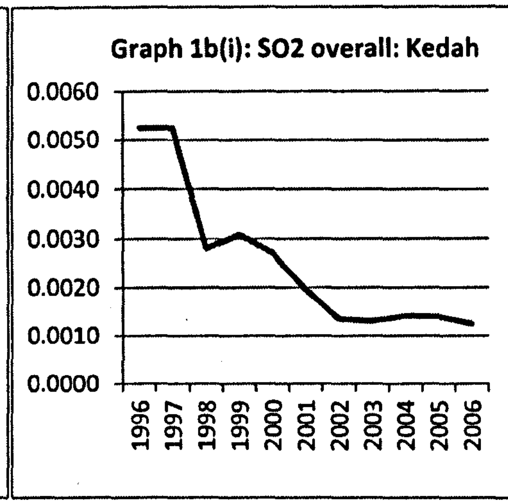
Table 5.2: List of environment monitoring stations

		Environment Monitoring Stations
1		**Johor**
	1	Muar
	2	Pasir Gudang, Johor Bahru
	3	Perling, Johor Bahru
	4	Sek. Vok. Larkin
2		**Kedah**
	5	Alor Star
	6	Bakar Arang, Sungai Petani
	7	Langkawi
3		**Kelantan**
	8	Maktab Sultan Ismail, Kota Bharu
	9	Pengkalan Chepa
4		**Melaka**
	10	Bandaraya Melaka
	11	Bkt. Rambai
5		**Negeri Sembilan**
	12	Nilai
	13	Seremban
	14	Port Dickson
6		**Pahang**
	15	Balok Baru, Kuantan
	16	Indera Mahkota, Kuantan
	17	Jerantut
7		**Perak**
	18	Jalan Tasik, Ipoh
	19	Kg. Air Putih, Taiping
	20	Sek. Keb. Jalan Pegoh, Pegoh
	21	Seri Manjung
	22	Tanjung Malim
8		**Perlis**
	23	Kangar
9		**Pulau Pinang**
	24	ILP, Perai
	25	Seberang Jaya, Perai
	26	USM
10		**Selangor**
	27	Kajang
	28	Gombak
	29	Kuala Selangor

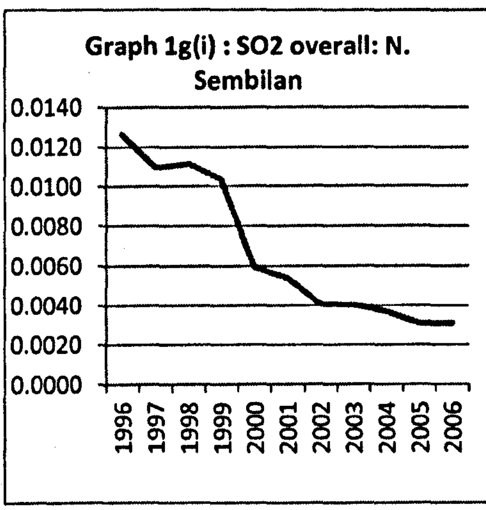
	30	Pelabuhan Klang
	31	Petaling Jaya
	32	Shah Alam
11		**Terengganu**
	33	Kemaman
	34	Kuala Terengganu
	35	Paka
12		**Sabah**
	36	Keningau
	37	Kota Kinabalu
	38	Sandakan
	39	Tawau
13		**Sarawak**
	40	Bintulu
	41	Kuching
	42	Limbang
	43	Miri
	44	Petra Jaya
	45	Sarikei
	46	Samarahan
	47	Sibu
	48	Sri Aman
	49	Kapit
14	50	**W. P. Kuala Lumpur**
15	51	**W.P. Labuan**
16	52	**W.P. Putrajaya**



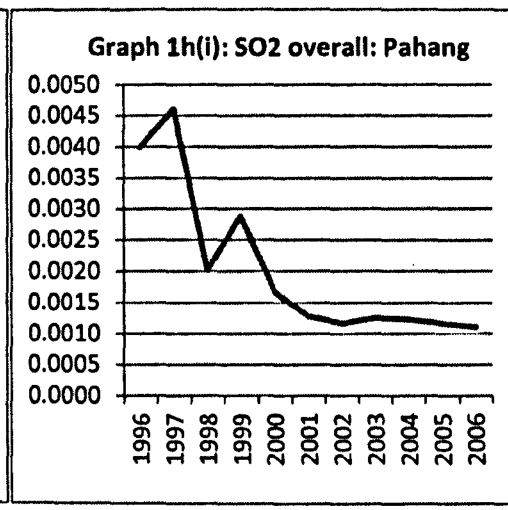
Graph 1a(i): SO2 overall: Johor



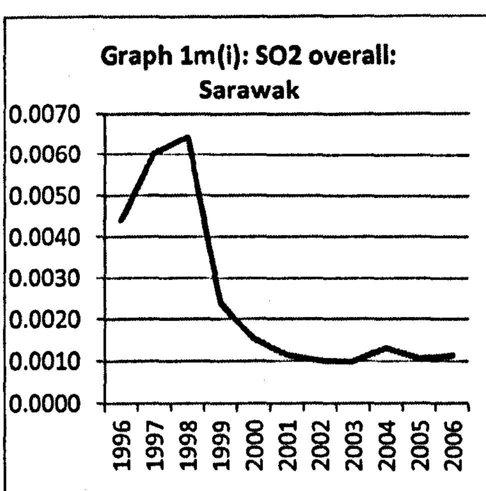
Graph 1b(i): SO2 overall: Kedah



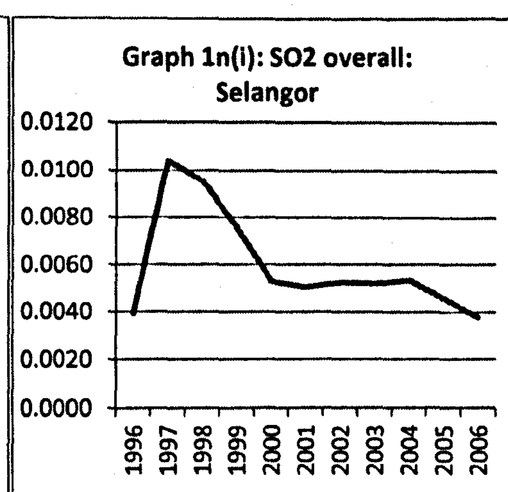
Graph 1g(i) : SO2 overall: N. Sembilan



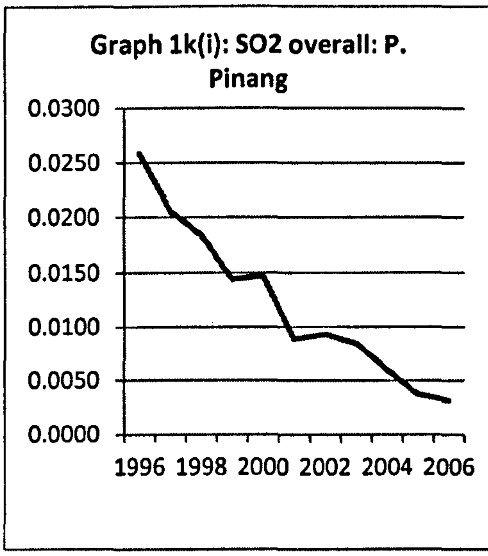
Graph 1h(i): SO2 overall: Pahang

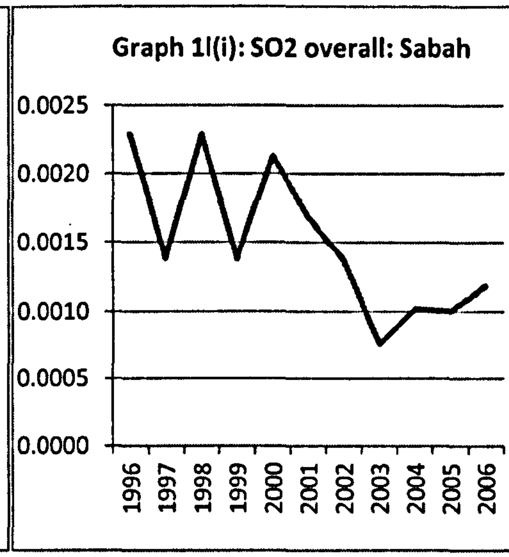


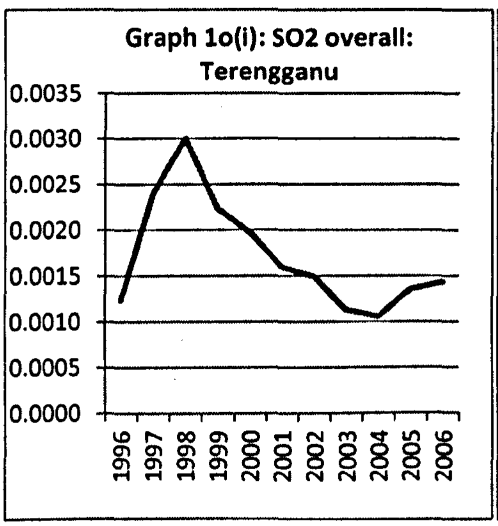
Graph 1m(i): SO2 overall: Sarawak

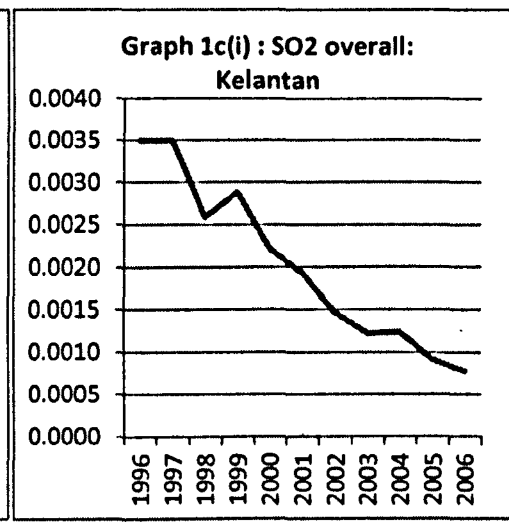


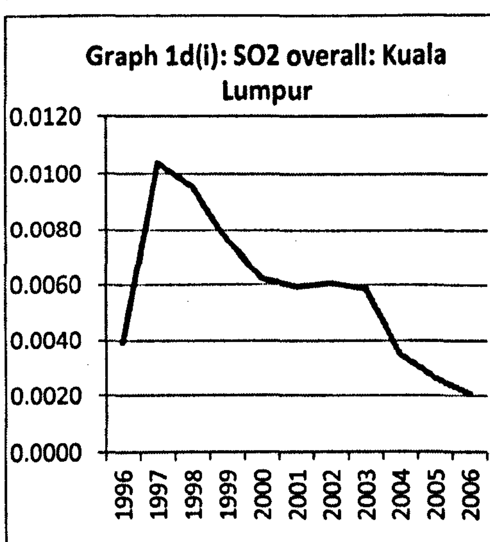
Graph 1n(i): SO2 overall: Selangor

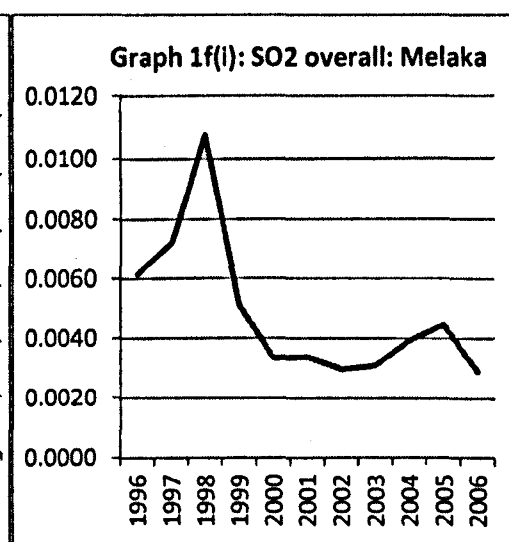

Graph 1k(i): SO2 overall: P. Pinang
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
1996 1998 2000 2002 2004 2006


Graph 1l(i): SO2 overall: Sabah
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006


Graph 1o(i): SO2 overall: Terengganu
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006


Graph 1c(i) : SO2 overall: Kelantan
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006


Graph 1d(i): SO2 overall: Kuala Lumpur
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006


Graph 1f(i): SO2 overall: Melaka
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006

CHAPTER 6

An Industry Level Analysis of the Relationship between Trade and the Environment in the Malaysian Economy

6.1 Introduction

In this second study of our investigation of the trade-environment relationship we focus on an industry level analysis. This provides another route for the research to investigate the direct implications of trade-induced industrial expansion. It is broadly recognised in the literature that the production process together with consumption activity are the leading factors for environmental deterioration. Emissions from industrial production activity led to increased pollution emissions besides other sources such as transportation and other economic activities. In this study, data on industrial activity and international trade in manufacturing products are used along with data on industrial air pollution. To pursue this, we continue our investigation on a single country case using the Malaysian manufacturing sector. Compared to a cross-country study which is used to provide the international perspective, this study has several advantages such as being able to measure the three well-known effects (scale, technique and composition) of particular industries; and the strength and significance of the effects of each on air industrial pollution emissions. This study also aims to examine the effects according to four periods of national economic development plans which are known as the Malaysian Plans (MP). The analysis on various sub-samples will also be done for selected sub-groups of industries and sub-samples for a group of dirty industries and a group of less dirty industries. This empirical study will give a better understanding of the trade-environment relationship especially in the context of evidence from the industrial level of the nation.

In the next section we describe the background, problem statement and significance of study. This is followed by section 6.3 which provides a brief description related to Malaysian manufacturing industry. Section 6.4 deals with data preparation construction. In section 6.5 we outline the modelling technique that we will use. These are followed by results of estimations and discussion of the findings and finally conclusions in sections 6.6 and 6.7 respectively.

6.2 The background, problem statement and significance of study

In recent years, the world's commitment towards maintaining a good quality environment was spurred by the worryingly increased rate of environment deterioration that has occurred in many parts of the world. Even though industrialisation is generally associated with environmental deterioration, it is imprudent to ignore the potential that nations may have gained and experienced environment improvement along with industrial expansion led by trade. Hence it is very important to examine how the country's industrial level characteristics such as the used factors of labour and capital, industry and exports composition as well as output (income) per capita can determine the pattern of the environment-trade relationship. To do this, the study will look at empirical evidence based on industry level analysis of Malaysian manufacturing trade.

Industrial emission is recognised as an important contributor to domestic air pollution. Therefore this study aims to examine whether industrial expansion along with trade liberalisation contributes to the deterioration of air quality and how industrial characteristics influence the effects. This study is focused on manufacturing industries for at least two reasons. First, manufacturing products are Malaysia's main exports and imports and are expected to be so for many years in the future. Second, most of previous studies and public at large also have mainly focused around the negative impact of trade in the manufacturing sector on the environment, particularly in "pollution-intensive" goods. Therefore, compared to other sectors, manufacturing trade is the sector that is frequently 'singled out' by many as the cause of pollution.

Mani and Wheeler (1998) in their study have grouped manufacturing industries into two groups. These are dirty-industry and less dirty-industry groups and are grouped according to their respective level of air pollution emissions. Therefore the study will also evaluate the environment-trade relationship using sub-samples of industries where we will re-group the whole list of industries in this study into the two groups using the classification[19] proposed by Mani and Wheeler (1998). The classification helps us to investigate the notion that rapid output expansion led by trade in the dirty-industry group significantly contributes toward air quality deterioration. This analysis will be done separately for each type of pollutant. Apart from that, this study also attempts to examine the relationship in the case of four industry groups, namely Food, beverages and tobacco (FBT), Textile and wearing apparel (TWA), Chemicals and pharmaceutical (CPH) and Electrical and electronics (EES).

The study will cover the period from 1985 to 2005. This period of study will then be divided into four sub periods, 1985-1989, 1990-1994, 1995-1999 and 2000–2005. The four periods are associated with the periods of national economic development plans which are known as Malaysian Plans (MP)[20]. Hence one could also refer to the periods according to the development plan whereby 1985-1989 is referred to as 5th MP, 1990-1994 is referred to as 6th MP, 1995-1999 is referred to 7th MP and 2000-2005 is referred to as 8th MP. Using these sub-samples, we will examine the environment effect of trade in the four periods of Malaysian economic development plans. This study will find whether the phases of the country's development can alter the overall findings.

Continuing from the previous examination, this study proceeds with the same type of air pollutants, namely sulphur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and particulate matter (PM). However, instead of using air pollution concentration, this study will be using industrial air pollution emissions. Industrial air pollution emission is the amount of pollution released by industrial activity. Thus, the pollution emissions in the atmosphere will be related to the production of each industry. This is the main advantage of emission over

[19] A list of dirty industries is shown in Appendix 6.1.
[20] A brief explanation of the Malaysian Plans is shown in the Appendix 6.2

concentration measurements. The four air pollutants which are considered as local pollution have been identified in the literature as among the major contribution to air pollution and are regarded as very harmful to human health. The diseases related to these pollutants are asthma and other respiratory illness. The pollutants also contribute to other major phenomena such as acid rain, dust and hazard. Cole and Elliot (2003) stated that while city-level concentrations provide more information regarding the human health impact of particular pollutants in the area, the national pollution emissions provide more information on wider environmental issues.

6.3 Manufacturing industry

Economic growth is an important element in the national development goals. Moving from a self-reliance economy to a dependent economy has stimulated the manufacturing trade. Manufacturing industry in Malaysia started on a small scale and limited itself to supply consumer products needed by domestic residents. Industries such as textiles, food products and plastic product industries were among the early industries that existed. Even though Malaysia was rich with natural resources the goods were exported to other countries in the form of raw material goods. Therefore in the early years of economic development, from the 1960s until the early 1980s the impact of industrial activity on the environment was obscure. The sources of pollution in these years mainly came from agricultural activity. Besides that there were no specific areas officially designated for industrial and mass production activity. Hence, during the period most factories had been built close to residential areas. Among the key areas affected were Petaling Jaya and Klang.

In the early 1980s Malaysia embarked on an industrialization strategy with the implementation of an industrial master plan to guide the country to achieve developed economy status. From 1980 onwards industrial activity and international trade liberalisation have taken place rapidly. Over the years, despite the tremendous socioeconomic benefits harvested from the rapid industrialisation, the environment quality has also begun to deteriorate which has caused unease to the wellbeing of the people. Over time, the public concern regarding the emission of harmful substances and poisonous gas such as SO2, CO, NO2 and PM began to rise.

As Dasgupta *et al.* (2002) have noted, there are at least three main reasons why developed economies push for stringent environment regulation. The first reason is pollution damage receives greater attention when a nation has achieved basic levels in health and education through investment. The second reason is because higher income societies normally have a more capable technical personnel and budgets for monitoring enforcement activities and the third reason is because higher income and education had empowered local communities to enforce higher environmental standards, regardless of the national government's stance. In contrast, often it has been observed that developing countries do not value the environment as highly as in developed countries. This led to a lack of environmental regulation, which provides cheap environment input for industrial activity in developing countries. It also induces resources to be overused and cause irreparable degradation. However when people's income started to increase, they become more concerned and aware of the importance of environment control and started asking producers to internalise their externalities and preserve the environment or mitigate the environmental degradation. As it is commonly seen in many developing countries such as Malaysia, the country is not in a position to be very selective for inward investments in order to push for industrial expansion. Investors, local or foreign, are allowed to set-up their business interests despite the environmental consequences as long as the business provides economic benefits to the country. This rapid industrialization has led to the construction of many large factories without the appropriate waste treatment facilities being built. Thus 'dirty' and 'clean' industries are free to exist in the country with nominal rejection from the people. This phenomenon took place especially during the early stage of development.

Table 6.1 below presents the annual average of key economic variables of manufacturing industry in Malaysia by the three-digit International Industrial Classification (ISIC) between 1985 and 2005. Among 28 industries (3 digit-ISIC), industry 383 (Machinery, electric), industry 382 (Machinery, except electrical) and industry 351 (Industrial chemicals) are the top-three industries that recorded the highest total trade during the period. Dirty industries amounted to one-fifth of the total trade of the nation. Meanwhile, 12 industries recorded trade intensity[21] of less than 0.50 which is considered to indicate being less involved in international trade. During the period the overall trade intensity of the manufacturing sector is 1.35 with 1.09 and 1.47 recorded for the dirty-industry and less dirty-industry groups respectively.

Table 6.1: Annual average key economic variables of manufacturing sector in Malaysia between 1985 and 2005 (RM mill.)

ISIC	Value Added	Exports	Imports	Total Trade	Net Exports	Trade Intensity
311	4624	14787	5527	20314	9260	0.62
313	636	164	231	394	-67	0.15
314	564	359	149	508	210	0.29
321	1365	2717	3045	5762	-328	1.26
322	1039	2245	154	2398	2091	0.72
323	39	149	283	433	-134	2.87
324	125	304	165	469	139	1.29
331	2610	7742	442	8184	7300	0.90
332	837	0	0	0	0	0.00
341	965	783	2675	3458	-1891	1.23
342	1290	249	445	694	-196	0.22
351	4573	10119	13485	23604	-3367	1.68
352	1306	1271	2386	3657	-1115	0.84
353	3573	5028	5953	10981	-925	0.94
354	0	1	25	26	-25	0.00
355	2164	3294	552	3846	2742	0.41
356	2239	4357	1557	5914	2800	0.78
361	153	170	85	255	85	0.08
362	630	619	752	1372	-133	0.96
369	2008	681	740	1421	-60	0.25
371	1555	2004	6589	8593	-4585	0.87
372	296	3674	9767	13440	-6093	29.30
381	2210	1876	2365	4242	-489	0.53
382	4240	40091	29669	69761	10422	3.46
383	15083	72908	64184	137092	8724	1.76
384	3076	3893	11846	15739	-7952	1.67
385	648	5177	11258	16435	-6080	6.75
390	494	2515	1159	3674	1356	2.28
Total	58342	187177	175488	362665	11689	1.35
Dirty	17517	31921	42814	74736	-10893	1.09
Oth.	40825	155256	132674	287929	22582	1.47

Note: The description of the ISIC codes can be found in Appendix 6.4.

[21] Trade intensity is derived from value of total trade divided by value of output of respective industry.

6.4 Data Preparation

In this chapter, the study will continue to use the industrial and trade statistics computed in the previous chapter. These data are used along with the industry air pollution emissions which we have to calculate. One of the most staid constraints faced by many researchers in this area is the shortage of the environmental indicators. Environmental data are much scarcer than economic statistics and even in OECD countries the environmental indicators are only available from the 1970s. Shafik (1994) has stated that, in the past a lack of available environmental data for empirical evidence made the arguments on the relationship between economic growth and environmental quality remain on a purely theoretical basis for a long time. Given the lack of long time-series of environmental data, most empirical studies have adopted a cross-country approach in their research. This present study which uses a single country approach is considered as an alternative to the traditional cross-country approach. Despite the absence of comprehensive data, this study explores the various techniques and possibilities to overcome the problem.

The main step is to estimate the industrial pollution emission for each ISIC industry. Compared to concentration pollution data, the pollution emissions data are not readily available. In fact, the emissions are not directly observable and need to be constructed. Industrial air pollution, which relates to pollution by the industrial production processes and industrial fuel burning, contributed significantly to the present level of pollution. Despite the existence of the Malaysian Department of Environment since 1976, its focus is mostly on enforcement activities. Measurement of pollution levels is done based on geographic area and not on economic activity. The absence of comprehensive data on industrial pollution for Malaysia can be attributed to various constraints such as an inadequate level of manpower, financial, lagging technology and lack of experts to monitor the data gathering and unavailability of the estimation of pollution intensity data equivalent to the Industrial Pollution Projection System (IPPS). At present, the activities by the relevant agencies are restricted to monitoring air quality for limited types of air pollutants. Data available are too general for any in-depth analysis of industrial air pollution by the country's manufacturing industries. In contrast, industrial data on output, cost structure, international trade and employment are collected periodically and are readily available.

In the absence of industrial pollution data in Malaysia, the best we can do is to approximate the specific industry pollution emission load using the Industrial Pollution Projection System (IPPS)[22] coefficients developed by the World Bank. It is widely recognised that there is a lack of plant level monitoring of industrial pollution in developing countries. Such limitations have traditionally made it very difficult for environmental regulators in developing countries, to estimate pollution levels to set priorities and strategies for abatement. In the early 1990s, the World Bank developed the IPPS "to exploit the fact that industrial pollution is heavily affected by the scale of industrial activity and its sectoral composition" (Hettige *et al.*, 1994). IPPS provides sector estimates of pollution intensity expressed as pollution per unit output or pollution per employee. They have merged production and emissions data from a very large sample in the United States in 1987. These intensities are widely used as proxies to estimate pollution loads in diverse industrial sectors in countries with insufficient data. There have been increasing applications of IPPS in this area of research. Previous studies using the IPPS include Kahn (2003), Schatan (2003), Cole (2004), Ederington *et al.* (2004), and Gamper-Rabindran (2006).

Thus, the IPPS provides estimates for the amount of pollution (load) produced from a unit of production (indicated by employment) by specific industry. Using the provided coefficients, one is able to calculate the level of pollution emission based on the number of employees recorded in each industry. The method assumes constant emissions per unit of economic activity (per employee or unit of output) in detailed four digit ISIC industry, and calculates changes due to the scale and composition of industry. In this study, the data for industry pollution emissions have been constructed by multiplying employment number, as reported by the Annual Manufacturing Statistics of the Department of Statistics, Malaysia, by the IPPS intensities coefficient prepared by the World Bank. The four emission load estimates are SO2, CO, NO2 and PM.

[22] The IPPS background is described in the Appendix 6.3. The more detailed IPPS is described in Hettige *et al.*(1995).

In order to capture the dynamic of the technology, we modified the yearly coefficient using electricity intensities consumption in each industry reported in the Annual Manufacturing Survey. Thus, the adjusted emissions are used to incorporate the changes of technology. In the annual survey, each company covered in the survey is required to report their electricity consumption used in production. Based on this survey, the compilation of the electricity consumption at 4-digit ISIC has been established annually. Using the data, we have computed an electricity coefficient which is a ratio of the electricity consumption over the value of output of industry. The coefficient is computed for each industry. Using this coefficient, we computed the index where the year 1985 is used as the reference (base) period, and we named this index as an industry electricity consumption (IEC) index. This index then will be applied to the yearly emissions that are estimated through the IPPS coefficient. Therefore, as the results, the amount of emission produced by industry has been adjusted using the IEC index. If the index is 100, it means that the pollution load emission estimated has to be multiplied by one (1), while, if the IEC index is 95, then the pollution load estimation will be multiplied with 0.95.

Justification and Limitation of IPPS

IPPS pollution intensity was developed with the purpose of providing data on pollution that can be used by developing countries, if such data are lacking or limited to carry out environmental pollution analysis. The IPPS data were based on the US data because comprehensive data on pollution and production by its manufacturing industries were readily available, which made it possible to produce estimates of pollution intensities. The US, as one of the leading industrialized countries in the world, has extensive manufacturing industries thus allowing one to obtain a comprehensive data set on pollution intensities covering all kinds of manufacturing industries. The IPPS data, albeit with some potential biases, can be adopted by developing countries such as Malaysia taking into consideration that the manufacturing industries in the country employ much of the production technology that is similar to the US. The IPPS data were also estimated according to the ISIC codes of classification used by most developing countries including Malaysia, which makes the application of the data much easier.

The application of IPPS may contribute to biases due to differences in technology and production processes of the industries in Malaysia to those in the US as emissions may vary. The accuracy of the results thus depends on how closely Malaysia's technologies mirror the US technologies. This study assumes that production technologies of the Malaysian manufacturing industries are similar to the US. However these emissions are then adjusted using electricity intensity consumption in each industry as reported in the Annual Manufacturing Survey. Thus, the adjusted emissions are used to incorporate the changes of technology in Malaysian industries. The analysis carried out by this study is to provide an indication of the potential for air pollution by the industries of Malaysia. It is not an attempt to present an absolute or actual pollution loads by the industries.

Ideally this study requires country specific coefficients that vary over time rather than just the U.S. coefficients for one year. As discussed earlier, unfortunately no comprehensive data on manufacturing emissions exists for many developing countries such as Malaysia and many previous studies assume that the sector specific emission intensities estimated from data on manufacturing in the United States can serve as proxies for the relative emission intensities for the same sectors in other countries. It can be argued that emission intensities are higher in developing countries, due to lack of emission controls (less strict environmental regulations), obsolete technologies and lower skill levels. Despite this caution, it suggests that relative emission intensities among sectors are similar across countries. For example in the case of industries such as industrial chemicals, cement, fertilizer and pesticides, refineries and primary metals, pulp and paper, which have the highest pollution in the U.S. will likely be the same industries where pollution is high in other countries.

This study has shown that it is possible to use the emissions factors available in IPPS to estimate industrial pollution emissions in Malaysia. Some of the results will undeniably provide new information to the environmental regulators and policy makers in Malaysia. However, since the industrial pollution specific estimation is based on one year coefficients of IPPS and using simplifying assumption, the findings are subjected to various limitations as explained in the literature. The limitations of IPPS used by many studies are summarised by Beghin and Portier

(1997) "none of existing studied on industrial pollution pattern really capture the abatement due to cleaner technology, because they constructed the data assuming that technology is common to all countries and is consistent over time. By construction, cleaner aggregate manufacturing output only arises from changing the composition of manufacturing activities". The limitations of simplifying assumption are recently discussed in Gamper-Rabindran (2001) and Laplante and Meisner (2001).

Several other authors have also explained the limitation of IPPS and cautioned readers from drawing too strong an inference from the findings that are based on IPPS estimations. For instance, Bruneau (2001) suggests that one would expect that rankings in OECD countries would mirror those of the US since production technologies are likely quite similar. However this need not necessarily be the case with developing countries since they may use quite different technologies than the US and so have quite different emissions performances. Levinson (2000) argues that, if environmental regulations and technological progress have succeeded in reducing the pollution emitted per unit of output from the dirtiest industries, using the IPPS exaggerates the degree to which the change in the composition of the U.S. manufacturing sector has reduced pollution. Dessus *et. al.*, (1994) provide input-based estimates of effluent intensities for several countries which includes Brazil, China, Japan, Mexico and the United States. They find that, although the set of dirty industries is essentially similar for these countries, the intensities for given effluents vary widely across countries. For example, their estimations show that chemicals in Mexico have airborne toxic release intensities about four times those in the United States. They explain that both different compositions and different input mixes for given productions across countries may lead to different pollution intensity in each country. Furthermore, Pargal and Wheeler (1995) show that it is likely that a large variation in pollution intensities within a country will depend on the origin and vintage of the investment. As such their firm-level study in Indonesia shows that foreign and domestic private firms in the country with plants of the same vintage and efficiency have similar intensities, but pollute much less than corresponding public entities. They also find that older plants exhibit higher intensities for all types of ownership. Hence, they conclude that studies relying on the assumption of similar pollution intensities across countries and time can be biased. Cole (2000) explains that since the pollution intensities are estimated for one year only, applying them to industrial production levels for a number of years illustrates how compositional changes alone affect manufacturing emissions during the period of study. He suggests that the IPPS sectoral production intensities should be used with appropriate modifications.

In this study as explained earlier, the adjustment is done by using data on electricity intensity consumption. It is admitted that these data's problems have indirectly prevented a fully satisfactory applied analysis of the environment and trade relationship in developing countries such as Malaysia. This method may not be similar to what other papers have done when faced with a similar data constraint. In Malaysia, industrial level environment-trade linkage studies are still in their infancy. It is possible that in future study, researchers will be able to take into account for the country actual pollution intensities which will replace the estimations used in this current study. In terms of present knowledge, this is the first time that the IPPS methodology is applied to this country. It is therefore possible to provide estimates of the emissions of a number of pollutants that are not currently made available by the authorities.

In this study our analysis is focused at ISIC 4-digit and ISIC 3-digit level. The lists of both are shown in Table iiia and Table iiib in Appendix 6.4. The ISIC 4-digit classification involves 79 industries while the ISIC 3-digit classification consists of 28 industries in manufacturing activity. Table 6.2 below presents the average pollution intensities for four pollutants for Malaysia's industry between 1985 and 2005. The table also provides each industry's share of total manufacturing value added. In each column, the five largest values are highlighted. Appendix 6.5 also shows the average pollution intensities according to sub-periods. Table 6.2 shows that relative to other industries, Machinery and electric product (ISIC 383) is the most outstanding in terms of contribution to total manufacturing value added (26%) as well as the contribution to total manufacturing exports (39%). Despite that, this industry cannot be referred to as the key contributor to air pollution as shown by a low pollution intensity, i.e. 0.99 (SO2), 0.87 (CO), 0.48 (NO2) and 0.43 (PM). Industries that recorded sizeable pollution intensities across the four pollutants are Iron and steel (ISIC 371), Non-ferrous metals (ISIC 372), Other non-metallic mineral products (ISIC 369), Petroleum refineries (ISIC 353), Industrial chemicals, Paper and products (ISIC 341), and Food products (ISIC 311).

Table 6.2: Average of pollution intensities (SO2, CO, NO2 and PM), share of manufacturing value added, exports and export-output ratio, 1985-2005

ISIC	Industry	% VA	% Exp.	eor	SO2	CO	NO2	PM
311	Food products	**7.93**	**7.89**	0.47	2.77	0.76	2.78	**1.30**
313	Beverages	1.09	0.09	0.06	4.43	0.23	2.82	0.06
314	Tobacco	0.97	0.19	0.21	3.89	0.31	2.36	0.03
321	Textiles	2.34	1.45	0.60	1.92	0.35	2.53	0.05
322	Wearing apparel, except footwear	1.78	1.20	0.70	0.06	0.01	0.02	0.00
323	Leather products	0.07	0.08	**1.10**	2.03	0.15	0.51	0.05
324	Footwear, except rubber or plastic	0.21	0.16	0.89	0.02	0.00	0.00	0.00
331	Wood products, except furniture	4.47	**4.13**	0.90	2.51	12.14	4.85	0.48
332	Furniture, except metal	1.43	0.00	0.00	0.45	0.34	0.32	0.30
341	Paper and products	1.65	0.42	0.25	**27.16**	**30.79**	**14.95**	**1.52**
342	Printing and publishing	2.21	0.13	0.08	0.03	0.15	0.04	0.00
351	Industrial chemicals	**7.84**	**5.40**	0.69	4.38	2.34	4.84	0.12
352	Other chemicals	2.24	0.68	0.27	4.04	**28.58**	1.57	0.82
353	Petroleum refineries	**6.13**	2.84	0.42	**24.95**	**12.96**	**14.35**	0.25
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
355	Rubber products	3.71	1.76	0.37	3.61	0.15	1.25	0.05
356	Plastic products	3.84	2.32	0.56	0.10	0.01	0.02	0.02
361	Pottery china, earthenware	0.26	0.09	0.06	0.00	0.00	0.00	0.00
362	Glass and products	1.08	0.33	0.42	3.00	1.61	**5.96**	0.13
369	Other non-metallic mineral products	3.44	0.36	0.12	**20.14**	2.12	**11.39**	**16.26**
371	Iron and steel	2.67	1.07	0.19	**22.09**	**34.42**	**9.59**	**6.10**
372	Non-ferrous metals	0.51	1.96	**9.72**	**152.07**	**70.74**	4.95	**1.40**
381	Fabricated metal products	3.79	1.00	0.22	0.22	1.46	0.73	0.01
382	Machinery, except electrical	**7.27**	**21.37**	**1.57**	0.55	0.59	0.25	0.00
383	Machinery, electric	**25.85**	**38.89**	0.99	0.87	0.48	0.43	0.01
384	Transport equipment	5.27	2.09	0.44	0.43	0.30	0.22	0.03
385	Professional and scientific equipment	1.11	2.76	**1.76**	0.03	0.00	0.05	0.00
390	Other manufactured products	0.85	1.34	**1.56**	0.12	0.03	0.08	0.02
	Total Manufacturing	100.0	100.0	0.71	4.61	4.03	2.85	1.14

Note: VA is the abbreviation for value added, Exp is exports and eor is exports-output ratio. % VA reports each industry's share of total manufacturing value added. Pollution intensities are measured as tonnes per million Malaysian ringgit of value added.

Table 6.3 presents the average share of electricity consumption by industry in the manufacturing sector during the whole period of study (1985-2005) and for four sub-periods. In each column, the five largest values are highlighted in bold. The industry that consumed most electricity was machinery and electric products (ISIC 383) during the whole period (1985-2005) and in all sub-periods except sub-period 1985-1989. In the three latest sub-periods (1990-1994, 1995-1999 and 2000-2005) its share remained stable around 18.5 to 19.3 per cent. The other bigger spenders on electricity include Iron and steel (ISIC 371), Other non-metallic mineral products (ISIC 369), Industrial chemicals (ISIC 351), Food products (ISIC 311) and Textiles (ISIC 321). These data reveal that industries with a high value added contribution to the manufacturing sector does not necessarily imply being the main electricity purchasers.

Table 6.3: Average share of electric consumption by industry, 1985-2005

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	**7.57**	**12.68**	**8.67**	**7.38**	**6.94**
313	Beverages	0.55	0.86	0.78	0.63	0.44
314	Tobacco	0.30	0.64	0.31	0.34	0.24
321	Textiles	6.15	**6.84**	**6.36**	**7.50**	5.41
322	Wearing apparel, except footwear	0.93	1.29	1.33	0.97	0.80
323	Leather products	0.04	0.04	0.06	0.04	0.04
324	Footwear, except rubber or plastic	0.18	0.50	0.33	0.19	0.11
331	Wood products, except furniture	5.05	5.91	5.79	5.65	4.54
332	Furniture, except metal	1.19	0.66	0.90	1.10	1.34
341	Paper and products	2.47	1.57	2.18	2.42	2.64
342	Printing and publishing	0.98	1.41	1.08	0.94	0.93
351	Industrial chemicals	**8.51**	5.54	6.14	6.86	**10.06**
352	Other chemicals	1.44	1.38	1.11	1.10	1.66
353	Petroleum refineries	2.63	2.44	1.71	2.75	2.79
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	4.65	6.77	6.06	4.57	4.17

356	Plastic products	5.97	4.18	5.46	5.02	**6.68**
361	Pottery, china, earthenware	0.54	0.00	0.00	0.00	0.96
362	Glass and products	2.01	1.52	1.37	2.08	2.16
369	Other non-metallic mineral products	**7.70**	**13.51**	**10.38**	**8.29**	6.30
371	Iron and steel	**9.57**	**10.97**	**10.84**	**9.58**	**9.15**
372	Non-ferrous metals	0.85	0.64	0.83	1.45	0.59
381	Fabricated metal products	3.12	2.25	2.69	3.19	3.27
382	Machinery, except electrical	4.21	1.55	2.81	3.34	5.16
383	Machinery, electric	**19.06**	**13.06**	**18.49**	**20.14**	**19.27**
384	Transport equipment	2.74	2.32	2.43	2.90	2.77
385	Professional and scientific equipment	0.98	0.70	1.23	1.02	0.93
390	Other manufactured products	0.64	0.75	0.67	0.54	0.67
	Total Manufacturing	100.0	100.0	100.0	100.0	100.0

Note: Percentage share of electricity reports each industry's share of total manufacturing electricity consumption.

Table 6.4 presents the average trade intensity[23] for manufacturing output. It shows that most industries are involved with international trade. Trade intensity that is recorded as higher than one (1) means the industry's total trade exceeds its output. The non-ferrous metals industry recorded the highest trade intensity during the whole period and all the four sub-periods. The total manufacturing sector's trade intensity is 1.35 with sub-period 1995-1999 recording the highest trade intensity of 1.42 while sub-period 1985-1989 is shown as the lowest at 1.21.

[23] Trade intensity is calculated as the sum of exports and imports over output of the industry.

Table 6.4: Average of trade intensity by industry, 1985-2005

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	0.62	0.63	0.67	0.60	0.59
313	Beverages	0.15	0.15	0.13	0.15	0.17
314	Tobacco	0.29	0.04	0.16	0.29	0.59
321	Textiles	1.26	1.39	1.41	1.10	1.16
322	Wearing apparel, except footwear	0.72	0.69	0.85	0.74	0.62
323	Leather products	**2.87**	2.12	1.99	**3.57**	**3.66**
324	Footwear, except rubber or plastic	1.29	0.65	1.24	1.10	**2.03**
331	Wood products, except furniture	0.90	0.95	0.95	0.87	0.86
332	Furniture, except metal	0.00	0.00	0.00	0.00	0.00
341	Paper and products	1.23	1.58	1.38	1.19	0.84
342	Printing and publishing	0.22	0.19	0.23	0.20	0.26
351	Industrial chemicals	1.68	1.82	1.59	1.59	1.71
352	Other chemicals	0.84	0.81	0.89	0.91	0.77
353	Petroleum refineries	0.94	1.30	1.01	1.06	0.48
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	0.41	0.17	0.43	0.52	0.50
356	Plastic products	0.78	0.55	0.80	0.91	0.84
361	Pottery, china, earthenware	0.08	0.00	0.00	0.00	0.28
362	Glass and products	0.96	0.92	1.24	0.79	0.91
369	Other non-metallic mineral products	0.25	0.19	0.28	0.28	0.25
371	Iron and steel	0.87	0.74	0.91	1.02	0.82
372	Non-ferrous metals	**29.30**	**37.46**	**39.91**	**11.37**	**28.62**
381	Fabricated metal products	0.53	0.57	0.53	0.48	0.54
382	Machinery, except electrical	**3.46**	**3.62**	**3.93**	**4.06**	**2.43**
383	Machinery, electric	**1.76**	1.94	1.54	1.57	1.95
384	Transport equipment	1.67	**2.28**	**2.17**	1.64	0.78
385	Professional and scientific equipment	**6.75**	**8.53**	**6.38**	**6.35**	**5.91**
390	Other manufactured products	2.28	**2.41**	**2.61**	**2.30**	1.87
	Total Manufacturing	1.35	1.21	1.39	1.42	1.37

6.5 Methodology and model

As discussed in the literature review in Chapter 4, there are various techniques used in this area of study. Early empirical studies were dominated by cross-country analysis and largely focused on developed countries but more recently have shifted to cross-industry studies. Broadly, we could divide the method of study into two categories. One is using econometric techniques and the other one uses the input-output table method. In the case of the econometric technique, some studies use cross-section data analysis and some use panel data analysis.

In this research as in the previous and next chapters (5 and 7), the analysis is based on the econometric technique. Empirically, the analysis on the trade-environment relationship commonly starts with the basic model. The basic model is used to examine the relationships between income and a pollution indicator. Following Cole (2003), the basic equation that will be used in this study is shown as model (1) below. Model (1) then will be extended to include other variables as shown in model (2) and model (3). In model (2) the variables capital-labour ratio and trade intensity are included while for model (3), it has been extended further to include an interaction of trade intensity with an industry's capital-labour ratio.

$$E_{it} = \gamma_o + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \qquad (1)$$

Where for the year t, E denotes per capita emissions in industry i and Y represents output per capita of industry i and ε_{it} is the error term.

$$E_{it} = \gamma_o + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 KL_{it} + \beta_4 KL_{it}^2 + \beta_5 TR_{it} + \varepsilon_{it} \qquad (2)$$

Where KL and TR represent the capital-labour ratio and trade intensity respectively. All the other variables have been defined in equation (1).

$$E_{it} = \gamma_o + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 KL_{it} + \beta_4 KL_{it}^2 + \beta_5 TR_{it} + \beta_6 TRKL_{it} + \varepsilon_{it} \qquad (3)$$

Where $TRKL$ denotes an interaction of trade intensity with the industry capital-labour ratio. All the other variables have been defined in equations (1) and (2).

In terms of pollution determinants, many of the studies surveyed and discussed in Chapter 4 (Literature Review) have identified income (output) per capita as a key predictor of pollution levels and used this to test the pollution haven hypothesis (PHH). Income or output per capita captures the scale and technique effects of the expansion of industry output. Consistent with the theoretical background, we expect the sign of income or output to be positive. An increase in industrial activity to produce output (income) will produce externalities such as industrial air pollution emissions. Specifically, the emissions in metric tons per capita would increase with income (output). It is also shown in the literature that the capital-labour ratio is an important variable to be used to test its impact on pollution. Using the factor endowment hypothesis (FEH), trade-led growth of capital intensive industries exports dirty manufacturing goods and trade-led growth of labour intensive industries exports clean manufacturing goods. Due to the importance of these two key explanatory variables in examining the trade-environment relationship, most of the studies include them in their model specification to test at least two hypotheses, first the hypothesis of income (output) per capita increasing pollution emissions and second the hypothesis that the capital-labour ratio increases pollution. In this single country study, we hypothesise that trade has played some role in environmental degradation. Hence, the two explanatory variables are included to examine what are the characteristics of industries that drive the pollution effect.

Using panel data econometric analysis, this study will apply the same modified model specification used in the Chapter 5 of the state level / regional study. The model used is shown below:

$$\begin{aligned} E_{kt} = {} & \alpha_0 + \alpha_1 kl_{kt} + \alpha_2 (kl_{kt})^2 + \alpha_3 icpct_{kt-1} + \alpha_4 (icpct_{kt-1})^2 + \alpha_5 kl_{kt} icpct_{kt-1} \\ & + \alpha_6 tr_{kt} + \alpha_7 tr_{kt} kl_{kt} + \alpha_8 tr_{kt} (kl_{kt})^2 + \alpha_9 tr_{kt} icpct_{kt-1} + \alpha_{10} tr_{kt} (icpct_{kt-1})^2 \\ & + \alpha_{11} tr_{kt} kl_{kt} icpct_{kt-1} + \alpha_{12} tm + \varepsilon_{kt} \end{aligned} \tag{4}$$

Where for the year t, E_{kt}, refers to per capita emissions in industry k, kl_{kt} denotes the capital-labour ratio, $icpct_{kt-1}$ is one period lagged constant price manufacturing output per capita (measures income), $kl_{kt}\, icpct_{kt-1}$ is the cross product of kl and $icpct$, tr_{kt} is the ratio of exports to output manufacturing (measures trade intensity), $tr_{kt}\, kl_{kt}$ is an interaction of trade intensity with an industry's capital-labour ratio and $tr_{kt}\, icpct_{kt}$ is an interaction of trade intensity with industry k's output. $tr_{kt}\, kl_{kt}\, icpct_{kt-1}$ represents the interaction of trade intensity, kl ratio and $icpct$. tm denotes a linear time trend and ε_{kt} is the error term. In this model, the quadratic one period lagged constant price manufacturing output per capita represents the EKC submission which suggests that the environment degradation increases with income before decreasing. Because it is difficult to find direct measures of environmental stringency, per capita output (income) is also used as a proxy for that. The capital-labour ratio, which is one of the industry characteristics considered, is used to examine the hypothesis that the capital-labour ratio affects the relationship between pollution and trade intensity, which is the key variable in this study, used as a proxy of trade liberalisation. Unlike the previous chapter, for this chapter the four-digit ISIC is used as the unit of observation and the dependent variable is pollution emission for the four different air pollutants (SO2, CO, NO2 and PM). This study estimated the model separately for the four air pollutants. Other than that, this study also estimated each of the four pollutants separately using four sub-periods, four sub-groups and dirty-group and less dirty-group industries.

6.6 Results of estimations and discussions

Using the econometric models discussed earlier, this study has made several estimations which can be divided into four parts. The four parts are;

i. Estimations based on the overall sample, Malaysia's manufacturing trade at 4 digit ISIC (79 industries) by using Model (1), Model (2) and Model (3);

ii. Estimations based on the overall sample, Malaysia's manufacturing trade at 4 digit ISIC (79 industries). In order to know whether the period of study will alter the results, we first evaluated the data covering the whole period of study, 1985 to 2005, and then we re-estimated the equation in four sub-periods: 1985-1989, 1990-1994, 1995-1999 and 2000-2005. The sub-groups follow the four phases of Malaysian Plans (MP), i.e. period 1985-1989(MP5), 1990-1994(MP6), 1995-1999(MP7) and 2000-2005(MP8). All the estimations are using Model (4);

iii. Estimations according to four groups of products namely; Food, beverages and tobacco (FBT), Textile and wearing apparel (TWA), Chemicals and pharmaceutical (CPH) and Electrical and electronics (EES) by using Model (4); and

iv. Estimations according to a group of pollution intensive products (PI) and a group of non-pollution intensive products (NPI) by using Model (4).

All four parts are aimed at evaluating the environmental and trade linkages using Malaysia's manufacturing trade data for the period 1985 to 2005. The unit of observation is 4-digit ISIC and comprises 79 industries. The theoretical consideration in this study is to relate the argument that trade has played some role in environmental degradation directly and indirectly, where the effect is determined by industry characteristics i.e. the capital labour ratio and output (income).This study evaluates separately for each industrial pollution emission, namely SO2, C0, NO2 and PM.

Panel data is a dataset in which the behaviour of the same entities is observed across time. In this study, the industries at 4-digit ISIC are the entities or units of observation. Panel data allows us to control for variables which cannot be observed or quantified such as the workforce culture and the industry history. Other than that, it also helps to control for unobserved variables that change over time but not across industries. This has been done through the introduction of a time trend in the model. In terms of application, fixed effects model and random effects model are commonly used for panel data studies. In order to examine the appropriate model, this study employed a Hausman test which is one of the diagnostic tests available in panel data analysis. In this study, estimations for all four parts stated above are done for both the fixed effects model and random effects models. This section only presents and discusses results from the fixed effect model. Results for the random effect model are shown in the Appendix of this chapter.

6.6.1 Estimations based on the overall sample using Models (1), (2) and (3)

This study first estimated Model (1) with OLS regression. These estimates do not include control variables and have no fixed effects. The results of estimations are shown in Table 6.5. It shows that increases in income per capita cause an increase in all emissions at a low level of income per capita and then decreases at a high level of income per capita. At much higher levels of income per capita, the emissions start to increase again. Regardless of the sign, the coefficient of SO2 is the highest in absolute number compared to the other three pollutants.

Table 6.5: The determinants of industrial pollution emissions (OLS model)

Variable	SO2	CO	NO2	PM
$\alpha_1 y$	1.764***	0.594***	0.772***	0.913***
	(0.165)	(0.053)	(0.077)	(0.134)
$\alpha_2 ysq$	-0.514***	-0.117***	-0.202***	-0.283
	(0.594)	(0.019)	(0.028)	(0.048)
cons	0.074	0.053**	0.057	0.044
	(0.030	(0.010)	(0.014)	(0.025)
R^2	0.068	0.121	0.067	0.028
observations	1659	1659	1659	1659
turn. point(US$)	6,864	10,154	7,644	6,452

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

Next we examine the relationship using Model (2) with OLS regression. These estimations included capital-labour ratio and trade as explanatory variables. The results of these estimations are shown in Table 6.6a. The results show that the pattern of the effect of income per capita on emissions is the same as the previous estimation; only the size of the coefficients is slightly smaller. In terms of the capital-labour ratio, an increase in the capital-labour ratio used by the industries causes emissions to increase at a diminishing rate for all pollutants. It is also shown that trade intensity coefficients are statistically insignificant for all pollutants. This shows that trade per se does not seem to cause the pollution, rather it is the production activity led by trade that produced the industrial air pollution.

Table 6.6a: The determinants of industrial pollution emissions (OLS model)

Variable	SO2	CO	NO2	PM
$\alpha_1 y$	1.123***	0.267***	0.398***	0.717***
	(0.175)	(0.054)	(0.081)	(0.145)
$\alpha_2 ysq$	-0.324***	-0.019	-0.092***	-0.216***
	(0.062)	(0.019)	(0.028)	(0.051)
$\alpha_3 kl$	0.086***	0.045***	0.050***	0.031***
	(0.010)	(0.003)	(0.004)	(0.008)
$\alpha_4 klsq$	-0.0010***	-0.0005***	-0.00053***	-0.0005***
	(0.00017)	(0.00005)	(0.00007)	(0.0001)
$\alpha_5 tr$	-0.003	-0.0010	-0.003	-0.005
	(0.006)	(0.002)	(0.003)	(0.005)
cons	-0.069*	-0.022*	-0.023	-0.003
	(0.035)	(0.011)	(0.016)	(0.030)
R^2	0.1152	0.2356	0.1404	0.0380
observations	1659	1659	1659	1659
turn. point (US$)	6,932	28,105	8,652	6,639

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

As discussed in the literature, to reveal the full trade-environment relationship we have to include an interaction term between the trade intensity variable with the other determinants. Therefore, we continue the examination of the relationship using Model (3) with OLS regression. These estimations are extended from the model estimated earlier where in this model we have included an interaction term of trade and capital-labour ratio as an explanatory variable. The results of estimations are shown in Table 6.6b. As shown in the table, the pattern of the effect of income per capita and capital-labour ratio on the emissions is similar to the results of model (2). However as it shows, the trade coefficient posted a positive sign for all emissions, which is in contrast to the estimations of model (2). This is the theoretical effect at a zero capital-labour ratio. The coefficient on the interaction shows that the trade effect declines with the capital-labour ratio. As mentioned earlier, the trade intensity variable alone does not give much interpretation on the environment-trade relationship.

Table 6.6b: The determinants of industrial pollution emissions (OLS model)

Variable	SO2	CO	NO2	PM
a_1y	1.102***	0.258***	0.386***	0.699***
	(0.175)	(0.053)	(0.080)	(0.144)
a_2ysq	-0.321***	-0.018	-0.090***	-0.213***
	(0.061)	(0.019)	(0.028)	(0.051)
a_3kl	0.102***	0.050***	0.058***	0.044***
	(0.011)	(0.003)	(0.005)	(0.009)
a_4klsq	-0.0010***	-0.0005***	-0.00058***	-0.0006***
	(0.00016)	(0.00005)	(0.00007)	(0.0001)
a_5tr	0.023**	0.009***	0.011***	0.017***
	(0.009)	(0.003)	(0.004)	(0.008)
a_6trkl	-0.027***	-0.010**	-0.015***	-0.023***
	(0.007)	(0.002)	(0.003)	(0.006)
cons	-0.080**	-0.026**	-0.029*	-0.012
	(0.035)	(0.011)	(0.016)	(0.029)
R^2	0.1221	0.2450	0.1500	0.0458
observations	1659	1659	1659	1659
turn. point(US$)	6,866	28,667	8,578	6,563

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

This study next estimates Model (1) and Model (3) separately with fixed effects and random effects models. In the following tables are the results followed by the discussions of the fixed effects model. The results for the random effect model are shown in Appendix 6.6 of this chapter. Compared to the OLS estimations, this panel data method is considered as more robust in our examination of the environment and trade relationship, since it controls for unobserved industry characteristics. Table 6.7a shows results of estimations using model (1). It shows that all the coefficients are statistically significant and the signs are the same across emissions despite differences in the strength and size of the coefficients. The results imply that there is statistical evidence to show that rises in income per capita cause the industrial pollution emissions to increase. When the country's income per capita reaches a high level, an increase in income per capita reduces the emissions. Then at much higher level of the country's per capita income a rise in income per capita causes the pollution emissions to start to increase again for all four pollutants. Despite the fact that the evidence is not completely consistent with the EKC, we can insist that it still portrays the part of EKC where one expects the emissions to rise when income increases and then fall at higher income levels (similar trend as EKC for *y* and *ysq*). Perhaps the limitation is that the time series data used in this study is not long enough to warrant precise examination of EKC. As shown in the literature the evidence on EKC is mostly found in cross-country studies.

Table 6.7a: The determinants of industrial pollution emissions (fixed effects model)

Variable	SO2	CO	NO2	PM
$\alpha_1 y$	0.569***	0.267***	0.272***	0.223***
	(0.060)	(0.026)	(0.028)	(0.045)
$\alpha_2 ysq$	-0.132***	-0.043***	-0.055***	-0.054***
	(0.019)	(0.008)	(0.009)	(0.014)
cons	0.184***	0.089***	0.105***	0.106***
	(0.009)	(0.004)	(0.004)	(0.006)
R^2*(within)*	0.0607	0.1138	0.0745	0.0170
R^2*(between)*	0.0713	0.1343	0.0702	0.0288
R^2*(overall)*	0.0604	0.1192	0.0617	0.0230
corr	0.1548	0.1842	0.1449	0.1076
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79
turn. point(US$)	8,621	12,419	9,891	8,259

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

Table 6.8a shows the results from the estimation of Model (3) where variables capital-labour ratio (*kl*) and trade openness (*tr*) are included as the explanatory variables together with income per capita. As can be seen, the pattern of income per capita coefficients (*y*, *ysq* and *ysqsq*) for all four industrial pollution emissions are similar to the estimations of Model (1) although the size of coefficients has dropped slightly. In the case of the capital-labour ratio (*kl*), an increase in the ratio leads to an increase in all pollution emissions with the exception of PM emissions which show the opposite. It is worth noting that the coefficient of CO is not statistically significant. At a high capital-labour ratio (*klsq*), an increase in capital-labour ratio causes SO2 and NO2 emissions to decrease whilst the CO and PM emissions show the opposite relationship. In other words there is evidence of an inverse u-shaped for SO2 and NO2. Turning to trade which is the variable of interest, the results show statistical evidence that increased trade would lead to a decrease in SO2 and CO industrial pollution emissions if the capital-labour ratio was zero. However estimations for NO2 and PM are statistically insignificant, though both negative. The interacted term of trade and capital-labour ratio coefficient (*trkl*) which is used to examine the argument of the factor endowment hypothesis (FEH) shows that an increase in trade intensity causes SO2, CO, NO2 and PM industrial pollution emissions to increase more, the larger is the capital-labour ratio. All the coefficients are statistically significant except for PM emission. As such, the FEH argument that trade increases pollution more when capital-labour ratio is high is consistent with the findings.

Table 6.8a: The determinants of industrial pollution emissions (fixed effects model)

Variable	SO2	CO	NO2	PM
$a_1 y$	0.524***	0.236***	0.247***	0.254**
	(0.063)	(0.026)	(0.029)	(0.047)
$a_2 ysq$	-0.120***	-0.033***	-0.048***	-0.060*
	(0.019)	(0.008)	(0.009)	(0.014)
$a_3 kl$	0.010***	0.009	0.007*	-0.006*
	(0.004)	(0.002)	(0.002)	(0.003)
$a_4 klsq$	-0.00010***	0.0001**	-0.00006***	0.00004
	(0.00005)	(0.00002)	(0.00002)	(0.00004)
$a_5 tr$	-0.004***	-0.002***	-0.0006	-0.0004
	(0.003)	(0.001)	(0.0012)	(0.0020)
$a_6 trkl$	0.002***	0.001**	0.0007**	0.001
	(0.002)	(0.0009)	(0.001)	(0.002)
cons	0.164***	0.070***	0.092***	0.117***
	(0.013)	(0.005)	(0.006)	(0.010)
R2(within)	0.0663	0.1321	0.0810	0.0203
R2(between)	0.1020	0.2214	0.1206	0.0099
R2(overall)	0.0862	0.1926	0.1029	0.0093
corr	0.1957	0.2635	0.2115	0.0473
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79
turn. point(US$)	8,733	14,303	10,292	8,467

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

For each of our estimations for model (1), Model (2) and Model (3), we have also provided results of the turning point of the EKC as shown at the bottom of Table 6.5 to Table 6.10. Evidence from cross-country studies shows that the turning point varies and is largely influenced by the countries selected in the sample. The well known study by Grossman and Krueger (1993) suggests that as a country's per capita income reaches a level of US$ 4,000 to US$ 5,000, pollution tends to ease. For Selden and Song (1994) the turning point is in the vicinity of US$ 10,000 in the case of SO2 and NO2. In this study, based on a single country, the turning point is in the range of US$ 6,452 to US$ 28, 667. The lowest turning point is recorded for PM as shown in Table 6.5 while the highest turning point is recorded for CO as shown in Table 6.6b. The estimations also show that the turning point is not stable across different types of pollutants (SO2, CO, NO2, PM) which is consistent with cross-country findings. In general, the estimations show that the turning point for SO2 is consistently stable and low for all models i.e. in the range of US$ 6,864 to US$ 8,744.

6.6.2 Examination based on the overall sample using Model 4

Using model (4), we continue the examination encompassed in four scenarios. These include first, estimations based on data for the whole period; second, estimations based on data for sub-periods; third, estimations based on product-groups; and fourth, estimations based on the groups of pollution intensive industries (PI) and non-pollution intensive industries (NPI). The results of estimations are shown and discussed in this section to section 6.6.5.

Table 6.9a below shows results from the estimation of model (4) based on data for the full period of the study using a fixed effects model. The estimations covered all four emissions which were estimated separately.

Table 6.9a: The determinants of industrial pollution emissions (fixed effects model)

Variable	SO2	CO	NO2	PM
$a_1 kl$	0.008	0.067*	0.043	-0.059**
	(0.031)	(0.038)	(0.030)	(0.029)
$a_2 klsq$	0.171**	0.156	0.041	0.097
	(0.082)	(0.102)	(0.081)	(0.078)
$a_3 y$	0.198***	0.413***	0.221***	0.115***
	(0.041)	(0.051)	(0.041)	(0.039)
$a_4 ysq$	-0.134**	-0.301***	-0.116**	-0.092*
	(0.053)	(0.066)	(0.052)	(0.050)
$a_5 kl*y$	0.056*	0.047	0.119***	-0.003
	(0.031)	(0.039)	(0.031)	(0.029)
$a_6 tr$	-0.054	-0.120**	-0.110***	-0.058
	(0.040)	(0.049)	(0.039)	(0.038)
$a_7 tr*kl$	0.064	0.114	0.153*	0.028
	(0.084)	(0.105)	(0.083)	(0.080)
$a_8 tr*klsq$	0.812**	0.645	0.222	0.230
	(0.375)	(0.466)	(0.372)	(0.355)
$a_9 tr*y$	-0.332***	-0.227	-0.289***	-0.249**
	(0.112)	(0.140)	(0.111)	(0.106)
$a_{10} tr*ysq$	0.071	-0.561***	0.039	0.041
	(0.165)	(0.205)	(0.163)	(0.156)
$a_{11} tr*y*kl$	0.241*	0.288*	0.535***	0.018
	(0.136)	(0.169)	(0.135)	(0.129)
$a_{12} time$	0.008	-0.002	0.005	0.012**
	(0.006)	(0.008)	(0.006)	(0.006)
cons	-0.0005	-0.006	-0.011	-0.004
	(0.008)	(0.010)	(0.008)	(0.007)
R^2(within)	0.0892	0.2004	0.1191	0.0308
R^2(between)	0.0770	0.1953	0.0913	0.0132
R^2(overall)	0.0732	0.1923	0.0891	0.0134
corr.	0.1333	0.1444	0.1308	0.0422
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

We begin the discussion with the capital-labour ratio, which is the first explanatory variable in the model. The ratio is used to represent composition effects as well as being an important explanatory variable to evaluate the FEH argument. The estimations show that except for PM pollution emission, all the emissions show a positive relationship between emissions and capital-labour ratio (*kl*) at low levels of the ratio although some of the coefficients are statistically insignificant. When the ratio is increased to a higher level (*klsq*) an increased capital-labour ratio leads to a larger increase in emissions, so the effect is increasing at an increasing rate. However there is a different effect for PM emissions which actually decrease with the capital-labour ratio though at a decreasing rate. In spite of that, only SO2, CO and PM coefficients are statistically significant. These results may suggest that increased availability of capital led to the expansion in pollution-intensive industries more than the expansion in less pollution intensive industries. This scenario is recognised as negative composition effects. Meanwhile, following the FEH theory, an increase in the capital-labour ratio should lead to increased emissions (positive relationship). The well known argument is that large capital intensive industries are also the most polluting industries. Capital intensive industries typically utilise machines and equipments extensively in their production. Moreover they engage various product mixes in their production as well as involving various transformation processes towards producing the end products. All these factors contribute to releasing externalities excessively as well as consuming more fossil energy in running their machines. Essentially, in this case there is strong potential for positive coefficients at a high level capital-labour ratio. In contrast, labour intensive industries are likely to be cleaner and use fewer machines and also are unlikely to involve many transformation processes. Despite that, other arguments also can be put forward such as technique effects. As per capita income-led trade is growing, there will be an opportunity to build-up the country's capability of higher-end technology production which would use more energy efficient technology and is more environmentally friendly. Thus, the use of capital accumulation in that manner could cause a negative capital-labour ratio coefficient at higher levels of the capital-labour ratio. It means that an increase in the capital-labour ratio will decrease the emissions. Here the positive effect of the higher capital-labour ratio is dominating.

The next explanatory variable is income per capita. The results show that initially pollution emissions increase along with income per capita for all pollutants and then further increases in income lead to a decrease in emissions. This shows that the evidence of the income-environment relationship for manufacturing industry in Malaysia does resemble the EKC. Various arguments could be put forward to explain these findings. At a higher level of income, people and government are more concerned about the environment. Also government/people have more money to invest in environmental protection. Could producers retaliate at the more stringent environment regulation or are there shifts in manufacturing composition itself from pollution intensive industry to less pollution industry? This can be reinforced by the government's policy which is more selective in approving new investment or existing expansion of FDI and domestic investments. This is due to people activism on environmental issues who with higher income capability attach higher utility to the environment and enable them to be selective. This is in contrast to when they are at a lower income level which limits their capacity to be more selective and their main priority is to overcome poverty and fulfil their basic needs. It is mentioned in the literature that due to poverty and income disparity, the environment and natural resources are used intensively by breadwinners for their daily necessities. Also if the environment is not correctly priced, this will lead producers/factories to use the environment 'freely' in their production. This externality will continue for some time before it is mitigated by the 'income effect' that is manifested by a stricter environment regulation. This early scenario in economic progress is well documented in the EKC theory. We may also suggest that the decreasing emissions along with per capita income that occurred are consistent with the argument that when an economy moves to a high income level the technique effects outplay the scale effects.

Now we turn to the trade variable which is the theme for this study. In the literature it has been argued that trade liberalization is a determinant of pollution, with the direction of the effect depending on the country's comparative advantage. Then it was also argued that the country's comparative advantage depends on the country's factor endowment and the country's environment stringency. Essentially, the country characteristics that are at play fits with the comparative advantage argument. The deliberations are sufficient to convince us of the importance of the country characteristics in determining the pattern of trade flows as well as their effect on the environment. Using this line of argument, use of trade intensity on its own as a pollution determinant is not really appropriate. Therefore as suggested in the literature, this study used the trade intensity interacted with a country's determinants of comparative advantage. Specifically, trade intensity is interacted with each sector's capital-labour ratio to capture the factor endowment argument and with per capita income (as a proxy of environmental regulation) to test the pollution haven argument. In this study, the interaction terms are the interaction of industry exports intensity with the industry capital-labour ratio and the interaction of industry exports intensity with the industry output (proxy of income).

This industry level study is an effort to examine how the evidence of the trade-environment relationship will be different when the model used in cross-country analyses is applied in a single country study with some modifications. Stern, *et. al.*, (1996) recommend that a more fruitful approach to the analysis of the relationship between trade liberalisation (economic growth) and environmental would be the examination of the historical experience of individual countries, using econometric and also qualitative historical analysis. As shown in the literature, one would expect that the inflow of foreign direct investment (along with trade liberalisation) into developing country such as Malaysia would reduce local pollution (halo effect), for given levels of industrial output and composition. Expansion of economic activity led by trade on the other hand will magnify the environmental degradation (scale effect). In general, free traders and normal producers seek to maximise production and profits as the central objective of their economic activity, without taking into consideration social and environmental costs.

Thus this study examines the argument that trade liberalisation has both a direct and an indirect effect on pollution and these could be opposite in sign. Specifically, this industry level study aims to investigate the causes of pollution in Malaysia over the period 1985-2005 and in particular focus on what role trade has played. This study examines whether the rise in pollution can be associated with growth of exports from industries i.e. has pollution risen more in industries that have traded more, in which case if it has then one can hypothesise that trade has played some role in the change in pollution. Whereas if pollution changes have been unrelated to trade changes, then the source of the growth in pollution has been something else such as domestic production and consumption or transportation. If pollution has increased more from those industries that have increased trade, this study examines what are the characteristics of those industries that drive pollution. Hence using the estimated model, the interaction effects are the main coefficients of interest. This study looks at how the pollution effect of trade varies with the characteristics of the industry (output, capital-labour ratio). In this estimation, a fixed effect model is employed. Hence, with fixed effects the main focus is only looking at changes within industries and not considering 'between' changes in the industrial structure of output. In sum the result of this analysis is important to explain changes in pollution in Malaysia and the role that trade has played. Unlike cross-country analysis (ACT, 2001 and Cole and Elliot, 2003), looking at a single country in this chapter and the previous chapter, this study does not test the PHH since generally there is no variation in regulations amongst industries or regions within Malaysia.

Considering that most of the theoretical arguments on trade-environment such as PHH and FEH are focused on cross-country analysis, we need to reassess and align the arguments to suit to a single country analysis. Firstly, in the model, the capital-labour ratio variable is used as an indicator of the factor endowment hypothesis where in a cross-country study, the assumption is that the differences in factor abundance between countries influence the pattern of trade. However in this single country analysis, the capital-labour ratio varies across industries and over time. Thus in this study capital-labour ratio is used to capture the factor's availability and production technology of the industry. In other words, the factors employed are different across industries. Essentially, the prevailing capital-labour ratio employed in each industry represents the technology / production structure of the industry and does not necessarily depend on factor abundance. However the way that the technology is employed in the each industry is correlated with factor endowment in the country. This effectively alters the production and trade pattern. Secondly, the analysis in this study is based on time series data (1985-2005) using panel data analysis. Theoretically as the country becomes more developed, capital abundance status will likely be easier to reach. Despite that, growth in labour is constrained by a shortage supply of labour force due to declining fertility rates along with development. As such, the capital-labour ratio varies over time. Thirdly, we should also consider the argument of technique effects even though the model is not directly testing the effect. Basically, techniques effects arise when a high income (output) acts as a catalyst in driving the change in old technology to a more advanced technology which is normally more environmentally friendly and uses resources efficiently.

Turning back to the results of the estimation, they show that the pure trade intensity (i.e. at zero income and capital-labour ratio) expansion caused pollution emission of all type of pollutants to decrease. However, the statistically significant evidence is limited to CO and NO2 only. As stated above trade per se should not be considered as a determinant for emissions. Instead we should use interaction terms, which are more appropriate in examining the trade and environment relationship. Theoretically, the industry with a low (high) capital-labour ratio will find pollution falling (rising) in response to trade liberalisation.

Our a priori expectation is a positive relationship as the Malaysian manufacturing industries are in the transition phase from being excessive labour-intensive industries towards being capital-intensive industries. It is well documented in the country's economic master plan (such as a series of Malaysian Industrial Master Plans and Malaysian Development Plans) that the government has put in efforts to shift the economy from a labour-based economy to a capital-based economy. The country has taken steps to reduce the existence of low value added industries and replaced them with high value added industries. The government believes that the country's dependence on cheaper labour as a source of comparative advantage is no longer sustainable. This is due to heightened competition with other developing countries. Essentially a high factor productivity (through increases in human capital) and high impact investment are the current themes of the country's economic policies.

The interaction terms of trade and capital-labour ratio (*tr*kl* and *tr*klsq*) which are used to test the FEH argument shows that the terms are both positive for all four pollutants. In other words, an increase in trade would cause pollution emissions to increase at an increasing rate along with rising capital-labour ratio. However, all coefficients are not statistically significant except for SO2 and NO2 emissions. These results support the FEH argument. The appropriate explanation for this is to relate how the industry responds to trade in view of more capital being available through foreign capital inflow as well as through expansion of domestic investment derived from income accumulation generated by trade. This leads us to discuss the role of the composition effects of trade as pioneered by Grossman and Krueger (1998). The composition effects imply that an expansion of industries whose production technology uses capital more intensively should produce more pollution emissions. Therefore a positive coefficient is expected for the interacted terms. The results of the estimations concur with this argument. Thus, in the case of SO2 and NO2 emissions there is statistical evidence to show that increases in trade led to increases in emissions in sectors with a high capital-labour ratio.

Finally with regard to the interaction term between trade intensity and income (output) per capita (which represents the PHH argument), we find that trade liberalisation causes pollution emission to decrease at an increasing rate for SO2, NO2 and PM emissions, though the quadratic effect is statistically insignificant. For CO emission, trade expansion decreases emissions at an increasing rate as income (output) increases. Theoretically, in the case of cross-country studies, it is argued that a low-income country with low level environmental regulations would find that increase in trade liberalisation will increase their pollution as their comparative advantage in dirty production deepens. Essentially, the PHH works due to a lack of environmental regulation in developing countries compared to developed countries. However this argument is not relevant in this industry level study of a single country. It means operations of all industries in the country are binding by the same set of environmental regulations. One may see some slight differences on environmental requirements for certain industries along with other non-economic conditions such as ownership restriction. Other than that, we can argue that even though this single country study faces the same level of environmental stringency the industries still have potential influences from the legislative differences with other countries, which caused Malaysia's factories to move in or move out of certain industries in search of environmental comparative advantage. It is the same as in the case of national currency where it changes (strength, i.e. appreciate or depreciate over time) its value due to changes to domestic economic fundamental / structure or changes in other countries' economies. In addition to that, a change in environmental-related policies over time also affects law abiding companies. The role of people's desire (awareness) towards environmental standards may change over the period. Essentially, although all industries face the same income at any point in time, the effect of income can be shown changes over time.

6.6.3 Examination based on sub-periods of study

Instead of using the overall sample period as discussed earlier, we examine model (4) according to four sub-periods separately. This section presents the results of estimations for four sub-periods for each pollutant. The four sub-periods are; 1985-1989, 1990-1994, 1995-1999 and 2000-2005. These sub-periods are closely related to the country's five-year development plans known as the Malaysian Plans as shown in appendix 6.2. The plan has been in place since 1956 with this first plan run between 1956 and 1960. Each plan has its own theme and provides policy statements that give the direction of the nation's economy, such as industries that have priority for the government's incentives, new focus / areas for economic expansion and assessment of the overall industry performance and the challenges faced. Thus this sub-period analysis will serve our interest to gauge whether the findings of environment-trade relationship are stable or consistent in each sub-period.

The discussions on the results of estimations for these sub-periods will focus on trade interaction term variables, i.e. an interaction of trade and capital-labour ratio and an interaction of trade and income per capita. The results of the estimations are shown in Table 6.10a to Table 6.13a starting with SO2 then followed by CO, NO2 and PM emissions accordingly.

Firstly this study starts by examining the effect of trade on SO2 emission as shown in Table 6.10a. In terms of an interaction term between trade and capital-labour ratio (*tr*kl*) we find that estimations for the sub-periods provide mixed results. Sub-periods 1985-1989 and 1995-1999 show that industries with a low capital-labour ratio causes SO2 emission to decrease in response to trade liberalization albeit only the coefficient for sub-period 1995-1999 is statistically significant. This initial fall in the effect is in contrast to the pattern shown in the case of estimations on the whole period. Meanwhile, all estimated coefficients on the interaction terms (*tr*kl* and *tr*klsq*) for sub-periods 1990-1994 and 2000-2005 are statistically insignificant. Turning to the interaction terms of trade and income per capita (*tr*y*), they show that trade causes SO2 emission to decrease for an industry with a low income (output) per capita and SO2 emission to increase for an industry with a high income (output) per capita for sub-period 1990-1994, sharing the same pattern as the whole period (i.e. SO2 emission declines with an interaction term between trade and income per capita at a increasing rate). For sub-period 1995-1999, trade expansion causes SO2 emission to decrease at both low and high income per capita. In case of sub-periods 1985-1989 and 2000-2005, the effect is similar, whereby SO2 emission increases with trade at a low income per capita and decreases at a high income per capita, though the coefficients are not statistically significant.

Table 6.10a: The determinants of SO2 industrial pollution emission (fixed effects model)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
a_1kl	0.008	-0.075	0.068	-0.803***	-0.049
	(0.031)	(0.072)	(0.120)	(0.138)	(0.030)
a_2klsq	0.171**	0.441*	0.100	1.113***	0.217***
	(0.082)	(0.245)	(0.439)	(0.381)	(0.056)
a_3y	0.198***	0.332***	0.289***	1.186***	0.340***
	(0.041)	(0.128)	(0.109)	(0.195)	(0.076)
a_4ysq	-0.134**	-1.005**	-0.243*	-0.742***	-0.229***
	(0.053)	(0.426)	(0.137)	(0.185)	(0.055)
a_5kl*y	0.056*	0.061	0.185	-0.259*	-0.020
	(0.031)	(0.084)	(0.217)	(0.135)	(0.028)
a_6tr	-0.054	-0.107	-0.276	0.207	-0.189**
	(0.040)	(0.161)	(0.173)	(0.177)	(0.075)
a_7tr*kl	0.064	-0.093	0.467	-0.415	-0.026
	(0.084)	(0.274)	(0.497)	(0.339)	(0.086)
$a_8tr*klsq$	0.812**	1.431	-0.704	3.481*	-0.041
	(0.375)	(1.254)	(2.015)	(1.833)	(0.255)
a_9tr*y	-0.332***	0.225	-0.441*	-0.164	0.310
	(0.112)	(0.331)	(0.267)	(0.282)	(0.199)
$a_{10}tr*ysq$	0.071	-1.911	0.159	-1.074**	-0.347**
	(0.165)	(1.315)	(0.394)	(0.531)	(0.162)
$a_{11}tr*y*kl$	0.241*	0.078	1.346	-1.408***	0.242**
	(0.136)	(0.481)	(0.908)	(0.529)	(0.117)
$a_{12}time$	0.008	-0.034**	0.018	0.011	-0.029*
	(0.006)	(0.017)	(0.021)	(0.040)	(0.015)
cons	-0.0005	-0.147***	-0.019	0.034	0.048**

	(0.008)	(0.047)	(0.032)	(0.030)	(0.019)
R^2*(within)*	0.0892	0.1086	0.1844	0.2620	0.4362
R^2*(between)*	0.0770	0.0393	0.0492	0.0019	0.0115
R^2*(overall)*	0.0732	0.0373	0.0503	0.0025	0.0149
corr	0.1333	0.1222	0.0342	-0.5467	-0.0943
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

Note: There is an exception that trade is led to increase SO emission for period 1995-1999 but still not significant.

The results of estimations for sub-periods in case of CO emission are shown in Table 6.11a below. Starting with the interaction term between trade and capital-labour ratio (*tr*kl*) we find that only results or sub-period 1995-1999 are statistically significant. The results show that trade expansion causes CO emissions to increase with the capital-labour ratio up to a turning point and then decreases. This suggests that technique effects at a high capital-labour ratio contributed to the results. All estimated coefficients of the interaction terms (*tr*kl* and *tr*klsq*) for the other three sub-periods are statistically insignificant. With regard to interaction term of trade and income per capita (*tr*y*), the coefficients for sub-periods 1985-1989, 1990-1994 and 2000-2005 are statistically significant. However, only coefficients for sub-period 1990-1994 are consistent with the results of estimations based for on overall period where trade causes CO emission to decrease more, the higher the income per capita. For sub-periods 1985-1989 and 2000-2005 CO emission increases with trade at a low income per capita and CO emission decreases with trade at a high income per capita.

Table 6.11a: The determinants of CO industrial pollution emission (fixed effects model)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$a_1 kl$	0.067*	-0.120	-0.088	-0.343***	-0.064
	(0.038)	(0.074)	(0.153)	(0.085)	(0.066)
$a_2 klsq$	0.156	0.734***	0.778	-0.446*	0.320***
	(0.102)	(0.250)	(0.559)	(0.235)	(0.121)
$a_3 y$	0.413***	0.464***	0.744***	0.460***	0.896***
	(0.051)	(0.131)	(0.139)	(0.120)	(0.165)
$a_4 ysq$	-0.301***	-1.216***	-0.686***	-0.283**	-0.630***
	(0.066)	(0.435)	(0.174)	(0.114)	(0.121)
$a_5 kl*y$	0.047	0.065	-0.206	-0.013	-0.143**
	(0.039)	(0.086)	(0.277)	(0.083)	(0.062)
$a_6 tr$	-0.120**	-0.295*	-0.377*	-0.473***	-0.371**
	(0.049)	(0.164)	(0.221)	(0.109)	(0.163)
$a_7 tr*kl$	0.114	-0.115	0.344	0.234	-0.128
	(0.105)	(0.279)	(0.633)	(0.209)	(0.187)
$a_8 tr*klsq$	0.645	2.022	0.256	-4.257***	-0.382
	(0.466)	(1.279)	(2.568)	(1.132)	(0.558)
$a_9 tr*y$	-0.227	0.570*	-0.442	0.042	0.256
	(0.140)	(0.337)	(0.340)	(0.174)	(0.435)
$a_{10} tr*ysq$	-0.561***	-4.197***	-0.922*	-0.515	-0.917***
	(0.205)	(1.341)	(0.502)	(0.328)	(0.353)
$a_{11} tr*y*kl$	0.288*	0.140	1.209	0.172	-0.007
	(0.169)	(0.490)	(1.158)	(0.326)	(0.256)
$a_{12} time$	-0.002	-0.001	-0.003	-0.013	-0.071*
	(0.008)	(0.017)	(0.027)	(0.024)	(0.033)
cons	-0.006	-0.127***	0.045	-0.014	0.045
	(0.010)	(0.048)	(0.040)	(0.019)	(0.042)
R^2(within)	0.2004	0.2534	0.3802	0.3963	0.3045
R^2(between)	0.1953	0.1059	0.1169	0.0103	0.0923
R^2(overall)	0.1923	0.1030	0.1211	0.0127	0.0976
corr	0.1444	0.1823	-0.0829	-0.2288	-0.1760
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

Table 6.12a below shows the results of estimations for sub-periods in the case of NO2 emission. Looking at interaction terms between trade and capital-labour ratio (*tr*kl*) we find that none of the estimations in each sub-period share the same pattern as estimations based on the whole period. Estimations for sub periods 1985-1989, 1990-1994 and 1995-1999, show that trade led NO2 emissions to decrease at lower capital-labour ratios and to increase at higher capital-labour ratios. However only results for sub periods 1990-1994 and 1995-1999 show statistical evidence to support FEH argument. Meanwhile the opposite trend is found for

estimations in the sub-period 2000-2005 and the coefficients are statistically significant. Results of estimations for sub-period 1985-1989 are statistically insignificant. Turning to the interaction terms between trade and income per capita ($tr*y$), only coefficients for sub-periods 1995-1999 and 2000-2005 are statistically significant. For sub-period 1995-1999, trade expansion causes NO2 emission to decrease at both low and high income per capita, while in the case of sub-period 2000-2005, increasing trade led to NO2 emissions increasing at a low income per capita and decreasing at a high income per capita.

Table 6.12 a: The determinants of NO2 industrial pollution emission (fixed effects model)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$\alpha_1 kl$	0.043	-0.071	-0.183*	-0.866***	-0.022
	(0.030)	(0.077)	(0.100)	(0.132)	(0.030)
$\alpha_2 klsq$	0.041	0.506*	0.980***	2.042***	0.067
	(0.081)	(0.262)	(0.365)	(0.365)	(0.056)
$\alpha_3 y$	0.221***	0.346**	0.253	1.250***	0.323***
	(0.041)	(0.137)	(0.091)	(0.187)	(0.076)
$\alpha_4 ysq$	-0.116**	-0.968**	-0.281**	-0.798***	-0.211***
	(0.052)	(0.455)	(0.114)	(0.177)	(0.056)
$\alpha_5 kl*y$	0.119***	0.075	-0.242	-0.410***	0.020
	(0.031)	(0.090)	(0.181)	(0.129)	(0.028)
$\alpha_6 tr$	-0.110***	-0.156	0.095	0.699***	-0.024
	(0.039)	(0.172)	(0.144)	(0.169)	(0.075)
$\alpha_7 tr*kl$	0.153*	-0.015	-0.400	-0.715**	0.187**
	(0.083)	(0.292)	(0.414)	(0.325)	(0.086)
$\alpha_8 tr*klsq$	0.222	1.363	2.874*	8.029***	-0.876***
	(0.372)	(1.339)	(1.678)	(1.755)	(0.257)
$\alpha_9 tr*y$	-0.289***	0.204	-0.277	-0.126	0.289
	(0.111)	(0.353)	(0.222)	(0.270)	(0.201)
$\alpha_{10} tr*ysq$	0.039	-2.082	-0.398	-1.205**	-0.365**
	(0.163)	(1.404)	(0.328)	(0.508)	(0.163)
$\alpha_{11} tr*y*kl$	0.535***	0.288	-0.722	-2.131***	0.465***
	(0.135)	(0.513)	(0.757)	(0.506)	(0.118)
$\alpha_{12} time$	0.005	-0.025	0.019	0.002	-0.031**
	(0.006)	(0.018)	(0.018)	(0.038)	(0.015)
cons	-0.011	-0.131***	0.052**	0.115***	0.061***
	(0.008)	(0.051)	(0.026)	(0.029)	(0.020)
R^2(within)	0.1191	0.1316	0.2904	0.2436	0.2909
R^2(between)	0.0913	0.0549	0.0480	0.0050	0.0006
R^2(overall)	0.0891	0.0526	0.0493	0.0058	0.0013
corr	0.1308	0.1417	0.0655	-0.5465	-0.1611
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

Results of estimations for sub-periods in the case of PM emission are shown in Table 6.13a below. For the interaction term between trade and capital-labour ratio (*tr*kl*) we find only coefficients for sub-periods 1995-1999 are statistically significant which shows evidence to support the FEH argument where trade led PM emission to decrease at a low capital-labour ratio and increase at a high capital-labour ratio.

Table 6.13a: The determinants of PM industrial pollution emission (fixed effects model)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$a_1 kl$	-0.059**	-0.064	-0.062	-0.863***	0.001
	(0.029)	(0.073)	(0.101)	(0.136)	(0.019)
$a_2 klsq$	0.097	0.162	0.161	2.164***	0.002
	(0.078)	(0.248)	(0.367)	(0.377)	(0.036)
$a_3 y$	0.115***	0.215*	0.132	1.191***	0.042
	(0.039)	(0.130)	(0.091)	(0.193)	(0.049)
$a_4 ysq$	-0.092*	-0.684	-0.138	-0.762***	-0.027
	(0.050)	(0.431)	(0.114)	(0.183)	(0.036)
$a_5 kl*y$	-0.003	-0.029	0.011	-0.357***	-0.013
	(0.029)	(0.085)	(0.182)	(0.133)	(0.018)
$a_6 tr$	-0.058	-0.108	-0.046	0.799***	-0.010
	(0.038)	(0.163)	(0.145)	(0.175)	(0.048)
$a_7 tr*kl$	0.028	-0.158	-0.031	-0.751**	-0.018
	(0.080)	(0.277)	(0.416)	(0.336)	(0.055)
$a_8 tr*klsq$	0.230	0.691	0.583	9.189***	-0.029
	(0.355)	(1.268)	(1.687)	(1.816)	(0.164)
$a_9 tr*y$	-0.249**	0.017	-0.320	-0.152	-0.009
	(0.106)	(0.334)	(0.223)	(0.279)	(0.128)
$a_{10} tr*ysq$	0.041	-1.058	0.072	-1.122**	-0.032
	(0.156)	(1.329)	(0.330)	(0.526)	(0.104)
$a_{11} tr*y*kl$	0.018	-0.255	-0.113	-2.016***	-0.042
	(0.129)	(0.486)	(0.761)	(0.524)	(0.075)
$a_{12} time$	0.012**	-0.036	0.022	0.009	-0.008
	(0.006)	(0.017)	(0.018)	(0.039)	(0.010)
cons	-0.004	-0.126***	-0.009	0.108***	0.015
	(0.007)	(0.048)	(0.026)	(0.030)	(0.012)
R^2(within)	0.0308	0.0245	0.0377	0.2252	0.0064
R^2(between)	0.0132	0.0082	0.0132	0.0036	0.0207
R^2(overall)	0.0134	0.0081	0.0133	0.0042	0.0205
corr	0.0422	0.0473	0.0369	-0.5294	0.1113
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

Overall, there are at least two important findings that need to be highlighted from this sub-period examination. Firstly, we observe that the result of estimations for the period 1995-1999 provided a higher number of coefficients that are significant for all the emissions compared to the coefficients for the other periods. Secondly, some of the coefficients have changed their sign, size, and level of significance between periods. This exercise does not mean to compare with the results or findings based on the overall period of study (1985-2005). The mixed results shown in these sub-sample analyses are expected especially in view of the fact that the expansion of each industry over time is not uniform thus altering the composition of industry within the manufacturing sector.

6.6.4 Examination based on the product-groups

This section discusses the results of estimations according to product group. The estimations involved are four product groups namely: Food, beverages and tobacco (FBT), Textile and wearing apparel (TWA), Chemicals and pharmaceutical (CPH) and Electrical and electronics (EES). The results of the estimations are show in Table 6.14a to Table 6.17a below which start with SO2 followed by CO, NO2 and PM.

We start the examination with the effect of trade on SO2 emission by the sub-group products as shown in Table 6.14a. In terms of the interaction terms between trade and capital-labour ratio (*tr*kl*) we find that only coefficients for sub-group TWA and EES are statistically significant. In the case of sub-group TWA, the effect of trade expansion on SO2 emissions increases with the capital-labour ratio up to a turning point. The opposite trend is shown for sub-group EES, though the positive quadratic effect dominates. Turning to the interaction term between trade and income per capita (*tr*y*), there is statistical evidence to show that trade expansion causes SO2 emission to decrease at both low and high income per capita for sub-groups FBT and EES. The estimations for the other two sub-groups are statistically insignificant.

Table 6.14a: The determinants of SO2 industrial pollution emission based on product-group (fixed effects model)

Variable	Overall	FBT	TWA	CPH	EES
a_1kl	0.008	0.162	0.064***	0.061	0.095***
	(0.031)	(0.342)	(0.017)	(0.049)	(0.013)
a_2klsq	0.171**	1.163	-0.623***	0.116	-1.006***
	(0.082)	(2.213)	(0.093)	(0.173)	(0.148)
a_3y	0.198***	-0.776**	0.042*	-0.278**	0.015***
	(0.041)	(0.385)	(0.023)	(0.120)	(0.003)
a_4ysq	-0.134**	-1.869***	-0.130	1.102*	-0.014***
	(0.053)	(0.721)	(0.249)	(0.647)	(0.004)
a_5kl*y	0.056*	0.699**	0.071*	0.081	-0.028***
	(0.031)	(0.317)	(0.038)	(0.061)	(0.005)
a_6tr	-0.054	-3.270***	-0.276	-0.423	0.045
	(0.040)	(0.671)	(0.178)	(0.444)	(0.028)
a_7tr*kl	0.064	0.344	0.009	0.268	-0.018
	(0.084)	(1.398)	(0.079)	(0.218)	(0.016)
$a_8tr*klsq$	0.812**	4.155	-0.737*	-0.246	0.580**
	(0.375)	(7.994)	(0.400)	(0.886)	(0.294)
a_9tr*y	-0.332***	-4.248***	0.051	-0.642	-0.006
	(0.112)	(1.646)	(0.096)	(0.443)	(0.008)
$a_{10}tr*ysq$	0.071	-13.932***	-1.375	-0.999	-0.053***
	(0.165)	(3.878)	(1.276)	(2.864)	(0.012)
$a_{11}tr*y*kl$	0.241*	1.499	-0.034	0.822***	0.007
	(0.136)	(2.059)	(0.173)	(0.318)	(0.016)
$a_{12}time$	0.008	-0.002	-0.0003*	-0.001	-0.0003
	(0.006)	(0.005)	0.0002)	(0.009)	(0.001)
cons	-0.0005	-0.513***	-0.272***	0.010	-0.288***
	(0.008)	(0.171)	0.033)	(0.097)	(0.012)
R^2(within)	0.0892	0.7980	0.7080	0.5287	0.5587
R^2(between)	0.0770	0.5557	0.7373	0.8561	0.7560
R^2(overall)	0.0732	0.2177	0.4340	0.6808	0.7057
corr	0.1333	0.2878	0.5518	0.6541	0.2395
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

Table 6.15a below shows the results of estimations for sub-group products in the case of CO emission. Looking at an interaction term between trade and capital-labour ratio (*tr*kl*) we find that with the exception of sub-group FBT all coefficients for sub-group products are statistically significant. For all sub-groups, the trade effect increases with the capital-labour ratio, though at a decreasing rate for TWA and CPH. For the interaction term between trade and income per capita (*tr*y*), there

is statistical evidence to show that trade expansion causes CO emission to decrease more as income per capita rises for sub-groups FBT and EES, sharing the pattern of estimations showed in the whole period.

Table 6.15a: The determinants of CO industrial pollution emission based on product-group (fixed effects model)

Variable	Overall	FBT	TWA	CPH	EES
a_1kl	0.067*	0.005	0.038***	0.297***	-0.070
	(0.038)	(0.093)	(0.010)	(0.096)	(0.089)
a_2klsq	0.156	0.787	-0.356***	-0.442	0.554
	(0.102)	(0.601)	(0.054)	(0.338)	(1.041)
a_3y	0.413***	-0.144	0.023	-0.473**	0.113***
	(0.051)	(0.105)	(0.014)	(0.234)	(0.021)
a_4ysq	-0.301***	-0.522***	-0.062	1.438	-0.070***
	(0.066)	(0.196)	(0.145)	(1.260)	(0.027)
a_5kl*y	0.047	0.229***	0.043**	0.235**	-0.268***
	(0.039)	(0.086)	(0.022)	(0.120)	(0.033)
a_6tr	-0.120**	-0.718***	-0.174*	-0.990	0.315
	(0.049)	(0.182)	(0.103)	(0.864)	(0.194)
a_7tr*kl	0.114	0.070	0.019	0.815*	0.205*
	(0.105)	(0.380)	(0.046)	(0.425)	(0.111)
$a_8tr*klsq$	0.645	2.528	-0.477**	-2.965*	3.409
	(0.466)	(2.170)	(0.232)	(1.726)	(2.075)
a_9tr*y	-0.227	-1.039	0.037	-1.218	-0.009
	(0.140)	(0.447)	(0.056)	(0.864)	(0.054)
$a_{10}tr*ysq$	-0.561***	-3.496***	-0.873	-1.883	-0.542***
	(0.205)	(1.053)	(0.741)	(5.578)	(0.086)
$a_{11}tr*y*kl$	0.288*	0.742	0.010	1.749***	0.374***
	(0.169)	(0.559)	(0.100)	(0.619)	(0.110)
$a_{12}time$	-0.002	-0.002*	-0.0002**	0.017	-0.011**
	(0.008)	(0.001)	0.0001)	(0.018)	(0.005)
cons	-0.006	-0.363***	-0.359***	0.194	-0.203**
	(0.010)	(0.046)	0.019)	(0.189)	(0.085)
R^2(within)	0.2004	0.7625	0.6891	0.4774	0.7673
R^2(between)	0.1953	0.7628	0.7277	0.2255	0.9433
R^2(overall)	0.1923	0.4985	0.4192	0.2203	0.8656
corr	0.1444	0.5473	0.5410	0.2211	0.7355
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

Table 6.16a below shows the results of estimations for sub-group products in the case of NO2 emissions. For the interaction term between trade and capital-labour ratio (*tr*kl*) we find that there is statistical evidence that an increase in trade led NO2 emissions to increase more as the capital-labour ratio increase up to a turning point for sub-group CPH. For sub-group EES trade expansion causes NO2 emission to increasingly more as the capital-labour ratio rises. This relationship is similar to the estimations for the full economy. None of the coefficients on the interaction terms are statistically significant for sub groups FBT and TWA. Turning to the interaction term between trade and income per capita (*tr*y*), there is statistical evidence that trade expansion causes NO2 emission to decrease at both low and high income per capita for sub-groups FBT, CPH and EES. The estimations for sub-group TWA are statistically insignificant. None of sub-group products shared the same trend of relationship shown in the estimations based on the full economy.

Table 6.16a: The determinants of NO2 industrial pollution emission based on product-group (fixed effects model)

Variable	Overall	FBT	TWA	CPH	EES
$a_1 kl$	0.043	0.098	0.181***	0.167***	0.023
	(0.030)	(0.272)	(0.050)	(0.064)	(0.030)
$a_2 klsq$	0.041	1.382	-1.748***	-0.120	-0.285
	(0.081)	(1.759)	(0.271)	(0.223)	(0.348)
$a_3 y$	0.221***	-0.480	0.079	0.021	0.043***
	(0.041)	(0.306)	(0.068)	(0.155)	(0.007)
$a_4 ysq$	-0.116**	-1.602***	-0.019	-0.310	-0.028***
	(0.052)	(0.573)	(0.723)	(0.832)	(0.009)
$a_5 kl*y$	0.119***	0.627**	0.203*	0.226***	-0.094***
	(0.031)	(0.252)	(0.110)	(0.079)	(0.011)
$a_6 tr$	-0.110***	-2.424***	-0.635	-1.242**	0.132**
	(0.039)	(0.533)	(0.517)	(0.570)	(0.065)
$a_7 tr*kl$	0.153*	0.309	-0.014	0.651**	0.039
	(0.083)	(1.111)	(0.230)	(0.281)	(0.037)
$a_8 tr*klsq$	0.222	4.596	-1.727	-1.318	1.511**
	(0.372)	(6.352)	(1.163)	(1.139)	(0.693)
$a_9 tr*y$	-0.289***	-3.076**	0.051	-0.074	-0.008
	(0.111)	(1.308)	(0.278)	(0.570)	(0.018)
$a_{10} tr*ysq$	0.039	-11.124***	-2.976	-6.516*	-0.186***
	(0.163)	(3.082)	(3.710)	(3.682)	(0.029)
$a_{11} tr*y*kl$	0.535***	1.693	-0.156	1.477***	0.119***
	(0.135)	(1.636)	(0.503)	(0.409)	(0.037)

$\alpha_{12}time$	0.005	-0.002	-0.001	-0.007	-0.004**
	(0.006)	(0.004)	0.001)	(0.012)	(0.002)
cons	-0.011	-0.431***	-0.362***	-0.169	-0.252***
	(0.008)	(0.136)	0.097)	(0.124)	(0.029)
R^2(within)	0.1191	0.7864	0.7110	0.6014	0.7733
R^2(between)	0.0913	0.7852	0.6978	0.8130	0.9381
R^2(overall)	0.0891	0.4318	0.3584	0.7169	0.8719
corr	0.1308	0.4963	0.4893	0.6079	0.7227
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

For PM emissions, the results of estimations for sub-group products are shown in Table 6.17a. Looking at the interaction term between trade and capital-labour ratio (*tr*kl*) we find that there is statistical evidence that the size of the increases in PM emissions caused by trade increases with the level of the capital-labour ratio for sub-group CPH. For sub-group EES trade expansion causes PM emission to increase more as the capital-labour ratio rises. This relationship is similar to the results for the full economy although none of coefficients for the full economy are statistically significant. None of the coefficients on the interaction terms are statistically significant for sub groups FBT and TWA. For the interaction term between trade and income per capita (*tr*y*), there is statistical evidence that trade expansion causes PM emissions to decrease more the higher the level of income per capita for sub-groups FBT and EES. The estimations for sub-groups TWA and CPH are statistically insignificant.

Table 6.17a: The determinants of PM industrial pollution emission based on product-group (fixed effects model)

Variable	Overall	FBT	TWA	CPH	EES
a_1kl	-0.059**	0.101	0.002***	0.004***	-0.002***
	(0.029)	(0.268)	(0.001)	(0.001)	(0.001)
a_2klsq	0.097	1.026	-0.020***	-0.011***	0.012**
	(0.078)	(1.732)	(0.003)	(0.004)	(0.006)
a_3y	0.115***	-0.713**	0.001*	-0.005**	0.0004***
	(0.039)	(0.302)	(0.001)	(0.002)	(0.0001)
a_4ysq	-0.092*	-1.328**	-0.005	0.026**	-0.0002
	(0.050)	(0.564)	(0.008)	(0.013)	(0.0002)
a_5kl*y	-0.003	0.506**	0.002*	0.004***	-0.0005***
	(0.029)	(0.248)	(0.001)	(0.001)	(0.0002)
a_6tr	-0.058	-2.613***	-0.006	-0.005	0.002**
	(0.038)	(0.525)	(0.006)	(0.009)	(0.001)
a_7tr*kl	0.028	0.118	-0.001	0.015***	0.001
	(0.080)	(1.094)	(0.003)	(0.004)	(0.001)
$a_8tr*klsq$	0.230	3.819	-0.020	-0.059***	0.025**
	(0.355)	(6.256)	(0.013)	(0.018)	(0.012)
a_9tr*y	-0.249**	-3.587***	-0.001	-0.004	-0.001**
	(0.106)	(1.288)	(0.003)	(0.009)	(0.0003)
$a_{10}tr*ysq$	0.041	-10.527***	-0.025	0.008	-0.001
	(0.156)	(3.035)	(0.042)	(0.058)	(0.0005)
$a_{11}tr*y*kl$	0.018	0.929	-0.003	0.027***	0.002***
	(0.129)	(1.612)	(0.006)	(0.006)	(0.001)
$a_{12}time$	0.012**	-0.001	-0.00001*	0.001***	0.0001***
	(0.006)	(0.004)	0.00001)	(0.0002)	(0.00003)
cons	-0.004	-0.402***	-0.150***	-0.140***	-0.147***
	(0.007)	(0.134)	0.001)	(0.002)	(0.0005)
$R^{2(}within)$	0.0308	0.8023	0.7211	0.5453	0.4648
$R^{2(}between)$	0.0132	0.0706	0.7845	0.2497	0.4678
$R^2(overall)$	0.0134	0.0623	0.5324	0.2285	0.4549
corr	0.0422	0.0605	0.6278	0.2461	0.2498
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

Here we discuss further the findings of sub-group products mentioned earlier. In the case of textile and wearing apparel (TWA), it has shown a positive relationship at a low capital-labour ratio and changed to a negative at a high capital-labour ratio for SO2 and CO emissions, while for NO2 and PM the relationship becomes increasingly more negative as the capital-labour ratio rises, though none of the coefficients are statistically significant. In the case of food, beverages and tobacco (FBT) the relationship is positive for both low and high level of capital-labour ratios but their coefficients are statistically insignificant. With the exception of NO2, chemicals and pharmaceutical (CPH) portrays a similar relationship as TWA. For industries in electrical and electronics (EES), the evidence is mixed across the pollutants. At a low capital-labour ratio the relationship is positive and then turns to a negative relationship at a higher level in case of SO2 and NO2, while for CO and PM the reverse is true. A potential explanation for these results is that for TWA industries the industry is largely labour intensive and is not involved in any complex transformation process in their production activity. Because this industry is labour intensive, at a high capital-labour ratio the capital abundance encourages the merging of small size establishments into the bigger establishments. Compared to small establishments, the bigger establishments are more organised and operate more formally as a business entity. Their capability is more likely to reach economies of scale where it is normal for big entities to have 24 hour-operation using a multiple-shifts workforce and high specialisation along with a moderate level of skilled-labour. Thus we can say that an increase in capital abundance in a less polluting industry contributes to a reduction of pollution emission.

The result of estimation shows that CPH also mostly emulates the same scenario as TWA. In the context of CPH the industry is considered relatively capital intensive and is likely to be associated with pollution outcomes (i.e. a polluter). Therefore the positive effect of trade on pollution shown at lower capital-labour ratios is in line with our expectation. The changed relationship into negative at higher levels of the capital-labour ratio can be attributed to pollution abatement technology as well as other factors such as investment in new technology that are more environmentally friendly. Compared to TWA which is populated by home-grown companies, CPH is dominated by multinational and state-owned companies. Therefore it is reasonable for one to claim that the production technology used in this industry is dictated by the international standard which forcefully internalises the harmful externalities. This finding actually echoed Dinda *et. al* (2000), which indicates the potential ambiguity in using capital abundance as a measurement for industrial composition, since the "capital intensive sector could also be more likely to be clean technology owner".

The scenario in TWA and EES concurs with the overall effect of trade on pollution for all pollutants, where the effect mostly decreases with output per capita. Thus it appears that the technique effect is dominant for TWA. In the case of CPH, the pollution decreases with output per capita at a decreasing rate for all pollutants except NO2. Hence in the CPH industry the technique effects are dominating the scale effect. For FBT, emissions decrease at an increasing rate. It implies that the technique effect is superior to scale effect in FBT industries. This is unsurprising due to the fact that this industry is where the country is ranked as the top exporter of palm oil in the world. Thus as a leading producer a lot of R&D expenditure has been carried out to improve the production technology. Among the recent and advanced technology is the success in processing biodiesel using palm oil which has been a niche area that increases Malaysian exports earnings.

6.6.5 Examination based on groups of the pollution intensive industry (PI) and non-pollution intensive industry (NPI)

This section presents and discusses the results of estimations for groups of pollution intensive industry (PI) and non-pollution intensive industry (NPI). The results are shown in Table 6.18a to Table 6.21a below starting with SO2 emission followed by CO, NO2 and PM emissions.

Results of estimations for SO2 emission are shown in Table 6.18a. In terms of the interaction term between trade and capital-labour ratio (*tr*kl*) we find that only coefficients for sub-group NPI are statistically significant. It is worth noting that the number of observations for the PI group is relatively small compared to the NPI group and these results in higher standard errors on the coefficients of the PI group. It shows that trade expansion in NPI industries causes SO2 emissions to increase, the effect size increasing with the capital-labour ratio up to a point. This pattern is different from the overall estimations where trade expansion causes SO2 emission to increase at both low and high capital-labour ratios although the coefficients are statistically insignificant. Turning to the interaction term between trade and income per capita (*tr*y*), it also shows that only NPI's coefficients are statistically significant, though the coefficients are actually larger for the PI industries. The results suggest that the effect of trade expansion on pollution in NPI industries initially falls then rises with income per capita.

Table 6.18a: The determinants of SO2 industrial pollution emission based on groups of pollution intensive industry and non pollution intensive industry (fixed effects model)

Variable	Overall	PI	NPI
$a_1 kl$	0.008	-0.235***	0.075***
	(0.031)	(0.090)	(0.029)
$a_2 klsq$	0.171**	0.448**	-0.260
	(0.082)	(0.197)	(0.295)
$a_3 y$	0.198***	1.466***	0.029**
	(0.041)	(0.347)	(0.013)
$a_4 ysq$	-0.134**	-3.989**	0.062***
	(0.053)	(1.921)	(0.018)
$a_5 kl*y$	0.056*	-0.027	0.214***
	(0.031)	(0.130)	(0.020)
$a_6 tr$	-0.054	-2.332**	-0.069
	(0.040)	(1.085)	(0.082)
$a_7 tr*kl$	0.064	0.500	0:185***
	(0.084)	(0.315)	(0.065)
$a_8 tr*klsq$	0.812**	0.080	-0.677
	(0.375)	(0.937)	(0.918)
$a_9 tr*y$	-0.332***	-1.062	-0.171***
	(0.112)	(1.182)	(0.037)
$a_{10} tr*ysq$	0.071	-11.855	0.345***
	(0.165)	(8.022)	(0.058)
$a_{11} tr*y*kl$	0.241*	0.268	0.350***
	(0.136)	(0.590)	(0.074)
$a_{12} time$	0.008	-0.003	0.004
	(0.006)	(0.022)	(0.002)
cons	-0.0005	0.027	-0.183***
	(0.008)	(0.257)	(0.024)
R^2*(within)*	0.0892	0.2829	0.1793
R^2*(between)*	0.0770	0.0854	0.5177
R^2*(overall)*	0.0732	0.0955	0.4223
corr	0.1333	0.0561	0.5465
observations	1659	441	1218
num.of groups	79	21	58

Note: it seem that when the model focused on dirty industry in the analysis, none of coefficients related to PHH is significant for all type of emission pollution.

Turning to results of estimations for CO emission as shown in Table 6.19a, the interaction term between trade and capital-labour ratio (*tr*kl*) coefficients shows that the coefficients for sub-groups NPI and PI are statistically significant. In the case of sub-group PI, the results show that trade expansion causes CO emission to increase more as the capital-labour ratio rises, though at a decreasing rate. For sub-group NPI, trade expansion leads CO emission to increase with the capital-labour ratio at an increasing rate. The pattern for NPI is similar to the pattern in the overall estimations although the coefficients are statistically insignificant. For the interaction term between trade and income per capita (*tr*y*), only NPI's coefficients are statistically significant where it shows that trade expansion on NPI causes CO emission to decrease more the higher is income per capita, sharing the pattern in the overall economy estimations.

Table 6.19a: The determinants of CO industrial pollution emission based on groups of pollution intensive industry and non pollution intensive industry (fixed effects model)

Variable	Overall	PI	NPI
$\alpha_1 kl$	0.067*	-0.493***	-0.059**
	(0.038)	(0.093)	0.027)
$\alpha_2 klsq$	0.156	0.860***	0.727***
	(0.102)	(0.205)	(0.272)
$\alpha_3 y$	0.413***	2.344***	0.087***
	(0.051)	(0.361)	(0.012)
$\alpha_4 ysq$	-0.301***	-0.206	-0.011
	(0.066)	(1.998)	(0.017)
$\alpha_5 kl*y$	0.047	-0.471***	-0.142***
	(0.039)	(0.135)	(0.018)
$\alpha_6 tr$	-0.120**	-1.340	0.091
	(0.049)	(1.129)	(0.075)
$\alpha_7 tr*kl$	0.114	0.716**	0.270***
	(0.105)	(0.328)	(0.060)
$\alpha_8 tr*klsq$	0.645	-2.326**	1.217
	(0.466)	(0.974)	(0.848)
$\alpha_9 tr*y$	-0.227	1.145	-0.040
	(0.140)	(1.229)	(0.034)
$\alpha_{10} tr*ysq$	-0.561***	-9.651	-0.358***
	(0.205)	(8.345)	(0.053)
$\alpha_{11} tr*y*kl$	0.288*	0.112	0.516***
	(0.169)	(0.613)	(0.069)

$a_{12}time$	-0.002	-0.024	-0.006***
	(0.008)	(0.023)	(0.002)
cons	-0.006	1.106***	-0.206***
	(0.010)	(0.267)	(0.022)
R^2(within)	0.2004	0.5418	0.7226
R^2(between)	0.1953	0.3499	0.9061
R^2(overall)	0.1923	0.3605	0.8271
corr	0.1444	0.1988	0.6953
observations	1659	441	1218
num.of groups	79	21	58

Results of estimations for NO2 emissions are shown in Table 6.20a below. The coefficients on the interaction terms between trade and capital-labour ratio (*tr*kl*) show that the trade expansion effect on NO2 emissions increases with the capital-labour ratio at a decreasing rate in the case of sub-group NPI. The coefficients are statistically significant. The pattern is different to the one in the overall estimations where trade expansion led to NO2 emissions increasing continuously with the capital-labour ratio. None of the coefficients in sub-group PI are statistically significant. In terms of the interaction term between trade and income per capita (*tr*y*), only NPI's coefficients are statistically significant where it shows that trade expansion on NPI causes NO2 emissions to decrease at an increasing rate with income per capita. This relationship is similar to the pattern in the overall economy estimations. Meanwhile, no evidence of a relationship is found in the case of PI.

Table 6.20a: The determinants of NO2 industrial pollution emission based on groups of pollution intensive industry and non pollution intensive industry (fixed effects model)

Variable	Overall	PI	NPI
$a_1 kl$	0.043	-0.256***	0.032
	(0.030)	(0.090)	0.024)
$a_2 klsq$	0.041	0.460**	0.056
	(0.081)	(0.198)	(0.246)
$a_3 y$	0.221***	1.563***	0.045***
	(0.041)	(0.349)	(0.011)
$a_4 ysq$	-0.116**	-3.888**	0.041***
	(0.052)	(1.931)	(0.015)
$a_5 kl*y$	0.119***	0.060	0.110***
	(0.031)	(0.131)	(0.017)
$a_6 tr$	-0.110***	-2.085*	-0.014
	(0.039)	(1.091)	(0.068)
$a_7 tr*kl$	0.153*	0.218	0.199***
	(0.083)	(0.317)	(0.054)
$a_8 tr*klsq$	0.222	0.347	-0.013
	(0.372)	(0.942)	(0.765)
$a_9 tr*y$	-0.289***	-1.183	-0.133***
	(0.111)	(1.188)	(0.030)
$a_{10} tr*ysq$	0.039	-10.280	0.144***
	(0.163)	(8.066)	(0.048)
$a_{11} tr*y*kl$	0.535***	0.589	0.396***
	(0.135)	(0.593)	(0.062)
$a_{12} time$	0.005	-0.006	0.001
	(0.006)	(0.022)	(0.002)
cons	-0.011	0.119	-0.189***
	(0.008)	(0.259)	(0.020)
R^2(within)	0.1191	0.2950	0.3450
R^2(between)	0.0913	0.0989	0.4413
R^2(overall)	0.0891	0.1095	0.4006
corr	0.1308	0.0544	0.4201
observations	1659	441	1218
num.of groups	79	21	58

Finally, the results of estimations for PM emissions are shown in Table 6.21a below. In the case of the interaction terms between trade and capital-labour ratio (*tr*kl*), they show that there is statistical evidence that trade expansion causes PM emission to increase at a low capital-labour ratio and decrease at a high capital-labour ratio in the case of sub-group NPI. There is no evidence of a relationship in the case of sub-group PI. The pattern is different to the results shown in the overall economy estimations where trade expansion led PM emissions to increase more as the capital-labour ratio rises. For interaction terms between trade and income per capita (*tr*y*), again, only NPI's coefficients are statistically significant where it shows that the trade expansion effect on NPI causes PM emissions to decrease at a decreasing rate with income per capita. This relationship is similar to the results shown in the overall economy estimations.

Table 6.21a: The determinants of PM industrial pollution emission based on groups of pollution intensive industry and non pollution intensive industry (fixed effects model)

Variable	Overall	PI	NPI
a_1kl	-0.059**	-0.277***	0.053**
	(0.029)	(0.091)	(0.023)
a_2klsq	0.097	0.439**	-0.192
	(0.078)	(0.199)	(0.231)
a_3y	0.115***	1.020***	0.010
	(0.039)	(0.350)	(0.011)
a_4ysq	-0.092*	-4.218**	0.060***
	(0.050)	(1.941)	(0.014)
a_5kl*y	-0.003	0.007	0.186***
	(0.029)	(0.132)	(0.016)
a_6tr	-0.058	-1.915*	-0.064
	(0.038)	1.096)	(0.064)
a_7tr*kl	0.028	-0.037	0.139***
	(0.080)	(0.318)	(0.051)
$a_8tr*klsq$	0.230	1.395	-0.680
	(0.355)	(0.947)	(0.719)
a_9tr*y	-0.249**	-1.803	-0.136***
	(0.106)	(1.194)	(0.029)
$a_{10}tr*ysq$	0.041	-8.506	0.314***
	(0.156)	(8.107)	(0.045)
$a_{11}tr*y*kl$	0.018	-0.176	0.261***
	(0.129)	(0.596)	(0.058)
$a_{12}time$	0.012**	0.021	0.003*
	(0.006)	(0.023)	(0.002)
cons	-0.004	-0.193	-0.129***
	(0.007)	(0.260)	(0.019)
$R^{2(}within)$	0.0308	0.1509	0.1736
$R^{2(}between)$	0.0132	0.0741	0.6046
$R^2(overall)$	0.0134	0.0742	0.4511
corr	0.0422	0.1091	0.5914
observations	1659	441	1218
num.of groups	79	21	58

In sum, PI and NPI groups' analysis shows that for a sub-group PI, the coefficients of the interaction terms between trade and capital-labour ratio (*tr*kl*) for all pollutants are statistically insignificant except CO emission. The scenario in NPI is rather mixed. In the case of SO2, NO2 and PM, at a low level capital-labour ratio, there exhibits a positive relationship between trade and pollution, which turns negative at some high level of the capital-labour ratio. For CO the relationship is positive for both a low and a high level of capital-labour ratios. These results show that for industries that are less polluted, trade expansion with more accessibility to capital will be in favour to the environment. The trade expansion will lead to reductions in all the emissions except CO emissions.

6.7 Conclusion

This study has shown several important findings. Firstly, referring to the factor endowment hypothesis, this study finds evidence of negative composition effects in the case of SO2, CO and PM emissions on the basis of pure capital-labour ratio coefficients as shown in Table 6.9a. With trade expansion, this study finds that trade would cause pollution emissions to increase at an increasing rate along with rising capital-labour ratios for SO2 and NO2. Secondly, this industrial level study has found evidence that the pollution effect of trade varies with output (income).The findings show that the effect of an expansion of trade on pollution decreases with output (income).

Thirdly, our further analyses on sub-samples according to sub-periods, product-groups and pollution intensity classifications have provided mixed results. Despite that, the examination gives some insight to enhance our understanding of the trade-environment relationship especially in this industrial level study. Among others, we have seen that in the case of the sub-period analysis, we find that for certain periods the evidence can support or differ from each other. This is also true in the case of product-groups analysis. However, it is worth highlighting that for sub-period 1995-999, the coefficients estimated are mostly significant especially in case of NO2 and PM emissions.

Finally, the results show that the various estimations done in this study in an effort to evaluate the effect of trade on industrial pollution emissions for Malaysia's manufacturing trade during the period of 1985 to 2005 do not provide conclusive evidence to support completely each of the theoretical predictions in this area of study.

Appendix 6.1

Table i. List of dirty industries

	Four Digit ISIC Description	ISIC
1	Sawmills, planning & other wood mills	3311
2	Wooden & cane containers; small cane ware	3312
3	Wood & cork products, n.e.c	3319
4	Pulp, paper & paperboard	3411
5	Paper & paperboard containers & boxes	3412
6	Pulp, paper & paperboard articles	3419
7	Industrial chemicals except fertilizer	3511
8	Fertilizers & pesticides	3512
9	Synthetic resins, plastics materials, & manmade fibres	3513
10	Paints, varnishes, & lacquers	3521
11	Drugs and medicines	3522
12	Soap, cleaning preps., perfumes, & toilet preps.	3523
13	Chemicals products, n.e.c	3529
14	Petroleum refineries	3530
15	Misc. petroleum & coal products	3540
16	Glass and glass products	3620
17	Structural clay products	3691
18	Cement, lime, and plaster	3692
19	Nonmetallic mineral products, n.e.c	3699
20	Iron and steel	3710
21	Nonferrous metals	3720

	Three Digit ISIC Description	ISIC
1	Manufacture of wood products, except furniture	331
2	Manufacture of paper and products	341
3	Manufacture of industrial chemicals	351
4	Manufacture of other chemicals	352
5	Manufacture of petroleum refineries	353
6	Manufacture of miscellaneous petroleum and coal products	354
7	Manufacture of glass and products	362
8	Manufacture of other non-metallic mineral products	369
9	Manufacture of iron and steel	371
10	Manufacture of non-ferrous metals	372

Appendix 6.2

Malaysian Development Plans –Overview

Malaysia is a multi-racial country that has achieved remarkable progress in its economic and social development through a series of five year development plans since independence (1957). The plans are used as a base for development planning, policy formulation and implementation. The details provided below indicate the development plan periods:-

Table ii. Development Plans

Development Plans	Plan Period
1. The First Malaya Plan	1956-1960
2. The Second Malaya Plan	1961-1965
3. The First Malaysia Plan	1966-1970
4. The Second Malaysia Plan	1971-1975
5. The Third Malaysia Plan	1976-1980
6. The Fourth Malaysia Plan	1981-1985
7. The Fifth Malaysia Plan	1986-1990
8. The Sixth Malaysia Plan	1991-1995
9. The Seventh Malaysia Plan	1996-2000
10. The Eighth Malaysia Plan	2001-2005

The country's first five-year plan, 1956-1960, which was implemented on the eve of independence focused on the economic expansion required to absorb the growing labour force and on the provision of basic needs and facilities such as education, health, sanitation, water supply and electricity.

The second five-year plan, 1961-1965, saw the formation of Malaysia with the incorporation of Sabah and Sarawak. Improvement in the rural areas, provision of greater employment opportunities, diversification of agriculture, expansion of industrial activities and the expansion of social facilities were the main objectives of the plan. The country's rapid population growth of 3.1% per annum was a major concern of the government.

The First Malaysia Plan, 1966 – 1970, was also concerned with population issues and focused on providing education and health facilities as well as more employment opportunities.

The Second Malaysia Plan, 1971-1975, saw the formulation of the New Economic Policy (NEP) which for the next 20 years focused on the socio-economic planning of the country. The NEP was a socio-economic policy designed to achieve national unity through the two-pronged objectives of eradicating poverty, irrespective of race and restructuring of society to eliminate the identification of race with economic functions.

The Third, Fourth and Fifth Malaysia Plan which spread over the 1976 – 1990 period advanced the implementation of the NEP.

The Sixth Malaysia Plan (1991 –1995) marked the launching of the National Development Policy (NDP) as the successor to the New Economic Policy (NEP) in achieving the ultimate goal of national unity. The NDP retained the major features of the NEP and incorporated new strategies to increase the effectiveness in bringing about balanced development.

The Seventh Malaysia Plan, 1996 – 2000, presents an important phase for charting new courses and strategies to face future challenges. Amongst the major challenges were to provide sufficient skilled workers and create a more technology-oriented culture to affect the structural transformation towards a productivity-driven economy. The plan aims to accelerate the attainment of the objectives of balanced development as envisaged under the National Development Policy (NDP) with the overriding objective of creating a more united and just society. The plan indicates the need for balanced growth between urban and rural areas and improved housing standards and quality of life for the people.

The Eighth Malaysia Plan, 2001 – 2005, marked the nation's development programme in the new millennium. The Plan continued to implement programmes and projects which will encourage and activate economic activities and improve the quality of life of Malaysians.

Background of IPPS

IPPS allows estimates of industrial pollution to be made from manufacturing activity data. IPPS provides pollution intensity factors, which can be used with the manufacturing data (production output or employment) to estimate pollution or emission load. The pollution intensity factors were developed based on manufacturing activity data from the U.S. Manufacturing Census and emissions data from the U.S. Environmental Protection Agency (EPA).

The US Manufacturing Census maintains a database known as the Longitudinal Research Database (LRD) which contains information from the Census of Manufactures (CM) and the Annual Survey of Manufacturers (ASM). While the CM contains information on all manufacturing establishments in the United States, the ASM seeks further and more detailed information on a subset of those companies. Once an establishment has been selected to be part of the ASM, information is collected from the chosen company once a year, for a period of 5 years. The LRD thus contains detailed information on approximately 200,000 plants.

The EPA maintains a number of databases on pollution emissions. These include the Toxics Release Inventory (TRI), the Aerometric Information Retrieval System (AIRS), the National Pollutant Discharge Elimination System (NDPES), and the Human Health and Ecotoxity database (HHED). All of the data sets have been used in the calculation of pollution intensities. Upon combining the LRD's database with the various EPA databases, it is possible to calculate pollution intensity factors for approximately 20,000 plants. So far, the pollution intensities produced are based on the manufacturing activity for the year 1987. The intensities are based on three economic variables – total output, value added and employment. Any unit of measurement can be used to estimate pollution loads. It has been shown that the ranking of industrial industries is almost identical whether the value of output or employment is used as the unit of measurement (Hettige *et al.*, 1995). The choice of the unit of measurement appears not to impact the ranking of industrial sectors by their pollution load. For the purpose of policy-making, it is the ranking that is of relevance.

Table iiia: Industry at 3-digit ISIC

No	ISIC	Description
1	311	Manufacture of food products
2	313	Manufacture of beverages
3	314	Manufacture of tobacco
4	321	Manufacture of textiles
5	322	Manufacture of wearing apparel, except footwear
6	323	Manufacture of leather products
7	324	Manufacture of footwear, except rubber or plastic
8	331	Manufacture of wood products, except furniture
9	332	Manufacture of furniture, except metal
10	341	Manufacture of paper and products
11	342	Manufacture of printing and publishing
12	351	Manufacture of industrial chemicals
13	352	Manufacture of other chemicals
14	353	Manufacture of petroleum refineries
15	354	Manufacture of miscellaneous petroleum and coal products
16	355	Manufacture of rubber products
17	356	Manufacture of plastic products
18	361	Manufacture of pottery, china, earthenware
19	362	Manufacture of glass and products
20	369	Manufacture of other non-metallic mineral products
21	371	Manufacture of iron and steel
22	372	Manufacture of non-ferrous metals
23	381	Manufacture of fabricated metal products
24	382	Manufacture of machinery, except electrical
25	383	Manufacture of machinery, electric
26	384	Manufacture of transport equipment
27	385	Manufacture of professional and scientific equipment
28	390	Manufacture of other manufactured products

Table iiib: Industry at 4-digit ISIC

No	ISIC	Description
1	3111	Meat products
2	3112	Dairy products
3	3113	Preserved fruits & vegetables
4	3114	Fish products
5	3115	Oils and fats
6	3116	Grain mill products
7	3117	Bakery products
8	3118	Sugar factories & refineries
9	3119	Confectionery products
10	3121	Food products, n.e.c
11	3122	Prepared animal foods
12	3131	Distilled spirits
13	3132	Wine industries
14	3133	Malt liquors and malt
15	3140	Tobacco manufactures
16	3211	Spinning, weaving & finishing textiles
17	3212	Made-up textiles except apparel
18	3213	Knitting mills
19	3214	Carpets and rugs
20	3215	Cordage, rope & twine
21	3219	Textiles, n.e.c
22	3220	Wearing apparel
23	3231	Tanneries and leather finishing
24	3232	Fur dressing and dyeing
25	3233	Leather products
26	3240	Footwear
27	3311	Sawmills, planing & other wood mills
28	3312	Wooden & cane containers; small cane ware
29	3319	Wood & cork products, n.e.c
30	3320	Furniture & fixtures, non-metal
31	3411	Pulp, paper & paperboard
32	3412	Paper & paperboard containers & boxes
33	3419	Pulp, paper & paperboard articles
34	3420	Printing & publishing
35	3511	Industrial chemicals except fertilizer
36	3512	Fertilizers & pesticides
37	3513	Synthetic resins, plastics materials, & manmade fibres
38	3521	Paints, varnishes, & lacquers
39	3522	Drugs and medicines
40	3523	Soap, cleaning preps., perfumes, & toilet preps.
41	3529	Chemicals products, n.e.c
42	3530	Petroleum refineries
43	3540	Misc. petroleum & coal products
44	3551	Tires and tubes
45	3559	Rubber products, n.e.c

46	3560	Plastics products, n.e.c
47	3610	Pottery, china, & earthenware
48	3620	Glass and glass products
49	3691	Structural clay products
50	3692	Cement, lime, and plaster
51	3699	Non-metallic mineral products, n.e.c
52	3710	Iron and steel
53	3720	Nonferrous metals
54	3811	Cutlery, hand tools, & general hardware
55	3812	Furniture & fixtures of metal
56	3813	Structural metal products
57	3819	Fabricated metal products
58	3821	Engines and turbines
59	3822	Agricultural machinery & equipment
60	3823	Metal & wood working machinery
61	3824	Special industrial machinery & equipment
62	3825	Office, computing & accounting machinery
63	3829	Machinery & equipment, n.e.c
64	3831	Electrical industrial machinery
65	3832	Radio, TV, & communication equipment
66	3833	Electrical appliances & housewares
67	3839	Electrical apparatus and supplies, n.e.c
68	3841	Shipbuilding and repairing
69	3842	Railroad equipment
70	3843	Motor vehicles
71	3844	Motorcycles and bicycles
72	3845	Aircraft
73	3851	Professional & scientific equipment
74	3852	Photographic and optical goods
75	3853	Watches and clocks
76	3901	Jewellery and related articles
77	3902	Musical instruments
78	3903	Sporting and athletic goods
79	3909	Manufacturing industries, n.e.c

Table iva: Average of SO2 intensities manufacturing value added

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	2.77	3.86	3.24	2.19	1.96
313	Beverages	4.43	9.68	4.23	2.98	1.43
314	Tobacco	3.89	2.60	3.49	4.65	4.67
321	Textiles	1.92	3.16	2.00	1.07	1.53
322	Wearing apparel, except footwear	0.06	0.09	0.06	0.04	0.04
323	Leather products	2.03	2.71	2.67	1.32	1.51
324	Footwear, except rubber or plastic	0.02	0.03	0.03	0.02	0.02
331	Wood products, except furniture	2.51	3.63	2.68	1.99	1.88
332	Furniture, except metal	0.45	0.74	0.51	0.30	0.29
341	Paper and products	**27.16**	43.31	**29.10**	**19.29**	18.64
342	Printing and publishing	0.03	0.05	0.03	0.02	0.02
351	Industrial chemicals	4.38	5.45	5.05	3.82	3.40
352	Other chemicals	4.04	5.89	4.30	3.37	2.84
353	Petroleum refineries	**24.95**	51.16	**30.43**	**16.11**	5.89
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	3.61	4.55	4.42	2.64	2.98
356	Plastic products	0.10	0.17	0.12	0.07	0.06
361	Pottery, china, earthenware	0.00	0.00	0.00	0.00	0.16
362	Glass and products	3.00	5.40	3.04	1.70	2.03
369	Other non-metallic mineral products	**20.14**	28.68	**21.74**	**16.72**	**14.55**
371	Iron and steel	**22.09**	28.63	**21.74**	**20.40**	**18.34**
372	Non-ferrous metals	**152.07**	**236.16**	**146.45**	**75.51**	150.50
381	Fabricated metal products	0.22	0.35	0.22	0.16	0.15
382	Machinery, except electrical	0.55	0.98	0.60	0.37	0.29
383	Machinery, electric	0.87	1.44	1.02	0.58	0.50
384	Transport equipment	0.43	0.75	0.43	0.33	0.26
385	Professional and scientific equipment	0.03	0.04	0.03	0.02	0.02
390	Other manufactured products	0.12	0.20	0.12	0.08	0.08
	Total Manufacturing	4.61	7.74	4.94	3.39	2.75

Note: SO2 intensities are measured as tonnes per million ringgit Malaysia of value added.

Table ivb: Average of CO intensities manufacturing value added

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	0.76	1.05	0.88	0.60	0.54
313	Beverages	0.23	0.51	0.22	0.16	0.07
314	Tobacco	0.31	0.21	0.28	0.37	0.37
321	Textiles	0.35	0.58	0.37	0.20	0.28
322	Wearing apparel, except footwear	0.01	0.01	0.01	0.00	0.00
323	Leather products	0.15	0.20	0.20	0.10	0.11
324	Footwear, except rubber or plastic	0.00	0.00	0.00	0.00	0.00
331	Wood products, except furniture	12.14	17.53	12.96	**9.61**	**9.08**
332	Furniture, except metal	0.34	0.56	0.39	0.22	0.22
341	Paper and products	**30.79**	**49.10**	**32.99**	**21.87**	**21.13**
342	Printing and publishing	0.15	0.24	0.15	0.11	0.11
351	Industrial chemicals	2.34	2.91	2.70	2.04	1.82
352	Other chemicals	**28.58**	**41.64**	**30.43**	**23.86**	**20.10**
353	Petroleum refineries	**12.96**	**26.58**	**15.81**	8.37	3.06
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	0.15	0.19	0.19	0.11	0.13
356	Plastic products	0.01	0.01	0.01	0.01	0.00
361	Pottery, china, earthenware	0.00	0.00	0.00	0.00	0.00
362	Glass and products	1.61	2.90	1.63	0.91	1.09
369	Other non-metallic mineral products	2.12	3.01	2.28	1.76	1.53
371	Iron and steel	**34.42**	**44.61**	**33.88**	**31.79**	**28.57**
372	Non-ferrous metals	**70.74**	**109.86**	**68.12**	**35.13**	**70.01**
381	Fabricated metal products	1.46	2.34	1.47	1.07	1.03
382	Machinery, except electrical	0.59	1.06	0.65	0.40	0.31
383	Machinery, electric	0.48	0.79	0.56	0.32	0.28
384	Transport equipment	0.30	0.53	0.30	0.23	0.18
385	Professional and scientific equipment	0.00	0.01	0.01	0.00	0.00
390	Other manufactured products	0.03	0.05	0.03	0.02	0.02
	Total Manufacturing	4.03	6.54	4.38	2.87	2.61

Note: CO intensities are measured as tonnes per million ringgit Malaysia of value added.

Table ivc: Average of NO2 intensities manufacturing value added

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	2.78	3.87	3.25	2.20	1.97
313	Beverages	2.82	6.17	2.69	1.90	0.91
314	Tobacco	2.36	1.58	2.11	2.81	2.83
321	Textiles	2.53	4.15	2.63	1.41	2.01
322	Wearing apparel, except footwear	0.02	0.03	0.02	0.02	0.02
323	Leather products	0.51	0.68	0.67	0.33	0.38
324	Footwear, except rubber or plastic	0.00	0.00	0.00	0.00	0.00
331	Wood products, except furniture	4.85	7.01	5.18	3.84	3.63
332	Furniture, except metal	0.32	0.53	0.36	0.21	0.21
341	Paper and products	**14.95**	**23.85**	**16.02**	**10.62**	**10.26**
342	Printing and publishing	0.04	0.06	0.04	0.03	0.03
351	Industrial chemicals	4.84	6.02	5.58	**4.22**	3.75
352	Other chemicals	1.57	2.28	1.67	1.31	1.10
353	Petroleum refineries	**14.35**	**29.43**	**17.50**	**9.27**	3.39
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	1.25	1.57	1.53	0.91	1.03
356	Plastic products	0.02	0.04	0.03	0.02	0.01
361	Pottery, china, earthenware	0.00	0.00	0.00	0.00	0.00
362	Glass and products	**5.96**	**10.75**	**6.05**	3.38	**4.05**
369	Other non-metallic mineral products	**11.39**	**16.21**	**12.29**	**9.45**	**8.22**
371	Iron and steel	**9.59**	**12.44**	**9.44**	**8.86**	**7.96**
372	Non-ferrous metals	4.95	7.69	4.77	2.46	**4.90**
381	Fabricated metal products	0.73	1.18	0.74	0.54	0.52
382	Machinery, except electrical	0.25	0.44	0.27	0.17	0.13
383	Machinery, electric	0.43	0.71	0.50	0.28	0.25
384	Transport equipment	0.22	0.39	0.22	0.17	0.13
385	Professional and scientific equipment	0.05	0.07	0.05	0.03	0.03
390	Other manufactured products	0.08	0.14	0.09	0.06	0.05
	Total Manufacturing	2.85	4.86	3.06	1.96	1.72

Note: NO2 intensities are measured as tonnes per million ringgit Malaysia of value added.

Table ivd: Average of PM intensities manufacturing value added

ISIC	Industry	85-05	85-89	90-94	95-99	00-05
311	Food products	**1.30**	**1.81**	**1.52**	**1.03**	**0.92**
313	Beverages	0.06	0.14	0.06	0.04	0.02
314	Tobacco	0.03	0.02	0.03	0.04	0.04
321	Textiles	0.05	0.08	0.05	0.03	0.04
322	Wearing apparel, except footwear	0.00	0.00	0.00	0.00	0.00
323	Leather products	0.05	0.07	0.07	0.03	0.04
324	Footwear, except rubber or plastic	0.00	0.00	0.00	0.00	0.00
331	Wood products, except furniture	0.48	0.69	0.51	0.38	0.36
332	Furniture, except metal	0.30	0.49	0.34	0.20	0.19
341	Paper and products	**1.52**	**2.43**	**1.63**	**1.08**	**1.05**
342	Printing and publishing	0.00	0.00	0.00	0.00	0.00
351	Industrial chemicals	0.12	0.15	0.14	0.11	0.09
352	Other chemicals	0.82	1.19	0.87	0.68	0.57
353	Petroleum refineries	0.25	0.52	0.31	0.16	0.06
354	Miscellaneous petroleum and coal products	0.00	0.00	0.00	0.00	0.00
355	Rubber products	0.05	0.07	0.06	0.04	0.04
356	Plastic products	0.02	0.04	0.02	0.02	0.01
361	Pottery, china, earthenware	0.00	0.00	0.00	0.00	0.00
362	Glass and products	0.13	0.23	0.13	0.07	0.09
369	Other non-metallic mineral products	**16.26**	**23.15**	**17.54**	**13.50**	**11.74**
371	Iron and steel	**6.10**	**7.91**	**6.01**	**5.64**	**5.07**
372	Non-ferrous metals	**1.40**	**2.17**	**1.35**	**0.69**	**1.38**
381	Fabricated metal products	0.01	0.02	0.01	0.01	0.01
382	Machinery, except electrical	0.00	0.00	0.00	0.00	0.00
383	Machinery, electric	0.01	0.01	0.01	0.00	0.00
384	Transport equipment	0.03	0.06	0.03	0.03	0.02
385	Professional and scientific equipment	0.00	0.00	0.00	0.00	0.00
390	Other manufactured products	0.02	0.04	0.02	0.02	0.02
	Total Manufacturing	1.14	2.04	1.28	0.77	0.57

Note: PM intensities are measured as tonnes per million ringgit Malaysia of value added.

Table 6.9b: The determinants of industrial pollution emissions (random effects model)

Variable	SO2	CO	NO2	PM
a_1y	0.577***	0.272***	0.275***	0.227***
	(0.060)	(0.025)	(0.028)	(0.043)
a_2ysq	-0.134***	-0.044***	-0.056***	-0.055***
	(0.019)	(0.008)	(0.009)	(0.014)
cons	0.183	0.088**	0.105**	0.106
	(0.117)	(0.037)	(0.055)	(0.096)
R^2*(within)*	0.0607	0.1138	0.0745	0.0170
R^2*(between)*	0.0715	0.1344	0.0703	0.0289
R^2*(overall)*	0.0605	0.1193	0.0618	0.0231
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79
turn. point(US$)	8,612	12,364	9,821	8,255

Table 6.10b: The determinants of industrial pollution emissions (random effects model)

Variable	SO2	CO	NO2	PM
a_1y	0.529***	0.239***	0.248***	0.256***
	(0.063)	(0.026)	(0.029)	(0.047)
a_2ysq	-0.121***	-0.033***	-0.048***	-0.060***
	(0.019)	(0.008)	(0.009)	(0.014)
a_3kl	0.011***	0.010	0.007***	-0.006*
	(0.004)	(0.002)	(0.002)	(0.003)
a_4klsq	-0.0001*	0.0001**	-0.00007***	0.00003
	(0.00005)	(0.00002)	(0.00002)	(0.00004)
a_5tr	-0.0035	-0.0015	0.0006	-0.0004
	(0.0026)	(0.001)	(0.001)	(0.002)
a_6trkl	0.0016	0.001	0.0008	0.001
	(0.002)	(0.0009)	(0.001)	(0.002)
cons	0.162	0.067*	0.091*	0.116
	(0.114)	(0.033)	(0.052)	(0.095)
R^2*(within)*	0.0662	0.1320	0.0809	0.0203
R^2*(between)*	0.1041	0.2268	0.1237	0.0112
R^2*(overall)*	0.0880	0.1971	0.1055	0.0102
corr	0	0	0	0
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79
turn. point(US$)	8,744	14,485	10,333	8,533

Table 6.11b: The determinants of industrial pollution emissions (random effects model)

Variable	SO_2	CO	NO_2	PM
$\alpha_1 kl$	0.014	0.083**	0.051*	-0.056*
	(0.030)	(0.038)	(0.030)	(0.029)
$\alpha_2 klsq$	0.161**	0.133	0.029	0.091
	(0.082)	(0.102)	(0.081)	(0.078)
$\alpha_3 y$	0.202***	0.421***	0.224***	0.117***
	(0.041)	(0.051)	(0.041)	(0.039)
$\alpha_4 ysq$	-0.138***	-0.310***	-0.119**	-0.094*
	(0.053)	(0.066)	(0.052)	(0.050)
$\alpha_5 kl*y$	0.056*	0.043	0.119***	-0.003
	(0.031)	(0.039)	(0.031)	(0.029)
$\alpha_6 tr$	-0.058	-0.130***	-0.114***	-0.061
	(0.040)	(0.050)	(0.039)	(0.038)
$\alpha_7 tr*kl$	0.068	0.116	0.158*	0.030
	(0.084)	(0.105)	(0.084)	(0.080)
$\alpha_8 tr*klsq$	0.774**	0.565	0.178	0.205
	(0.375)	(0.470)	(0.372)	(0.355)
$\alpha_9 tr*y$	-0.335***	-0.234*	-0.293***	-0.252**
	(0.112)	(0.139)	(0.111)	(0.106)
$\alpha_{10} tr*ysq$	0.070	-0.571***	0.040	0.041
	(0.165)	(0.206)	(0.163)	(0.156)
$\alpha_{11} tr*y*kl$	0.243*	0.275	0.537***	0.019
	(0.136)	(0.170)	(0.135)	(0.129)
$\alpha_{12} time$	0.007	-0.004	0.005	0.012**
	(0.006)	(0.008)	(0.006)	(0.006)
cons	-0.001	-0.007	-0.011	-0.004
	(0.103)	(0.081)	(0.101)	(0.109)
R^2(within)	0.0892	0.2001	0.1191	0.0307
R^2(between)	0.0799	0.2033	0.0948	0.0146
R^2(overall)	0.0758	0.1993	0.0921	0.0146
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	1659	1659	1659
numb. of groups	79	79	79	79

6.12b. SO_2 by period (RE)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$a_1 kl$	0.014	-0.030	0.083	-0.536***	-0.038
	(0.030)	(0.073)	(0.118)	(0.132)	(0.030)
$a_2 klsq$	0.161**	0.339	0.076	0.575	0.202***
	(0.082)	(0.250)	(0.429)	(0.379)	(0.056)
$a_3 y$	0.202***	0.389***	0.299***	0.790***	0.335***
	(0.041)	(0.128)	(0.102)	(0.156)	(0.070)
$a_4 ysq$	-0.138***	-1.132***	-0.253*	-0.497***	-0.241***
	(0.053)	(0.429)	(0.130)	(0.172)	(0.055)
$a_5 kl*y$	0.056*	0.077	0.192	-0.056	-0.017
	(0.031)	(0.086)	(0.212)	(0.119)	(0.028)
$a_6 tr$	-0.058	-0.127	-0.273	0.032	-0.220***
	(0.040)	(0.164)	(0.167)	(0.175)	(0.069)
$a_7 tr*kl$	0.068	-0.092	0.456	-0.135	-0.021
	(0.084)	(0.279)	(0.485)	(0.337)	(0.086)
$a_8 tr*klsq$	0.774**	1.462	-0.682	1.646	-0.063
	(0.375)	(1.279)	(1.977)	(1.849)	(0.258)
$a_9 tr*y$	-0.335***	0.184	-0.429*	-0.218	0.213
	(0.112)	(0.333)	(0.257)	(0.282)	(0.184)
$a_{10} tr*ysq$	0.070	-1.959	0.145	-0.643	-0.324**
	(0.165)	(1.334)	(0.379)	(0.523)	(0.161)
$a_{11} tr*y*kl$	0.243*	0.081	1.333	-0.594	0.243**
	(0.136)	(0.490)	(0.886)	(0.489)	(0.116)
$a_{12} time$	0.007	-0.038**	0.016	-0.007	-0.031**
	(0.006)	(0.017)	(0.021)	(0.041)	(0.015)
cons	-0.001	-0.159*	-0.021	0.022	0.044
	(0.103)	(0.091)	(0.100)	(0.144)	(0.111)
R^2(within)	0.0892	0.1057	0.1839	0.2515	0.4352
R^2(between)	0.0799	0.0853	0.0541	0.0017	0.0201
R^2(overall)	0.0758	0.0817	0.0552	0.0025	0.0240
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

6.13b. CO by period (RE)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
a_1kl	0.083**	-0.075	-0.093	-0.218***	0.021
	(0.038)	(0.076)	(0.154)	(0.085)	(0.065)
a_2klsq	0.133	0.657**	0.920	-0.681***	0.197
	(0.102)	(0.259)	(0.565)	(0.241)	(0.121)
a_3y	0.421***	0.562***	0.720***	0.501***	0.739***
	(0.051)	(0.131)	(0.127)	(0.104)	(0.124)
a_4ysq	-0.310***	-1.498***	-0.686***	-0.324***	-0.608***
	(0.066)	(0.441)	(0.164)	(0.110)	(0.113)
a_5kl*y	0.043	0.068	-0.262	-0.031	-0.121**
	(0.039)	(0.089)	(0.277)	(0.077)	(0.059)
a_6tr	-0.130***	-0.347**	-0.286	-0.604***	-0.550***
	(0.050)	(0.169)	(0.216)	(0.111)	(0.125)
a_7tr*kl	0.116	-0.162	0.019	0.282	-0.104
	(0.105)	(0.288)	(0.635)	(0.214)	(0.189)
$a_8tr*klsq$	0.565	2.267*	1.523	-5.310***	-0.581
	(0.470)	(1.324)	(2.608)	(1.170)	(0.569)
a_9tr*y	-0.234*	0.523	-0.437	0.035	-0.309
	(0.139)	(0.343)	(0.331)	(0.179)	(0.340)
$a_{10}tr*ysq$	-0.571***	-4.532***	-0.988**	-0.615*	-0.691**
	(0.206)	(1.376)	(0.487)	(0.332)	(0.343)
$a_{11}tr*y*kl$	0.275	0.062	0.626	0.262	0.021
	(0.170)	(0.506)	(1.158)	(0.315)	(0.250)
$a_{12}time$	-0.004	-0.007	-0.006	-0.016	-0.070**
	(0.008)	(0.018)	(0.028)	(0.026)	(0.033)
cons	-0.007	-0.152**	0.050	-0.034	0.023
	(0.081)	(0.081)	(0.088)	(0.106)	(0.115)
R^2(within)	0.2001	0.2492	0.3760	0.3876	0.2958
R^2(between)	0.2033	0.1478	0.1395	0.0495	0.1663
R^2(overall)	0.1993	0.1446	0.1434	0.0531	0.1703
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

6.14b. NO2 by period (RE)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$a_1 kl$	0.051*	-0.022	-0.165*	-0.601***	-0.009
	(0.030)	(0.078)	(0.099)	(0.127)	(0.031)
$a_2 klsq$	0.029	0.403	0.941***	1.501***	0.045
	(0.081)	(0.265)	(0.361)	(0.365)	(0.057)
$a_3 y$	0.224***	0.408***	0.265***	0.853***	0.322***
	(0.041)	(0.135)	(0.087)	(0.151)	(0.070)
$a_4 ysq$	-0.119**	-1.119**	-0.291***	-0.553***	-0.226***
	(0.052)	(0.454)	(0.110)	(0.166)	(0.055)
$a_5 kl*y$	0.119***	0.087	-0.226	-0.201*	0.022
	(0.031)	(0.091)	(0.178)	(0.115)	(0.028)
$a_6 tr$	-0.114***	-0.184	0.076	0.503***	-0.062
	(0.039)	(0.173)	(0.141)	(0.168)	(0.069)
$a_7 tr*kl$	0.158*	-0.014	-0.378	-0.434	0.190**
	(0.084)	(0.295)	(0.408)	(0.324)	(0.088)
$a_8 tr*klsq$	0.178	1.397	2.778*	6.162***	-0.912***
	(0.372)	(1.356)	(1.661)	(1.779)	(0.262)
$a_9 tr*y$	-0.293***	0.164	-0.306	-0.209	0.185
	(0.111)	(0.353)	(0.217)	(0.271)	(0.186)
$a_{10} tr*ysq$	0.040	-2.180	-0.378	-0.774	-0.347**
	(0.163)	(1.413)	(0.321)	(0.504)	(0.163)
$a_{11} tr*y*kl$	0.537***	0.291	-0.670	-1.277***	0.463***
	(0.135)	(0.519)	(0.746)	(0.471)	(0.118)
$a_{12} time$	0.005	-0.029	0.017	-0.015	-0.033**
	(0.006)	(0.018)	(0.018)	(0.039)	(0.015)
cons	-0.011	-0.145	0.048	0.101	0.057
	(0.101)	(0.093)	(0.101)	(0.142)	(0.108)
R^2*(within)*	0.1191	0.1287	0.2898	0.2352	0.2890
R^2*(between)*	0.0948	0.0960	0.0545	0.0059	0.0058
R^2*(overall)*	0.0921	0.0926	0.0557	0.0068	0.0074
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

6.15b. PM by period (RE)

Variable	1985-2005	1985-1989	1990-1994	1995-1999	2000-2005
$\alpha_1 kl$	-0.056*	-0.032	-0.055	-0.662***	0.001
	(0.029)	(0.073)	(0.099)	(0.130)	(0.019)
$\alpha_2 klsq$	0.091	0.090	0.144	1.735***	0.001
	(0.078)	(0.250)	(0.361)	(0.373)	(0.036)
$\alpha_3 y$	0.117***	0.249**	0.143	0.783***	0.047
	(0.039)	(0.128)	(0.087)	(0.156)	(0.047)
$\alpha_4 ysq$	-0.094*	-0.753*	-0.148	-0.506***	-0.032
	(0.050)	(0.430)	(0.110)	(0.170)	(0.035)
$\alpha_5 kl*y$	-0.003	-0.021	0.015	-0.145	-0.014
	(0.029)	(0.086)	(0.178)	(0.118)	(0.018)
$\alpha_6 tr$	-0.061	-0.119	-0.055	0.670***	-0.014
	(0.038)	(0.164)	(0.141)	(0.172)	(0.046)
$\alpha_7 tr*kl$	0.030	-0.151	-0.025	-0.507	-0.019
	(0.080)	(0.279)	(0.408)	, (0.331)	(0.055)
$\alpha_8 tr*klsq$	0.205	0.684	0.546	7.864***	-0.037
	(0.355)	(1.278)	(1.659)	(1.817)	(0.164)
$\alpha_9 tr*y$	-0.252**	-0.020	-0.331	-0.228	-0.019
	(0.106)	(0.333)	(0.217)	(0.277)	(0.123)
$\alpha_{10} tr*ysq$	0.041	-1.041	0.074	-0.657	-0.032
	(0.156)	(1.334)	(0.321)	(0.515)	(0.103)
$\alpha_{11} tr*y*kl$	0.019	-0.241	-0.094	-1.249***	-0.044
	(0.129)	(0.489)	(0.745)	(0.483)	(0.075)
$\alpha_{12} time$	0.012**	-0.039	0.020	-0.005	-0.008
	(0.006)	(0.017)	(0.018)	(0.040)	(0.010)
cons	-0.004	-0.133	-0.011	0.103	0.015
	(0.109)	(0.094)	(0.104)	(0.148)	(0.115)
R^2*(within)*	0.0307	0.0232	0.0375	0.2178	0.0064
R^2*(between)*	0.0146	0.0321	0.0155	0.0025	0.0236
R^2*(overall)*	0.0146	0.0311	0.0156	0.0032	0.0233
corr	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	395	395	395	474
num.of groups	79	79	79	79	79

6.16b.SO2 for sub-group (RE)

Variable	Overall	FBT	TWA	CPH	EES
$a_1 kl$	0.014	-0.182	0.400***	0.041	0.079***
	(0.030)	(0.389)	(0.084)	(0.069)	(0.012)
$a_2 klsq$	0.161**	4.908*	-1.890***	0.725***	-0.866***
	(0.082)	(2.526)	(0.458)	(0.256)	(0.148)
$a_3 y$	0.202***	3.108***	0.361***	-0.350**	0.017***
	(0.041)	(0.164)	(0.076)	(0.145)	(0.003)
$a_4 ysq$	-0.138***	-8.434***	-1.246	2.411***	-0.016***
	(0.053)	(0.451)	(0.830)	(0.866)	(0.004)
$a_5 kl*y$	0.056*	2.188***	0.791***	-0.149*	-0.028***
	(0.031)	(0.317)	(0.189)	(0.082)	(0.005)
$a_6 tr$	-0.058	-2.974***	-0.498	0.802	0.049*
	(0.040)	(0.763)	(0.693)	(0.564)	(0.028)
$a_7 tr*kl$	0.068	0.199	1.418***	-0.663**	-0.018
	(0.084)	(1.588)	(0.394)	(0.322)	(0.016)
$a_8 tr*klsq$	0.774**	15.859*	-6.255***	3.123**	0.633**
	(0.375)	(9.135)	(1.956)	(1.363)	(0.299)
$a_9 tr*y$	-0.335***	10.848***	0.513	-0.581	-0.011
	(0.112)	(0.959)	(0.353)	(0.554)	(0.007)
$a_{10} tr*ysq$	0.070	-45.529***	-0.734	4.702	-0.054***
	(0.165)	2.920)	(4.841)	(3.949)	(0.012)
$a_{11} tr*y*kl$	0.243*	9.643***	2.873***	-0.308	0.007
	(0.136)	(2.135)	(0.881)	(0.450)	(0.016)
$a_{12} time$	0.007	-0.009*	-0.002**	-0.049**	-0.0004
	(0.006)	(0.005)	(0.001)	(0.014)	(0.001)
cons	-0.001	-0.300	-0.457***	0.187	-0.279***
	(0.103)	(0.194)	(0.117)	(0.118)	(0.012)
$R^{2(}within)$	0.0892	0.7284	0.2168	0.4110	0.5542
$R^{2(}between)$	0.0799	0.9966	0.9202	0.9388	0.7991
$R^2(overall)$	0.0758	0.9847	0.8098	0.8055	0.7380
corr	0 (assumed)	0 (assumed)	0 (assumed)	0	0 (assumed)
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

6.17b.CO for sub-group (RE)

Variable	Overall	FBT	TWA	CPH	EES
$a_1 kl$	0.083**	-0.012	0.237***	0.629*	-0.122
	(0.038)	(0.096)	(0.048)	(0.360)	(0.103)
$a_2 klsq$	0.133	1.058*	-1.123***	-1.143	0.958
	(0.102)	(0.618)	(0.261)	(1.337)	(1.251)
$a_3 y$	0.421***	0.206**	0.209***	-2.953***	0.211***
	(0.051)	(0.086)	(0.044)	(0.758)	(0.021)
$a_4 ysq$	-0.310***	-1.114***	-0.701	12.208***	-0.149***
	(0.066)	(0.170)	(0.473)	(4.512)	(0.030)
$a_5 kl*y$	0.043	0.379***	0.466***	-0.136	-0.289***
	(0.039)	(0.084)	(0.108)	(0.429)	(0.041)
$a_6 tr$	-0.130***	-0.688***	-0.362	3.172	0.460*
	(0.050)	(0.188)	(0.395)	(2.937)	(0.238)
$a_7 tr*kl$	0.116	0.122	0.865***	-0.392	0.123
	(0.105)	(0.392)	(0.225)	(1.680)	(0.139)
$a_8 tr*klsq$	0.565	3.341	-3.874***	-5.050	5.563**
	(0.470)	(2.236)	(1.116)	(7.105)	(2.557)
$a_9 tr*y$	-0.234*	0.255	0.352*	-7.176**	-0.164***
	(0.139)	(0.394)	(0.202)	(2.888)	(0.059)
$a_{10} tr*ysq$	-0.571***	-6.262***	-0.859	39.261*	-0.616***
	(0.206)	0.959)	(2.762)	(20.581)	(0.098)
$a_{11} tr*y*kl$	0.275	1.568***	1.753***	0.296	0.286**
	(0.170)	(0.556)	(0.502)	(2.347)	(0.132)
$a_{12} time$	-0.004	-0.003**	-0.001**	0.042	-0.027***
	(0.008)	(0.001)	(0.001)	(0.073)	(0.006)
cons	-0.007	-0.343***	-0.467***	1.206**	-0.191*
	(0.081)	(0.051)	(0.067)	(0.616)	(0.104)
R^2*(within)*	0.2001	0.7518	0.2102	0.2154	0.7469
R^2*(between)*	0.2033	0.9388	0.9185	0.4291	0.9437
R^2*(overall)*	0.1993	0.9056	0.8045	0.3366	0.8894
corr	0 (assumed)	0 (assumed)	0 (assumed)	0	0 (assumed)
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

6.18b.NO2 for sub-group (RE)

Variable	Overall	FBT	TWA	CPH	EES
a_1kl	0.051*	-0.016	1.173***	0.220***	-0.023
	(0.030)	(0.298)	(0.254)	(0.077)	(0.035)
a_2klsq	0.029	3.159	-5.456***	0.582**	0.055
	(0.081)	(1.923)	(1.384)	(0.286)	(0.423)
a_3y	0.224***	1.729***	1.085***	-0.147	0.079***
	(0.041)	(0.185)	(0.231)	(0.162)	(0.007)
a_4ysq	-0.119**	-5.331***	-4.009	1.337	-0.058***
	(0.052)	(0.413)	(2.505)	(0.964)	(0.010)
a_5kl*y	0.119***	1.556***	2.341***	-0.039	-0.102***
	(0.031)	(0.249)	(0.569)	(0.092)	(0.014)
a_6tr	-0.114***	-2.253***	-1.656	0.495	0.182**
	(0.039)	(0.585)	(2.091)	(0.628)	(0.081)
a_7tr*kl	0.158*	0.604	4.160***	-0.270	0.010
	(0.084)	(1.218)	(1.191)	(0.359)	(0.047)
$a_8tr*klsq$	0.178	9.969	-17.957***	3.033**	2.259***
	(0.372)	(6.958)	(5.907)	(1.519)	(0.871)
a_9tr*y	-0.293***	5.144***	1.602	0.006	-0.063***
	(0.111)	(0.973)	(1.067)	(0.617)	(0.020)
$a_{10}tr*ysq$	0.040	-28.631***	-3.816	1.514	-0.219***
	(0.163)	2.543)	(14.616)	(4.399)	(0.033)
$a_{11}tr*y*kl$	0.537***	6.836***	8.466***	0.016	0.078*
	(0.135)	(1.667)	(2.659)	(0.502)	(0.045)
$a_{12}time$	0.005	-0.008**	-0.006**	-0.055**	-0.010***
	(0.006)	(0.004)	(0.003)	(0.016)	(0.002)
cons	-0.011	-0.311**	-0.994***	0.048	-0.236***
	(0.101)	(0.150)	(0.354)	(0.132)	(0.035)
R^2(within)	0.1191	0.7444	0.2127	0.4776	0.7499
R^2(between)	0.0948	0.9879	0.9172	0.9656	0.9460
R^2(overall)	0.0921	0.9752	0.8033	0.8580	0.8959
corr	0 (assumed)	0 (assumed)	0 (assumed)	0	0 (assumed)
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

6.19b. PM for sub-group (RE)

Variable	Overall	FBT	TWA	CPH	EES
$a_1 kl$	-0.056*	-0.464	0.013***	0.012***	-0.002***
	(0.029)	(0.300)	(0.003)	(0.004)	(0.0005)
$a_2 klsq$	0.091	5.372***	-0.065***	-0.039***	0.012**
	(0.078)	(1.962)	(0.015)	(0.014)	(0.006)
$a_3 y$	0.117***	2.845***	0.012***	-0.029***	0.0004***
	(0.039)	(0.097)	(0.002)	(0.008)	(0.0001)
$a_4 ysq$	-0.094*	-7.355***	-0.045*	0.131***	-0.0002
	(0.050)	(0.326)	(0.027)	(0.046)	(0.0001)
$a_5 kl*y$	-0.003	1.776***	0.026***	0.006	-0.001***
	(0.029)	(0.242)	(0.006)	(0.004)	(0.0002)
$a_6 tr$	-0.061	-2.152***	-0.009	0.033	0.002**
	(0.038)	(0.590)	(0.022)	(0.030)	(0.001)
$a_7 tr*kl$	0.030	-1.110	0.046***	0.016	0.001
	(0.080)	(1.219)	(0.013)	(0.017)	(0.001)
$a_8 tr*klsq$	0.205	18.270***	-0.205***	-0.170**	0.025**
	(0.355)	(7.074)	(0.063)	(0.072)	(0.011)
$a_9 tr*y$	-0.252**	10.819***	0.013	-0.076**	-0.001**
	(0.106)	(0.560)	(0.011)	(0.029)	(0.0003)
$a_{10} tr*ysq$	0.041	-40.192***	0.028	0.476**	-0.001*
	(0.156)	(2.113)	(0.156)	(0.209)	(0.0005)
$a_{11} tr*y*kl$	0.019	7.718***	0.092***	0.036	0.002***
	(0.129)	(1.624)	(0.028)	(0.024)	(0.001)
$a_{12} time$	0.012**	-0.002	-0.0001**	0.001	0.0001***
	(0.006)	(0.004)	(0.00003)	(0.001)	(0.00003)
cons	-0.004	-0.163	-0.157***	-0.132***	-0.147***
	(0.109)	(0.150)	(0.004)	(0.006)	(0.001)
R^2*(within)*	0.0307	0.7141	0.2401	0.1684	0.4647
R^2*(between)*	0.0146	0.9987	0.9323	0.5028	0.4702
R^2*(overall)*	0.0146	0.9863	0.8289	0.3866	0.4575
corr	0 (assumed)	0 (assumed)	0 (assumed)	0	0 (assumed)
observations	1659	315	231	252	462
num. of groups	79	15	11	12	22

6.20b. SO2 for overall, dirty and non-dirty (RE)

Variable	Overall	Dirty	Non-Dirty
$a_1 kl$	0.014	-0.232***	0.111***
	(0.030)	(0.091)	(0.035)
$a_2 klsq$	0.161**	0.444**	-0.310
	(0.082)	(0.200)	(0.359)
$a_3 y$	0.202***	1.462***	0.071***
	(0.041)	(0.348)	(0.016)
$a_4 ysq$	-0.138***	-3.963**	0.040*
	(0.053)	(1.950)	(0.022)
$a_5 kl*y$	0.056*	-0.030	0.267***
	(0.031)	(0.132)	(0.024)
$a_6 tr$	-0.058	-2.299**	-0.053
	(0.040)	(1.103)	(0.099)
$a_7 tr*kl$	0.068	0.485	0.218***
	(0.084)	(0.319)	(0.080)
$a_8 tr*klsq$	0.774**	0.114	-0.575
	(0.375)	(0.951)	(1.119)
$a_9 tr*y$	-0.335***	-1.190	-0.178***
	(0.112)	(1.190)	(0.043)
$a_{10} tr*ysq$	0.070	-11.375	0.363***
	(0.165)	(8.155)	(0.069)
$a_{11} tr*y*kl$	0.243*	0.236	0.410***
	(0.136)	(0.598)	(0.090)
$a_{12} time$	0.007	-0.004	-0.001
	(0.006)	(0.023)	(0.003)
cons	-0.001	0.025	-0.182***
	(0.103)	(0.385)	(0.033)
R^2(within)	0.0892	0.2828	0.1736
R^2(between)	0.0799	0.0879	0.5528
R^2(overall)	0.0758	0.0979	0.4626
corr	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	441	1218
num.of groups	79	21	58

6.21b. CO for overall, dirty and non-dirty (RE)

Variable	Overall	Dirty	Non-Dirty
$\alpha_1 kl$	0.083**	-0.495***	-0.080**
	(0.038)	(0.094)	(0.032)
$\alpha_2 klsq$	0.133	0.863***	1.038***
	(0.102)	(0.207)	(0.331)
$\alpha_3 y$	0.421***	2.406***	0.180***
	(0.051)	(0.359)	(0.013)
$\alpha_4 ysq$	-0.310***	-0.284	-0.084***
	(0.066)	(2.025)	(0.019)
$\alpha_5 kl*y$	0.043	-0.484***	-0.143***
	(0.039)	(0.137)	(0.022)
$\alpha_6 tr$	-0.130***	-1.305	0.121
	(0.050)	(1.145)	(0.092)
$\alpha_7 tr*kl$	0.116	0.676**	0.246***
	(0.105)	(0.330)	(0.074)
$\alpha_8 tr*klsq$	0.565	-2.286**	1.983*
	(0.470)	(0.986)	(1.044)
$\alpha_9 tr*y$	-0.234*	1.148	-0.137***
	(0.139)	(1.228)	(0.037)
$\alpha_{10} tr*ysq$	-0.571***	-9.482	-0.445***
	(0.206)	(8.471)	(0.061)
$\alpha_{11} tr*y*kl$	0.275	0.038	0.467***
	(0.170)	(0.620)	(0.083)
$\alpha_{12} time$	-0.004	-0.028	-0.015***
	(0.008)	(0.023)	(0.003)
cons	-0.007	1.101***	-0.184***
	(0.081)	(0.351)	(0.028)
R^2(within)	0.2001	0.5417	0.7031
R^2(between)	0.2033	0.3526	0.9132
R^2(overall)	0.1993	0.3637	0.8563
corr	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	441	1218
num.of groups	79	21	58

6.22b. NO for overall, dirty and non-dirty (RE)

Variable	Overall	Dirty	Non-Dirty
$a_1 kl$	0.051*	-0.250***	0.063**
	(0.030)	(0.091)	(0.029)
$a_2 klsq$	0.029	0.450**	0.055
	(0.081)	(0.202)	(0.299)
$a_3 y$	0.224***	1.550***	0.090***
	(0.041)	(0.351)	(0.013)
$a_4 ysq$	-0.119**	-3.826*	0.015
	(0.052)	(1.969)	(0.018)
$a_5 kl*y$	0.119***	0.058	0.155***
	(0.031)	(0.133)	(0.020)
$a_6 tr$	-0.114***	-2.040*	0.007
	(0.039)	(1.113)	(0.083)
$a_7 tr*kl$	0.158*	0.209	0.220***
	(0.084)	(0.322)	(0.066)
$a_8 tr*klsq$	0.178	0.360	0.203
	(0.372)	(0.960)	(0.933)
$a_9 tr*y$	-0.293***	-1.339	-0.151***
	(0.111)	(1.200)	(0.036)
$a_{10} tr*ysq$	0.040	-9.644	0.153***
	(0.163)	(8.235)	(0.057)
$a_{11} tr*y*kl$	0.537***	0.557	0.441***
	(0.135)	(0.603)	(0.075)
$a_{12} time$	0.005	-0.007	-0.004*
	(0.006)	(0.023)	(0.002)
cons	-0.011	0.119	-0.185***
	(0.101)	(0.375)	(0.027)
R^2(within)	0.1191	0.2949	0.3308
R^2(between)	0.0948	0.1015	0.5230
R^2(overall)	0.0921	0.1119	0.4784
corr	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	441	1218
num.of groups	79	21	58

6.23b. PM for overall, dirty and non-dirty (RE)

Variable	Overall	Dirty	Non-Dirty
$\alpha_1 kl$	-0.056*	-0.277***	0.082***
	(0.029)	(0.092)	(0.028)
$\alpha_2 klsq$	0.091	0.438**	-0.257
	(0.078)	(0.203)	(0.284)
$\alpha_3 y$	0.117***	1.004***	0.044***
	(0.039)	(0.354)	(0.012)
$\alpha_4 ysq$	-0.094*	-4.144**	0.042**
	(0.050)	(1.981)	(0.017)
$\alpha_5 kl*y$	-0.003	0.003	0.230***
	(0.029)	(0.134)	(0.019)
$\alpha_6 tr$	-0.061	-1.868*	-0.058
	(0.038)	(1.120)	(0.079)
$\alpha_7 tr*kl$	0.030	-0.050	0.170***
	(0.080)	(0.324)	(0.063)
$\alpha_8 tr*klsq$	0.205	1.434	-0.673
	(0.355)	(0.966)	(0.886)
$\alpha_9 tr*y$	-0.252**	-1.978	-0.139***
	(0.106)	(1.208)	(0.034)
$\alpha_{10} tr*ysq$	0.041	-7.827	0.327***
	(0.156)	(8.283)	(0.055)
$\alpha_{11} tr*y*kl$	0.019	-0.212	0.312***
	(0.129)	(0.607)	(0.071)
$\alpha_{12} time$	0.012**	0.021	0.000
	(0.006)	(0.023)	(0.002)
cons	-0.004	-0.191	-0.130***
	(0.109)	(0.388)	(0.026)
$R^{2(}within)$	0.0307	0.1508	0.1678
$R^{2(}between)$	0.0146	0.0765	0.6213
$R^2(overall)$	0.0146	0.0764	0.4891
corr	0 (assumed)	0 (assumed)	0 (assumed)
observations	1659	441	1218
num.of groups	79	21	58

CHAPTER 7

Pollution Haven Effect: Malaysian Bilateral Trades

7.1 Introduction

One could suggest that the overall economic benefits of international trade are realized through the means of accumulation of all the foreign earnings that result from the country's bilateral trades. In this view the size of economic gains from the external trade are depending on the volume and the number of countries traded with. Trading with more countries means more opportunity for the country's produces to be traded which spur economic prosperity and people's well-being. Despite this stereotype argument that focuses on the economic benefit, it is also important to know the impact of bilateral trades on the domestic environment. Is it true that it does not matter with which country we are trading. Basically, an increase in mass production in one country would cause an increase in industrial activity that would eventually lead to accumulation of environmental pressure.

In this study our aim is to investigate whether there is evidence that the bilateral trade pattern plays a significant role in the current state of the national environment quality. The analysis of the effect of trade on the environment in the case of regional and industrial studies presented in the previous chapters suggests that the findings are inconclusive. Investigating the environment-trade relationship based on the bilateral trade dimension certainly will enhance our understanding of the relationship. Perhaps this study will shed some evidence on whether particular bilateral trade can be regarded as evidence of the PHH phenomena or otherwise. Hence, using data on Malaysian bilateral trades with its trading partners, we will investigate whether we can conclusively conclude that Malaysian bilateral trades with certain countries have contributed to the environmental degradation while Malaysian bilateral trades with other countries have not caused environmental deterioration.

Since the PHH is an argument relating trade flows to country characteristics (high income with strict environmental standards and low income with lower environmental regulations), one should expect that the variation in trade patterns across bilateral trade is related to the country characteristics. This study will rely on the broadly accepted fact that countries in the north are viewed as more advanced in environmental regulations while countries in south are still lagging behind, and so which are likely to be repositories for pollution intensive industry. Indeed, rich countries today show greater concern about the environment than poor countries do. Following this argument, one could suggest that environmental regulatory differences can have impacts on trade flows/pattern of bilateral trade. Thus, this bilateral study's aims to investigate whether the level of environment regulation between Malaysia and its trading partners has influenced their trade patterns and shown any evidence of PHH. In this examination, in the view of the PHH, Malaysia's bilateral exports to developing countries should comprise mainly less intensive pollution products while Malaysia's bilateral exports to developed economies should heavily contain pollution intensive products. In this analysis, countries such as Australia, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Russian, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom and United State of America are seen as developed economies. While countries such as Bangladesh, Brazil, Brunei, Cambodia, China, Hungary, India, Indonesia, Laos, Mexico, Myanmar, Pakistan, Philippines, South Africa, Sri Lanka, Thailand and Vietnam are considered as less developed economies.

The following two sections provide an overview of bilateral trade in Malaysia and are followed by a brief review of the environment perspective in Malaysia and some of her trading partners. The fourth and fifth sections discuss the problem statement and the theoretical consideration and empirical review. The sixth and seventh sections deal with the methodology and data, and results and discussions. The last section is the conclusion.

7.2 Malaysia bilateral trade in brief

Malaysia's trading partners were initially limited to a few major industrial economies such as the U.S, Japan and European countries. These countries are recognised as the 'traditional market' for Malaysia's exports and continuously stand as Malaysia's key allies in global trade. In the early years the number of trading partners was small and the amounts and type of products traded were not substantial. Malaysia was initially famous in global trade as a main supplier for natural rubber and tin ore that were mainly used for industrialisation in major developed countries. Both commodities were the key raw materials in the production of heavy industries such as machinery and car production. In that period, the range of products traded was mainly related to natural resources and agriculture-based products before switching dramatically into more diversified manufactured products in the late 1980s.

The government efforts to accelerate the development of the manufacturing sector as an engine of economic growth were promoted mainly through a policy shift from external sector earnings that were largely dependent on exports of the primary commodities towards export-oriented industrialization. The efforts were supported by the introduction of the Investment Incentives Act in 1968 and this has been further supported with the set-up of Heavy Industries Corporation of Malaysia (HICOM) in 1981. In 1986, the Promotion of Investment Act was implemented to give a further boost for the investment liberalization in the country. All these efforts triggered a flow of resources from primary industries to manufacturing industries.

In the period from the 1990s onwards, as a result of the dedicated effort and commitment shown by the government towards liberalisation together with a favourable economic climate, the country had experienced a significant increase in the volume of trade with the rest of the world. In the year 2005, Malaysia had traded with more than 200 countries in the world and registered a record of RM one trillion in value of goods in exports and imports. This continuous surge in the number of Malaysia's trading partners can be attributed to various factors. It is believed that the key factor to this success is directly linked to the bold step taken by the government in promoting the nation's outward looking policy which provided various incentives and the favourable business climate that had gained investor confidence and attracted investment into the country. The influx of inflow of investments which mainly ventured into the industrial sector had helped to accelerate the transformation of the country's economy from a primary economy into an industrial one. With reference to Malaysia, Athukorala and Menon (1999) assert that "FDI has undoubtedly been the engine of manufactured export expansion...There has been a boom in the amount of FDI coming into the country, particularly since the mid-1980s; between 1987 and 1991 foreign capital inflows have increased almost ten-fold. By the late 1980s FDI inflows had decisively shifted from production for the domestic market to using Malaysia as a base for manufacturing for the global market."

Another key factor that has contributed to the bilateral expansion is the relative comparative advantage that arises from the factor abundance of labour. A long period with a cheap labour force and excess supply of other factors of production such as land and natural resources continued to be the main sources of comparative advantage that attract investments in the fast growing industrial sector in the economy. The evidence is seen with the existence of many factories that are particularly associated with labour intensive industry such as clothing, electronics, electrical and equipment products. There is also evidence to show that the resource-based industries such as furniture and wood-based products, chemicals and plastic products are growing rapidly in response to a surge in demand in export markets. Other than the two key factors, the Malaysian economy is always portrayed as a much opened economy that has many pre-requisite requirements that is in favour of international trade such as a stable political environment and the existence of strong national institutions encompassed of executives, legislatives and judiciary. As a former British colony, the country is in heritage of a strong foundation rule and laws that can be used as the safeguard for businesses operating in the country. All these have had lead Malaysia to be a favourable trading partner for many countries in the world.

Currently, the major export destinations for Malaysian goods are the United States, Singapore, China, Japan, Australia, Indonesia, Taiwan, India, Pakistan, Hong Kong, the United Arab Emirates, Thailand and the European Union countries. Other than that there are also new trading partners added to the list particularly those from the emerging markets such as countries from the African and South American regions. The country's main export revenue contribution was made by electrical and electronic products which had overtake the contribution from primary commodities. Other key export products are crude petroleum, liquefied natural gas (LNG), wood and wood-based products as well as palm oil and palm oil-based products.

In term of bilateral trade policy, Malaysia has pursued trade expansion that involved numerous bilateral trade agreements and various regional trade agreements. This multilateral trade liberalisation strategy had been implemented vigorously in the early 1990s and as a result it had shown a strong inroad of Malaysian products beyond the traditional markets. With the efforts, many trade related negotiations have been concluded between Malaysia and trading partners. The ASEAN Free Trade Area (AFTA) and the Free Trade Area Agreements (FTA) are the latest efforts to strengthen Malaysia's position in the global trade. The recent efforts on trade liberalisation policy by the government are shown in Table 7.1 at Appendix 1.

The success of the government trade policy is also fuelled by various advances in infrastructure and logistics that have provided a favourable environment for industrial activity and economic growth. Apart from that a less stringent environment regulation contributes to the continuous existence a significant number of lower end production technologies factories in the country (such as the assembly and processing lines of electrical products). However, environmental and pollution control policies had started to receive a significant standing in the government policies since the early 2000s when various new initiatives and legislations related to the environment began to take effect. Among others are the requirements for an environmental impact study before any major development can be started, a more holistic approach on the needs of environment monitoring processes and better data collection on environment statistics as well as enhancing the pollution control by empowering the environment authorities.

Turning back to the trade destination, despite continuing efforts by the government to expand its market, the major share of Malaysian export destinations remain to its traditional trading partners. Table 7.2a shows that Singapore, Japan and the United States have steadily been the leading trade partners of Malaysia, accounting for more than 50% of the country's annual exports during the period of 1990 to 2000. However in recent years as shown in 2006, the contribution of Malaysian exports to Japan and Singapore shows a slow down despite the actual value of the exports continuing to increase. In terms of region, the contribution of exports to ASEAN and North America regions seem to be stable during the period with only a marginal decline in 2006. The contribution of the country's exports to Europe is on a declining trend while the opposite pattern is shown for Indochina region. In terms of imports, as shown in Table 7.2b, the country's source of imports comes mainly from Indochina followed by ASEAN regions.

Table 7.2a: Direction of Trade, share (%)

	1990	1995	2000	2006
Asean	**29.2**	**27.8**	**27.2**	**26.8**
Indonesia	0.8	1.3	1.6	2.2
Singapore	24.6	21.3	19.7	16.6
Thailand	2.2	3.2	3.2	5.0
Europe	**19.2**	**14.9**	**14.8**	**13.7**
France	1.8	1.0	0.8	1.5
Germany	5.0	3.4	2.7	2.3
Netherlands	3.3	2.5	4.6	4.1
UK	5.1	4.3	3.4	2.0
North America	**22.8**	**24.0**	**23.8**	**22.3**
Canada	1.0	0.8	0.9	0.7
USA	21.5	22.7	22.2	21.0
Indochina	**18.8**	**24.1**	**25.0**	**24.6**
China	1.9	2.7	3.0	7.5
Hong Kong	4.2	5.8	4.9	5.6
Japan	8.8	10.5	11.2	6.9
Korea	2.2	2.1	2.4	2.3
Taiwan	1.6	3.0	3.5	2.3
South Asia	**2.5**	**2.3**	**2.3**	**2.9**
India	1.0	1.0	1.5	1.8
Pakistan	1.1	1.1	0.4	0.6
Australia	1.6	1.4	2.2	2.4
Gulf	1.4	1.5	1.3	2.0
South American	0.0	0.8	0.6	0.8
ROW	4.5	3.1	2.9	4.6
Total	**100.0**	**100.0**	**100.0**	**100.0**

Table 7.2b: Imports from country origin, share (%)

	1990	1995	2000	2006
Asean	**19.0**	**17.1**	**23.8**	**23.7**
Indonesia	0.8	1.3	2.5	3.0
Singapore	15.8	12.8	15.0	12.6
Thailand	1.8	2.3	3.5	5.1
Europe	**17.7**	**17.7**	**12.5**	**13.1**
France	1.6	3.1	1.7	1.7
Germany	4.5	4.6	3.1	4.8
Netherlands	0.8	0.7	0.7	0.7
UK	5.7	2.9	2.0	1.5
North America	**18.1**	**16.8**	**17.8**	**14.0**
Canada	0.8	0.5	0.4	0.5
USA	17.3	16.3	17.2	13.4
Indochina	**37.0**	**41.8**	**38.9**	**41.6**
China	1.4	2.0	3.6	12.6
Hong Kong	2.0	2.2	2.9	2.8
Japan	25.2	28.1	21.9	14.3
Korea	2.7	4.2	4.7	5.9
Taiwan	5.7	5.2	5.9	5.9
South Asia	**0.8**	**0.7**	**0.9**	**1.0**
India	0.6	0.6	0.8	0.9
Pakistan	0.1	0.1	0.1	0.0
Australia	3.1	2.4	1.6	1.6
Gulf	0.3	0.2	0.5	1.1
South American	0.8	0.5	0.4	0.9
ROW	3.1	2.7	3.6	3.1
Total	**100.0**	**100.0**	**100.0**	**100.0**

Table 7.3a and Table 7.3b show the compositions of exports and imports for the selected countries. The overall pattern shows that the key Malaysian exports and imports to/from those countries are electrical and electronics products. For exports, Table 7.3a shows that in the case of a group of developed countries[24], exports of electrical and electronics products constituted the higher share. While for a group of developing countries[25], with the exception of China, the composition of exports is more widespread including food, beverages and tobacco products, chemicals and

[24] Developed countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Russian, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom and United State of America.(24).

[25] Developing countries: Bangladesh, Brazil, Brunei, Cambodia, China, Hungary, India, Indonesia, Laos, Mexico, Myanmar, Pakistan, Philippines, South Africa, Sri Lanka, Thailand and Vietnam. (17)

pharmaceuticals, and electrical and electronics products. For imports, electrical and electronics products is also the bigger share of Malaysia's imports from most of its trading partners as shown in Table 7.3b. In the case of FBT the share of imports is lower as compared to exports for most of the trading partners.

Table 7.3a: Export's composition of selected countries, annual average share (%), 1990-2006

	FBT	TWA	WWP	PPP	CP	NMP	MP	EE	MM
Asean	**5.5**	**1.8**	**2.2**	**1.1**	**13.0**	**3.2**	**5.7**	**63.4**	**4.1**
Indonesia	12.0	2.7	0.5	1.2	26.1	4.6	8.8	39.9	4.3
Singapore	4.1	1.6	1.2	1.1	10.8	3.0	4.7	69.2	4.2
Thailand	3.4	0.9	6.6	0.7	15.1	2.7	6.5	60.1	4.0
Europe	**7.5**	**4.4**	**4.2**	**0.3**	**3.7**	**6.7**	**3.3**	**65.4**	**4.6**
France	0.9	5.4	2.3	0.3	2.4	7.4	1.7	75.3	4.4
Germany	4.1	4.4	2.1	0.2	4.6	4.9	5.5	69.7	4.7
Netherlands	13.9	1.2	5.8	0.1	5.0	2.0	1.6	66.7	3.7
UK	3.0	6.8	4.8	0.7	2.2	11.7	2.3	65.9	2.6
North America	**1.4**	**4.4**	**1.4**	**0.1**	**2.3**	**6.0**	**1.5**	**78.9**	**4.0**
Canada	1.7	9.6	1.5	0.2	1.1	10.9	5.1	65.3	4.7
USA	1.4	4.2	1.4	0.1	2.4	5.9	1.4	79.2	4.0
Indochina	**7.2**	**1.6**	**8.1**	**0.4**	**12.3**	**3.7**	**4.1**	**58.8**	**3.9**
China	21.1	0.7	7.8	0.4	16.9	1.9	4.0	44.2	3.2
Hong Kong	4.2	2.9	3.2	0.7	10.0	2.5	2.8	70.0	3.6
Japan	3.9	1.4	10.5	0.3	11.0	5.5	3.9	58.0	5.4
Korea	7.4	0.7	11.9	0.2	17.1	3.8	7.1	50.2	1.6
Taiwan	3.7	1.4	7.9	0.3	10.5	2.5	4.9	66.2	2.6
South Asia	**53.3**	**1.9**	**0.8**	**0.5**	**14.7**	**3.2**	**3.9**	**20.9**	**0.9**
India	44.3	0.5	0.4	0.3	16.3	2.7	4.1	30.2	1.2
Pakistan	80.7	0.3	0.8	0.2	8.4	1.1	1.3	6.8	0.3
Australia	5.8	1.2	5.2	1.2	11.3	11.4	7.2	54.3	2.6
Gulf	16.7	1.4	5.8	0.4	4.7	7.1	3.7	38.5	21.5
South American	21.6	1.1	5.1	0.8	7.3	9.4	4.4	48.2	2.1
ROW	31.8	3.4	4.2	0.9	7.6	7.4	6.3	36.5	1.9
Total	7.8	2.8	3.9	0.5	8.6	4.9	3.9	63.4	4.2
Developed	4.3	2.9	3.8	0.5	7.1	5.1	3.4	68.2	4.5
Developing	19.7	1.7	4.6	0.7	16.2	3.4	5.8	44.8	3.0

Note: Food, beverages and tobacco (FBT), Textile, wearing apparel (TWA), Wood and wood products (WWP), Pulp and paper products (PPP), Chemicals and pharmaceutical (CP), Non-metallic mineral products (NMP), Metal products (MP), Electrical and electronics (EE), and Miscellaneous manufacturing (MM).

Table 7.3b: Import's composition of selected countries, annual average share (%), 1990-2006

Description	FBT	TWA	WWP	PPP	CP	NMP	MP	EE	MM
Asean	**4.5**	**1.5**	**0.6**	**2.0**	**21.4**	**2.5**	**6.6**	**57.0**	**3.9**
Indonesia	13.4	5.4	3.7	8.4	17.7	3.6	12.6	33.1	2.1
Singapore	0.8	0.7	0.0	1.1	27.6	2.3	6.4	55.9	5.2
Thailand	11.8	2.2	0.7	2.2	13.5	3.5	5.3	58.3	2.3
Europe	**2.8**	**1.2**	**0.2**	**2.6**	**11.9**	**1.7**	**13.8**	**56.2**	**9.6**
France	4.7	1.2	0.0	1.7	11.5	1.3	4.2	71.4	4.1
Germany	0.8	0.7	0.1	2.0	10.0	1.9	7.2	65.0	12.3
Netherlands	10.8	1.1	0.1	4.1	19.2	1.3	12.1	39.3	12.1
UK	2.6	1.4	0.0	3.6	11.1	2.1	17.4	53.9	7.9
North America	**1.3**	**0.4**	**0.3**	**1.8**	**8.1**	**1.3**	**4.5**	**74.7**	**7.6**
Canada	2.8	0.8	1.3	10.5	29.9	0.9	9.7	39.4	4.7
USA	1.2	0.4	0.2	1.5	7.5	1.3	4.3	75.7	7.8
Indochina	**0.7**	**2.8**	**0.1**	**1.2**	**8.3**	**2.5**	**11.8**	**64.3**	**8.3**
China	3.1	6.0	0.4	0.9	7.4	3.3	7.9	66.1	4.9
Hong Kong	1.1	7.3	0.1	1.2	5.7	2.1	5.9	64.7	12.0
Japan	0.2	0.8	0.0	1.0	8.3	2.8	13.5	63.5	9.9
Korea	0.1	2.1	0.0	1.2	8.7	1.3	13.1	70.1	3.5
Taiwan	0.7	6.0	0.1	2.0	10.3	2.0	10.6	60.1	8.2
South Asia	**21.7**	**9.0**	**0.1**	**1.3**	**20.5**	**1.7**	**15.6**	**25.6**	**4.5**
India	22.5	6.4	0.1	1.5	19.3	1.6	17.0	27.3	4.4
Pakistan	17.6	34.9	0.0	0.1	39.4	0.6	1.2	3.6	2.6
Australia	27.6	4.2	0.3	1.9	10.7	0.8	38.2	13.6	2.6
Gulf	0.6	0.6	0.0	0.5	71.1	0.4	23.0	2.7	1.1
South American	17.3	5.2	0.6	3.0	6.8	0.4	54.5	10.9	1.3
ROW	8.2	3.3	0.3	1.3	11.5	1.7	15.9	55.2	2.6
Total	3.2	2.0	0.3	1.7	12.2	2.1	10.6	61.0	7.0
Developed	2.0	1.5	0.1	1.6	12.5	2.0	10.6	61.8	7.9
Developing	8.6	4.4	1.0	2.4	10.3	2.9	9.4	57.9	3.1

Note: Food, beverages and tobacco (FBT), Textile, wearing apparel (TWA), Wood and wood products (WWP), Pulp and paper products (PPP), Chemicals and pharmaceutical (CP), Non-metallic mineral products (NMP), Metal products (MP), Electrical and electronics (EE), and Miscellaneous manufacturing (MM).

In a comparison, Malaysia's exports to a group of developed countries are higher than Malaysia's exports to a group of developing countries for all the nine sub-groups of the products as shown in Table 7.3c. Despite that, the composition of food, beverages and tobacco (FBT) is about the same for both groups of countries. For imports, Malaysian imports of wood and wood product (WWP) from a group of developing countries is higher than its imports from a group of developed countries.

Imports of the other eight sub-groups are mainly sourced from developed countries as shown in Table 7.3d.

Table 7.3c: Export composition (%) group of countries, annual average, 1990-2006

	FBT	TWA	WWP	PPP	CP	NMP	MP	EE	MM
Developed	44.9	85.6	77.5	74.0	66.7	83.6	70.5	86.6	86.9
Developing	41.0	10.1	18.8	20.1	30.3	11.2	24.0	11.4	11.6
ROW	14.1	4.3	3.7	5.8	3.0	5.2	5.5	2.0	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 7.3d: Import composition (%) group of countries, annual average, 1990-2006

	FBT	TWA	WWP	PPP	CP	NMP	MP	EE	MM
Developed	51.0	60.9	38.5	76.5	84.2	76.2	82.1	82.8	92.1
Developing	41.7	34.3	58.4	21.3	13.1	21.5	13.7	14.7	6.8
ROW	7.3	4.8	3.1	2.2	2.7	2.3	4.3	2.6	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

7.3 The environmental perspective in Malaysia and its trading partners

The availability of a good environment regulation to govern economic activity will help to restrain the speed of environmental deterioration and mitigate the negative consequences. By and large, strict regulation can act as a deterrent to polluters. This is important because in some cases, environmental degradation is beyond repair no matter how many resources were used. Hence, it is better to have ample protection as it is undisputedly less costly than the rehabilitation costs one has to compensate. It is broadly accepted in the literature that the stringency of environmental regulation in the country is closely associated with the phase of the country's development which is mainly measured by the country's per capita income. Thus, in order to know the country's practice towards environment, the simple yard stick which is widely available is using the country's per capita income. Based on general observation, one can come to the conclusion that the valuation of environmental standards appears to be higher in high income countries than it is in low income countries. In this regards, the amount of money spent in maintaining the environment standards is also higher in developed countries compared to developing countries. The scenario led many researchers to make a general assumption that environmental regulations are on a par amongst most developed countries and often superior to developing countries. The scenario also can be implied that developed countries are well ahead in terms of environment rehabilitation and protection. This is comprehended in the various discussions in the literature such as Copeland and Taylor (1994) who suggest that trade alters the composition of output in both North (developed countries) and South (developing countries) because of differences in the stringency of their pollution regulation.

Besides the level of development, there are others factors that influence the environment standards in many countries such as political regimes and cost of resource based energy. It is mentioned in the literature, democracy regimes that promote political freedom will encourage more people to recognise the importance of maintaining environment standards. The freedom spurs environmental activities that create a high level of awareness and participation in various efforts to preserve and maintain the environmental standards. Due to resource abundances and low base of consumption, cost of energy is relatively low in many developing countries. This excess supply and low cost of energy gives advantages for the energy intensive industry to be operated in developing countries. This certainly helps to attract capital flow into developing countries.

It is also recognised that the existence of multinational companies (MNCs) across the globe can be seen as a catalyst for better environmental practices among firms in developing countries. In the long-run, MNCs and the agglomeration effects will bring the local producers on board towards a good environmental practice which often gives priority on environment protection. According to WTO (1999) trade liberalisation may have motivated the transfer of technology. Other than the profit motive, there are also many MNCs that exercised their good judgement in preserving the environment and they consistently implemented their good practice /corporate governance irrespective of their locations. WTO (1999) suggests that, "even if no regulations are imposed, whether formally and informally, it may still be in the interest of firms to make at least a minimum of effort to control pollution so as to safeguard their reputation, to avoid consumer boycotts in environmentally conscious (export) markets, and to reduce the risk of legal liabilities, should a major environmental accident occur, such as the Bhopal accident in India". In fact many multinational firms seem to be heading towards a policy of standardized technologies for all their production plants in the world, including with respect to pollution abatement. According to the US International Trade Commission (1995), much research indicates that multinational firms tend to replicate the technologies employed in their home markets when operating in developing countries. WTO (1999) has also put forward the argument of Palmer *et al.* (1995) that "multinational firms base their technology decisions not only on the current regulatory framework, but on what they expect in the future. Rather than retrofitting abatement equipment at great expense in at a later date, it makes commercial sense to install state-of-the-art technologies at the time the investment is made." Thus, it is widely anticipated that the presence of MNCs with a good environment practice would put extra pressure for domestic companies to follow suit.

Meanwhile, the voluntary environmental management standards (ISO 14000) promulgated by the International Organization for Standardization (ISO) is another international effort to encourage firms to be more vigilant in controlling and managing environment standards in their operating. The ISO 14000 standards have provided companies, regardless of size or type, with a common framework for analyzing and managing the environmental impact of products and processes, including performance evaluations, life-cycle assessment, environmental labelling, and auditing. Although the implementation of ISO 1400 is voluntary, certification is increasingly becoming a commercial necessity. In 1997, 5000 certificates had been awarded in 55 countries, an increase of 300 per cent from the previous year (WTO, 1999).

Cole (2003) observes that in the developed countries the environmental regulations comprise formal and informal regulation. The latter is something that does not really exist in developing countries. Unlike in developed countries, because of a lack of awareness and low quality living standards in developing countries, there is hardly any commitment among the society to act as an informal "care taker" for the environment. In sum, the 'self regulation' and a high level of civil society are widely missing in developing countries. In a worse scenario, the literature insists that poverty and income disparity are linked to environmental degradation. As such, due to economic difficulty, a bigger segment of society has no choice but disregard the environment standards to support the economic activity expansion which promises job creation and income for living. Esty (2001) has singled-out poverty for the deterioration of environment standards. The researcher urges that "it is clear that poverty can force people to make short-term choices that degrade the environment, like cutting down nearby trees for firewood despite the likelihood of future soil erosion". Hence, it is very likely that developing countries are not in a favourable position to implement a very stringent environment regulation. It is certainly ill-advised to do so unilaterally which limits its effectiveness because some pollutants are transboundary in nature and some are sourced from consumption. Moreover, the final consumption characteristics of consumers in developing countries are mainly only around necessity goods due to their low per capita income and hence purchasing power. Esty (2001) also insists that "the hope for trade liberalization will lead to economic growth that will alleviate poverty and generate resources for environmental investment sometimes seems to rely on a tenuous chain of events which may well unravel under real-world conditions".

Meanwhile, Pargal and Wheeler (1996) urge that survey evidence from developing countries suggests that local communities can sometimes exert effective pressure on firms to clean up their act even without the backing of formal regulation and laws. This however depends very much on the socio-economic structure of the community in which the factory is located, including educational and income levels. For instance, in Indonesia they found a significant difference in pollution intensity between factories of the same industry located in communities with relatively high educational and income levels and factories located in communities with low educational and income levels. Hartman *et al.* (1997) find a similar pattern on the pollution intensity of pulp and paper plants in Bangladesh, India, Indonesia and Thailand. WTO (1999) concludes, "these finding suggests that affluent communities with relatively educated populations can exert effective pressure on industries to clean up, while poorer and uneducated communities find it more difficult to make firms behave in an environmentally responsible way".

Compared to developed countries, there is no formal environmental market in most developing countries. For instance, while developed countries have a pollution tax system whereby firms have to pay in order to release their pollution emissions from the factory, developing countries often disregard the guidelines or requirements provided by WTO and other international bodies in the area related to environmental standards such as the level of cutting trees per acre, percentage of deforestation, percentage of tropical forest per population and product labelling. Countries in Europe and other developed nations seem have shown more appreciation and commitment towards all efforts for maintaining the environment standards.

In many developed countries, there is a market called Emission Trading System (ETS) to trade unused pollution licenses or quota. The system requires the producers of pollution goods which emit significant amounts of emissions to have the permit/license before producing the goods. The firms can choose the type of production technology they will use. The more pollution technology they use, the more quotas they need to buy. If environmentalists also buy the permits, it will push up the price. This will encourage firms to opt for using abatement technology. Thus, there is a formal market of supply and demand for the environment. As such, in developed countries, a 'polluters pay' principle is very much practiced. While in developing countries, in the absence of proper valuation of the environment, polluters act as free riders on the country's environmental assimilative absorption capacity.

In terms of international effort to protect the environment, a restriction of movements for certain products have been in place. For example, the international community has gone to a great extent to control the exports and imports of harmful products to the environment such as ozone-depleting chemicals like chlorofluorocarbons (CFCs), halons, carbon tetrachloride (CTC), methyl chloroform and methyl bromide. In other words, the movement of the products and other hazardous materials between countries has been controlled. There is a list of products whose movement is being controlled and the list is continuously being reviewed and monitored under the United Nations Environment Program (UNEP) especially in term of cross-border transactions in international trade. In the long term, trading of these harmful products is planned to be phased-out. Currently under the program the use of such products is being gradually reduced, and research and development is in progress to find the substitution for the products. For example, the use of chlorofluorocarbons in refrigerators, air conditioning and other electrical appliances has been slowly reduced and replaced with other materials.

As discussed earlier, a country's per capita income is commonly used as a yardstick to categorise the country according to its economic achievement. According to World Bank (2009) criteria, the income group is classified as shown in Table 7.4 below. Meanwhile, based on well-known empirical evidence of EKC as discussed in the literature review in Chapter 4, the level of income (per capita GDP) that made the EKC curve turn downward is associated with environment improvement as a result of the strong financial capability of the country. Empirically, the amount is between $5000 to $8000 as suggested by Grossman and Krueger(1993), Shafik and Bandyopadhyay(1992), and Seldon and Song (1994). Generally, it's about a middle-income group of the classification.

Table 7.4: Income group classification

Income group	**GNP per capita ($, 1991)**
Low income countries	Less than 635
Middle income countries	Between 635 and 7910
High income countries	More than 7910

Source: World Bank (2009)

The literature provides less detail on the environment practice of specific countries in the world. Here we broadly discuss the environment perspective and practice in some of Malaysia's trading partners. The USA, Germany, UK, France, Japan and Netherlands are among developed countries that are considered as in the forefront in managing the environment. In the case of OECD countries, pollution abatement costs (PAC) are believed to account for between 1 and 5 per cent of production costs (WTO, 1999). In terms of percentage of GDP, the expenditure in selected OECD countries was between 0.8 and 1.6 per cent for the period 1981-1990 as shown in Table 7.5a. Meanwhile, as stated in the pollution-abatement costs and expenditure report of the Census Bureau (1996), the average industry in the U.S.A. spent some 0.6 per cent of its revenue on pollution abatement. In the case of the pollution intensive industries such as petroleum and coal products, primary metal industries and paper and chemicals and allied products the PAC were between 1.5 per cent and 2 per cent of value of shipment (WTO, 1999). The detail is shown in Table 7.5b below.

Table 7.5a: Pollution abatement and control expenditure for selected OECD countries as percentage of GDP

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
United States	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.4	1.4
France	0.9	0.9	0.9	0.8	0.9	0.8	1	1	1	1
West Germany	1.5	1.5	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.6
Netherlands	-	1.2	-	-	1.3	1.5	1.5	-	1.5	-
UK	1.6	-	-	-	1.3	1.3	-	-	-	1.5

Source: Jaffe *et al.*(1995)

Table 7.5b: Pollution abatement operating costs (PAC) by US industry (1993)

SIC	Industry	Pollution Abatement Operating Costs (million US$)	Value of Shipment (million US$)	Abatement Cost/Value of Shipment (%)
29	Petroleum and coal products	2793	144715	1.93
28	Chemicals and allied products	4802	314744	1.53
33	Primary metal industries	2144	142384	1.51
26	Paper and allied industries	1948	133486	1.46
32	Stone, clay and glass products	544	65574	0.83
31	Leather and leather products	52	9991	0.52
34	Fabricated metal products	742	175137	0.42
22	Textile mills products	280	73951	0.38
30	Rubber and miscellaneous plastic product	409	122776	0.33
20	Food and kindred products	1368	423257	0.32
37	Transportation equipment	1327	414614	0.32
36	Electronic and other electric equipment	716	233342	0.31
24	Lumber and wood products	279	94547	0.3
25	Furniture and fixtures	137	47349	0.29
38	Instruments and related products	383	136916	0.28
39	Miscellaneous manufacturing industries	85	42426	0.2
35	Industry machinery and equipment	488	277957	0.18
27	Printing and publishing	266	172737	0.15
21	Tobacco products	33	28384	0.12
	Average of all industries	18796	3054287	0.62

Source: WTO (1999)

In the Asian region, Japan is regarded as a leading nation in implementing a strict environmental regulation. Mani and Wheeler (1997) describe that the environment standards and regulation are comparable with the OECD standards. They state that "cities like Tokyo, Osaka, and Kyoto enacted some pollution control measures by mid-1950's. From 1967 to 1970, regulations covering industrial air and water emissions were enacted in rapid succession". Brandon and Ramankutty (1993) in Mani and Wheeler (1997) provide a summary of initial national environment legislation in selected countries in Asia as shown in Table 7.5c. It's shown that Japan had instituted the environment legislation as early as 1958.

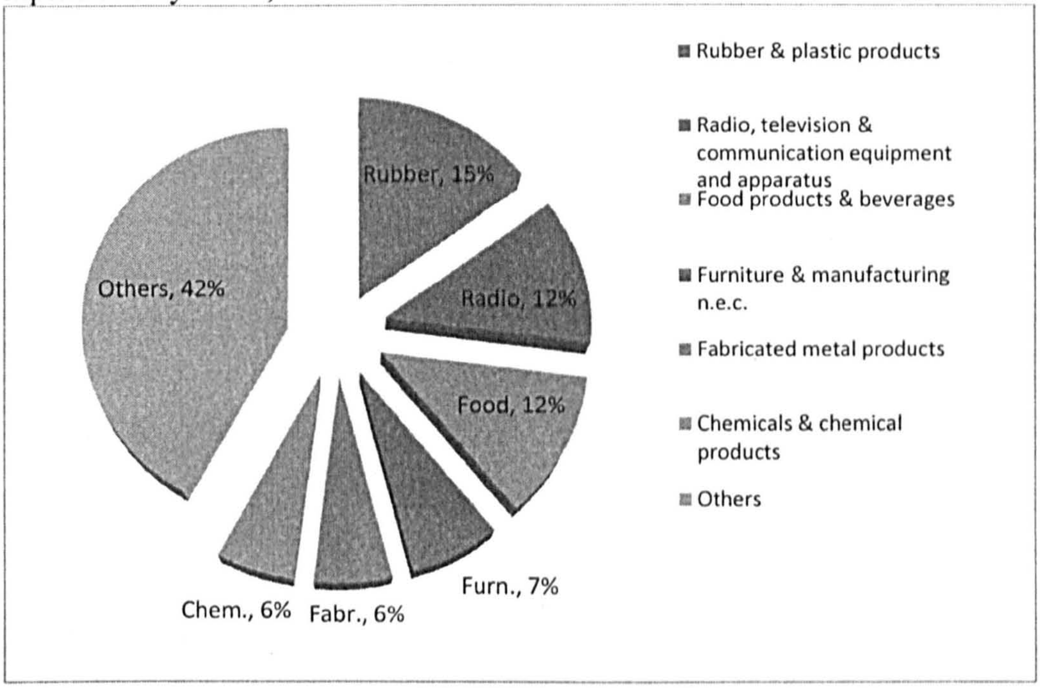
Table 7.5c: Initial national environment legislation in selected countries in Asia

Country	Air	Water	Toxics
Japan	1967	1958	1958
NICs			
Hong Kong			
Singapore	1978	---	---
Korea			
Taiwan	1975	---	
Developing East Asia			
Malaysia	1977	1977	1979
Indonesia	1988	1988	---
Thailand	1975	1975	1989
China	1985	1985	1989
Philippines			
South Asia			
India	1974	1981	1986
Pakistan	1983	1983	---
Bangladesh	---	---	---

Source: Brandon and Ramankutty (1993)

Turning back to Malaysia, based on the Survey of Environmental Protection Expenditure report of the Department of Statistics, Malaysia (2008), the number of establishments in manufacturing industry with environmental protection expenditure in 2007 is seen to be encouraging. A total of 1,872 manufacturing establishments were involved in the survey and 67.2 per cent of them reported incurring expenditure to protect the environment (DOSM, 2008). Chart 7.1 below shows the percentage distribution of establishments with environmental protection expenditure for major manufacturing sub-sectors in 2007. This survey was the first conducted by the department and thus no data are available for the years prior to 2007.

Chart 7.1: Percentage distribution of establishments with environmental protection expenditure by sector, 2007.



Note: Number of establishments: 1,258

Source: Department of Statistics, Malaysia.

Recently it has been announced that the country's authorities plan to introduce a new requirement for listed companies in Bursa Malaysia Stock Exchange to state their financial allocation towards maintaining higher environmental standards in their annual reports. The amount of their spending on environment protection expenditure and, research and development (R&D) towards environmental friendly technology will be published. As an encouragement, the government will also provide certain incentives such as tax rebates and grants. This is seen as another commitment by the government to improve environment consciences amongst the firms in the country.

7.4 Problem statement

In this chapter, we examine the evidence for the PHH in the case of bilateral trade between Malaysia and its trading partners across regions. This will allow us to look specifically at the evidence from a bilateral trade point of view. The countries are comprised of Malaysia's trading partners for the period of the study. The selected countries are mainly Malaysia's major trading partners. Some of the countries are Malaysia's trading partners that have significantly contributed to the country's foreign earnings for several decades while others are new trading partners. The specific question to be answered by this study is to find the evidence that shows Malaysia's bilateral exports to a particular country causes more air pollution emission. Furthermore this provides evidence whether Malaysia's bilateral exports to developed countries are more/less polluting than Malaysia's bilateral exports to developing countries. This study will also provide a qualitative evaluation of the environment regulation framework in these countries. Thus we can see how the different levels of stringency plays a role in dictating the goods being traded, if any.

Thus instead of examining the environmental effect of trade in each country as has been done in a cross-country analysis, this study investigates the effect of each bilateral trade on the exporter's (home country) environment. Our dependent variable is industrial pollution emission that emitted in the country where the goods are produced for export market, in this case, Malaysia.

In this study, we examine four air industrial pollutants, SO2, CO NO2 and PM separately. We will compare the result of each pollutant and examine whether the effect of bilateral trade on the environment is the same for all the pollutants. This analysis will provide additional evidence as to whether the effect holds for all four air pollutants.

Unlike Anweitler *et al.* (2001) who examine PHH by linking trade liberalization with the changes in pollution concentration, here we will employ directly the bilateral trade data to investigate the industrial pollution emissions. For this study, the data covers 41 of Malaysia's bilateral trades, which includes 15 developing countries and 26 developed countries from 1990 to 2006. The list of the countries involved is shown in Appendix 2. Specifically, this study will focus on the examination of;

i. Malaysia's bilateral exports with countries in the ASEAN (Association of South East Asian Nations) region;
ii. Malaysia's bilateral exports with selected countries in Europe;
iii. Malaysia's bilateral exports with selected countries in the Indochina region;
iv. Malaysia's bilateral exports with selected countries in the South Asia region;
v. Malaysia's bilateral exports with selected countries in North America;
vi. Bilateral trade between Malaysia and her top 14 trading partners, namely Australia, China, Germany, Hong Kong, India, Indonesia, Japan, Korea, Netherlands, Singapore, Taiwan, Thailand, UK and USA; and
vii. The 'regional' bilateral trade including ASEAN, Europe, North America, Indochina and South Asia.

This study will examine all of these Malaysian bilateral trades in terms of the PHH discussed earlier. In the literature, it is broadly anticipated that developed countries with high income have strict environmental regulation while developing countries with a low income possess a rather lax environmental regulation. Thus, this study will examine the evidence of the PHH which suggests a direct link between environmental differences and trade flows. Particularly, the study will allow us to examine evidences from a bilateral trade point of view. In this study we intend to find any evidence of PHH in Malaysia's bilateral trade with those selected countries. Is there any evidence that imports from one country are less polluted while exports to another one are more polluted, or no effect at all? This study will show how the pattern of trade with various countries has different impacts on the country's environment. It is also important to see how the results of this study can be compared with the cross-country studies for better understanding of the trade and environment relationship. Also, this study will provide the empirical evidence on the question whether Malaysia is being used as a pollution haven or other countries are being used by Malaysia as a pollution haven.

7.5 Theoretical consideration and empirical review

Some argue that to have a uniform environmental standard is almost impossible and can be counterproductive and could lead to optimal welfare failure. Esty (2001) states that "economists point out that the existence of divergence circumstances, including variations in societal preferences about the optimal level of environmental protection, is what makes gains from trade possible. If environmental rules vary because of differences in climate, weather, geography, existing pollution level, population density, risk preferences, level of development, or other 'natural' factors, the variation in standards should be considered welfare-enhancing and appropriate. Diversity circumstances generally make uniformity less attractive than standards tailored to the heterogeneous conditions that exist."

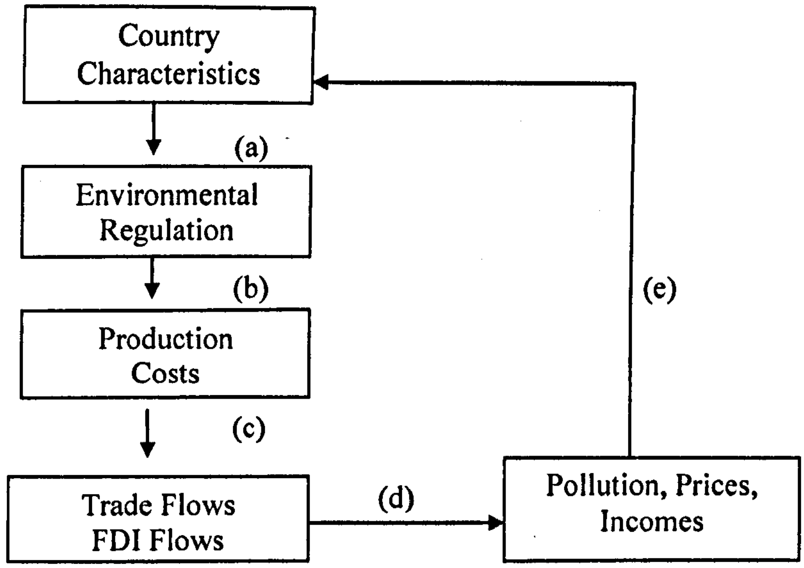
As discussed in the literature, the different levels of stringency of environmental regulation provide an impetus for factory movements from one country to another. According to Sheldon (2006) there is a tendency for the country to lower their environmental regulation to outdo the other countries in order to achieve a competitive edge or using a low environmental regulation as a source of comparative advantage. This scenario is regarded as the race to the bottom. Levinson *et al.* (2003) find that despite trade among industrialised economies being on the rise, environmental regulation differences have stronger effects on the trade between industrialised and developing economies.

Despite many countries pursuing their trade liberalisation agenda there are also arguments that certain countries are purposely using their environment policy to influence international trade pattern. According to Dean (1986), there is a tendency that developed countries are using their strict environmental requirements to control the cheaper goods from the developing countries. A number of trade disputes such as the tuna-dolphin case (the United States banned Mexican tuna imports because the fishing methods resulted in incidental dolphin deaths), beef hormone dispute (the European Union has refused to adjust its 'no added hormones in beef' food safety standards despite a series of WTO rulings that its regulations had no scientific foundation and were in contravention of the rules of international trade) and the U.S. sanctions against Thai shrimp caught using methods that killed endangered sea turtles (Esty, 2001) are examples of the heightened tussles for on-going 'muscle' that consistently occupied WTO and various parties' agendas. The lengthy process settlement as well as prolonged tension between the south and the north made the differences on environmental discipline become obvious. Meanwhile, there is also an argument between countries in the north and countries in the south with regard to the responsibility to control the deforestation and preserve the natural tropical forest. The countries in the South continuously argue that because they have to preserve a large size of their forest which is not only for them but for the sake of the whole world, then the developed countries in the North should provide them with compensation. To a certain extent it seems that the developed countries are not being fair to the South. The strong pressure from developed nations is causing the South to not able to exploit their land freely for economic development. In contrast, the developed countries thought that the developing countries are not doing enough to protect the eco-system and well-being of the world.

There is also an extensive discussion on the role of environmental abundance in the form of absorptive capacity. Like labour and capital which are traditionally treated as the key production factors that influence the country's comparative advantage, the abundance of absorptive capacity may also determine the comparative advantage of the country. Hence it can alter the pattern of trade flows and this certainly influences the effect of trade on the environment. It is widely observed that this unconventional production factor provides developing countries a comparative advantage over developed countries. As articulated by the EKC, at the early stage of development the environmental degradation is expected. This is associated with the low value put on the environment which means the marginal utility is almost zero. Thus the environmental deterioration is incorrectly priced or the producer has not been obliged to internalise the cost of environment (externalities). This is known as a free ride for the producers. Essentially for producers in a pollution intensive industry the costs of production are cheaper in the developing countries which is directly facilitated them to improve their competitiveness compared to the higher cost of producing in the developed countries.

According to Ederington *et al.* (2004) in their study on U.S. manufacturing for the period 1972-1994, there is no evidence that the U.S. exports are getting cleaner and nor the U.S. imports' contents are more dirty. Also there is little evidence for factory displacement. Taylor (2001) has provided an extensive review of this trade and environment link. He states that, "PHH is at the centre of the trade and environment debate since it makes a direct link between differences across countries in their environmental regulation and trade flows....the hypothesis predicts liberalized trade in goods will lead to the relocation of pollution intensive production from high income and stringent environmental regulation countries to low income and lax environmental regulation countries." To give the insight of the hypothesis he presents it using a schematic diagram as shown by Figure 7.1 below. The analysis of the trade and environment linkage started by examining the country's characteristics such as access to the production technologies, opportunities for abatement and the country's specific endowments of production factors which influenced the level of stringency of environmental regulation in the country. Then the stringency of the environment will be passed through the production technology of the factory which constituted the essential amount of total cost. This affects the relative price among the countries which then determines the trade pattern as well as other economic commitments (variables) such as FDI. In sum, he describes that trade that alters production ultimately affects pollution, income and world prices. He goes on to suggest that "they set in motion another round of adjustment with the fixed point of this system being a general equilibrium where trade, pollution and regulatory stringency are all determined simultaneously."

Figure 7.1 : The pollution haven hypothesis unbundled



Source: Taylor (2001).

Leonard (1988), Low and Yeats (1992) and Tobey (1990) do not find any evidence to suggest that "dirty" industries move from countries with stringent environmental regulations to countries with weak regulations. Dean (1992) argues that PHH does not hold where there is a relatively low share of pollution control and abatement expenditures in total costs of production. Baumol and Oates (1988) using a simple partial equilibrium model conclude that less developed countries that choose uncontrolled domestic pollution as a means to improve their economic position will voluntarily be the repository of the world's dirty industries.

There is also another tool known as factor intensity composition (FIC) which can be used to descriptively examine how expansion of manufacturing led by trade has experienced a transformation in terms of product composition which has influenced the level of industrial pollution emission. Table 7.6 below shows the factor intensity composition of manufacturing exports for 1975, 1984 and 1990 for the country. The transition from predominant exports that are agriculture resource intensive (ARI) and unskilled labour intensive (ULI) manufactures to human capital intensive (HCI) and technology intensive (TI) manufactures can be used to support the evidence of modest impact of bilateral exports on the industrial pollution emissions. With high HCI and TI it means that the level of depending on raw materials will decrease and output per unit input will increase. This directly decreases the pollution intensity. Other than that, the transformation of the manufacturing sector is expected to be part of an economic maturity process. With the transformation, in the long term the economy will shift from a production-based economy (P-economy) to a knowledge-based economy (K-economy). Hence, implying high-technology and knowledge-based manufacturing is considered as a key for the sector to sustained and environmental friendly growth.

Table 7.6: Malaysia's Factor Intensity Composition of Manufactured Exports (%)

	1975	1984	1990
Agriculture resource	13	10	5
Mineral resource	1	2	3
Unskilled labour	52	43	32
Technology	18	27	28
Human capital	16	19	31

Source: Hajinoor and Saleh (2000)

7.6 Methodology and data

Descriptive analysis

In the literature, many different approaches of varying degrees of sophistication have been employed on the environment and trade linkages but not specifically for bilateral trade study. Despite not having a specific method to identify whether the bilateral trade with country A is more towards pollution expansion or whether trade with country B is more towards pollution contraction, several methods used in the literature were found to be workable in this research setting. For the first part of the analysis we will employ two descriptive analyses namely Pollution Terms of Trade (PTOT) and Specialization Index (SI). Despite being less scientific, both techniques are still considered sufficient to produce indicative results.

Pollution terms of trade (PTOT):

The Pollution Terms of Trade (PTOT) concept was first introduced by Antweiler (1996). This index measures the pollution content of the value of exports relative to the pollution content of the value of imports. Having a value greater than one implies that on average the pollution content of exports is greater than the pollution content of imports. We will construct this index for each Malaysian bilateral trade i.e. the PTOT of 41 bilateral trades between Malaysia and its trading countries. This study involves measuring industrial pollution emission in each industry's exports and imports with the assumption that the technologies used are the same in the selected countries in the specific sector. The findings obtained by this approach will give a broad indication about Malaysia's position with respect to being a pollution haven. The formula is shown as:

$$PTOT_{index} = \frac{Export \;\; pollution \;\; intensity}{Import \;\; pollution \;\; intensity}$$

Specialization index (SI) of pollution intensive industries:

We will also calculate the specialization index (SI) of pollution intensive industries between Malaysia and its bilateral countries. If the index is a positive value, this means that Malaysia is a net exporter of that industry, while if it is a negative, Malaysia is a net importer. In other words, Malaysia has a comparative advantage in pollution-intensive industries when the sign is positive, whereas a negative sign means the opposite. This method is similar to Low and Yeat (1992) and Mani and Wheeler (1998) but their analyses were on global trade. Here we look at the SI of 41 bilateral trades between Malaysia and its major trading partners.

Thus, following the dirty industry classification[26] of Mani and Wheeler (1997), we will compute the specialization index (SI) of each bilateral trade. The list of air pollution-intensive industries proposed by Mani and Wheeler (1997) as shown in Table 7.7 below is used for the SI computation. The previous cross-country studies show that the rank of manufacturing industries according to their pollution intensity appears to be fairly stable across countries and pollutants. The indexes will show whether the bilateral trade between Malaysia and its trading partners gained comparative advantage in pollution-intensive product during the period 1990-2006. The formula is shown as:

$$SI = \frac{X_{kt}^{i} - M_{kt}^{i}}{X_{kt}^{i} + M_{kt}^{i}}$$

Where, *k* is industry, *i* is bilateral country and *t* is a period i.e. a year of bilateral trade.

Table 7.7: Ranking of the dirtiest manufacturing industries

Rank	Air	Water	Metals	Overall
1	Iron and steel	Iron and steel	Nonferrous metals	Iron and steel
2	Nonferrous metals	Nonferrous metals	Iron and steel	Nonferrous metals
3	Non-metallic mineral	Pulp and paper	Industrial chemicals	Industrial chemicals
4	Petro. coal prod.	Misc. manufac.	Leather products	Petro. refineries
5	Pulp and paper	Industrial chemicals	Pottery	Non-metallic mineral
6	Petro. refineries	Other chemicals	Metal products	Pulp and paper
7	Industrial chemicals	Beverages	Rubber products	Other chemicals
8	Other chemicals	Food products	Electrical products	Rubber products
9	Wood products	Rubber products	Machinery	Leather products
10	Glass products	Petro. products	Non-metallic mineral	Metal products

Source: Mani and Wheeler (1997)

[26] The dirty industry classification is classified by Mani and Wheeler (1997) according to the level of pollution emitted. The highest ten polluted industries are considered as dirty industries.

Econometric model

Turning to econometric analysis, a simple specification is used to evaluate the effect of bilateral trade on the industrial air pollution emissions. The key explanatory variables include bilateral exports and a series of interactions between all bilateral exports in the sample and dummy variables for each selected bilateral trade. The capital-labour (*kl*) ratio and national income are the other explanatory variables that are included as control variables. All the variables except for the capital-labour ratio are expressed as value in the national currency, Ringgit Malaysia (in RM million). The econometric specification is shown below.

$$Expoll_{it} = \alpha_0 + \alpha_1 ex_{it} + \alpha_2 \sum_{i=n} ex_i * j_{it} + \alpha_3 y_t + \alpha_4 kl_t + e_{it} \quad (1)$$

Where, subscripts *i* and *t* denote bilateral trade and year, *Expoll* denotes industrial pollution emission induced by bilateral trade, *ex* is bilateral exports, *ex*j* are interactions of bilateral export with country dummy variables. *y* is gross national income, *kl* denotes capital-labour ratio and *e* is the error term.

Since bilateral trade tends to be influenced by unobserved or unmeasured characteristics such as different levels of political relationship, culture and history, here we use a panel of data and a fixed effects model to control for the unobserved characteristics of bilateral trade. If these are not controlled for, and are correlated with the explanatory variables of interest such as the level of exports then this could lead to a biased result. Essentially, the use of fixed effects means we are only looking at variation in exports within each bilateral trade (the unit of observation) relationship and its effects on pollution.

Using the above model, the study will be investigating the environment and trade relationship in the case of bilateral trade between Malaysia and its 41 major trading countries. The dependent variable is industrial pollution emission for four types of pollutant, namely SO2, CO, NO2 and PM. In this study, the unit of observation is the Malaysian bilateral trades. We estimate the model separately for each type of industrial pollution emission. The equation is estimated for Malaysian bilateral trades according to five regions, namely ASEAN, Europe, Indochina, South Asia and North America. The study then will also examine the top 14 Malaysian trading partners and finally Malaysian bilateral trade within region ('bilateral region') for the period 1990-2006.

Data

In the first step of this study, we need to choose the Malaysian bilateral trades that are to be examined. Factors that were taken into consideration when doing the selecting are the significance of each Malaysian bilateral trade (export value) and the composition of trading partners that constituted from various regions including ASEAN, Europe, Hindi, Indochina, North America, South America and Gulf regions. Using these considerations, a sample of 41 countries is selected from the annual average of 218 countries that Malaysia traded with between 1990 and 2006. This study is conducted for the period of 1990 to 2006 because during the period the Malaysian bilateral trades' expansion occurred rapidly. In 2006, the share of these 41 countries constituted 92 per cent of total exports. The list and the ranking of these 41 countries are shown in Table 7.8 in Appendix 2. The key data used in this study will be a detailed level of Malaysia's exports and imports with each 41 trading partners during the period of study. To remove the influence of price changes, all the data series used will be expressed in constant 2000 prices which allow for a comparison to be made among the years of the study.

The second step, using International Trade Statistics data base provided by Department of Statistics, Malaysia (DOSM) we examine and compile the annual Malaysian export and import manufacturing products at five-digit SITC for each of the 41 bilateral trades. The annual value of each export product and import product at five-digit SITC then is converted to four-digit ISIC for each bilateral trade. From the Annual Manufacturing Survey data, this study then has established the average number of employees used per unit output of four-digit ISIC. Then this annual ratio (coefficient) is applied to each bilateral exports and imports (at four-digit ISIC) which will give us the annual average number of employees used to produce product of exports (and imports) at four-digit ISIC for each bilateral trade, annually.

Then, the third step, in order to estimate the industrial pollution emissions of each bilateral exports (and imports), the yearly number of employees used to produce exports at four-digit ISIC for each bilateral trade then is applied to their respective IPPS coefficients[27] (four-digit ISIC). This gives us the amount of industrial pollution emissions for each exports (and imports) at four-digit ISIC of each bilateral trade's exports for each year. These results of estimations are then aggregated to arrive at total industrial pollution emissions (due to exports as well as imports) of each Malaysian bilateral trade. This computation is done for each of the four pollutants annually for the period of the study.

In this study because we also need to have the data according to the global region, the results of the data computation at the individual bilateral trade level will then be aggregated and grouped according to the global regions.

After the process of data computation is completed, the data will be used to estimate the effect of bilateral trade on industrial pollution emissions using the econometric model of equation (1). The estimations will be done individually for each of Malaysia's bilateral trades with the ASEAN countries and selected countries in Europe, North America, Indochina, South Asia, South America and Gulf regions, Australia and New Zealand. The separate estimates are carried-out for each of four pollutants. Generally, the selected countries are well represented regions and also vary in terms of level of development and per capita income which provides better opportunities to model Malaysia's bilateral trade effect on the environment.

Clearly, the absolute size of pollution emissions of each pollutant we obtain through this process is crucially dependent on the emission coefficients of IPPS. Essentially, data computation of detailed exports for each bilateral trade is straightforward despite its massive work process. But for industrial pollution emissions its computations are done through various proxies and assumptions which

[27] IPPS is acronym for Industrial Pollution Projection System. The IPPS coefficients are from Hettige *et al.* (1995). For the detailed explanation please refer to the Appendix 6.3 of Chapter 6.

presumably are not perfect. But in the absence of the data which is a common problem in this area of study, using this approach is needed for this research at least for this moment in time before the appropriate data are available in the future.

For the descriptive analysis, we have constructed two indicators, namely; pollution terms of trade (PTOT) and bilateral specialization index (SI). These descriptive indicators are designed to provide a broad (simple) perspective/ trend of each bilateral trade and pollution emissions relationship. This is our first examination that provides a first look at the relationship. For PTOT, using the results of our estimations of industrial pollution emissions at the aggregated bilateral level we computed the PTOT using the formula discussed earlier. This is done separately for all four pollutants for each of 41 Malaysian bilateral trades. Thus the PTOT of each pollutant of 41 bilateral trades will be examined. In the case of SI, exports and imports at 4-digit ISIC of each bilateral trade will be aggregated into two groups, which are products of pollution intensive industry (PI) and products of non-pollution intensive industry (NPI). Then using the SI formula stated earlier, we computed the SI for PI and NPI for each of 41 Malaysian bilateral trades.

7.7 Results and discussion

7.7.1 Descriptive analysis:

Our analyses started by examining the trend of products of pollution intensive industries (PI) in each Malaysian bilateral trade. The list of PI is the same as used by Mani and Wheeler (1997) as shown in Table 7.7 above. Using this classification, we have calculated the percentage of pollution intensive products (PI) in both exports and imports for each Malaysian bilateral partner. Table 7.9a & Table 7.9b show the selected results of the computation. The composition of PI of total exports to the Europe region started at high double digits then followed a lower trend in the later period. In the case of North America, its PI was initially at low single digit levels and hovers between 4.0 per cent to 5.7 per cent throughout the period. ASEAN, Indochina and South ASIA regions show higher compositions of PI throughout the period. Turning to imports, the composition of PI total imports shows mixed trends for all regions albeit generally at a higher percentage than for exports, with the South Asia region recording the highest percentage at 50.1% in 2006.

Table 7.9a: Percentage of pollution intensive products of total exports (%)

	1990	1995	2000	2006
Asean	**24.1**	**19.9**	**18.1**	**30.8**
Indonesia	42.0	31.5	43.9	50.5
Singapore	19.7	15.4	13.4	26.4
Thailand	68.8	37.0	23.2	34.8
Europe	**19.7**	**10.0**	**8.7**	**10.9**
France	18.0	6.3	7.9	3.9
Germany	6.7	7.2	8.1	9.6
Netherlands	44.0	20.6	9.2	8.5
UK	15.2	7.8	6.8	10.7
North America	**4.0**	**3.9**	**5.7**	**5.4**
Canada	6.1	2.6	7.2	12.3
USA	3.9	4.0	5.8	5.1
Indochina	**30.7**	**29.2**	**22.2**	**25.6**
China	18.7	37.4	32.4	20.8
Hong Kong	18.1	21.7	17.5	15.1
Japan	35.0	26.0	21.4	31.8
Korea	44.1	56.1	25.7	44.2
Taiwan	35.8	28.9	20.7	29.5
South Asia	**18.0**	**10.4**	**18.7**	**37.0**
India	21.0	12.4	16.4	41.5
Pakistan	5.7	3.5	9.8	24.1
Australia	42.5	27.8	19.1	27.3
Gulf	21.3	9.9	13.5	21.5
South American	4.3	13.8	17.3	22.1
ROW	14.3	11.1	17.2	21.6
Total	**19.6**	**16.3**	**14.8**	**20.6**

Table 7.9b: Percentage of pollution intensive products of total imports (%)

	1990	1995	2000	2006
Asean	**44.6**	**27.7**	**27.4**	**37.4**
Indonesia	56.1	47.5	42.1	46.8
Singapore	48.5	28.5	30.1	44.9
Thailand	14.2	16.2	23.0	25.9
Europe	**40.9**	**23.8**	**24.9**	**27.4**
France	42.3	9.2	12.5	13.7
Germany	28.3	16.5	19.9	14.3
Netherlands	32.5	33.0	29.7	33.7
UK	56.0	32.5	19.2	30.8
North America	**16.8**	**16.5**	**12.1**	**14.2**
Canada	67.0	68.5	55.8	43.7
USA	14.4	14.8	11.2	13.2
Indochina	**23.8**	**23.0**	**19.9**	**20.9**
China	36.3	34.6	17.5	14.8
Hong Kong	20.4	17.6	9.2	7.1
Japan	22.4	20.4	20.2	28.7
Korea	33.4	30.3	27.5	20.1
Taiwan	23.3	28.7	19.2	22.0
South Asia	**25.6**	**41.9**	**31.1**	**50.1**
India	19.7	41.3	32.0	51.7
Pakistan	51.2	61.9	26.8	26.0
Australia	55.7	55.6	48.1	63.5
Gulf	97.8	89.9	95.4	96.5
South American	83.9	71.6	69.9	69.6
ROW	61.4	41.5	21.5	25.6
Total	**32.2**	**24.6**	**22.1**	**27.1**

We then pursue our investigation by looking at export-import ratios of pollution intensive products for each bilateral trade. The selected ratios are shown in Table 7.10 below. As can be seen, all regions registered export-import ratio less than one except for ASEAN and South Asia regions. It means that overall Malaysian bilateral trade with Europe, North America, Indochina, Gulf and South America shows that imports of PI products exceed exports of PI products.

Table 7.10: Export- import ratios of pollution intensive products (PI)

	1990	1995	2000	2006
Asean	**0.6**	**1.0**	**0.9**	**1.1**
Indonesia	0.6	0.6	0.7	0.9
Singapore	0.5	0.8	0.7	0.9
Thailand	4.4	2.8	1.1	1.5
Europe	**0.4**	**0.3**	**0.5**	**0.5**
France	0.4	0.2	0.3	0.3
Germany	0.2	0.3	0.4	0.4
Netherlands	4.3	2.0	2.3	1.6
UK	0.2	0.3	0.7	0.5
North America	**0.2**	**0.3**	**0.7**	**0.7**
Canada	0.1	0.1	0.3	0.5
USA	0.3	0.3	0.8	0.7
Indochina	**0.5**	**0.6**	**0.8**	**0.8**
China	0.5	1.2	1.7	1.0
Hong Kong	1.4	2.9	3.7	4.9
Japan	0.4	0.4	0.6	0.6
Korea	0.8	0.8	0.5	1.0
Taiwan	0.3	0.5	0.7	0.6
South Asia	**1.8**	**0.7**	**1.8**	**2.5**
India	1.4	0.4	1.1	1.8
Pakistan	0.6	0.6	2.9	17.5
Australia	0.3	0.3	0.6	0.8
Gulf	0.7	0.7	0.4	0.5
South American	0.0	0.3	0.4	0.3
ROW	0.3	0.3	0.7	1.5
Total	**0.5**	**0.6**	**0.8**	**0.9**

Meanwhile, as shown in Table 7.11 below, during the period 1990-2006 the growth of exports of pollution intensive products (XPI) is higher than the growth of exports of non-pollution intensive products (XNPI) for bilateral trade with ASEAN (except Thailand), South Asia, North America, Gulf and South American regions, while Europe, Australia and Indochina are on the opposite. On the other hand, during the same period the growth of imports of pollution intensive products (MPI) is lower than the growth of imports of non pollution intensive products (MNPI) for all regions (countries) except South Asia region.

Table 7.11: Growth over the period of study PI and NPI (%)

	XPI	XNPI	MPI	MNPI
Asean	**964**	**659**	**517**	**730**
Indonesia	2929	2051	1810	2667
Singapore	725	463	337	404
Thailand	934	4170	2892	1321
Europe	**255**	**616**	**191**	**434**
France	62	781	113	878
Germany	491	300	214	642
Netherlands	117	1750	479	450
UK	152	279	-15	145
North America	**1107**	**776**	**286**	**370**
Canada	1156	485	122	483
USA	1060	774	318	364
Indochina	**890**	**1176**	**480**	**587**
China	3779	3303	2038	6884
Hong Kong	921	1165	197	891
Japan	551	651	329	208
Korea	827	821	671	1435
Taiwan	940	1286	475	519
South Asia	**2097**	**720**	**1426**	**422**
India	3078	1089	2318	455
Pakistan	2072	312	-22	132
Australia	747	1564	241	146
Gulf	1230	1213	2042	3403
South American	81347	12788	414	1070
ROW	1278	737	186	1221
Total	**853**	**797**	**397**	**534**

We then proceed by comparing the growth of the bilateral exports and growth of each type of pollution emission for the period of study as shown in Table 7.12a below. It shows that even though the growth of bilateral exports with countries in the Europe region had increased more than two-fold, the growth of the industrial pollution emissions due to the exports are much lower and in fact there are negative growths for SO2 and CO. With the exception of South America, the other regions also show a similar trend. Meanwhile in the case of imports as shown in Table 7.12b, all the regions as well as the overall (total) show growth in its industrial pollution emissions are much lower than the growth of the bilateral imports during the period. The most striking trend is negative growth of all four pollutants compared to its corresponding imports for Europe and North America regions.

Table 7.12a: Growth over the period of study for exports and emissions (%)

	Exports	SO2	CO	NO2	PM
Asean	**358**	**89**	**83**	**153**	**69**
Indonesia	1284	465	389	416	514
Singapore	237	29	24	81	-19
Thailand	1023	251	162	207	389
Europe	**253**	**-22**	**-30**	**65**	**130**
France	313	-65	-71	-33	0
Germany	127	46	44	95	46
Netherlands	522	-60	-70	45	121
UK	98	11	5	27	-23
North America	**388**	**51**	**96**	**196**	**163**
Canada	244	22	115	218	133
USA	387	52	89	197	212
Indochina	**553**	**96**	**101**	**177**	**130**
China	1819	577	711	478	214
Hong Kong	571	189	92	132	40
Japan	293	3	53	89	61
Korea	408	66	74	162	21
Taiwan	594	106	107	225	106
South Asia	**486**	**68**	**98**	**173**	**61**
India	783	69	126	253	14
Pakistan	181	40	128	82	34
Australia	624	108	106	196	271
Gulf	624	343	278	283	274
South American	8604	21449	31347	22978	91841
ROW	403	96	3	128	87
Total	**398**	**72**	**66**	**154**	**111**

Table 7.12b: Growth over the period of study for imports and emissions (%)

	Imports	SO2	CO	NO2	PM
Asean	**635**	**3**	**9**	**48**	**129**
Indonesia	2186	773	541	281	926
Singapore	372	-52	-51	-7	-47
Thailand	1544	487	546	354	259
Europe	**335**	**-57**	**-53**	**-37**	**-34**
France	554	-73	-70	-55	-64
Germany	521	7	2	-29	-17
Netherlands	460	-10	-9	-7	6
UK	55	-89	-89	-79	-82
North America	**356**	**-18**	**-27**	**-44**	**-20**
Canada	241	-72	-74	-69	-57
USA	357	-6	-16	-39	-13
Indochina	**562**	**58**	**57**	**17**	**66**
China	5126	561	525	321	245
Hong Kong	750	-30	-34	-27	-5
Japan	235	35	27	-23	20
Korea	1179	68	79	80	99
Taiwan	509	26	48	2	140
South Asia	**679**	**362**	**386**	**94**	**205**
India	822	395	405	176	201
Pakistan	53	-60	-54	-82	392
Australia	199	-37	-37	-39	-26
Gulf	2072	122	130	273	152
South American	519	390	205	187	26
ROW	586	-52	-72	-34	25
Total	**490**	**-12**	**-11**	**2**	**34**

The pollution terms of trade (PTOT) index has been computed for each one of 41 countries, from 1990 to 2006. The index is defined as a ratio of the average pollution content per value of exports over the average pollution content per value of imports. A PTOT less than one means Malaysia's bilateral exports to the particular country on average have a lower pollutant emissions content compared to its imports from the country. The PTOT indexes for 35 countries are presented in Table 7.13a to Table 7.13d below where we examine the indexes according to region. Table 7.13a shows the index for selected countries (main trading partners) in our study. Malaysia's bilateral trades with countries such as China, Thailand, Netherland, Hong Kong and India largely indicate that on average Malaysian exports contain more pollution relative to its imports of products for all the four pollutants, except for PM in the case of Thailand and CO of India. However bilateral trades with countries such as Indonesia, Singapore, Germany, UK, the USA (except PM), Japan, Korea, Taiwan and Australia have the opposite outcome. The results of this descriptive analysis show that with a few exceptions, the overall trend of Malaysia's bilateral trades with developed countries (except Netherlands) is to emit less pollution emissions compared to the bilateral trade with developing countries (except Indonesia). These results suggest that the theoretical concerns that developed countries are more likely using developing countries to outsource the production of dirty products is not unchallenged. In sum, prior expectation that Malaysia's trade liberalisation with advanced economies will cause more environment deterioration seems groundless.

Table 7.13a: Annual average PTOT of selected countries, 1990-2006

Country	SO2	CO	NO2	PM
China	1.28	1.10	1.72	5.30
Indonesia	0.35	0.27	0.43	0.31
Singapore	0.63	0.69	0.74	2.83
Thailand	1.07	1.34	1.03	0.77
Germany	0.33	0.22	0.32	0.93
Netherlands	2.06	1.64	2.13	12.71
UK	0.12	0.17	0.45	0.71
USA	0.42	0.36	0.52	1.21
Hong Kong	1.18	1.60	3.40	4.93
Japan	0.33	0.36	0.49	0.43
Korea	0.53	0.57	0.80	0.97
Taiwan	0.44	0.52	0.55	0.61
India	1.84	0.85	1.77	7.61
Australia	0.16	0.22	0.68	0.97

Table 7.13b shows specifically the PTOT with ASEAN countries. Brunei, Cambodia and Myanmar registered relatively higher PTOT compared to other countries for all four pollutants, while Indonesia, Singapore (except PM) and Laos (for SO2 and CO) have PTOT less than one for all the four pollutants. PTOT for the Philippines, Thailand (except PM) and Vietnam are all more than one but its size is not high. In sum, despite not having ample evidence to show a specific trend, we still can see a pattern that bilateral trade with certain developed and middle income countries such as Singapore and Indonesia recorded low (less than one) PTOT while

bilateral trade with less developed countries register much higher PTOT. One would not be wrong to suggest that most of Malaysia's bilateral exports to ASEAN nations exhibit relatively higher pollution content than its imports for all four pollutants.

Table 7.13b: Annual average PTOT of ASEAN countries, 1990-2006

Country	SO2	CO	NO2	PM
Brunei	15.21	22.46	51.62	89.57
Cambodia	18.36	8.85	16.33	23.39
Indonesia	0.35	0.27	0.43	0.31
Laos	0.11	0.09	1.05	1.67
Myanmar	17.14	7.36	18.07	68.01
Philippines	1.17	1.59	3.20	2.14
Singapore	0.63	0.69	0.74	2.83
Thailand	1.07	1.34	1.03	0.77
Vietnam	1.80	2.28	6.96	6.19

In the case of Malaysian bilateral trade with selected European countries, almost all the countries recorded PTOT less than one for the first three emissions (SO2, CO and NO2). Only Denmark (except CO), Hungary (except CO and PM), Ireland (for CO), Netherlands and Spain (for SO2) have PTOT greater than one, implying that the pollution content of exports is greater than the pollution content of imports from these trading partners. For PM, only Belgium, Finland, France, Germany, Switzerland and UK recorded PTOT less than one while the other eight countries have a PTOT greater than one. The detail is shown in Table 7.13c below. Thus other than the exceptions, Malaysian exports seems to produce less pollution than its imports when trading with these selected European nations.

Table 7.13c: Annual average PTOT of selected European countries, 1990-2006

Country	SO2	CO	NO2	PM
Belgium	0.51	0.75	0.51	0.43
Denmark	1.26	0.97	1.33	13.21
Finland	0.03	0.02	0.02	0.03
France	0.21	0.22	0.28	0.25
Germany	0.33	0.22	0.32	0.93
Hungary	1.20	0.65	1.16	2.21
Ireland	0.58	1.09	0.66	1.31
Italy	0.69	0.48	0.70	1.56
Netherlands	2.06	1.64	2.13	12.71
Russia	0.29	0.13	0.29	1.25
Spain	1.01	0.40	0.53	1.76
Sweden	0.25	0.08	0.18	1.64
Switzerland	0.04	0.04	0.07	0.08
United Kingdom	0.12	0.17	0.45	0.71

Table 7.13d below shows the PTO for Malaysian bilateral trade with selected countries in the North America, Indochina and South Asia regions. For the North American region among the three countries only Mexico recorded PTOT greater than one for all the four emissions which implies that pollution content in exports is higher compared to its imports, while Malaysian bilateral trade with USA recorded PTOT greater than one for PM despite having PTOT less than one for the other three emissions. In the case of the Indochina region, Malaysia is exporting more clean goods and importing more dirty goods from Japan, Korea and Taiwan as shown by the evidence of PTOT that are less than one for all the four emissions. Exports to those countries are mainly semiconductor products, electronic and electrical products and accessories. From this, one may imply that Malaysia is not a pollution haven for these three countries. However, the opposite scenario is shown for China and Hong Kong. Finally, with the exception of CO for India, all four countries in the South Asia region recorded PTOT greater than one which implies that Malaysia is exporting more dirty goods and importing clean goods from those countries.

Table 7.13d: Annual average PTOT of North America, Indochina and South Asia countries, 1990-2006

Country	SO2	CO	NO2	PM
North America				
Canada	0.17	0.15	0.17	0.48
Mexico	1.62	1.19	1.63	2.39
USA	0.42	0.36	0.52	1.21
Indochina				
China	1.28	1.10	1.72	5.30
Hong Kong	1.18	1.60	3.40	4.93
Japan	0.33	0.36	0.49	0.43
Korea	0.53	0.57	0.80	0.97
Taiwan	0.44	0.52	0.55	0.61
South Asia				
Bangladesh	62.42	42.20	45.93	560.35
India	1.84	0.85	1.77	7.61
Pakistan	34.68	14.02	7.62	280.27
Sri Lanka	34.16	42.97	42.86	399.39

With regards to the specialization index (SI) computation, the results are presented in Table 7.14a and 7.14b. As discussed earlier, a positive SI means that the country is a net exporter of the group of products (PI or NPI) and a negative SI means a net importer. The selected countries' specialization indexes are shown in Table 7.14a below. In the case of bilateral trades that involved pollution intensive (PI) industries, with the exception of Hong Kong and Netherlands, all the other countries that show negative SI are Malaysia's bilateral trades with nations from the developed country categories (except Indonesia). Positive SI's that involved 27 countries mostly come from Malaysia's bilateral trade with a group of developing countries. Thus, there is a compelling (overwhelming) overall trend which shows that the expansion of Malaysian bilateral trade with developing countries such as with China, India and Pakistan leads to Malaysia specializing more on dirty industry while trades with advanced economies such as Germany, Japan and the US shows the opposite. This result is actually consistent with the PTOT analysis discussed earlier.

Table 7.14a: Annual average SI of selected countries, 1990-2006

Country	SI		
	PI	NPI	All
China	0.22	-0.16	-0.07
Indonesia	-0.23	-0.10	-0.15
Singapore	-0.15	0.31	0.20
Thailand	0.16	-0.01	0.03
Germany	-0.50	-0.12	-0.17
Netherlands	0.31	0.75	0.68
UK	-0.37	0.29	0.17
USA	-0.28	0.22	0.18
Hong Kong	0.55	0.38	0.41
Japan	-0.30	-0.37	-0.35
Korea	-0.12	-0.44	-0.35
Taiwan	-0.18	-0.22	-0.21
India	0.11	0.44	0.35
Australia	-0.25	0.31	0.10

Table 7.14b: Annual average SI, 1990-2006

Country	SI		
	PI	NPI	All
Asean			
Brunei	0.94	0.96	0.96
Cambodia	0.80	0.93	0.90
Indonesia	-0.23	-0.10	-0.15
Laos	-0.49	0.96	0.28
Myanmar	0.82	0.85	0.84
Philippines	0.57	-0.33	-0.20
Singapore	-0.15	0.31	0.20
Thailand	0.16	-0.01	0.03
Vietnam	0.74	0.34	0.52
Europe			
Belgium	-0.26	0.50	0.31
Denmark	-0.15	0.10	0.06
Finland	-0.92	0.32	-0.02
France	-0.59	-0.04	-0.10
Germany	-0.50	-0.12	-0.17
Hungary	-0.21	0.78	0.73
Ireland	-0.31	-0.23	-0.23
Italy	-0.38	-0.20	-0.24
Netherlands	0.31	0.75	0.68
Russia	-0.77	0.82	-0.18
Spain	-0.49	0.58	0.32
Sweden	-0.80	-0.47	-0.52
Switzerland	-0.90	-0.58	-0.74
United Kingdom	-0.37	0.29	0.17
North America			
Canada	-0.61	0.54	0.28
Mexico	0.07	0.69	0.65
USA	-0.28	0.22	0.18
Indochina			
China	0.22	-0.16	-0.07
Hong Kong	0.55	0.38	0.41
Japan	-0.30	-0.37	-0.35
Korea	-0.12	-0.44	-0.35
Taiwan	-0.18	-0.22	-0.21
South Asia			
Bangladesh	0.96	0.91	0.93
India	0.11	0.44	0.35
Pakistan	0.54	0.90	0.85
Sri Lanka	0.97	0.82	0.87

Based on the descriptive computations, there are three findings that have to be taken noted of. Firstly, these simple indicators reveal that Malaysian bilateral trades either with developing or developed economies do not support PHH and Malaysia does not use less developed countries as pollution havens. Secondly, if we compare the pattern of SO2 industrial emissions that have arisen from Malaysia's bilateral trade with European countries and Malaysia's bilateral trade with ASEAN countries, the pattern of SO2 industrial emissions for ASEAN countries show a relatively higher level. Thirdly, examinations according to the four pollutants show that SO2, CO and NO2 emissions generally provide the similar trends in each discussion above while for PM it is seen to deviate from the other three emissions.

7.7.2 Econometric analysis

In the following section, the study will analyse the results of the econometric model equation (1). As discussed earlier in this study we apply fixed effect panel data. The estimations are performed separately for all four industrial pollution emissions. Our discussion is according to region, starting with ASEAN, followed by European, Indochina, South Asia and North American countries. Apart from that the study will also discuss the estimations in the case of selected countries and groups of countries by region.

Essentially, the econometric analysis based on fixed effects is employed where we are only looking at variation in exports within each bilateral trade relationship and its effects on pollution. The estimated coefficients measure the effect of each bilateral trade on the pollutant. Hence we are interested in examining whether Malaysia's bilateral trade with its trading partners will lead to more pollution or otherwise. In other words, the model will show us how the environmental impact of Malaysia bilateral exports to each trading partner is different or otherwise. Following the PHH argument, we expect that Malaysia's bilateral trade with developed economies causes more environmental degradation in comparison to Malaysia's bilateral trade with less developed economies. In sum, we should expect that the variation of trade patterns across bilateral trades which is associated with the countries' characteristics will affect the local pollution differently.

7.7.2a Malaysian bilateral trade with ASEAN countries

Using the econometric model as shown in equation (1) we examine the effect of the bilateral exports between Malaysia and nine countries in the ASEAN region on four industrial pollution emissions separately. The countries involved are, Thailand (tha), Brunei (bru), Cambodia (cam), Indonesia (ido), Laos (lao), Myanmar (mya), Philippines (phi), Singapore (sin) and Vietnam (vie). The other countries are grouped as the rest of the world (rowas). Table 7.15 below shows the results of the estimations. Using bilateral exports to Thailand as the reference, the results show that increases in exports to Thailand increase emissions of all the four pollutants. A similar pattern is shown for bilateral exports to Indonesia (except PM), Myanmar (except SO2 and NO2), and Vietnam. However the opposite trend is seen for Brunei, Cambodia, Laos, Singapore and Philippines (except CO). Among all these countries only Singapore is considered as a more advanced country relative to Malaysia while the rest are considered on a par or lower relative to Malaysia in terms of their level of development and economic achievement. It is worth highlighting that the increase in exports to developed country i.e. Singapore did not lead to increased pollution emissions. In the case of Thailand, Indonesia (except PM), Myanmar (except SO2 and NO2), and Vietnam despite their status as developing countries, increasing exports led to increases in pollution emissions. These results suggest that there is no comprehensive evidence showing that Malaysian bilateral exports with ASEAN countries caused rapid pollution emissions and vice versa. It is also worth noting, that Malaysia's bilateral exports to Thailand (except PM) provides a statistically significant coefficient, while only the effects for Singapore, Indonesia (for NO2) and Vietnam (for CO and NO2) are statistically significantly different to those for Thailand.

Table 7.15: Determinants of export industrial pollution emissions (the four pollutants) employed interaction for ASEAN countries (Thailand as a reference)

FE	SO2		CO		NO2		PM	
a_1ex	0.495	***	0.290	***	0.200	***	0.030	
	(0.084)		(0.041)		(0.024)		(0.019)	
$a_2ex*bru$	-1.86		-0.78		-0.79		-0.40	
	(2.06)		(1.02)		(0.60)		(0.48)	
$a_3ex*cam$	-3.04		-1.08		-1.47		-0.94	
	(4.88)		(2.42)		(1.41)		(1.14)	
$a_4ex*ido$	0.21		0.16		0.15	**	-0.05	
	(0.20)		(0.10)		(0.06)		(0.05)	
$a_5ex*lao$	-67.2		-22.6		-30.0		-21.2	
	(92.8)		(46.0)		(26.8)		(21.6)	
$a_6ex*mya$	-0.054		0.575		-0.243		0.013	
	(2.63)		(1.30)		(0.76)		(0.61)	
$a_7ex*phi$	-0.046		0.028		-0.030		-0.013	
	(0.273)		(0.135)		(0.079)		(0.064)	
$a_8ex*sin$	-0.525	***	-0.321	***	-0.137	***	-0.044	**
	(0.087)		(0.043)		(0.025)		(0.020)	
$a_9ex*vie$	0.209		0.333	*	0.179	*	0.073	
	(0.362)		(0.179)		(0.105)		(0.084)	
$a_{10}ex*rowas$	-0.363	***	-0.221	***	-0.112	***	0.010	
	(0.084)		(0.042)		(0.024)		(0.020)	
$a_{11}gni$	0.012	***	0.003	***	0.003	***	0.003	***
	(0.002)		(0.001)		(0.001)		(0.0005)	
$a_{12}kl$	-2300	***	-509	**	-249	*	-598	***
	(518)		(257)		(150)		(121)	
$a_{13}cons$	7988	***	3029	***	1388	***	1627	***
	(122)6		(607)		(355)		(285)	
R^2(within)	0.2569		0.2624		0.5552		0.2871	
R^2(between)	0.0745		0.0421		0.5913		0.0668	
R^2(overall)	0.0958		0.0616		0.5252		0.1227	
corr	0.0505		0.0101		0.4280		-0.0995	
observations	714		714		714		714	
num. of groups	42		42		42		42	

Note: For all of results in the tables, significance at 99 per cent, 95 per cent and 90 per cent confidence levels is donated by ***, ** and * respectively. Standard errors are reported in parenthesis.

Close examination of bilateral trade by regions has shown that bilateral trade with countries in the ASEAN region causes increased pollution emissions. This evidence has confirmed our expectation that the products traded between the countries have high pollution exposure. This is due the fact that apart from

Singapore, other ASEAN nations are deeply dependent on resource- based economic activities and the study anticipated that the region's comparative advantage is on resource-based and labour-intensive industry. The annual average of Malaysian manufacturing exports to the ASEAN region is RM 67,009 millions of which 23 per cent was contributed by dirty industries. On the other hand, Malaysian manufacturing imports from the region is at RM 16,094 millions and the share of dirty industries stood at 31 per cent. Apart from bilateral trade with Singapore, the composition of bilateral trade with ASEAN countries is skewed towards resource based products.

7.7.2b Malaysian bilateral trade with European countries

Malaysia's bilateral trades with European countries has increased rapidly since the late 1990s. For this study 14 countries that Malaysia traded with substantially over the period of the study are chosen. The countries involved are, Germany (ger), Belgium (bel), Denmark (den), Finland (fin), France (fra), Hungary (hun), Ireland (ire), Italy (ita), Netherland (net), Russia (rus), Spain (spa), Sweden (swe), Switzerland (swi) and the UK. The other countries are grouped as the rest of the world (roweu). Electrical and electronics products are Malaysia's main exports to those countries, for which the lowest is 30 percent for Denmark and the highest is 91 per cent for Hungary. Other than that, food, beverages, tobacco, textiles, wearing apparel, non-metallic mineral products, and metal products are also key products that were exported from Malaysia to those countries.

The result of estimating model (1) is presented in Table 7.16 below. It shows that although none of the coefficients are statistically significant except Netherlands (for PM), the negative sign for most of the coefficients (except Russia for CO, NO2 and PM, Netherlands for NO2 and PM), indicates that Malaysian exports to European countries largely lead to a decrease in all the four industrial pollution emissions. But because the coefficients of the estimations are statistically insignificant, we can only conclude that there is no statistical evidence that Malaysia's bilateral trades with countries in the European region increases industrial pollution emissions (except Netherlands for PM). This result is not unexpected because the main composition of products exported to European countries are electrical and electronics product which are less pollution intensive industry as well as labour intensive.

Table 7.16: Determinants of export industrial pollution emissions (the four pollutants) employed interaction for selected European countries (Germany as a reference)

FE	SO2	CO	NO2	PM
$\alpha_{1}ex$	-0.190	-0.132	-0.031	-0.016
	(0.246)	(0.123)	(0.071)	(0.057)
$\alpha_{2}ex*bel$	-0.041	-0.238	-0.141	-0.004
	(0.889)	(0.443)	(0.258)	(0.207)
$\alpha_{3}ex*den$	-2.180	-1.027	-0.879	-0.275
	(2.327)	(1.161)	(0.676)	(0.543)
$\alpha_{4}ex*fin$	-1.047	-0.443	-0.476	-0.256
	(1.009)	(0.503)	(0.293)	(0.235)
$\alpha_{5}ex*fra$	-0.295	-0.140	-0.143	-0.068
	(0.371)	(0.185)	(0.108)	(0.087)
$\alpha_{6}ex*hun$	-0.877	-0.375	-0.428	-0.225
	(0.996)	(0.497)	(0.289)	(0.232)
$\alpha_{7}ex*ire$	-0.421	-0.207	-0.269	-0.103
	(0.924)	(0.461)	(0.268)	(0.216)
$\alpha_{8}ex*ita$	-0.731	-0.200	-0.195	-0.016
	(0.888)	(0.443)	(0.258)	(0.207)
$\alpha_{9}ex*net$	-0.177	-0.168	0.068	0.126 **
	(0.261	(0.130	(0.076	(0.061
$\alpha_{10}ex*rus$	-0.034	0.198	0.018	0.325
	(1.105)	(0.551)	(0.321)	(0.258)
$\alpha_{11}ex*spa$	-0.583	-0.259	-0.264	-0.096
	(0.842)	(0.420)	(0.245)	(0.197)
$\alpha_{12}ex*swe$	-2.102	-1.128	-0.792	-0.196
	(2.036)	(1.016)	(0.592)	(0.475)
$\alpha_{13}ex*swi$	-2.102	-1.128	-0.792	-0.196
	(2.036)	(1.016)	(0.592)	(0.475)
$\alpha_{14}ex*uk$	-0.043	-0.020	-0.037	-0.035
	(0.331)	(0.165)	(0.096)	(0.077)
$\alpha_{15}ex*roweu$	0.283	0.178	0.111	0.041
	(0.245)	(0.122)	(0.071)	(0.057)
$\alpha_{16}gni$	0.015 ***	0.005 ***	0.003 ***	0.004 ***
	(0.002)	(0.001)	(0.001)	(0.001)
$\alpha_{17}kl$	-2138.8 ***	-387.9	-198.7	-584.0 ***
	(534.9)	(266.8)	(155.4)	(124.8)
$\alpha_{18}cons$	7361.6 ***	2595.8 ***	1193.9 ***	1582.2 ***
	(1262.3)	(629.6)	(366.7)	(294.6)
R^2(within)	0.2257	0.2214	0.5329	0.2535
R^2(between)	0.4615	0.3280	0.6873	0.2925
R^2(overall)	0.3416	0.2686	0.5973	0.2661
corr	0.4054	0.3349	0.5104	0.1781
observations	714	714	714	714
num. of groups	42	42	42	42

7.7.2c Malaysian bilateral trade with Indochina countries

The growing Chinese economy since its inception in the World Trade Organization (WTO) in 2001 has had a major impact on the pattern of world trade. The rise of China in the global economy and the rapid economic expansion of Japan, Korea, Hong Kong and Taiwan made the Indochina region a key contributor to global trade especially for electrical and electronics products. The volume and speed of international trade liberalisation has drastically changed since then. The world's trade expansion during the 1980-1990s period has seen many Indochina countries experience economic prosperity. Malaysia which has strong economic and culture ties with Indochina countries was also caught in the economic spillover from Indochina's economic boom. The amount of trade between Malaysia and Indochina countries has grown enormously since 1990 onwards. In 1990, the total trade between Malaysia and Indochina countries was RM 30,800 millions and surged to RM 242,525 millions in 2006. The main goods imported by Indochina countries from Malaysia are electrical and electronics products, food, beverages and tobacco, agriculture and resource based products such as oil palm, and chemicals and pharmaceutical products. Malaysia's imports from Indochina countries are mostly electrical and electronics products, and machinery and equipment.

Table 7.17 shows the results of estimations of Model (1) which provides the interactions for selected Indochina countries. Other countries are grouped as the rest of the world (rowin). The interaction coefficient measures the effect in the relevant country relative to the effect in China. It shows that except in the case of CO emission for Korea, all the coefficients are statistically significant. As can be seen, increases in Malaysian bilateral exports to China (chi) will lead to a rise in all four industrial pollution emissions. The effect of rising Malaysian bilateral exports to Hong Kong (hk), Japan (jap), Korea (ko) and Taiwan (tai) is more moderate. For example, in case of SO2 the effect is small and positive for Hong Kong and Korea while for Japan and Taiwan is marginally negative. For CO and NO2 industrial pollution emissions, the effect is positive for all bilateral trade except Taiwan (for CO). For PM industrial pollution emission, the effect is essentially zero for Hong Kong, Korea and Taiwan. Other than that, the positive effect in case of Japan is much lower than China.

Table 7.17: Determinants of export industrial pollution emissions (the four pollutants) employed interaction for Indochina countries (China as a reference)

FE	SO2		CO		NO2		PM	
a_1ex	0.707	***	0.203	***	0.273	***	0.183	***
	(0.048)		(0.027)		(0.013)		(0.011)	
a_2ex*hk	-0.557	***	-0.186	***	-0.232	***	-0.185	***
	(0.076)		(0.042)		(0.021)		(0.017)	
$a_3ex*jap$	-0.732	***	-0.088	***	-0.132	***	-0.167	***
	(0.068		(0.037		(0.019		(0.015	
a_4ex*ko	-0.564	***	-0.140		-0.166	***	-0.188	***
	(0.168)		(0.093)		(0.047)		(0.038)	
$a_5ex*tai$	-0.723	***	-0.257	***	-0.200	***	-0.192	***
	(0.138)		(0.077)		(0.039)		(0.031)	
$a_6ex*rowin$	-0.651	***	-0.173	***	-0.207	***	-0.166	***
	(0.050)		(0.027)		(0.014)		(0.011)	
a_7gni	0.013	***	0.004	***	0.003	***	0.003	***
	(0.002)		(0.001)		(0.001)		(0.000)	
a_8kl	-2142	***	-468	*	-222	*	-556	***
	(479)		(266)		(133)		(108)	
a_9cons	7618	***	2846	***	1312	***	1553	***
	(1132)		(628)		(315)		(255)	
$R^{2(}within)$	0.3599		0.2040		0.6446		0.4252	
$R^{2(}between)$	0.2107		0.5531		0.7365		0.3933	
$R^2(overall)$	0.1959		0.3562		0.6274		0.3718	
corr	0.1844		0.4734		0.5319		0.2181	
observations	714		714		714		714	
num. of groups	42		42		42		42	

7.7.2d Malaysian bilateral trade with North America countries

The characteristics of product traded between Malaysia and North American countries are mainly influenced by the presence of multinational companies especially in electrical and electronics industry. The result of estimating model (1) with interactions for the three North American countries (U.S., Canada (can) and Mexico (mex)) is presented in Table 7.18. Other countries are grouped as the rest of the world (rowno). The interaction coefficient measures the effect in the relevant country relative to the effect in U.S. The result shows that it is only Malaysian bilateral exports with the U.S. that has a positive relationship and it is statistically significant for all four industrial pollution emissions. However the size of its coefficients is small compared to the size of China's coefficients as shown in previous discussion. Hence, while increases in Malaysia's exports to the U.S can increase the industrial emissions, its effect is rather weak. Meanwhile, the effect of Malaysian bilateral exports with Canada and Mexico is negative though statistically insignificant for all the four emissions.

Table 7.18: Determinants of export industrial pollution emissions (the four pollutants) employed interaction for North America countries (USA as a reference)

FE	SO	CO	NO	PM
$\alpha_1 ex$	0.056 ***	0.045 ***	0.048 ***	0.016 ***
	(0.021)	(0.011)	(0.006)	(0.005)
$\alpha_2 ex*can$	-0.369	-0.034	-0.037	-0.082
	(0.740)	(0.380)	(0.202)	(0.171)
$\alpha_3 ex*mex$	-0.566	-0.191	-0.163	-0.207
	(0.654)	(0.336)	(0.178)	(0.151)
$\alpha_4 ex*rowno$	0.085 ***	0.002	0.078 ***	0.022 ***
	(0.029)	(0.015)	(0.008)	(0.007)
$\alpha_5 gni$	0.013 ***	0.004 ***	0.002 ***	0.003 ***
	(0.002)	(0.001)	(0.001)	(0.001)
$\alpha_6 kl$	-2337.2 ***	-514.7 *	-281.5 *	-601.1 ***
	(535.3)	(274.7)	(145.9)	(123.8)
$\alpha_7 cons$	7938.6 ***	2920.3 ***	1446.5 ***	1630.1 ***
	(1265.4)	(649.4)	(344.9)	(292.7)
R^2(within)	0.1973	0.1457	0.5737	0.2398
R^2(between)	0.9335	0.6923	0.9226	0.3132
R^2(overall)	0.5714	0.4133	0.7837	0.2737
corr	0.6796	0.5590	0.7275	0.2008
observations	714	714	714	714
num. of groups	42	42	42	42

7.7.2e Malaysian bilateral trade with South Asia countries

Table 7.19 presents the estimations of the effect of Malaysian bilateral exports with four South Asia countries, namely, India (ind), Bangladesh (ban), Pakistan (pak) and Sri Lanka (sri). Other countries are grouped as the rest of the world (rowhi). The interaction coefficient measures the effect in the relevant country relative to the effect in India. It is shown that amongst the four countries, we only find statistical evidence in the case of Malaysian bilateral exports to India where rising exports leads to a rise in all four pollution emissions. In comparison, the size of the effect is much bigger compared to the case of the U.S. as shown above.

Table 7.19: Determinants of export industrial pollution emissions (the four pollutants) employed interaction for South Asia countries (India as a reference)

FE	SO		CO		NO		PM	
a_1ex	0.703	***	0.211	*	0.380	***	0.278	***
	(0.213)		(0.109)		(0.061)		(0.049)	
$a_2ex*ban$	-0.629		-0.592		-0.244		0.134	
	(1.257)		(0.643)		(0.361)		(0.287)	
$a_3ex*pak$	-0.895		-0.297		-0.367		-0.300	
	(0.887)		(0.454)		(0.254)		(0.203)	
$a_4ex*sri$	-1.284		-0.367		-0.523		-0.211	
	(2.036)		(1.041)		(0.584)		(0.465)	
$a_5ex*rowhi$	-0.607	***	-0.165		-0.296	***	-0.251	***
	(0.213)		(0.109)		(0.06)1		(0.049)	
a_6gni	0.014	***	0.004	***	0.003	***	0.003	***
	(0.002)		(0.001)		(0.001)		(0.001)	
a_7kl	-2342	***	-518.6	*	-277.1	*	-604.8	***
	(536.6)		(274.5)		(153.9)		(122.6)	
a_8cons	7949	***	2935	***	1416	***	1651	***
	(1268)		(649)		(364)		(290)	
$R^{2(}within)$	0.1954		0.1490		0.5268		0.2563	
$R^{2(}between)$	0.6611		0.6443		0.6724		0.2768	
$R^2(overall)$	0.4053		0.3902		0.5817		0.2560	
corr	0.5133		0.5339		0.4998		0.1687	
observations	714		714		714		714	
num. of groups	42		42		42		42	

7.7.2f Malaysian bilateral trade with selected countries

Table 7.20 below shows the estimations that focused on the top 14 Malaysian bilateral trades, including China (chi), Indonesia(ido), Singapore(sin), Thailand(tha), Germany(ger), Netherland(net), United Kingdom (uk), USA, Hong

Kong (hk), Japan (jp), Korea (ko), Taiwan (tai), India (ind) and Australia (aus). The other countries are grouped as the rest of the world (rowsell). For this estimation, we use China as a reference. The interaction coefficient measures the effect in the relevant country relative to the effect in China. The results show that in the case of SO2 and NO2 industrial pollution emissions, an increase in Malaysia's exports to those countries causes no change in emission except for China, Thailand, Indonesia and India. For CO emission, increases in exports to China, Indonesia, Thailand, India and Australia has led to an increase in the emissions, with a zero effect for the other countries and a negative effect for the Netherlands. For PM industrial pollution emission, except for China, Netherlands and India, a rise in Malaysia's exports to those countries has little or no effect on emissions. It is worth noting that only China and India show that an increase in Malaysia's exports to their country will lead to a rise in the industrial pollution emission in all the four types of emissions. Essentially, most of the differential slopes are significant, suggesting that the effect of exports on the average level of pollution emissions do differ across bilateral exports. It is also observed that there is statistical evidence to show that if Malaysia were to increase its exports to countries other than China, the rate of the emission's rise will be slower.

Table 7.20: Determinants of export industrial pollution emissions (the four pollutants) employed (examining) interaction specification for the top 14 Malaysian bilateral trades, (China as a reference)

FE	SO2		CO		NO2		PM	
$a_1 ex$	0.744	***	0.234	***	0.301	***	0.211	***
	(0.040)		(0.022)		(0.010)		(0.008)	
$a_2 ex*ido$	0.049		0.238	***	0.091	**	-0.201	***
	(0.155)		(0.086)		(0.039)		(0.032)	
$a_3 ex*sin$	-0.761	***	-0.262	***	-0.231	***	-0.221	***
	(0.044)		(0.025)		(0.011)		(0.009)	
$a_4 ex*tha$	-0.209	***	0.066		-0.080	***	-0.169	***
	(0.077)		(0.043)		(0.019)		(0.016)	
$a_5 ex*ger$	-0.665	***	-0.235	*	-0.222	***	-0.184	***
	(0.200)		(0.110)		(0.050)		(0.041)	
$a_6 ex*net$	-1.009	***	-0.484	***	-0.222	***	-0.085	***
	(0.086)		(0.047)		(0.021)		(0.018)	
$a_7 ex*uk$	-0.778	***	-0.288	***	-0.288	***	-0.231	***
	(0.187)		(0.103)		(0.047)		(0.038)	
$a_8 ex*us$	-0.676	***	-0.183	***	-0.250	***	-0.192	***
	(0.042)		(0.023)		(0.010)		(0.009)	
$a_9 ex*hk$	-0.552	***	-0.197	***	-0.241	***	-0.203	***
	(0.065)		(0.036)		(0.016)		(0.013)	
$a_{10} ex*jap$	-0.738	***	-0.105	***	-0.145	***	-0.188	***
	(0.057)		(0.031)		(0.014)		(0.012)	
$a_{11} ex*ko$	-0.487	***	-0.116		-0.142	***	-0.191	***
	(0.148)		(0.082)		(0.037)		(0.030)	
$a_{12} ex*tai$	-0.680	***	-0.251	***	-0.192	***	-0.202	***
	(0.121)		(0.067)		(0.030)		(0.025)	
$a_{13} ex*ind$	0.093		0.041		0.135	***	0.089	**
	(0.173)		(0.095)		(0.043)		(0.035)	
$a_{14} ex*aus$	-0.339	**	0.056		-0.073	**	-0.148	**
	(0.138)		(0.076)		(0.034)		(0.028)	
$a_{15} ex*rowsell$	-0.399	***	-0.017		-0.133	***	-0.152	***
	(0.130)		(0.072)		(0.032)		(0.027)	
$a_{16} gni$	0.010	***	0.002	**	0.001	***	0.003	***
	(0.002)		(0.001)		(0.000)		(0.000)	
$a_{17} kl$	-2144.4	***	-442.8	*	-237.7	**	-580.8	***
	(427.1)		(235.7)		(106.5)		(87.4)	
$a_{18} cons$	7963.2	***	2964.0	***	1487.7	***	1682.9	***
	(1012.4)		(558.7)		(252.4)		(207.2)	
R^2(within)	0.5021		0.3872		0.7788		0.6307	
R^2(between)	0.0517		0.0597		0.7974		0.6049	
R^2(overall)	0.1078		0.0887		0.6949		0.5885	
corr	-0.0383		0.0037		0.5654		0.2783	
observations	714		714		714		714	
num. of groups	42		42		42		42	

7.7.2g Malaysian bilateral trade with regions

Instead of examining the effect of specific countries in the previous section, here the study has estimated the model (1) by including interactions of Malaysian bilateral trades with regions. The regions involved are, ASEAN (asen), Europe (euro), North America (noam), Indochina (inch), South Asia (hind), Australia and New Zealand (aunz), Gulf, and South American (soam). The other regions are grouped as the rest of the world (row). Table 7.21 presents the results of the estimations. The interaction coefficient measures the effect in the relevant region relative to the effect in Europe. In the case of Europe, during the period of study, on average increasing Malaysia's exports to the region decreased the emissions of SO2 and CO. However such rises have also caused an increase in NO2 and PM emissions. For all other regions, the results show that increasing Malaysian exports has led to a rise in SO2, CO and NO2 industrial pollution emissions except for ASEAN and North America (for CO). For PM emission, Europe, Gulf and South Asia show a positive relationship between PM emission and exports while ASEAN and North America show a zero relationship.

Table 7.21: Determinants of export industrial pollution emissions (the four pollutants) employed (examining) interaction specification for Malaysian bilateral trades with regions (Europe as a reference)

FE	SO2	CO	NO2	PM
$\alpha_1 ex$	-0.260 ***	-0.238 ***	0.044 **	0.093 ***
	(0.080)	(0.041)	(0.021)	(0.016)
$\alpha_2 ex*asen$	0.305 ***	0.246 ***	0.047 **	-0.093 ***
	(0.081)	(0.041)	(0.021)	(0.017)
$\alpha_3 ex*noam$	0.318 ***	0.282 ***	0.006	-0.073 ***
	(0.080)	(0.041)	(0.021)	(0.017)
$\alpha_4 ex*inch$	0.547 ***	0.349 ***	0.129 ***	-0.012
	(0.081)	(0.042)	(0.021)	(0.017)
$\alpha_5 ex*hind$	0.930 ***	0.400 ***	0.354 ***	0.217 ***
	(0.200)	(0.103)	(0.052)	(0.041)
$\alpha_6 ex*aunz$	0.574 ***	0.461 ***	0.164 ***	-0.021
	(0.169)	(0.087)	(0.044)	(0.035)
$\alpha_7 ex*gulf$	0.590 **	0.399 ***	0.120 *	0.021
	(0.262)	(0.135)	(0.068)	(0.054)
$\alpha_8 ex*soam$	0.604	0.285	0.218	0.161
	(0.734)	(0.378)	(0.191)	(0.152)

$a_9ex*row$	0.967 ***	0.494 ***	0.295 ***	0.202 ***
	(0.121)	(0.062)	(0.032)	(0.025)
$a_{10}gni$	0.012 ***	0.004 ***	0.002 ***	0.003 ***
	(0.002)	(0.001)	(0.001)	(0.000)
$a_{11}kl$	-2216 ***	-411.5	-268.2 **	-641.1 ***
	(497.9)	(256.1)	(129.6)	(103.1)
$a_{12}cons$	7806.6 ***	2738.7 ***	1475.6 ***	1789.4 ***
	(1178.8)	(606.4)	(306.8)	(244.2)
R^2(within)	0.3151	0.2674	0.6683	0.4797
R^2(between)	0.3215	0.1958	0.8780	0.5416
R^2(overall)	0.2872	0.1859	0.7594	0.5128
corr	0.2698	0.1953	0.6646	0.2241
observations	714	714	714	714
num. of groups	42	42	42	42

7.8 Conclusion

In this study we have examined 41 bilateral trades between Malaysia and its trading partners. Despite our prior beliefs that Malaysian bilateral trades with developed (developing) countries will increase (decrease) industrial pollution emissions, statistical evidence fails to provide comprehensive evidence that support the expectation. The result shows that while there are some bilateral trade exports that exhibit PHH there are other bilateral exports that do not. In fact Malaysia's bilateral trade with individual countries in Europe does not provide statistical evidence that bilateral trade effects the industrial pollution emissions. It is safe to conclude that based on these results is that each bilateral trade provides no uniform effect on the hosts' country environment. In fact in this study, we find ample evidence to show that the impact of bilateral exports varies across bilateral countries. Examined closely, we can see that the bilateral trade may affect the environment in either a positive or a negative way or it may have no effect at all depending on the composition of the products traded.

Cole *et al.* (2005) offer their view why some exports-led expansion may not necessarily mean more emissions. They elaborate, "...other things being equal we would expect a positive relationship between a firm's (country) total output and emissions, although we may expect this relationship to be diminishing at the margin.

Thus, it is possible that pollution normalised by output might decline as output increases, reflecting the benefits of economies of scale in both resource use and in pollution abatement." Essentially, industry with a bigger output implies that the industry is in a better position to have lower emissions per unit of output. Thus Malaysia's bilateral trade expansion with certain countries can in fact contribute towards a reduction in pollution. Here it is also important to highlight that we cannot disqualify the argument that the failure of comprehensive evidence on PHH means that there is strong possibility that the other factors determining the bilateral trade flows outweigh the importance of regulations differences between countries. Other than that, it is also good to emphasise that, as shown in many other studies, due to many limitations on the data requirements, our findings must be viewed as exploratory. However, the results should not restrict us from making quantitative inferences concerning the environment and trade linkages using the evidence of bilateral trade. We believe that in view of a lack of research in the case of bilateral trade (with a view to assessing the position of rapid expansion of Malaysian bilateral trade) it warrants a first attempt to assess the importance of trade and environment linkages.

With the above discussion in mind, even though the findings have not provided conclusive evidence on the effect of bilateral trade on industrial air pollution emission, we can draw several conclusions. First and foremost, the effect of the trade is more likely to be influenced by the composition of the exports. Second, bilateral trade in certain products and with certain countries may increase the pollution emissions. Third, the expanding number of bilateral trading partners does not necessarily mean an accumulation of pressure for the environment. Fourth, there is no overwhelming evidence for us to conclude that bilateral exports to developed countries cause more pollution emission than bilateral exports to developing countries. Fifth, in terms of type of pollutants, the effect of bilateral trade on SO2, CO and NO2 industrial pollution emissions have shown some similarity but not uniform. The effect on PM industrial pollution emission seems to differ from the other three emissions. Sixth, neither Malaysia is being used as a pollution haven nor other countries are being used by Malaysia as a pollution haven. These results may be found consistent with findings in other studies. For example, Ederington, et. al. (2004) in their study of imports and exports of U.S. manufacturing over the 1972-

1994 period find evidence against PHH. Finally, on average we find that during the period of 1990-2006 Malaysian bilateral exports grew higher than the growth of the pollution content of exports. Thus we could imply that there is an underlying trend towards cleaner industries over the period of this study in Malaysia's trade. Considering that Malaysia is on the path towards being a developed nation, this finding may well suit the EKC argument that the environment standards will be continue to progress as the country moves from a low economic status to a high economic status. However, whether Malaysia is in a position to further mitigate the pollution emissions from these bilateral exports over the coming decades and at the same time sustain its main source of foreign exchange remains a question. What is less easy to achieve is to secure the right balance between the need for trade expansion to stimulate economic growth and maintaining high environment standards. If achieved, Malaysia will be well on the path of sustainable development. Improvements in the production technology including energy efficiency, environment friendly and using fewer natural resources as well as giving out less externality should also continue to be pursued. Were Malaysia to reduce the effect of international trade on the environment, limits in the expansion of bilateral trade with certain countries (such as bilateral trade with less developed countries) is not necessary applauded.

In terms of future study, it would be interesting for further investigation in this bilateral trade dimension. Like in many previous studies, analysis is still around the three important effects of trade on the environment. Perhaps, one could examine the effects in terms of the strength of the effects among the bilateral trade. For example, in the case of Malaysia-US, is there statistical evidence to show that the technique effect is stronger compared to composition effect? The same thing can be investigated for other bilateral trades. Also for future study, we may want to answer other hypotheses such as, whether bilateral trade with developed countries shows the technique effect is more influence than the scale effect and should the technique effect be more dominant will it improve the environment. It might also be meaningful to examine the trade and environment relationship through assessing the role of MNCs which are a significant presence in the Malaysian economy. Their involvement in shaping Malaysian trade flow is evidenced from the intra trade trading and outsourcing activities that are on a rise in the country.

Appendix 7.1

Table 7.1: Bilateral and Regional Trading Agreements.

Partner/ Country	**Agreements**
ASEAN	a. ASEAN Framework Agreement on Services b. ASEAN Free Trade Area(AFTA)
China	ASEAN – China Free Trade area (ACFTA)
India	a. Malaysia India Comprehensive Economic Partnership Agreement b. ASEAN – India Framework Agreement on Comprehensive Economic Cooperation
Pakistan	Malaysia – Pakistan Free Trade Agreement
Australia	a. ASEAN – ANZCERTA Free Trade Agreement b. B. Australia – Malaysia Free Trade Agreement
New Zealand	a. Malaysia- New Zealand Free Trade Agreement b. ASEAN- ANZCERTA Free Trade Agreement
Korea	a. Malaysia- Korea Free Trade Agreement b. ASEAN – Korea Free Trade Agreement
United States	a. Malaysia – United States Trade and Investment Framework b. Malaysia- United States Free Trade Area
Japan	a. Japan- Malaysia Economic Partnership Agreement b. ASEAN – Japan Comprehensive Economic Partnership
Chile	Malaysia- Chile Free Trade Agreement

Appendix 7.2

Table 7.8: List of Malaysian bilateral trades

No	Country/region	Name	Code	RankX90	RankX06	RankM90	RankM06
	Asean	asen					
1	Brunei	bru	11	24	38	36	38
2	Cambodia	cam	12	39	40	38	39
3	Indonesia	ido	13	20	12	18	9
4	Laos	lao	14	38	41	39	35
5	Myanmar	mya	15	29	39	34	37
6	Philippines	phi	16	19	17	23	11
7	Singapore	sin	17	1	2	3	4
8	Thailand	tha	18	9	6	10	7
9	Vietnam	vie	19	37	18	31	24
	Europe	euro					
10	Belgium	bel	21	13	26	20	27
11	Denmark	den	22	26	34	24	33
12	Finland	fin	23	34	25	26	30
13	France	fra	24	11	16	11	12
14	Germany	ger	25	5	10	6	8
15	Hungary	hun	26	36	33	33	34
16	Ireland	ire	27	33	30	29	20
17	Italy	ita	28	18	22	12	16
18	Netherlands	net	29	7	7	19	18
19	Russia	rus	31	41	28	41	31
20	Spain	spa	32	23	20	27	28
21	Sweden	swe	33	25	35	15	22
22	Switzerland	swi	34	28	36	14	15
23	UK	uk	35	4	13	4	14
	North America	noam					
24	Canada	can	41	16	19	17	23
25	Mexico	mex	42	27	21	32	32
26	USA	us	43	2	1	2	2

	Indochina	inch					
27	China	chi	51	10	3	13	3
28	Hong Kong	hk	52	6	5	9	10
29	Japan	jap	53	3	4	1	1
30	Korea	ko	54	8	9	8	6
31	Taiwan	tai	55	14	11	5	5
	South Asia	hind					
32	Bangladesh	ban	61	32	32	37	40
33	India	ind	62	17	14	22	17
34	Pakistan	pak	63	15	23	28	36
35	Sri Lanka	sri	64	30	37	35	41
	Australia & N.Z	aunz					
36	Australia	aus	71	12	8	7	13
37	New Zealand	nzl	72	31	29	21	29
	Gulf	gulf					
38	Saudi Arabia	sau	81	21	27	25	19
39	UAE	uae	82	22	15	30	25
	South America	soam					
40	Brazil	bra	91	35	31	16	21
41	South Africa	sou	92	40	24	40	26
	ROW	row	99				

Note: RankX90, RankX06, RankM90 and RankM06 referred to ranking of exports in 1990, ranking of exports in 2006, ranking of imports in 1990 and ranking of imports in 2006 accordingly (the rank is from higher to lower value).

CHAPTER 8

Discussion and Policy Implication

8.1 Introduction

This study examines the extent of the effect of Malaysia's trade liberalisation on the environment during the period 1985 to 2006. During this time the country has transformed itself from an agricultural-based economy to become one of the most open economies in the world. To put this into perspective, in the earlier years of Malaysia's economy, the effect of industrial activity on the environment was very limited. Most of the pollution during period from the 1960s until the 1980s was from agricultural activities. Many of Malaysia's resources were exported as raw materials to other countries and processed outside the country thus minimising the amount of industrial activity taking place in the country. However from the 1980s onwards the country has begun to move aggressively in its economic expansion and the effect of industrial activities has begun to put pressure on the environment.

In doing this empirical study, we draw on the main theories and hypotheses discussed in the literature. In the often contentious debates over the environment and trade relationship, proponents of free trade drew from the EKC to argue that in developing nations like Malaysia, trade liberalisation would eventually lead to environmental improvements. Conversely, opponents of free trade evoked the Pollution Haven Hypothesis (PHH) to argue that free trade would automatically worsen environmental conditions in developing countries. The empirical findings obtained from this study give clues about Malaysia's trade liberalisation position with respect to environmental degradation.

The following section of this chapter will discuss the key findings of the three different approaches. The three approaches are the regional analysis, the industrial level study and the bilateral trade analysis. Section 8.3 will discuss the strength of the findings. The next section will discuss the policy implication of this study. This will be followed by recommendations and ideas for future analysis and then by the concluding remarks in section 8.5 and 8.6 respectively.

8.2 Summary findings

In general, this study shows that the likelihood of a uniform trend for the relationship is almost zero. The results show no single peculiarity that either supports or contradicts the main body of literature. As discussed in the literature, the effects of trade on the environment are country specific and each country will show different result according to its own circumstances. As evidence in this study shows, in spite of industrious efforts and contributions by many scholars in revealing the theories and hypotheses surrounding the relationship, the numerous empirical studies that look at the relationship are far from a common conclusion. This is due to the complexity and the nature of the trade-environment relationship which makes it difficult for any study to distinguish and establish (and isolate) a unique set of factors that determine the relationships. In summary, it is a great challenge because there are numerous factors that interplay in the trade-environment relationship as discussed in the literature.

Depending on the various types of approaches, functional forms, differences in measures of air pollution as well as type of air pollutants studied and the main explanatory variables/control variables used, the findings can vary, meaning that it is not clear which theories the evidence is most consistent with. The difficulty of arriving at 'straightforward' conclusions is consistent with the international evidence based on cross-country studies.

In this study we examine how Malaysia's trade liberalisation affected the environment. Our analysis covers four different air pollutants, namely SO2, CO, NO2 and PM. The study uses three routes to examine the trade-environment relationship which we referred it as regional, industry level and bilateral trade. Using the three routes, we review the effect of trade on the environment i.e. industrial air pollution in Malaysia which produced mixed results.

Another point to note is that in this study, we use two types of air pollution measurements. In the regional study chapter, we use ambient pollution concentration while in the industry and bilateral trade studies we use estimates of industrial pollution emissions. Also in the regional study, the 15 states are used as the unit of observation while in industry study, industry classifications at 4-digit ISIC are used. For bilateral trade study, the 41 selected bilateral trades are the unit of observation.

In the first approach, we use regional analysis to look for evidence. The study examines the relationship using the statistics of air pollution ambient concentrations at a sub-national level. This approach is interesting in the sense that it evaluates using the pollution concentration data measured by monitoring stations. The stations are being monitored by the public authority and the data are have been used as official environment statistics in government policy documents. The state is used for as the unit of observation as well as monitoring stations. In this study we also evaluate the trade-environment relationship in a sub-area analysis, namely urban areas, sub-urban areas and industrial areas, which is believed to be the first in this area of research especially in the case of Malaysia. Using this regional approach, the findings show that there is statistical evidence that the pollution effect of trade varies with the capital-labour ratio for SO2, NO2 and the overall API, but no evidence that the pollution effect of trade varies with income (output) in the case of any pollutant based on the overall area results, and also only weak statistical evidence that the pollution effect of trade varies with income for SO2 concentrations in industrial areas. Meanwhile, analysis of the trade marginal effect shows statistical evidence that the pollution effect of trade varies with both the capital-labour ratio and income in the case of SO2, CO and NO2. These overall findings support the argument that different levels of output (income) and factor endowments (capital-labour ratio) of the country (states) have a significant influence on determining the trade-environment relationship.

In the second approach using the industrial level study we have examined the trade effect at the industrial level. Different from the regional study, here our unit of observation is Malaysia's manufacturing trade at 4-digit ISIC (79 industries). The indicator of environment used is industrial pollution emission, which is estimated for each industry using the IPPS. Besides the shortcomings of the estimates discussed in the chapter we treat this as explanatory work for future work, as well as a basis for a comparison with the results found in the regional study. In this approach, we first evaluated the data covering the whole period of study, 1985 to 2005, and then we re-estimated the equation in four sub-periods: 1985-1989, 1990-1994, 1995-1999 and 2000-2005.This is considered as explanatory work out of curiosity whether the period of study will alter the results. Then we also made the estimations according to four groups of products namely: Food, beverages and tobacco (FBT), Textile and wearing apparel (TWA), Chemicals and pharmaceutical (CPH) and Electrical and electronics (EES) and finally estimated the equations separately for a group of pollution intensive products (PI) and a group of non-pollution intensive products (NPI). This industry study has shown that our evaluation of the Factor Endowment Hypothesis finds evidence of negative composition effects in the case of SO2, CO and PM emissions on the basis of pure capital-labour ratio coefficients. With trade expansion, this study shows that trade would cause pollution emissions to increase at an increasing rate along with rising capital-labour ratios for SO2 and NO2. Hence, these results support the Factor Endowment Hypothesis. The further analyses of sub-samples according to sub-periods, product-groups and pollution intensity classifications have shown mixed results. Overall, this study does not provide conclusive evidence to support completely each of the theoretical predictions in this area of study.

In the third approach we examined the relationship in the case of bilateral trade. In this approach, we aim to find if Malaysian bilateral trade provides evidence for the Pollution Haven Hypothesis. Specifically, the approach tries to answer the question whether Malaysia's trade causes itself to be a pollution hub or does Malaysia use other nations as a pollution hub. The data for this analysis were taken from the 1990 to 2006 period for 41 bilateral trades between Malaysia and its trading partners. Despite popular beliefs that bilateral trade with developed countries will cause environmental degradation in Malaysia, this study and analyses has proven otherwise. The idea that developed countries will uses Malaysia as a pollution haven due to its lack of environment regulation stringency has proved to be unfounded. For example, we find that Malaysia's bilateral trade with individual countries in Europe does not provide statistical evidence that bilateral trade affects industrial pollution emissions. It seems that trade with developed countries will benefit Malaysia more in both economic and environmental aspects. However this is not to say that the Pollution Haven Hypothesis is flawed. As discussed in this study, the trade and environment relationship of a country is not uniform and will be country specific. The evidence to support the hypothesis may not be present in Malaysia but it may be present in other countries. In sum, this bilateral study shows that there is no overwhelming evidence for us to conclude that bilateral exports to developed countries cause more pollution emissions than bilateral exports to developing countries and neither that Malaysia is being used as a pollution haven nor other countries are being used by Malaysia as a pollution haven.

The overall finding is consistent with the fact that the size of exports of 'dirty' goods is not particularly large, at about 21 per cent in 2006 (27 per cent for imports in 2006). However it is important for us to be cautious here, since even though the direct exports of 'dirty' products only constitute 21 per cent, there are also certain 'dirty' products being used as intermediate inputs for the 'clean' industry. This is indirectly being suppressed in this study. In other words, even though the direct exports of pollution goods constitute a minor part of the total exports, there is an indirect route whereby rubber, steel, metals and chemicals contribute to manufacturing machinery and transport equipment, which do not belong to the category of pollution goods. If one wants to capture this, the method of input-output table analysis is appropriate, to determine the backward and forward industry linkages.

The analysis of bilateral trade shows that overall export of pollution intensive goods has increased during the research period. These exports have grown from 19.6 per cent in 1990 to 20.6 per cent in 2006. On the regional basis, pollution intensive goods that were exported to the ASEAN region for the research period increased from 24.1 per cent in 1990 to 30.8 per cent in 2006. In 1990, 19.7 per cent of the goods that were sent to Europe were pollution intensive, and this has since then declined to 10.9 per cent in 2006. Meanwhile, in terms of imports, Malaysia has imported fewer pollution-intensive goods into the country over time. Europe once was a high exporter of pollution-intensive goods to Malaysia, which in 1990 amounted to 40.9 per cent of imports from Europe, but this has since gone down to 27.4 per cent in 2006. South Asia however has become the main exporter of pollution intensive goods to this country during the researched period, with the percentage of imports from south Asia that are pollution intensive being 25.6 per cent in 1990 but growing to 50.1 per cent by 2006. When putting this into ratio terms, i.e. export-import ratio, overall Malaysia has imported more pollution-intensive products than exported. It is noted that, in the case of bilateral trade with Europe, Malaysia's exports have doubled with a growth of 253 per cent during the study period. However the emission of SO2 and CO decreased during this period, with a decrease of 22 and 30 per cent respectively.

In terms of the pollution terms of trade (PTOT) analysis, it shows that on average, Malaysia's bilateral trade with developed countries often shows a PTOT[28] less than one. More often than not, Malaysia's exports to developing countries often have more pollution content than the ones to developed countries in relation to the pollution composition of imports. One may come to conclude from this evidence that Malaysia's trade liberalization with developed economy helps to improve the environment more. It seems that it is less likely that Malaysia would be a pollution haven when trading with developed countries. In another comparison between Malaysia and its bilateral trade partners, the specialization index (SI) computation was used. Based on the computation for a group of pollution intensive products[29], Malaysia's imports of pollution intensive products are mainly from developed countries. With the exception of Hong Kong and Netherlands, all the other 12 developed countries show negative SI[30]. Most of Malaysia's positive SIs are from trades with developing countries. These computations can lead one to conclude that bilateral trade with developing countries causes Malaysia to become more specialized in the pollution intensive industry in order to keep up with export demands. It is likely that Malaysia's trade with developing country is leading the country to become a pollution hub for developing countries. From these computations one can come to the realization that Malaysia does not use other

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[28] A PTOT of less than one means Malaysia's bilateral exports to that particular country on average have a lower pollutant emissions content compared to its imports from the respective country.

[29] The dirty industry classification is classified by Mani and Wheeler (1997) according to the level of pollution emitted. The highest ten polluted industries are considered as dirty industries.

[30] A negative SI means Malaysia is a net importer of pollution-intensive industries.

developing country as a pollution haven. In fact, SI computations seem to show the opposite.

This study also finds that on average during the period 1990-2006, Malaysian bilateral exports grew more than the growth of the pollution content of exports which implies that there is an underlying trend towards cleaner industries over the period of this study in Malaysia's trade. This is in line with the national efforts towards being a developed nation which may well suit the EKC argument that the environmental standards will continue to progress as the country moves from a low economic status to a high economic status. However we should not expect this will happen as natural / automatic process.

8.3 The strength of the findings and challenges

Comparing the results of the regional study, industry level study and bilateral trade study, all studies have their strengths. In this study, four types of pollutants which represent the most important sources of air pollution are used throughout the study. In each of the three approaches, estimations which have been produced separately, which provide significant results for one or more pollution coefficients, but with no uniform trend to suggest that any type of concentration is consistently significant. Despite this, there is some pattern that SO2 emission gives significant coefficients in many part of this study.

Both industry and regional studies use similar types of air pollutants, while the regional analysis also has a composite air pollution index. However, one measures air pollution concentration and the other one measures industrial air pollution emissions. In the case using of air pollution concentration, the main weaknesses is that the level of ambient concentration is not only contributed to by manufacturing output led by trade. Some pollution concentrations are caused by mobility sources such as transportation and energy power and also from open burning. However, it always can be said that the expansion of those activities (downstream activities) may well be considered as spillover effects of industrial growth led by trade. In the case of bilateral study we are able to investigate the products that have been traded between Malaysia and each trading partner. This is worth doing, because to precisely examine the Pollution Haven Hypothesis, it is very important to know in detail what kind of traded goods have actually led to a growth in each bilateral exports.

Overall, our examination of the trade-environment linkages by the regional / state level route is considered the strongest method used in this study. For the other two routes, the industrial level approach and the bilateral trade approach, the main limitation is on the estimations of industrial emissions, which depend on a strong assumption that the technology for industries in Malaysia and the US is identical. However we do take into account the dynamics of technology used by producers by employing the electricity consumption index computed in this study. Despite this, however, the use of IPPS in many other studies is not uncommon, though its effects on the study are not unchallenged.

In comparison to an investigation at the international level, this study is rather more specific in nature. The results can be viewed as showing that the country characteristics such as level of development and its specific comparative advantage, as well as the regulation framework and the environment absorptive capacity, are the key ingredients that nurture the path of the environment-trade relationship. This research is a single country study which has not often been undertaken previously. Hence it does not give us much opportunity to compare the findings, especially since this analysis is in the case developing county. An important study for Malaysia had been done by Vincent (1997). However the results from his study may not be compared directly. Essentially, that study is more focussed on testing the income and environment relationship of the Environmental Kuznets Curve Hypothesis for the period of the late 1970s into the early 1990s. The study does not directly consider a trade liberalisation variable in the model. The ambient concentration and industry water pollution (which are used in the estimations separately) are environmental indicators used as dependent variables, while the independent variable is income per capita. The control variables included in the model are estimations of state level per capita GDP and district-level population density. The study finds that pollution did not follow an inverted U-shaped EKC for any of the ambient concentrations or water pollutants. In comparison to Vincent (1997), our present study, even though we have used different approaches, also finds no conclusive evidence on the PHH and EKC. However, it is important to note that given the lack of data in the required form and the nature of the assumption in the analysis, the results must be interpreted with due caution.

The major obstacle in this study is the lack of suitable data. This problem is especially true for developing countries. As many previous studies have encountered, there is very little industry-specific pollution data (pollution per unit output) available on a country-by-country basis. In the past, the scarcity of environmental data for empirical evidence made the arguments on the relationship between economic growth and environmental quality remain purely on a theoretical basis. This continued for a long time. Given the lack of long time series of environmental data and the difficulty of extending long time series data for relevant variables in individual countries, most empirical studies have adopted a cross-country approach in their research.

In the context of Malaysia, the absence of comprehensive data on industrial pollution can be attributed to constraints in the shortage of manpower, financial resources, lagging technology and the expertise to monitor data gathering and estimating pollution intensity data that is equivalent to the Industrial Pollution Projection System (IPPS). At present, data collected are often too general for any in-depth analysis of industrial air pollution by the country's manufacturing industries.

Another issue faced by this area of study is on the pollution measurement. There are arguments on which type of measurement should be used. As discussed in the literature, for researchers to fully understand the effects of the determinants, emissions rates are of better use. However data on emission rates of the desirable form are scarce. This leads many researchers to use pollution concentration or ambient levels. However this too poses its own problems as discussed in the literature such as topography, procedures of measurements and equipment of monitoring stations.

As suggested in the literature, evidence for the PHH is difficult to find due to a number of reasons. In OECD countries as reported in Tobey (1990), the actual cost incurred by environmental regulation on average is about 2 % of total cost and the highest is 2.89 percent for the chemical industry (a heavily polluting industry). This clearly shows that factors of production such as labour are more important considerations for a company to expand their activity in other country. For example, cost of labour in China is extremely low compared to Japan or any other developed countries. Greather and de Melo (2004) also stress that, most pollution goods belong to intermediate goods and tend to have a high weight which can incur high transportation costs that hinder shifting location of production. In summary, it is likely that environmental regulations differences do not affect trade flows and location of factories as much as the PHH implies. But it is important to reiterate that even though regulations are not the decision factor the influencing the factor displacement decision as well as the pattern of trade flows, it wise for us to ponder what the scenario would be in the complete absence of environmental regulations.

8.4 The policy implications

The results have important implications for policy-makers in Malaysia who aspire to transform the economy into a fully industrialized nation in the near future. Economic growth led by trade is the outcome of growth in inputs and increases in the productivity of the inputs. Therefore, rapid industrialization requires higher and/or more efficient producers and fewer externalities for sustainable development. Given that over-consumption of resources such as energy can have negative impacts on the environment, there is much scope for the government to have appropriate development of resources for conservation strategies. There are three pillars of sustainable development: economic development, social development and environmental protection which need to be strengthened constantly with the same great importance. Even though there is no conclusive evidence to support or accept the evidence of the Pollution Haven Hypothesis in Malaysia, trade liberalisation and economic growth need to be pursued without compromising the ability of every citizen in the current and future generations to live with a high environment quality.

In recent years, the national commitment to sustainable development has deepened as shown by the incorporation of environmental issues into economic policies. In 2009, the government created the Energy, Green Technology and Water Ministry to act as a central agency to champion on environmental issues. Following this, the government also launched the National Green Technology policy to ensure that the objectives of national development including trade liberalisation policy continue to be balanced with environmental consideration. The policy outlines five thrusts: strengthening institutions, foster green technology development, building up necessary human resources, intensifying relevant research and innovation, and promotion and public awareness. Needless to say, that country's regulation and policy play a vital role in shaping the national economy and environmental landscape.

Currently, trade with developed countries still benefits Malaysia more both in economic and environmental terms. But it is questionable how long this will continue. International competition will get stiffer as globalisation and trade liberalisation gather momentum (Ariff, 2005). The environmental consequence of trade and foreign investment in China has caused great concerns as the pollution in the country increases with the expansion of the economy. This indicates that the international bilateral trade in the future may not bring as much advantages in environmental terms as it does now.

Besides that, we also have to look at Malaysia's trade with developing countries and its effect on the environment. As international trade continues, one has to question whether trade relations with these countries will become better for Malaysia both in economic and environmental terms. Will the competition cause Malaysia's exporters to cut corners and reduce production costs and increase pollution emissions? Technology transfers from Malaysia's trade with developed countries will help to improve Malaysia's production technology but these technologies are likely only to be used and applicable for exports to developed countries. Will they have any influence on exports to developing countries? More often than not Malaysia's technological standing is about the same as that which developing countries have. It is highly unlikely that technology transfers will drastically improve productions for goods exported to developing countries.

Being competitive is relative. Given that Malaysia's FDI is heavily export-oriented, this reinforces the fact that MNCs could be a key-driver for spearheading the environmental best practice of production technology. Malaysia's comparative advantage continues to reside in resource intensive and low to medium technology industries mainly in the areas of assembly and processing. MNC's can help the transfer of technologies that can improve Malaysia's production process. Future research on the role of MNCs and their impact on Malaysia's economy and environment can help to improve understanding of MNC's relations and their role and future in Malaysia. Based on the findings, cause and effects studies on the MNCs can shed a light for the existing policy especially with regards to FDI and taxes. At present, there is no policy statement on the possibility for the government to introduce the environmental tax for the polluters. This may change in the future.

Other than the government, another key factor that may influence the national economic and environment polices is the people's awareness. If one were to think of the environment as a traded good, when people become financially better-off, demand for higher standards of goods will increase. Thus, demand for better environment standards will increase. Such demand will put pressure on both government and producers. This scenario has been seen clearly in the country. Recently, many economic expansion activities in the country have had to be halted due to pressure from the people. This has put the government in the dilemma of toughening up the environment laws and losing economic competitiveness or facing the public's anger and sentiment and risk losing electorate votes.

Despite the issues discussed and a high degree of openness where Malaysia is ranked among the top 20 trading nations, the country has also shown a good performance in its efforts towards maintaining the environment. According to the latest Environmental Performance Index (EPI)[31] released in 2011, the index ranks Malaysia 25th among 132 nations, the best showing among ASEAN nations, and third best among Asia Pacific nations, after New Zealand and Japan. In summary, the right policies will also determine how a nation's trade and environment relationship is portrayed and the outcome of the nation's wellbeing.

[31] The EPI is developed by the United States' Yale and Columbia Universities, with the cooperation of the European Commission.

8.5 Recommendations and future analysis

The key recommendation is for the authorities to put emphasis on the improvement of data collection on environment statistics. Monitoring economic expansion that includes both production as well as external and the environment quality is a big effort. The environment and economic sustainability are equally important, and have to be paramount matters for policy-makers in Malaysia who aspire to transform the economy into a fully developed/industrialised nation by 2020. In many studies, researches were often hampered by the scarcity and lack of data. In this particular study, a lack of long time series data hampered and caused difficulties for the study. The main reason why only a certain period of the nation's timeline was chosen to be part of this study is because data were lacking in other time periods. The convenience of data availability leads the study to choose certain periods of the nation's growth to study. Improvement and investment in manpower and personnel skills can improve the nation's data collection capability especially for environmental data. It is believed that more comprehensive and high frequency data collection can help future studies in making better analysis and more accurate recommendations.

At present, a survey on environmental expenditure by companies has started being collected as part of official statistics systems. With these data readily available for a satisfactory period of time, they can be used for more robust analysis especially for the micro analysis of standard practice of companies in environmental conservations.

One of the noteworthy efforts taken in this thesis, we successfully computed several key industry-level trade and environment indicators to enable the public/user have a glimpse of the scenario of the trade-environment relationship in Malaysia. Among others are estimations of industrial emissions at 4-digit ISIC level for four types of pollutants. This study also has computed pollution terms of trade (PTOT) between Malaysia and its trading partners and regions. The Specialization Index (SI) of industry has also has been estimated. This study has also successfully established the country's concordance statistics of external trade (exports and imports) with the statistics of production. All these indicators are much needed and may be appropriate to be official statistics of the nation. Therefore, this study can be used as a platform for the subsequent efforts to be made if the indicators will be formalised and released to the public at large for their understanding of where the nation stands on environmental issues based on the statistics' evidence. These statistics also will be very important to policy-makers, especially to complement the Social Economic Environment Accounting of Malaysia (SEEAM) which is currently in an early stage of development. In relation to this, we determine to pursue this in the due course of our work in publishing official statistics.

In terms of future study, it would be interesting if a more in-depth investigation can be done on the bilateral trade dimension. Analysis of the trade dimension will still be based on the three important effects of trade on the environment. Perhaps, one can examine the effects in terms of the strength of the effects among the bilateral trade. For example, in the case of Malaysia-US, is there statistical evidence to show that the technique effect is stronger compared to the composition effect? Will this effect be the same for Malaysia-Germany bilateral trade? The same effort can be applied for other bilateral trades.

Also in the case of bilateral study, there is scope for improvement. In some cross-country studies it shows that it may possible to use CO2 emissions as a proxy for environmental quality. This may assume that the other factors which also contribute to this pollution concentration such as other economic (production) and consumption activities remain stable (i.e. it means that the variation comes from industrial activity led by trade). The official estimates show the main source of CO2 emission are mobile sources (transportation) and electricity generating activities.

The other possibility for future study is that it would be of great interest if the concept of mirror statistics[32] be extended to a mirror study on the selected bilateral trades. For example, in the case of bilateral trade Malaysia-Japan, this present study examined from Malaysia's perspective. The 'mirror' study which is similar to this can be extended to Japan's perspective. Perhaps by examining the

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[32] Mirror statistics are used mainly in the area of compiling international trade statistics. For example, statistics on Malaysia's merchandise exports to the U.S which were compiled by Malaysia's authorities can be compared with statistics on the U.S merchandise imports from Malaysia which were compiled by the U.S authorities.

findings through both perspectives for a selected bilateral trade, this will provide a more complete picture of the trade-environment relationship. This potential and possibility are much needed in view of the needs to reveal the possibility of the shortcoming of the data used in the study.

Perhaps one may also do an in-depth analysis and research to examine the trade and environment relationship through assessing the role of MNCs as a future study. MNCs' operations have become a significant presence in the Malaysian economy. Their involvement in shaping Malaysian trade flows is evidenced through the intra-trade trading and outsourcing activities that are on the rise in the country. In-depth research and analysis on how MNCs can influence technological advances in Malaysia and also how a 'greener' production line of the MNCs can influence local producers in shifting production into a much 'greener' way are among the studies that can be proposed for future work.

This study can be further developed with several focuses. Among others, the behaviour of firms towards environmental protection programs such as environmental management systems (EMS) can be examined. Specifically, firm level data on MNCs and domestic firms would be useful to analyse environmental aspects such as the transfer of better environmental practice to the country. With this study, we would be able to answer whether the presence of MNCs in Malaysia plays a role in promoting the international transfer of environment-friendly technologies as suggested by the pollution halo hypothesis. We will evaluate any evidence as shown in studies in other countries which suggests that foreign firms pollute less because they use superior technology in production and are more energy efficient. This means that we can evaluate the behaviour of firms in terms of characteristics of the firm such as in terms of the size (micro, small, medium, large), ownership (state owned, private), local versus MNCs, level of activism and environment awareness. The environment variable to be examined includes indicators such as incompliance to environmental regulations in operation, expenditure on environmental control and number of EMS. Following a firm level study approach such as in Albonoz, *et al.*, (2009), a similar study on Malaysia will be able to answer among others the following questions: 1) Do MNCs adopt cleaner technologies as compared to local firms?; 2) Do MNCs adopt similar technologies as those that have been used in their home country; and 3) Is there any evidence of environmental spillovers to local firms. As such, ultimately one can also closely examine the pollution halo hypothesis and pollution haven hypothesis in Malaysia, using firm level data which will be readily available in near future with the continued efforts of DOSM to collect such data in the recently launched Survey of Environmental Protection.

8.6 Concluding remarks

The debate on economic expansion, trade liberalization and their effect on the environment have been of public interest for many years, and show no sign of abating. It becomes the order of the day in every corner of the world that the policy-makers no longer have a free hand in executing any public policy that may jeopardise the quality of life. The 'green' group has made a big headway in the international and national socioeconomic policies. We have also seen that the tussle among both proponents and opponents of economic openness has continued to spread on local and international fronts. It becomes common for the 'green' group to wrestle with policy-makers to take their points into consideration in steering a country's economic and environment future.

In this context, it is believed that this study in the case of a single country has shed some light on the relationship and provides enough evidence to enhance our understanding on the relationship. Continuous study in this area is not only important for a nation's building but it also helps to diffuse the confrontation arguments between various interested parties, be they the government or the 'green' group. With the concerted efforts and more ample statistical evidence in hand, all the arguments can be based on facts and numbers in the process of consultations and discussions.

Finally, this study makes a significant contribution to the research in this area of study especially in the case of a single country. Although the finding of this analysis may be unique to Malaysia due to its specific institutional and structural characteristics, the research method employed in this study can be readily extended to include other less developed countries. After the pioneer study by Vincent (1997), this study is considered as another milestone for such an important topic for the country. Like many developed countries, Malaysia's goals to expand its economy in a sustainable manner are profound.

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Appendix A

A Trade and Environment Timeline

1881 After phylloxera, a tiny insect from the U.S., devastates European vineyards, six European countries sign the *International Convention Respecting Measures to be Taken Against the Phylloxera Vastatrix*, the first multilateral environmental agreement.

1882 France and Great Britain sign a *Commercial and Maritime Agreement* that contains an unconditional exception preserving the right of each party to define for itself the measures deemed necessary for "sanitary reasons."

1900 Eight countries sign the *Convention for the Preservation of Wild Animals, Birds and Fish in Africa*, that includes a system of export licenses for certain rare and endangered species, thus establishing one of the first conservation-related trade measures.

1906 An international conference in Bern adopts a convention that bans the use of white phosphorus in the manufacture of matches in order to protect the health of match producers. It notably regulates based on production *process* instead of final use.

1921 Italy and the Kingdom of the Serbs, Croats and Slovenes (Yugoslavia) sign a convention prohibiting trade in fish caught by methods judged to have "an injurious effect upon the spawning and preservation" of fisheries.

1920s through 1940s Bilateral agreements signed during this period begin to move away from unconditional exceptions for plant- and animal-related laws, and instead start to subject these exceptions to conditions.

1927 Twenty-nine countries sign the *International Convention for the Abolition of Import and Export Prohibitions and Restrictions*, which envisions the abolition of all non-tariff import and export restrictions but provides countries space to maintain some restrictions.

1928–1941 In the *Trail Smelter case*, two separate tribunals hold the Canadian government responsible for the damage in the U.S. caused by sulphur dioxide emissions from a zinc and lead smelter in southern British Columbia. They order Canada to compensate the United States.

1947 The *General Agreement on Tariffs and Trade* (GATT) signed by 23 countries in Geneva. Article XX, entitled "general exceptions," permits Member states to take measures "necessary to protect human, animal or plant life or health," as well as those "relating to the conservation of exhaustible natural resources," so long as the application of the measures does not constitute "a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade."

1948 Charter of the International Trade Organisation (ITO) written by 56 countries at the United Nations Conference on Trade and Employment in Havana. However, the U.S. Congress rejects the Havana Charter, and the ITO is not created.

1951 *International Plant Protection Convention* (IPPC) signed under the auspices of the UN Food and Agriculture Organisation. The Convention comes into force in 1952 and regulates phytosanitary measures taken towards pests and international trade.

1957 The *Treaty of Rome* establishes the European Economic Community. Article 36 includes a number of exceptions allowing for restrictions or bans on imports and exports for "the protection of health and life of humans, animals or plants."

1970 Germany introduces the *Vorsorgeprinzip*, literally "foresight principle," into domestic clean air legislation, introducing the precautionary principle into law. The law says that "society should avoid environmental damage by forward planning."

1971 The GATT Secretariat prepares a study on the effects of environmental policies on international trade for the **1972** Stockholm Conference. The report reflects concerns that policies aimed at environmental protection could become obstacles to trade.

1971 GATT Council of Representatives establishes the Group on Environmental Measures and International Trade (the EMIT group). However, since the Group was to convene only at the request of contracting parties, it did not meet until 1991.

1972 The *United Nations Conference on the Human Environment* held in Stockholm. The meeting increases prominence of trade and environment issues based upon concerns about the negative effects of strong environmental legislation on competitiveness. Leads to the creation of the United Nations Environment Programme (UNEP).

1972 OECD *Guiding Principles Concerning the International Economic Aspects of Environmental Principles* released. Includes the "Polluter Pays Principle," according to which the private sector bears pollution abatement costs that are included in the market price.

1972 Club of Rome publishes a study called *Limits to Growth* which, in spite of its clumsy projections, drew attention to the fact that economic growth based on continuous and increasing use of non-renewable resources was unsustainable.

1973 *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) signed. CITES comes into force in 1975 and regulates international trade in over 30,000 species, banning trade in some while establishing conditions for trade in others.

1973–1979 During the Tokyo Round, GATT contracting parties adopt the Agreement on Technical Barriers to Trade (TBT) after discussions on the extent to which technical regulations and standards implemented for environmental reasons could pose obstacles to trade flows.

1982 GATT Ministerial meeting decides to examine the exports of products that are prohibited in the exporting countries for environmental, health or safety reasons but are still exported, mostly to developing countries. Leads to the creation of the Working Group on the Export of Domestically Prohibited Goods and Other Hazardous Substances in 1989.

1982 A GATT dispute settlement panel rules that a U.S. ban on the import of all types of tuna and tuna products from Canada violates trade law. The panel rejects the U.S. attempt to use Article XX to justify the ban because no domestic environmental measures had been adopted.

1986 Uruguay Round of GATT trade negotiations begins. The round lasts seven years and includes the liberalisation of trade in agriculture and services, along with intellectual property rights, for the first time. Each new area has major implications for the environment.

1987 "Precautionary approach" mentioned for the first time at the international level in the Ministerial Declaration of the Second Conference on the Protection of the North Sea.

1987 *Montreal Protocol for the Protection of the Ozone Layer* adopted, enters into force in 1989. The Protocol requires developed countries to reduce their consumption of ozone-depleting substances and developing countries agree to gradually reduce consumption of such substances.

1987 World Commission on Environment and Development (also known as the Brundtland Commission) submits a report entitled *Our Common Future* to the United Nations. The report defines sustainable development as "satisfying present needs without compromising the ability of future generations to meet their own needs."

1988 European Court of Justice allows Denmark to keep in force a law requiring beer and soda to be sold in reusable bottles, rejecting the European Commission's argument that the policy constitutes a barrier to the free movement of goods within the European Economic Community.

1989 *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* adopted and comes into force in 1992. The Convention restricts the transboundary movement of hazardous wastes after an increase in such exports by developed countries.

1991 In the famous *Tuna-Dolphin* case, a GATT dispute settlement panel rules that a U.S. embargo on tuna imports from Mexico, imposed because Mexican tuna trawlers were using nets that killed more dolphins than permitted by American law, constitutes an unfair trade barrier.

1992 The *United Nations Conference on Environment and Development* held in Rio de Janeiro. The Rio "Earth Summit" re-focuses attention on sustainable development and the role of international trade in both poverty reduction and environmental protection. Adopts Agenda 21 as an action plan. Also adopts the Convention on Biological Diversity (CBD), which aims to support the conservation and sustainable use of biological resources and the sharing of benefits arising from their use, and the United Nations Framework Convention on Climate Change (UNFCCC), which seeks to stabilize greenhouse gas concentrations in the atmosphere in an effort to prevent dangerous anthropogenic interference with the climate system. Both agreements enter into force in 1994.

1994 Canada, the United States, and Mexico adopt the North American Free Trade Agreement (NAFTA), aimed at liberalizing trade and investment flows. Includes an investor-state arbitration mechanism and an environmental side agreement.

1994 In a follow-up to the 1991 *Tuna-Dolphin* case, a GATT panel rules that the United States' secondary embargo on tuna imports from countries that trade in tuna with embargoed countries (such as Mexico) is also not permissible.

1994 Uruguay Round of GATT negotiations culminates in the signing of the Marrakech Agreement Establishing the World Trade Organization (WTO). The preamble of the Agreement includes references to sustainable development, environmental protection, resource conservation, and a consideration for the needs of developing countries among the WTO goals. Creates a work program on trade and environment and a Committee on Trade and Environment (CTE) to oversee it.

1994 Negotiations on a Multilateral Agreement on Investment (MAI) launched at an Organisation for Economic Cooperation and Development (OECD) Ministerial Meeting. MAI process goes on to earn heated opposition from civil society groups, partly for environmental reasons, and ends in failure in 1998.

1994– present A rapid expansion in negotiations for bilateral and regional trade agreements. Some of the agreements that are eventually signed have detailed environment provisions; e.g., free trade agreements between the U.S. and Jordan (2000), Chile (2003) and Morocco (2004).

1996 The WTO holds its first Ministerial Conference in Singapore. The Committee on Trade and Environment submits its first Ministerial report; it calls for further study and makes no recommendations for changes to WTO rules.

1998 In the *Shrimp-Turtle* dispute, a WTO dispute settlement panel rules that countries have the right to take trade action to protect the environment but rules against a U.S. ban on shrimp imports from countries which do not impose measures to keep the incidental kill of sea turtles lower than the level permissible in the U.S., because the U.S. discriminated between WTO Members in the technical assistance and transition periods that were provided to shrimp producers from the Caribbean but not to producers from Asia.

1998 *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* adopted, and comes into force in 2004. Adopts a Prior Informed Consent (PIC) procedure, requiring approval before trade of listed chemicals.

1999 In the run-up to the Seattle WTO Ministerial Conference, the WTO Secretariat releases a special study on the relationship between trade and environment that concludes that trade would "unambiguously improve welfare if proper environmental policies were in place."

1999 The third WTO Ministerial Conference in Seattle becomes the centre of massive protests by environmental and civil society groups. The meeting ends in failure, with countries unable to agree on whether or not to launch a new round of negotiations.

2000 The Conference of the Parties to the *Convention on Biodiversity* adopts the *Cartagena Protocol on Biosafety*. The Protocol aims to protect biological diversity from the risks arising from living modified organisms created by modern biotechnology.

2001 *Stockholm Convention on Persistent Organic Pollutants* (POPs) is adopted and comes into force in 2004. It seeks to eliminate or restrict the production and use of all intentionally produced POPs and imposes certain trade restrictions to achieve this goal.

2001 At the Fourth WTO Ministerial Conference in Doha, Members agree to launch a new round of negotiations that explicitly include environmental issues for the first time. Negotiations are launched on the relationship between the WTO and multilateral environmental agreements; the liberalization of trade in environmental goods and services; and improving WTO disciplines on fisheries subsidies among other issues.

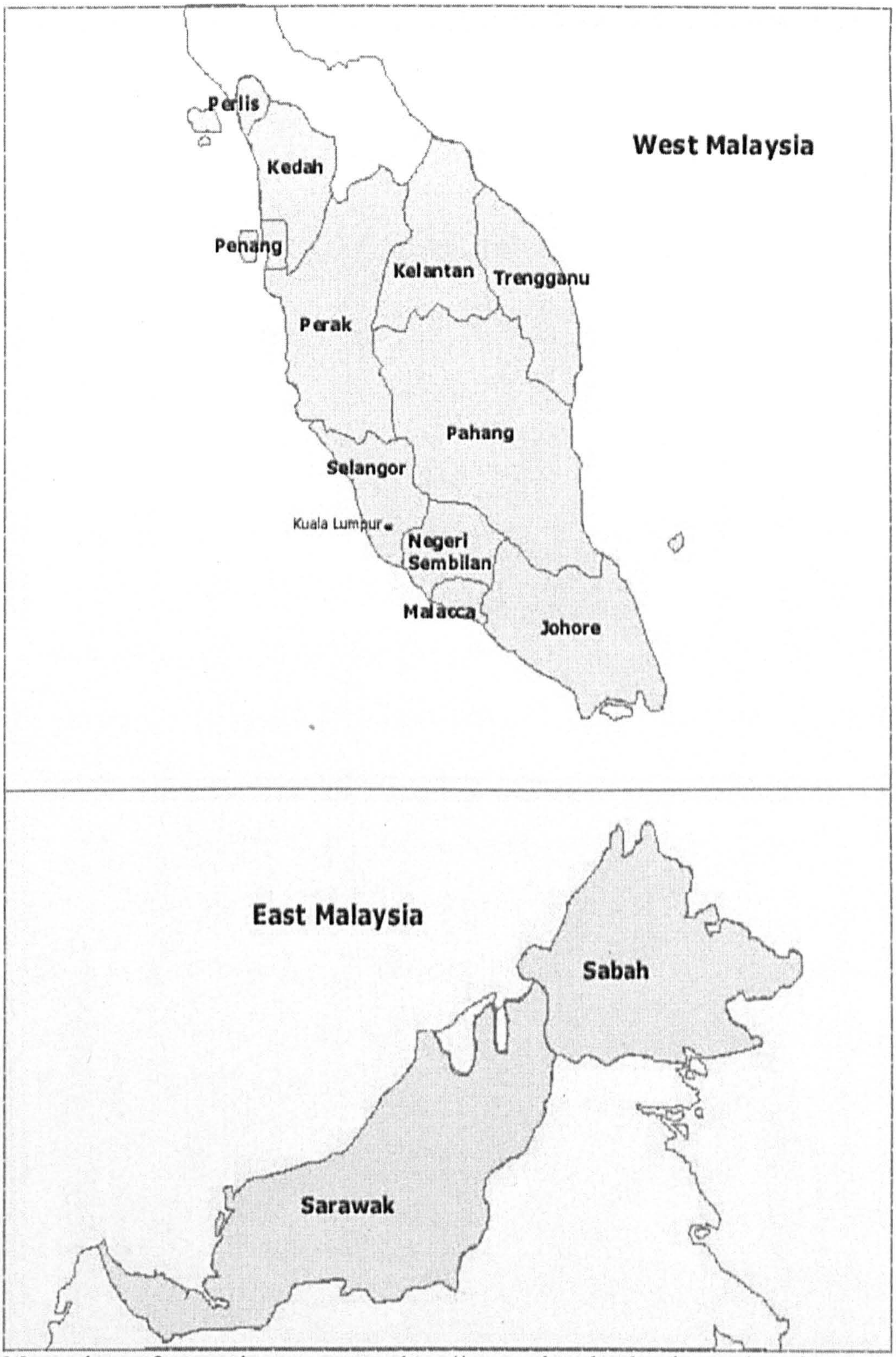
2002 The Parties to the Convention on Biological Diversity adopt the voluntary "Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization," setting out international standards on access and benefit- haring rules but falling short of international binding rules.

2002 Governments at the *World Summit on Sustainable Development* in Johannesburg adopt a *Plan of Implementation* which, among other actions, launches negotiations on an international regime to promote the sharing of benefits from the use of genetic resources (subsequently broadened to also cover facilitating access to such resources), and calls for all fisheries subsidies that contribute to illegal, unreported and unregulated fishing and to over-capacity to be eliminated.

2005 The Fifth WTO Ministerial Conference in Hong Kong ends without any significant headway on negotiations but with the sense that negotiators are slowly working through the Doha negotiating mandate, including its environmental provisions.

2006 A WTO dispute settlement panel issues final report on the complaint brought by the U.S., Canada and Argentina against an alleged EU moratorium on the approval of new biotech products, finding that the EU did in fact apply a moratorium that resulted in "undue delay" in approvals between 1999 and 2003 that was incompliant with the WTO Agreement on the Application of Sanitary and Phytosanitary Measures. The panel also rules against various national import restrictions instituted by EU member states, rejecting the EU's argument that the measures were necessary for precautionary purposes.

Source:A Resource Book (2007) published by International Institute for Sustainable Development (IISD), International Centre for Trade and Sustainable Development (ICTSD) and the Regional and International Networking Group (The Ring).



Map redrawn from an internet source http://www.virtualmalaysia.com/map/