Impact of trade openness on the environment:
An assessment of CO_2 emissions in Vietnam

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Mai Thi Tuyet Tran

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Since the innovation policy in 1986, the government of Vietnam has negotiated a number of free trade agreements to attract foreign investment and to boost the national economy. Vietnam has gained remarkable achievements in economic development as well as experiencing a degradation of the environment. Vietnam has comparative advantages in natural resource intensive products, and the closer international economic integration with trading partners is a prime source of additional pressures on the country's natural resources and environment. However, studies to assess the impact of economic development and trade openness on Vietnam's environment (measured by CO_2 emissions) are limited.

This study provides a quantitative assessment of the impact of trade openness, economic development and energy consumption on Vietnam's CO_2 emissions over a period of 29 years from 1985 to 2013. In particular, the study examines the impact of trade openness on CO_2 emissions in the long-run and short-run elasticities. In addition, the study examines the regulatory effect of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) on the environment and explores a way forward to integrate environmental considerations and commitments into free trade agreements in Vietnam.

Secondary data were obtained from the World Bank; the World Integrated Trade Solution; the World Development Indicators; the official sources of Vietnam's government bodies, such as the Ministries of Industry and Trade (MOIT), Natural Resources and Environment (MONRE), Finance (MOF); and Vietnam's General Statistical Office (GSO).

In terms of an empirical model, an Auto-regression Distributed Lag (ARDL) model was applied to estimate the impact of real per capita GDP, trade openness, and energy use on CO_2 emissions in the short-run and long-run elasticities. The results show a significant positive long-run elasticity between economic development, trade openness and energy use on CO_2 emissions in Vietnam. Trade liberalisation exhibits a positive impact (increasing impact) on CO_2 emissions. More specifically, a 1% increase in trade openness leads to a 0.19% increase in CO_2 emissions in the long-run elasticity. The empirical results show that the long-run relationship between economic development and CO_2 emissions in Vietnam can be expressed in an inverted U-curved function. In terms of energy consumption, the results show that energy usage positively affects CO_2 emissions. A 1% increase in energy usage leads to a 1.39% increase in CO_2 emissions in the long-run elasticity which strongly indicates the inefficiency of CO_2 treatment of energy use in Vietnam. Thus, the environmental quality can be improved with cleaner technology and stricter regulations on environmental protection incorporated into international economics at the policy level in Vietnam.

With regard to the regulatory effect of trade openness on the environment, the Environmental Impact Assessment method was applied to analyse the potential regulatory effects of the CPTPP on Vietnam's environment. We first analysed trade indicators including export data and the Revealed Comparative Advantage Index from 2000 to 2015 to examine the export pattern of Vietnam to CPTPP member countries. Next, we applied the Environmental Impact Assessment method on the CPTPP to screen and scope potential effects of trade openness on Vietnam's environment. The results show it is likely that Vietnam's textile sector will increase and its production pattern will change for it to be eligible for the CPTPP's rules of origin and tariff reductions. Further, the results show that trade openness activities would benefit the environment when enforceable environmental requirements are integrated into free trade policy.

The study results provide evidence of the possibility to protect and rehabilitate the environment along with Vietnam's economic development. The results also provide insights for Vietnam's policy makers to legalise the requirements on environmental impact assessment before, during, and after the negotiation of the free trade agreement.

Keywords: Trade openness, Environmental impact assessment, CO_2 emissions, Auto-regression Distributed Lag model, Vietnam.

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Abbreviations

ADB	Asia Development Bank
AFTA	ASEAN Free Trade Area
AIC	Akaike Information Criterion
APEC	Asia-Pacific Economic Cooperation
ARDL	Auto-regression Distributed Lag
ASEAN	Association of Southeast Asian Nations
BIC	Bayesian Information Criterion
CO_2	Carbon Dioxide
CGE	Computable General Equilibrium
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
ECM	Error Correction Model
EFTA	European Union Free Trade Association - Vietnam Free Trade Agreement
EIA	Environmental Impact Assessment
EKC	Environmental Kuznets Curve
EU	European Union
EVFTA	Europe-Vietnam Free Trade Agreement
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GHG	Green House Gases
GLS	Generalised Least Squares
GoV	Government of Vietnam
GSO	Vietnam's General Statistic Office
IMF	International Monetary Fund
IPCC	International Panel on Climate Change
MARD	Vietnam's Ministry of Agriculture and Rural Development
MFN	Most Favourable Nation
MOIT	Vietnam's Ministry of Industry and Trade
MONRE	Vietnam's Ministry of Natural Resources and Environment
OECD	The Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
RCA	Revealed Comparative Advantages Index
RCEP	The Regional Comprehensive Economic Partnership between ASEAN and China, Korean, Japan, India, Australia and New Zealand
UNEP	United Nations Environment Programme
UNFCCC	United Nation Framework Convention on Climate Change
VCUFTA	Vietnam - Custom Union Free Trade Agreement
VCCI	Vietnam Chamber of Commerce and Industry
VJEP	Vietnam and Japan Economic Partnership Agreement
WB	The World Bank
WDI	The World Development Indicators
WITS	The World Integrated Trade Solution
WTO	World Trade Organisation

Chapter 1
Introduction

1.1 Introduction

International economic integration and trade liberalisation have been common trends globally. A report by the World Trade Organization showed that as of 2017, there were 247 free trade agreements, which were registered with the WTO and came into force (WTO, 2017). The government of Vietnam (GoV), continually directed by the innovation policy[1] since 1986, has been negotiating a number of free trade agreements to attract foreign investment and to boost the national economy. Vietnam has trading relationships with 230 countries, with which 90 bilateral trade agreements have been signed; the Most Favourable Nation status has been applied to 89 countries and territories, and 40 agreements on avoiding duplicating taxes have been implemented. The country experienced remarkable achievements such as an increase in GDP by 6.43% per year and real GDP per capita by 4.93% per year, from 1985 to 2017 (WDI, 2018).

Vietnam has also experienced a degradation of the environment. For instance, Vietnam's CO_2 (carbon dioxide) emissions increased about seven-fold between 1985 and 2013, and accounted for 48% of total green-house gas (GHG) emissions in 2012 (WDI, 2016). In terms of energy consumption, the demand for energy in Vietnam depends heavily on the exploitation of fossil fuels, such as oil and coal (Zimmer, Jakob & Steckel, 2015) and other renewable energy sources, such as family-sized biomass and hydro power. Further, energy consumption of fossil fuels has increased dramatically and accounted for 29.6% in 1985 and 66.2% in 2012 of the country's total energy consumption (WDI, 2016).

Vietnam opens not only the goods and services sectors but has to follow environmental protection requirements. This poses a major challenge for the way Vietnam can best advance its interests while preserving the country's environment. For instance, through the implementation of a trade openness policy, there are some sectors and subsectors, such as textiles and garments, aquaculture and agriculture products where their export turnover is expected to increase in the future. However, the natural resource-based products and environmentally intensive sectors, such as crude oil, rice, coal and rubber, also emit large volumes of CO_2 in their production cycles.

[1] Innovation (or Doimoi in Vietnamese) is a wide range of policy measures introduced in 1986 to promote Vietnam's transition to a market economy (Le & Le, 2000).

The literature on economic growth, energy consumption and environmental pollution is well established. The theory on the Environmental Kuznets Curve (EKC) is widely applied to show the link between economic development and environmental conservation (Kohler, 2013; Stern, 2003). More specifically, environmental degradation and per capita income may be linked by an inverted U-shaped curve, showing that at the beginning stage of the development, where the per capita income is still low, the damage to the environment may exhibit an increasing trend. At the later stage of economic development, there will be a stable period at some middle income levels. With higher income levels, people are willing to pay more money to protect the environment. Consequently, the environmental quality will be improved along with economic development. However, the EKC theory is still debatable (Jayadevappa & Chhatre, 2000; Muradian & Martinez-Alier, 2001).

Recently, the government of Vietnam has strengthened its effort and commitment towards completing the environmental policy and legislation to implement environmental protection and to facilitate direct international investment. In the context of international economic integration, the nation determined one of six overall solutions: "development of an environmental economy sector to address environmental issues, increase economic growth, and create incomes and employment by other economic sectors" (GoV, 2012, pp. 86). Therefore, it is particularly important to assess trade openness impacts on Vietnam's environment to generate a systematic overview of the potential impacts on the domestic environment from trade commitments. In addition, it is important to quantify, economically and environmentally, the good and bad effects of the Free Trade Agreement (FTA) in order to develop appropriate policies to mitigate the negative environmental impacts and maximise the positive benefits from the FTAs.

1.2 Economic Development and Environmental Consequences in Vietnam

Since the innovation policy in 1986, Vietnam has gradually moved towards building and developing a market economy and has participated in international economic integration. Vietnam has gained remarkable achievements in economic development through the innovation process (Abbott, Bentzen, & Tarp, 2009; Anwar & Nguyen, 2011; and Tarp, Roland-Holst, & Rand, 2003). These include an establishment of political and economic relationships with 230 countries in the world (Report of Prime Minister Nguyen Tan Dung on the Social and Economic Status of Vietnam in 2013). Besides these are the considerable achievements in the main import and export sectors which have led to significant increases in per capita income.

Table 1-1: Data on GDP and Per Capita Income of Vietnam (1986-2018)

Indicator	Unit	1986	1988	1992	1997	2000	2007	2008	2012	2015	2017
GDP (current US$)	billion USD	26.33	25.42	9.867	26.844	33.64	77.414	99.13	155.82	193.56	223.86
Per capita income (current US$)	USD	437.13	401.8	144.1	361.25	433.3	919.2	1,333.5	1,754	2,111.1	2,343.1

Source: WDI, 2018

The data in Table 1.1 shows Vietnam's GDP increased 7.35 times (or 735%) and per capita income increased 4.83 times (or 483%) from 1986 to 2015. Specifically, GDP increased 1.28 times (128%) from 1986 to 2000 and 5.75 times (575%) from 2000 to 2015 while the per capita income increased 0.99 times (or 99%) from 1986 to 2000 and 4.87 times (or 487%) from 2000 to 2015. These statistics demonstrate a high and stable level of economic growth as well as the significant increase in the per capita income of Vietnam.

The main export products of Vietnam include crude oil, textiles, seafood, rice, electronics, computers and rubber. The export turnover of these sectors and sub-sectors accounted for a huge part of total turnover and gradually increased over the last 30 years. Calculation from the World Bank data in Table 1.2 shows that the export turnover of Vietnam in 2015 was 203 times (20,313%[2]) higher than that in 1986. Thus, exports became an important support for the economic development of Vietnam with the main export countries being the United States (US), European Union countries (EU), Japan, Korea, and China.

Table 1-2: Main Export and Import Data of Vietnam (1985-2015)

Indicator	Unit	1985	1986	1996	2000	2006	2012	2013	2014	2015
Export turnover	billion USD	0.7	0.798	7.25	14.4	39.8	114.52	132.0	150.2	162.1
Import turnover	billion USD	1.86	2.15	11.14	15.6	45.01	113.78	132.03	147.8	166.1

Source: WDI, 2016

With regard to the import sector, the import turnover of Vietnam in 2015 was 166.1 billion USD, an increase of 89 times (or 8,930%[3]) compared to its value in 1985. The main import products of Vietnam are petroleum products, steel, fertilizer, electronics, machinery and equipment with its main

[2] The export turnover of Vietnam in 1986 and 2015 are 0.798 billion USD and 162.1 billion USD, respectively.
[3] The import turnover of Vietnam in 1985 and 2015 are 1.86 billion USD and 166.1 USD, respectively.

trading partners being China, Korea, Japan, Taiwan and Singapore (Abbott et al., 2009; Anwar & Nguyen, 2011; Coxhead, 2007; Coxhead & Nguyen, 2011).

During the 30 year implementation of the innovation policy, the government of Vietnam has constantly strived to achieve a sustainable development objective, and follow international trends on mitigation and adaptation to climate changes. The international economic integration was not only taking place in the social and economic areas with considerable achievements, but also in environmental protection at a slower pace. Previous studies have showed that countries should pay more attention to the environment during their trading processes with one another (Batabyal, 1994; Baghdadi, Martinez-Zarzoso, & Zitouna, 2013) owing to the significant links among the three pillars of sustainable development: economic, social and environmental. International economic integration possibly contributed considerable pressures and challenges to the environment in various ways, including development of environment-intensive sectors/industries through the promoting of export and import products, such as agriculture, aquaculture and energy.

(i) Agriculture, Forestry and Aquaculture Sectors

With the policy of industrialisation during the international economic integration, the target of the government of Vietnam was to decrease the share in GDP of the agriculture, forestry and aquaculture sectors which yielded quite an impressive result. The sector's GDP share decreased from 40.5% in 1991 to 23% in 2002 and 19.7% in 2012. Although Vietnam's agriculture share of GDP has been declining, the rural areas are still home to over 70% of the population and the agricultural sector provides jobs for over half of the country's labour force. Farm production activities still depend on the farmers' experiences and traditional knowledge. Agricultural products experience low prices which force most farmers to use low cost inputs, such as pesticides and herbicides which harm the environment. Furthermore, a large proportion of young farmers try to find better jobs in urban and industrial areas, leading to low labour costs in Vietnam.

Vietnam is the world's second largest rice exporter, resulting in an increasing demand for fertilizers and pesticides and causing CO_2 emissions into the environment. According to the Ministry of Agriculture and Rural Development (MARD), the total amount of NPK fertilizers ($N+P_2O_5+K_2$) used in the agriculture sector in 2015 increased by 3.34 million tons, a seven-fold increase on the value in 1985, which negatively affects the environment and results in soil, water and air pollution (see Table 1.3). The use of fertilizers leaves a considerable amount of residues not absorbed by crops, which negatively affects the agricultural ecosystem, pollutes water sources, and might cause genetic modifications to a number of crops. Further, the development of agriculture also poses serious concerns about CO_2 and other greenhouse gas emissions, for instance, the emissions of CH_4

(methane), CO_2 and NO_2 (nitrogen dioxide) from grazing and from burning of biogas and sub-agricultural products, or from the use of nitrogen nutrients (Robaina-Alves & Moutinho, 2014).

Table 1-3: Amount of Nutrients Used in Vietnam's Agricultural Sector

(Unit: tons)

Year	Chemical fertilizer (*)	NPK fertilizer (*)	Insecticide	Pesticide	GHG emissions (million ton CO_2 equivalent)	GDP sector share (%)
1985	NA	469.2	NA	NA	NA	NA
1990	NA	560.3	NA	NA	NA	38.74
1995	931	1,223.7	15,566	NA	NA	27.18
2000	1,209	2,283	20,948	NA	65.10	24.53
2005	2,189.5	2,083	45,877	21,120	NA	19.3
2010	2,411.3	2,645.4	73,633	24,218	88.30	18.38
2015	3,729.1	3,304.1	100,260	39,106	NA	17.00

Note: NA - no data available
(*): thousand tons
Source: MONRE (2016); GSO (2017).

According to a report on the GHG inventory of the Ministry of Natural Resources and Environment (MONRE) of Vietnam, GHG emissions from the agricultural field were 65.10 million tons CO_2 equivalent (e.q.ton CO_2), accounting for 47.94% of the total national GHG emissions in 2000 (MONRE, 2016). The GHG emissions inventory data in 2010 revealed that agriculture's GHG emissions were around 88.30 million tons CO_2 equivalent, accounting for 33.2% of total emissions.

The GDP share of agriculture has decreased from 24.53% in 2000 to 18.38% in 2010 and 17.00% in 2015 (GSO, 2017); meanwhile the total CO_2 emissions from this sector have increased from 65.10 million tons of CO_2 in 2000 to 88.30 million tons of CO_2 in 2010 (Table 1.3). Previous studies showed that the developing countries will suffer environmental degradation when they emit CO_2 as the main source of greenhouse effects and air pollution (Ren, Yuan, Ma, & Chen, 2014; Saidi & Hammami, 2015; Tan, Lean, & Khan, 2014). Therefore, if our study shows that there is a co-integration between trade openness and CO_2 emissions, then a set of legal requirements and procedures on environmental protection during trade liberalisation could be developed and implemented to reduce the CO_2 emissions from production activities in Vietnam.

(ii) Industrial and Construction Sectors

Vietnam's industrial and construction sectors accounted for 33.25% of the national GDP in 2015, which reflects an increasing trend compared to 23.96% in 1991, in which the processing industries and pre-processing industries continually played an important role (GSO, 2017). However, the technology used in industrial production is still inefficient. It requires large amounts of natural resources and generates waste and pollution, which emits CO_2 into the environment. Therefore, the development of the industrial and construction sectors subsequently leads to increased pressure on the environment. Table 1.4 reveals that from 2007 to 2015 the exploitation of a number of important natural resources increased. Thus economic development in Vietnam still depends heavily on natural resources, which pose a threat to the environment, such as pollution, degradation and lower environmental quality.

Table 1-4: Exploitation of Selected Natural Resources in Vietnam (2007 - 2015)

Unit: thousands of tons

Product	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coal	42,483	39,777	44,078	44,835	45,824	42,083	41,064	41,086	41,664
Crude oil	15,920	14,904	16,300	15,014	15,180	16,739	16,705	17,392	18,746
Iron ore	NA	1,371.6	1,904.5	1,972.1	2,209.2	NA	2,495.3	2,719.0	2,691.0
Natural gas (*)	7,080.0	7,499.0	8,010.0	9,402.0	8,480.0	9,355	9,751.0	10,210	10,660
Textile fibres	384.9	392.9	538.3	810.2	967.1	1,152.8	1,321.9	1,560.0	1,905.3

Note: (*): million m^3
NA: No data available

Source: GSO, 2017

(iii) Energy Sector

The social and economic development of Vietnam has resulted in higher demand for an energy supply. Calculation from statistics data of the World Bank shows an increasing trend in fossil fuel energy consumption in Vietnam for the period from 1985 to 2013, which accounted for 29.6% and 66.2% of the country's total energy consumption in 1985 and 2013, respectively. The burning of such a huge volume of fuel emits harmful gases into the environment, particularly the emissions of CO_2 and other greenhouse gases (Marland, Rotty, & Treat, 1985). According to the forecasts from the National Electricity Development Program for the 2006-2030 period, thermal power (including coal and gas) and hydroelectricity will remain Vietnam's main sources of electricity. Of these, coal thermal power will account for 49.3% of the power infrastructure in 2020 (see Table 1.5). The exploitation of coal, crude oil (domestic and import sources) and gas will continue in the decades to come (GoV, 2017).

Table 1-5: Share (%) of Power Supply - Vietnam's Energy Development Plan (2020-2030)

Power source	Coal	Oil and gas	Hydro power	Renewable sources (small hydro, wind, and solar power, and biomass)			Import	Nuclear power
				Wind	Solar	Biomass		
2020	49.3	16.6	29.5	0.8	0.5	1.0	2.4	-
2025	55.0	19.0	20.5	1.0	1.6	1.2	1.6	-
2030	53.2	16.8	15.5	2.1	3.3	2.1	1.2	5.7

Source: Decision No. 428/QD-TTg dated 18/3/2016 approving the adjustment of the national energy development planning in the period 2011-2020 with the vision to 2030 (GoV, 2017).

1.3 Research Problems and Questions

Vietnam, which lies in the eastern part of the Indochina peninsula, shares land borders with China in the north, Laos and Cambodia to the west, the East Sea and the Pacific to the east and south. Vietnam has a 3,260 km (approximately) long coastline in the east. The total land area of Vietnam is around 305,000 km^2 and the population was estimated at 90.7 million in 2014 (GSO, 2017). The country has among the highest population density in Asia and globally, and also has various favourable conditions in relation to international trade because of its geographic attributes in the Mekong Delta and Asia region, low labour costs, and rich natural resources, among others.

Vietnam was admitted to the membership of the World Trade Organisation in 2007. In 2009, Vietnam participated in negotiations over the Comprehensive and Progressive Agreement for Trans Pacific (CPTPP). On the one hand, Vietnam has gained outstanding achievements and successes during international economic integration such as the growth of GDP and export sectors, as well as the successful facilitating of foreign investment and broadening of its service sectors. The liberalised trade also creates potential opportunities for Vietnam to specialise in production of the commodities that have comparative advantages.

On the other hand, international economic integration also brings various challenges to Vietnam's environment. In terms of energy consumption, the demand for energy in Vietnam depends heavily on the exploitation of fossil fuels, such as oil and coal (Zimmer et al., 2015) and other renewable energy sources, such as family-sized biomass and hydro power. In particular, energy consumption sourced from fossil fuel accounted for 29.6% in 1985 and 66.2% in 2012 of the country's total energy consumption (WDI, 2016). Vietnam has also experienced a major degradation of the environment. For instance, Vietnam's CO_2 emissions increased dramatically from 1985 to 2013. The emissions of CO_2 from energy use for production activities can be considered as one of the most important indicators that show the direct relationship between trade openness activities and the extent of environmental degradation.

Further, Vietnam's trading partnership with developed countries requires a very high standard of sanitation and environmental protection to reduce GHG emissions, develop clean and green products, and provide transparency in production processes. Meanwhile, the Law on the Environmental Protection of Vietnam was issued in 1993, and revised in 2005. The Law was revised again in 2014. However, presently there is no requirement for *ex-ante* and *ex-post* assessments of the impacts of trade activity on the environment. Therefore, the legislation system on investment and environmental protection of Vietnam should be reviewed, revised and upgraded to satisfy the requirements of international economic integration. This also helps Vietnam to address concerns about environmental protection, particularly the CO_2 emissions from economic production activities at the policy level.

The competitiveness of the domestic sectors in Vietnam is still weak and cannot fully take advantage of favourable opportunities from free trade agreements. For example, the most common activities in the industry sector are pre-processing and processing industries, with the main characteristics of low added value and low competiveness of products. Further, the production technology is inefficient and has not been upgraded systematically. Therefore, in order to produce one unit of product these sectors discharge a large amount of CO_2 into the environment. A calculation of the government of Vietnam showed that a 1.89 ton of CO_2 emissions was emitted into the environment when producing every ton of cement product (MONRE, 2012). The MONRE (2012) report also estimated that 234 million tons of CO_2 will be discharged by 2020 by the main industrial sectors such as the cement, steel and textile sectors. In terms of agricultural production, farming effectiveness is still low, and farmers tend to use low cost inputs such as pesticides and herbicides that causes environmental degradation.

In addition, the closer international economic integration with trading partners is a prime source of additional pressures on the country's natural resources and the environment. The natural resources are open-access to international trading partners, causing the acceleration of environmental damage and natural resources depletion. In the case of poor management by the central government and/or local provinces, the environmental consequences from economic development activities such as environmental pollution and over exploitation of natural resources would worsen significantly.

The heavy dependence on agriculture and natural resource intensive sectors for economic development is potentially harmful to the environment in Vietnam. Therefore, it is vital to develop a master plan for free trade negotiation to integrate environmental concerns into the development of the export and import sectors. This will help to reduce and mitigate the negative impacts of natural resource intensive sectors on the environment.

Generic research on the linkage between environmental consequences and development of economic activities is still limited in Vietnam. It remains ambiguous because it is problematic to assess the accurate value and impact of economic activities due to the lack of the availability of data and transparency of information. Another reason is the government's pursuit of external trade at the expense of the environment. Therefore, it is necessary to conduct a study to identify separately the impacts of trade openness on the environment in both the long-run and short-run elasticities. This also helps to integrate the environmental protection into Vietnam's trade liberalisation to ensure that future free trade programs benefit the environment. The research questions are:

Research question 1: What and how are environmental factors affected by trade openness activities in Vietnam?

Research question 2: What are the effects of free trade activities on CO_2 emissions in Vietnam, both in the long-term and short-term?

Research question 3: How would the Trans-Pacific Partnership agreement affect the CO_2 emissions in Vietnam via changing the production of textile and apparel goods?

Research question 4: How can environmental protection be integrated into economic development, particularly the free trade negotiation in Vietnam?

1.4 Research Objectives

The research objectives are to:

(i) Review and evaluate the current corpus of theory and practice in trade openness and environmental degradation in Vietnam.

(ii) Evaluate the long-run and short-run relationship between CO_2 emissions and GDP, energy consumption and trade liberalisation over a period of 29 years from 1985 to 2013 with regard to the environmental impact of the trade openness in Vietnam.

(iii) Analyse the possible impact of the CPTPP on the environment in Vietnam.

(iv) Suggest recommendations to promote the "good" effects and to mitigate the "bad" effects of trade openness on the environment in Vietnam.

(v) Propose mechanisms to include environmental protection into international economic integration at the policy level in a mutually supportive and sustainable manner in Vietnam.

1.5 Contribution of the Thesis

This is the first study that attempts to assess the environmental impacts of trade openness to conserve the environment during the economic development in nearly 30 years in Vietnam. The literature has widely documented that the effect of trade on the environment varies depending on the country and the type of environmental pollutants (Managi, Hibiki, & Tsurumi, 2009). If a country does not properly address the environmental consequences during its economic development, then people will suffer from their behaviours. These environmental consequences may not be simple to identify (or quantify) currently, but will be unavoidable for the future generations.

The findings from our study will help to answer our research questions - why, what and how environmental factors are affected by trade openness activities; how to integrate environmental factors into economic development; and how to quantitatively assess the environmental impacts of trade openness activities. Another contribution of the study is to measure the effect of trade activities on CO_2 emissions in Vietnam, which has not been discussed in previous studies. If the trade openness and CO_2 emissions are closely correlated and the impact is significant, then an adjustment of the government policy and institutional arrangements on free trade negotiation and implementation is necessary to mitigate the negative environmental effects.

There are a limited number of studies that examine environmental impacts from free trade agreements which are incorporated with and without environmental provisions into their contents. The current study helps to bridge the gap in the literature by providing evidence from a case study of Vietnam. Specifically, this study examines the benefits of incorporating environmental commitments into free trade agreements; the regulatory effects of the Trans Pacific Partnership Agreement on the environment; and the way forward to protect the environment in conjunction with the economic development in Vietnam.

For policy makers, the findings of this study are beneficial for the government of Vietnam in considering the integration of environmental concerns into its trade liberalisation charter. In particular, the findings of this study provide more insight into the formulation of a master plan and policy measures to assess the environmental impact before, during and after the negotiation of a free trade agreement.

1.6 Structure of the Thesis

The study framework of the thesis is as follows:

Chapter one introduces the research rationale, research purpose, research questions and objectives and the significance of the study.

Chapter two presents background information on Vietnam's economic development and trade liberalisation. The domestic concerns on environmental protection and legal requirements to protect the environment during the productions are also discussed in this chapter.

Chapter three reviews the literature on the theoretical approaches and practical applications of environmental impact estimation of trade openness. The published studies on the linkage of trade liberalisation and the environment in Vietnam are also reviewed in Chapter three.

Data and research methods are presented in Chapter four, including a research model of the short-run and long-run relationships between CO_2 emissions and trade openness in Vietnam, and the environmental impact assessment method of trade policy.

Chapter five presents the empirical model estimation results and discusses the environmental impact of the Trans-Pacific Partnership agreement in Vietnam.

Chapter six summarises the major findings, proposes academic and practical implications, highlights limitations of the study and provides recommendations for future research.

Chapter 2

Trade Openness and Environmental Concerns in Vietnam

This chapter presents a summary of trade openness and the environmental concerns in Vietnam. Section 2.1 presents the concept of comparative advantage theory in order to understand how Vietnam became a competitive partner in international trade. This section also presents the comparative advantages of Vietnam in trade openness, including low labour costs, rich natural resources, favourable geographic conditions and the willingness to participate in the free trade agreement of the Vietnamese government. Section 2.2 reviews the free trade integration of Vietnam for the period from 1985 to 2016. This section also discusses the extent that environmental requirements have been integrated into trade liberalisation in Vietnam. Section 2.3 presents the main environmental concerns, and the domestic regulative requirements to protect the environment in production and trade policy negotiation in Vietnam, followed by a summary of the chapter.

2.1 Comparative Advantages of Vietnam in International Trade Integration

2.1.1 Concepts of Comparative Advantages

Traditional trade theory pioneered by Adam Smith (1776) was based on the concept of the absolute advantage of each country. According to the theory of absolute advantage, there are two directions in a trade relationship. First, a country has to define the products with absolute advantage, and export the products that are most efficient in production. Second, the country imports the products that are least efficient in production compared to its trading partners.

Based on the absolute advantage in production, a country exploits its national resources in a more efficient manner, improves the production of its resource abundant products in trade with countries that are resource scarce. Smith (1776) explains that such a trade relationship is more beneficial than a non-trade one. Without trade, a country has to produce most of its products, and exploit its limited natural resources as input for production. Besides, a country could gain from international trade as the domestic producers would become more specialised in the production of the goods that have absolute advantage. Consequently, countries will gradually specialise in accordance with their respective absolute advantages under the free trade charter (Schumacher, 2012; Leen, 2014). In addition, international trade enables countries to benefit from labour division. Therefore, countries would produce more efficiently with a given supply of labour and natural resources as a result of international trade.

However, if a country has an absolute advantage in every product, then the concept of absolute advantage does not point towards the pattern of trade. The concept of comparative advantages was first introduced by David Ricardo (1817) to overcome the limitation of the principle of absolute advantage. According to Ricardo's concept, a country has a comparative advantage in production if the opportunity costs of producing a good compared to other goods in the country are lower than those of other countries. International trade is also beneficial to countries with no absolute advantages in production. A country benefits from international trade by producing and exporting products in which it has comparative advantages and lower opportunity costs. Besides, the country imports products that have fewer comparative advantages and higher opportunity costs than its trading partners. The comparative advantage theory is also explained by labour productivity and technology. The technology applied in the production of a nation is reflected in its labour productivity. The level of technology applied in production varies across countries, therefore the differences in technology partly contribute to trading relationships between countries.

The concept of comparative advantage is further explained by the Heckscher-Ohlin theory as a result of interaction between technology used in the production and a nation's resources such as natural and labour resources (Muradian & Martinez-Alier, 2001). Consequently, as a result of trade liberalisation, production which depends on human capital, manufacture and capital intensive activities would become a competitive competence of developed countries (Stern, 2003). On the contrary, developing countries would specifically develop domestic production in favour of the factors that have relative advantages such as natural and labour resources.

International trade can be seen as an important engine of economic growth globally and impact significantly on the welfare of an economy (Rutherford & Tarr, 2002) as well as on the natural resources and the environment. Krugman and Obstfeld (1997) argue that countries participate in international trade for two main reasons. These are resource availability and production scale (Krugman & Obstfeld, 1997 as cited in Wreford Anita, 2006). Specifically, countries differ from one another in terms of resource availability. Accordingly, each country produces different products and gains from such differences. In addition, if a country specialised in a typical product then it would produce it more efficiently in large quantity compared to producing a wide range of products on a smaller scale.

By and large, the resources, including natural and human resources in each country, play a very important role in trade relationships. The predominant production sectors of each country are heavily dependent on the comparative advantages of the country.

2.1.2 Comparative Advantages of Vietnam

The theory of comparative advantages conveys a deeper understanding of how Vietnam became a competitive partner in international trade. This section analyses the comparative advantages in the trade liberalisation of Vietnam based on four main characteristics, namely labour, natural resources, geographic location and the political motivation of the government of Vietnam.

Vietnam is rich in natural resources and possesses favourable geographic conditions for transportation as well as low labour costs. Subsequently, labour and natural resources play a vital role in trade liberalisation in Vietnam. Trade liberalisation in Vietnam has been coupled with the development of labour intensive products and intensive exploitation of natural resources (such as coffee, rice, handicrafts, processed foods and light manufactures) (Litchfield, McCulloch, & Winters, 2003). In return, Vietnam benefits from the technology transfers from developed countries such as the biotechnology transfer in accessing genetic resources under the WTO framework. Vietnam also benefits from further economic integration in terms of access to markets and specialising in traditional products in which Vietnam has comparative advantage (Abbott et al., 2009), such as textiles and garments, crude oil, fuel and footwear products.

Another important reason that Vietnam trades with foreign countries is the political objective behind the formation of FTAs. According to a study conducted by the Asia Development Bank (ADB) in 2008, the political factor is the primary motivation for a country to set up an FTA in addition to the economic benefits. Improving the political position in regional and international negotiation is targeted as one of the main priorities of Vietnam in the international integration process. Political goals play an important role for the government of Vietnam in considering engagement in free trade negotiations and globalisation (MOIT, 2016). For example, ADB's (2008) study shows that accession to the ASEAN[4] free trade area helps its member countries to facilitate domestic economic reform rather than meeting the primary purposes of ASEAN-based agreements (ADB, 2008).

In addition, there is a lack of certain private property rights in terms of natural resources such as land, water, and mineral resources. Besides, Vietnam is a socialist country and the government has centralized management power. This is a favourable condition for Vietnam in economic development since the government has the right to take away land from the people or exploit its mineral resources when necessary. Consequently, the government can adjust the domestic production pattern to minimise production that causes pollution and environmental degradation.

[4] The Association of Southeast Asian Nations (ASEAN) is a regional economic and political cooperation organisation among 10 Southeast Asian countries, including Brunei, Cambodia, Laos, Myanmar, Vietnam, Indonesia, Malaysia, Philippines, Singapore and Thailand. Vietnam officially joined ASEAN in 1995.

However, many environmental supporters claim that the environment may worsen in Vietnam for several reasons. Firstly, the existing administration system allows local government officials to decide how they can increase their provincial growth annually. As a result, the province's leaders prioritise economic development while paying less attention to regional pollution matters (Phuong, 1997). Secondly, Vietnam's state sectors and state monopoly enterprises benefit from the privileges of access to land, resources and quotas in doing their business (Fukase & Martin, 2001). This is a result of differentiation and discrimination in business that makes Vietnam a distorted economy in the region. As a consequence, the opaqueness of the management systems, particularly at provincial level, may worsen the environmental conditions locally (Fukase & Martin, 2001).

Although the cumulative benefits of trade liberalisation are well documented, the environmental consequences of integration in Vietnam have received only limited attention (Coxhead, 2007). Vietnam has noticeable comparative advantages in natural resource intensive products, and the closer international economic integration with trading partners is a prime source of additional pressures on the country's natural resources and the environment. Vietnam experienced not only an accelerated liberalisation of trade but also gained remarkable achievements in terms of trade policy and institutional reforms (Abbott et al., 2009). In the case of poor management of the central government or local provinces, the environmental consequences from economic development activities such as deforestation, environmental pollution, and over exploitation of natural resources would worsen. This may lead to an accelerating of environmental degradation and natural resource depletion (Abbott et al., 2009).

In summary, the abundance of natural resources, political motivation of the government, comparative advantage in low labour costs and geographic conditions are the primary factors that make Vietnam a competitive partner in international trade. However, economic development based on natural resource intensive sectors may cause serious consequences to the environment.

2.2 Overview of Free Trade Integration in Vietnam

2.2.1 Economic Integration Process in Vietnam

An overview of the economic integration process in Vietnam and its remarkable achievements are presented in Table 2.1. Briefly, the process is marked by the innovation policy of 1986. The main purpose of this policy is to transform the economy from economic socialism to a market economy directed by socialism and managed by the state. From 1986 to 1993, Vietnam experienced a gradual rise in GDP (5.60% per year) and per capita income (3.33% per year). The first Law on Environmental Protection of Vietnam was promulgated in 1993. The Law was then revised in 2005 and in 2014.

During the period from 1993 to 2005, Vietnam enjoyed a considerable increase in economic achievement. GDP and per capita income increased by 7.30% and 5.97% per year, respectively. From 2005 to the present, Vietnam has experienced a wide range of modifications in its domestic legal system, such as the revision of the commerce and trade laws and the environmental law.

The foremost milestones in economic development, particularly in terms of trade liberalisation in Vietnam were achieved by the WTO membership in 2007, and the accelerated negotiations for free trade agreements in 2010. Since then, Vietnam has been negotiating several important free trade agreements with developed countries.

Table 2-1: Overview of Economic Milestones in the Development of Vietnam (1986-2017)

1986-1993	**1986**	**Doimoi (the Renovation) – Economics reforms begin**
GDP increased 5.60% per year	1988	Import tariffs introduced
Per capita income increased 3.33% per year	1989	Market oriented reforms, Unified exchange rate
		State monopoly of foreign trade eliminated
	1990	Export processing zones established
	1991	Law on Import and Export Duties – established preferential tariffs
	1992	European Union trade agreement
	1993	**Law on Environmental Protection**
	1994	Quotas introduced
1994-2005	1995	Joined ASEAN
GDP increased 7.30% per year	1997	Asian Financial Crisis begins. Reduced requirements on firms to enter foreign trade
Per capita income increased 5.97% per year	1998	Joined APEC
	1999	MFN agreement with Japan
	2000	US-Vietnam Bilateral Trade Agreement (BTA) signed
	2001	CEPT/AFTA implementation plan under ASEAN begins
	2002	ASEAN-China Free trade area
		Implementation of US-BTA begins
	2003	ASEAN-Japan comprehensive economic partnership
2006-2017	2004	EU-Vietnam bilateral agreement on WTO Accession Competition Law
GDP increased 6.18% per year	**2005**	**Revised Laws on Environmental Protection**
Per capita income increased 5.08% per year		Revised Laws on Commerce and Trade
	2006	CEPT/AFTA under ASEAN to be completed
	2007	**Becoming a member of WTO**
1986-2017	**2010**	**Initiated free trade negotiation process of ASEAN+; TPPA, EVFTA, EFTA, VCUFTA...**
GDP increased 6.43% per year	**2014**	**Revised Law on Environmental Protection**
Per capita income increased 4.93% per year	**2015**	**Negotiation of TPPA concluded**
	2016	**Negotiation of EVFTA, EFTA, VCUFTA concluded**

Source: Abbott et al., 2009 and author's calculation, 2018

Coxhead (2007) and Abbott et al. (2009) showed that Vietnam has made considerable gains in economic development during the last 30 years. It now has trading relationships with 230 countries with which 90 bilateral trade agreements have been signed. The Most Favourable Nation status has been applied to 89 countries and territories, and 40 agreements on the avoiding of duplicating taxes have been implemented. In 1993, Vietnam normalized its relationships with the World Bank (WB), the Asia Development Bank (ADB), and the International Monetary Fund (IMF). Consequently, Vietnam received invaluable assistance with financial and human resources, and institutional arrangements.

In 1995, Vietnam officially joined the Association of South East Asia Nations. Since then it has committed itself to the ASEAN Free Trade Area (AFTA), instituting an implementation period of obligations and commitments under the Program of Common Effective Preferential Tariffs (CEPT) of the AFTA. In 1998, Vietnam became a member of Asia-Pacific Economic Cooperation Forum (APEC) and deployed the Individual Action Plan (IAP) of the APEC with the commitments on tariffs and non-tariffs, services, investment, intellectual property rights, trade and the environment in more than 15 areas. In 2000, Vietnam signed a bilateral trade agreement with the United States, which became Vietnam's second largest trading partner (MOIT, 2016).

One of the foremost milestones of the globalisation is that Vietnam became a full member of the WTO in 2007. The WTO membership enables Vietnam to join a new economic integration progress with other members. Since 2010, Vietnam has been actively involved in free trade negotiation aimed at reducing and eliminating tariff and non-tariff barriers to facilitate free trade activities. Some agreements that Vietnam has negotiated since 2010 include the Trans-Pacific Economic Partnership Agreement, the Europe - Vietnam Free Trade Agreement (EVFTA), the European Union Free Trade Association - Vietnam Free Trade Agreement (EFTA), and the Vietnam - Custom Union Free Trade Agreement (VCUFTA).

With regard to free trade agreements, based on data from the Vietnam Chamber of Commerce and Industry (VCCI) 16 free trade agreements have been negotiated and signed since 2016 (see Table 2.2). Of these 16 FTAs, 10 FTAs have been implemented including 6 FTAs signed as part of ASEAN and four FTAs signed as a nation. As well, Vietnam has recently completed negotiations for two FTAs with the European Union and Trans-Pacific countries in 2015. As of December 2016, Vietnam is still negotiating for four FTAs, which include the Regional Comprehensive Economic Partnership (RCEP) between ASEAN and China, Korea, Japan, India, Australia and New Zealand; an FTA between ASEAN and Hong Kong; an FTA between Vietnam and Israel; and an FTA between Vietnam and the European free trade area (VCCI, 2016). In addition, Vietnam has signed bilateral trade agreements (BTAs) with about ninety countries. The US, Japan and the European Union countries are Vietnam's main trading partners.

Table 2-2: FTA Negotiations in Vietnam

FTA signed on behalf of a member of Asean	FTA signed on behalf of a nation	FTA under negotiations
Asean - AEC	CPTPP	RCEP (Asean+6)
Asean - India	Vietnam - Japan	Vietnam - Israel
Asean - Australia/New Zealand	Vietnam - Chile	Vietnam - EFTA
Asean - Korea	Vietnam - Korea	Asean - Hong Kong
Asean - Japan	Vietnam - Eurasian Economic Union	
Asean - China	Vietnam - EU	

Source: Adapted from MOIT, 2017

2.2.2 Incoporating Environmental Concerns into Trade Liberalisation

According to the WTO, concerns for environmental protection generally have been integrated in the free trade process to ensure the protection of the environment and the sustainable use of limited natural resources (WTO, 2010). Various aspects of environmental issues have been incorporated into international trade agreements since 1970s (Jayadevappa & Chhatre, 2000). Until the early 1990s, the General Agreement on Tariffs and Trade (GATT) and the WTO are the major forums where the impact of trade on the environment is properly and officially addressed (Carrapatoso, 2008).

Significant progress on discussion of this link was achieved by the commencement of the Doha Round in 2001. One of the aims of environmental supporters in the Doha Round was to strike a balance between environmental protection from Multinational Environmental Agreements (MEA) and economic decisions from Free Trade Agreements. In addition, the establishment of the Committee of Trade and Environment (CTE) in the WTO and the Committee of Trade and Investment (CTI) in the Asia-Pacific Economic Cooperation Forum also marked the endeavors of the international community to protect the environment when establishing free trade relationships (Carrapatoso, 2008).

Previously, protection of the environment has been discussed in the preambles or side agreements of free trade agreements. Additional concern has been given to the protection of the environment, so it has been negotiated as an article in some drafts of FTAs (George & Serret, 2011). Anuradha (2011) claimed that the incorporation of environmental concerns tends to be addressed separately as a side agreement by developing countries. The main differences in environmental provisions which are integrated into FTAs are their enforcement mechanisms (Baghdadi et al., 2013).

Carrapatoso (2008) argued that the incorporation of environmental concerns into a free trade agreement negotiation is additionally based on the relationships between the trading countries, such as which countries will do the negotiating, their preferences and political points of views, economic development conditions and cultures of the countries. This is exemplified in the case where a developing country is a partner in negotiating a FTA and negotiators from developed countries tend to avoid citing their domestic requirements and concerns to protect the environment. Instead, they use specific skills such as political arguments to convince their counterparts on issues related to the integration of environmental protection into the free trade agreements (Carrapatoso, 2008).

The benefit of incorporating environmental commitments into free trade policy is still ambiguous and there are limited studies on Vietnam. Baghdadi et al.'s study (2013) examines whether free trade agreements which incorporated environmental provisions helped to reduce CO_2 emissions by estimating the CO_2 concentration emissions for 182 countries from 1980 to 2008. For those countries which signed trade agreements that integrated environmental protection, the CO_2 concentrations are lower than for the countries which signed trade agreements without concern for the environment. Further, Baghdadi et al.'s study found that only the FTAs which incorporated environmental concerns positively affected the environment. In a case study which reviewed the impact of trade policy on China's environment, Mao, Song, Kørnøv, & Corsetti (2015) found that an environmental impact assessment (EIA) on free trade policies ultimately improved both the environmental and economic benefits for China overall.

(i) Integration of Environmental Concerns into FTAs in Vietnam

In 1995, Vietnam signed a framework agreement with the European Union which became an important dialogue framework. This agreement provides a cooperative mechanism for trading and commercial activities between Vietnam and EU countries, and also incorporates environmental protection (Thanh & Duong, 2011). The concern for the environment at this stage is at the cooperative level, which stipulates that both parties agree to cooperate in protecting the environment. The detail on how to protect the environment via trade activities, however, has not been explored.

In 2012, Vietnam and the EU signed a framework agreement on a comprehensive partnership and cooperation that included not only the environment and natural resources protection but also cooperation on climate change. In terms of the environment and natural resources, the agreement aims at strengthening cooperation via technical assistance programmes, and transfer and utilisation of environment-friendly technologies. The cooperation on climate change aims at improving the energy performances of the economies more efficiently toward a green energy innovation. In order to achieve these objectives, the agreement sets out the cooperation framework focusing on technical cooperation and enhancing capacity building to address challenges in climate change.

Based on the framework agreement of 2012, Vietnam and the EU started to negotiate the EVFTA in 2013, which was completed in November 2015 with separate provisions on environmental protection integrated into it. Besides, Vietnam negotiated a separate free trade agreement with the EU Free Trade Area (the EFTA) (MOIT, 2016).

Vietnam and Japan signed an economic partnership agreement (VJEP) in 2008 which includes several provisions on environmental protection cooperation in the agreement. The VJEP aims at liberalising and facilitating trade in goods and services between both countries (MOIT, 2016). The environmental protection provisions in this agreement mainly focus on technical co-operation and capacity building.

The Vietnam - US Bilateral Agreement (BTA), which was signed in 2000, can be considered as the most comprehensive trade agreement in Vietnam since 2000 (Parker, Phan, & Nguyen, 2002). This trade agreement granted a framework that is designed to enhance trade between the two countries. The agreement includes provisions on market access, national treatment and tariff reduction. The agreement also specifies the elimination schedule for quantitative restrictions on several products in the industry and agriculture sectors.

Further, Vietnam is also required to commit broadly on opening up a range of service sectors for trade (Fukase, 2013) as a result of the BTA. Specifically, the BTA required a tariff reduction package from Vietnam on the most-favoured-nation (MFN) basis for 250 products which are mainly agricultural products. Besides, the business environment required improvement to enable the US companies to operate in Vietnam. However, there is no requirement on environmental protection in the 121 pages of the agreement[5]. This reflects that the environmental concerns have not been discussed and integrated into the trade activity in Vietnam during that period.

Vietnam showed a strong shift in incorporating environmental protection commitments into free trade policy during the negotiation of the CPTPP. In 2009, Vietnam officially negotiated the Trans-Pacific Partnership agreement with eleven other countries, namely Australia, New Zealand, Brunei, Malaysia, Singapore, Chile, Peru, Canada, Mexico, the United States and Japan. The CPTPP aims at establishing an extensive regional free trade agreement to promote international economic integration and liberalisation in trade and investment activities (CPTPP, 2017). The CPTPP is expected to further enhance regional economic integration among member countries as well as to create a foundation for FTA in the Asia Pacific region.

On October 4, 2015 the CPTPP announced the conclusion of the negotiations by the Ministers of the twelve CPTPP countries. In January 2017 the new administration of the US announced its withdrawal from the CPTPP; however, the eleven remaining members continued to negotiate the regional economic agreement without the US. This study uses the latest version of the CPTPP released in

[5] This is based on the authors' analysis of the BTA.

October 2015 and published on the Vietnam government's website to assess the impact of the free trade agreement on the environment in Vietnam. The eleven remaining members of the CPTPP (without the US) are collectively named the CPTPP member countries in this study.

The CPTPP covers basic conditions on trade promotion as well as obligations on labour, the environment, sanitary and phytosanitary measures, etc. In terms of environmental protection, particularly, the CPTPP encourages high levels of environmental protection through effective enforcement of environmental laws, and sustainable development through mutually supportive trade and environmental policies and practices. Details on environmental requirements incorporated into the CPTPP are described below.

(ii) Integration of Environmental Regulations into the CPTPP in Vietnam

Collectively, there are four main issues in the CPTPP that potentially generate a greater likelihood of CO_2 emissions in Vietnam[6], namely: national treatment and access for goods; rule of origin and origin procedures (ROO); environmental regulations and cooperation activities; and dispute settlement mechanisms.

National Treatment and Access to Goods

The CPTPP sets up tariff elimination and reduction on goods (industrial and agricultural goods) across CPTPP member countries, and facilitates international trade procedures (CPTPP, 2017, chapter 2). Almost all proposed tax reforms on goods by the CPTPP will be effective immediately after the date the CPTPP goes into effect; and the rest are eligible for a retention period of tax reform if agreed by CPTPP member countries. The integration of re-structured goods in the CPTPP (CPTPP, 2017, chapter 2, p. 5, 11) may encourage the recycling, restructuring and reassembling of separated parts to form new products which are considered as environmental friendly goods. By the legalisation of re-manufactured products, the CPTPP helps to reduce pressure on natural resources and waste disposal into the environment.

Rule of Origin and Origin Procedures

The CPTPP requires its member countries to prove the origin of goods to benefit from the tariff eliminations or reductions of the CPTPP. The CPTPP's "accumulation rule" treats material from a CPTPP member country similarly to material from other CPTPP member countries if it is used to produce a product in a CPTPP country. This ensures that CPTPP member countries are the main beneficiaries of the CPTPP.

Strengthening the administration of ROO may help in reducing costs and delays to traders, increasing

[6] This is based on the authors' analysis of the CPTPP.

transportation efficiencies and promoting a paperless working environment. Proving and providing the origin of goods also helps to avoid the situation of illegal exploitation of natural resources.

Environmental Regulations

The CPTPP creates enforceable commitments on a wide range of environmental issues such as commitments to the multilateral environmental agreements[7] and national environmental laws. The CPTPP also proposes to eliminate environmentally destructive subsidies, tariffs and other barriers to trade in environmental goods and services and cooperate toward a low-carbon economy.

Besides, the CPTPP proposes a cooperative mechanism in transitioning to a low emissions and resilient economy. This may cover areas such as energy efficiency; development of cost-effective and low emissions technologies; emissions monitoring; low emissions and resilient development. These regulations may benefit Vietnam's environment in terms of regulatory and technology effects.

Dispute Settlement Mechanism

Commitments on environmental protection will be enforced by the same dispute settlement procedures and mechanisms including trade sanctions for disputes arising from the CPTPP.

In summary, Vietnam has actively accelerated its participation into international economic integration during the last 30 years. A variety of free trade agreements with developed countries has been concluded and/or has been being negotiated, such as the CPTPP, the EVFTA, the EVTA, the RCEP, etc. However, environmental protection has not been integrated into commitments in FTAs. The CPTPP is the first free trade agreement that Vietnam has negotiated which covers a broad range of environmental concerns. In particular, the dispute settlement procedures will be applied for any unresolved environmental issues arising under the trade agreement. These commitments will ensure that Vietnam considers environmental priorities, adopts or modifies relevant environmental laws and policies to protect the environment. The enforceable commitments and dispute settlement mechanism enable Vietnam to protect the environment and consider any arising environmental issues more seriously during the implementation phase of the CPTPP.

2.3 Environmental Protection in Trading Activities in Vietnam

2.3.1 Energy Use and CO_2 Emissions in Vietnam

Air pollution is a serious environmental problem in Vietnam, particularly in the big cities and industrial areas. The main air pollution sources are transportation, industrial production, coal and

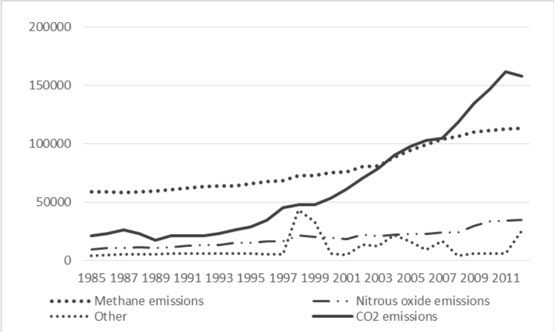
[7] The MEAs include the Convention on international trade in endangered species of wild fauna and flora (CITES); the Montreal Protocol on ozone depleting substances; the International Convention for the prevention of pollution from ships (MARPOL).

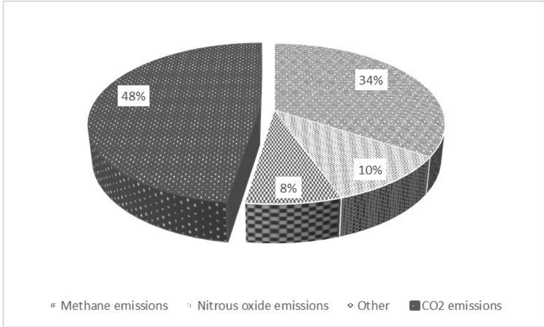
thermal production, production of steel, cement and construction material, and agricultural production. Air pollution is also sourced from production in small villages in rural areas. For example, the productions of weaving and dyeing emit dust, SO_2 (sulphur dioxide), and NO_2 to the surrounding environment, which are reported to be higher than the Vietnam air ambient standard (MONRE, 2008). Another air pollution contributor is from the electricity generation and combustion of wood for individual burning or agricultural products. However, CO_2 emissions from individual burning usually affect the local environment on a small scale and the quantity and scale of these discharged sources have been gradually improved (MONRE, 2012).

The emissions of CO_2 from energy use for production activities can be considered as one of the most important indicators that show the direct relationship between trade openness activities and the extent of environmental degradation (Halicioglu, 2009). Energy is an important input for production activities. It is expected that as production activities increase, more energy is used, and this consequently leads to more CO_2 emissions into the environment (Ang, 2008; Tan et al., 2014). If there is an increase in domestic production as a result of trade liberalisation then this may lead to a higher demand for energy consumption for the manufacturing and production of these products. Consequently, the increase in production may lead to higher emissions of CO_2 into the environment.

In terms of energy consumption, the demand for energy in Vietnam mainly depends on the exploitation of fossil fuel, such as oil and coal (Zimmer et al., 2015) and other sources, such as family sized biomass and hydro power. Statistical data from the World Bank (WDI, 2016) reveal a rising trend in energy consumption, sourced from fossil fuel in Vietnam, which accounted for 29.6% in 1985 and 66.2% in 2012 of the total energy consumption. In an effort to reform the power sector, the government of Vietnam approved a Master Plan for Power Development in 2011. The plan is designed to ensure growth in renewable energy sources that is expected to account for 4.5% in 2020 and 6% in 2030 in total electricity production in Vietnam (GoV, 2017; Zimmer et al., 2015).

Vietnam has also experienced a dramatic increase in CO_2 emissions, an increase of about seven-fold between 1985 and 2013. Particularly, the emissions of CO_2 account for 48% of total GHG emissions in Vietnam in 2012 (see Figure 2.1). Consequently, CO_2 becomes the main make-up of energy-related GHG emissions in Vietnam. In this current study, CO_2 emissions is used as a proxy for environmental degradation in order to examine the short-run and long-run co-integration between the environment and trade openness activity.





(a) Trends of GHG Emissions from 1985 to 2012 (b) The GHG Inventories in 2012

Figure 2-1: Trends of CO_2 Emissions in Vietnam (1985-2012)

Source: Author's calculation from the World Bank's WDI, 2016

Vietnam ratified the United Nations Framework on Climate Change Convention (UNFCCC) in 1994 and the Kyoto Protocol in 2002. Vietnam is a member of the non-Annex 1 Party of the UNFCCC therefore Vietnam does not have to commit to Green House Gases reduction. However, Vietnam has been actively implementing common obligations such as developing the National Communication on climate change, GHG inventory and assessing the mitigation measures and responding to activities on climate change. The first national report on UNFCCC was prepared in 2003 and the second report published in 2010. An overview of CO_2 emissions calculated for Vietnam compared with the world's average and other CPTPP member countries from 1985 to 2013 is presented in Table 2.3.

Table 2-3: Estimated CO_2 Emissions Per Person in Vietnam, CPTPP Member Countries and the World's Average (1985-2013)

Unit: metric tons per capita

	1985-1990	1991-2000	2001-2007	2008-2013
Vietnam	0.37	0.47	1.06	1.67
Mexico	3.82	3.69	3.89	3.92
Chile	2.08	3.20	3.79	4.42
The world's average	4.22	4.06	4.39	4.85
New Zealand	7.28	7.71	8.37	7.57
Malaysia	2.60	4.96	6.31	7.62
Peru	2.60	4.96	6.31	7.62
Singapore	13.18	15.24	8.01	8.45
Japan	7.97	9.29	9.69	9.32
Canada	16.27	16.14	16.91	14.57
Australia	15.63	16.16	17.26	17.17
United States	19.40	19.50	19.50	17.15
Brunei	18.13	16.50	14.70	22.03

Source: Author's calculation from the World Bank's WDI, 2016

Table 2.3 demonstrates that the CO_2 emissions per person in Vietnam increased steadily from 1985 to 2013; however, the emissions of CO_2 remain far lower than the world average value and those of other CPTPP member countries. Particularly, Vietnam had the least CO_2 emissions (per person) among the CPTPP member countries from 1985 to 2013. The smaller magnitude of CO_2 emissions in Vietnam is possibly due to the smaller scale of production compared to other CPTPP member countries and the high population density of Vietnam.

The increase in CO_2 emissions in Vietnam partially reflects the inefficiency of carbon-reduced technology in Vietnam. According to an assessment of the International Panel on Climate Change (IPCC), Vietnam is one of the top five countries in the world that will be severely affected by the impact of climate change. IPCC reveals that the emissions of CO_2 from Vietnam probably have local impacts rather than global impacts (IPCC, 2010 as cited in MONRE, 2010). Therefore, Vietnam should seriously consider environmental protection and CO_2 emissions in the economic development and trade liberalisation. A breakdown of the GHG inventory in Vietnam is presented in Figure 2.2.

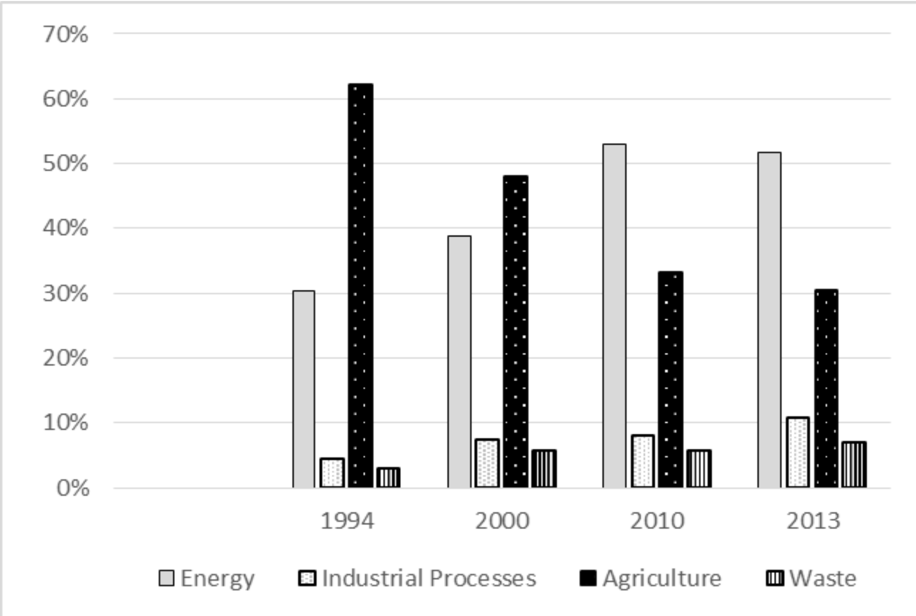


Figure 2-2: GHG Inventory Results by Sectors from 1994 to 2013 (by % CO_2 Equivalent)
Source: Author's calculation from MONRE, 2016

Figure 2.2 describes Vietnam's greenhouse emissions inventory results from 1994 to 2013. Overall, the agriculture and energy sectors are the main sources of CO_2 emissions in Vietnam. CO_2 emissions from the agricultural sector are 65.1 million tons, accounting for 47.9% of total emissions in 2000, followed by the energy sector (52.8 million tons of CO_2 equivalent, 35% of total emissions). From 2010, the energy sector became the main source of CO_2 emissions, which accounted for 53% and 51.6% of total GHG emissions in 2010 and 2013 respectively. Agriculture and energy are the two main sectors contributing to the economic development of Vietnam during the last decades. These sectors are expected to continue to play a vital role in the national economic development plan. Therefore, the environmental state in Vietnam will be significantly improved if CO_2 emissions are addressed properly in the economic development process.

2.3.2 Legal Requirements to Protect the Environment in Production and Trade Policy Negotiation Activities

The legal requirements on environmental protection have been established in a harmonious relationship with economic and social development in Vietnam in order to achieve the objective of sustainable development. Under the Constitution of Vietnam, the most important legal document on the environment is the Law on Environment Protection that provides for "activities of environmental protection; policies, measures and resources for environmental protection; rights and obligations of organizations, households and individuals in environmental protection" (GoV, 2014a, p.1).

The first Law on Environmental Protection implemented in 1993 aimed at protecting human health and the environment to achieve sustainable development and environmental conservation at the regional and global levels (GoV, 1993). The Law includes responsibilities on the environmental protection of economic activities by sectors but there was no specific article on environmental protection obligations in trade openness activity.

The Law on Environmental Protection was revised in 2005 and promulgated with a new scope of stipulation, structure and regulations based on revision and amendment of the 1993 Environmental Law. According to the Law on Environmental Protection (2005), an EIA report is legally applied to projects that have national importance and others that may have detrimental effects on the environment such as land-use plans, regional development projects, and development projects of watershed, marine, industry, agriculture, energy, and natural resource exploitation and use. Some examples of development projects[8] that have to conduct an EIA are the urban transportation project in Hanoi, 2007; the project on the exploitation of iron ore in Hatinh province, 2008 etc. The general provisions obligating environmental protection during international economic processes have been included. However, the procedures of the environmental impact assessment of trade policy were not addressed explicitly in the Law (GoV, 2005).

The Law on Environmental Protection was revised again by the Government of Vietnam and approved by the National Assembly in 2014. The EIA on trade policy is still not included in the environmental law. According to the Article 18 of the Law on Environmental Protection (GoV, 2014a), there are only three project groups which are obligated to prepare the EIA. These are (i) projects where investment permission must be decided by the authorization of the National Assembly, the Government and the Prime Minister; (ii) projects that interfere with or use land areas of nature reserve areas, national parks, historic and cultural areas, world heritage sites, biosphere reserves, classified scenic areas; and (iii) projects that may have detrimental effects on the environment (GoV,

[8] A list of EIA on development projects approved by the government of Vietnam from 2004 to date can be found at http://eia.vn/index.php/en/danh-sach-bao-cao-dtm-phe-duyet

2014a).

In terms of regulations on greenhouse gases and CO_2 emissions, the 2014 Law on Environmental Protection is the first Law to provide a legal framework to cope with climate change in Vietnam. However, Vietnam has already been involved in and discussed climate change nationally since 2000 (Zimmer et al., 2015). Accordingly, it is required to integrate climate change into social and economic development plans, including considerations on the emissions of greenhouse gases and development of renewable energy.

Collectively, Vietnam has promulgated a legal framework to protect the environment and reduce the emissions of greenhouse gases. However, there is a lack of legal requirements and specific guidelines to assess the impact of a proposed trade policy on the environment in Vietnam.

2.3.3 Lack of Requirements on Environmental Impact Assessment on Trade Policy in Vietnam

EIA can be defined as an activity that has been designed to identify and predict the impact of a project on the bio-geophysical-chemical environment and human health to minimise the adverse impact of a proposed project on the environment and humans (Anjaneyulu, 2011). The EIA ensures that countries take into account the responsibility of environmental conservation during economic and social development. The EIA can be used to determine impacts on the environment from a proposed project, or policy (Abaza, Bisset, & Sadler, 2004). Unlike an EIA on a project, an EIA on trade policy has its own unique characteristics and logical framework (Mao et al., 2015).

An EIA on trade policy is best characterized as a forecasting tool to investigate environmental impacts and/or opportunities resulting from a proposed free trade policy. Theoretically, trade policies affect the scale and structure of international trade by modifying export and import. That then alters the domestic production of a country and leads to corresponding changes in energy consumption and pollution emissions through scale, composition, and technique effects (Antweiler, Copeland, & Taylor, 2001). By conducting an EIA on a proposed free trade policy, timely and relevant modifications and recommendations can be introduced to improve the effectiveness of the proposed trade policy on the environment.

The EIA on the North American Free Trade Agreement (NAFTA)[9] in 1991 is considered a pioneering work of an EIA on trade policy (Gibson & Walker, 2001). Application of an EIA on a proposed policy, particularly trade policy, is generally used in developed countries such as the US, Canada, Japan, the OECD and the EU, among others. Particularly, in the US and Canada, the EIA is legally conducted on

[9] NAFTA is a free trade agreement among the US, Canada, and Mexico, which entered into force in 1994.

proposed trade policies and this process has been legalized in the internal legal framework (Gallagher, Ackerman, & Ney, 2002). In Canada, the government conducts strategic environmental assessments of trade and investment negotiations using a process that requires interdepartmental coordination and public consultations, as described in the 2001 Framework for Environmental Assessment of Trade Negotiations (McCormick, Shuttleworth & Chen, 2006).

In the US, the National Environmental Protection Act requires environmental assessments for all legislative proposals, policies, planning, decisions, and other important federal activities. In Japan, a study group on the environment and free trade agreements was established to work out the EIA guidelines in 2002 that take into account environmental protection measures. The EIA guidelines of Japan also indirectly promote environmental protection in other trade counterparts and encourage these countries to strengthen their environmental conservation in a cooperative manner (Government of Japan [GoJ], 2004).

China's Law on Environmental Impact Assessment (2002) regulates that an EIA must be implemented for major economic development plans such as plans for land-use, regional development, tourism and natural resource development, forestry, energy, water conservation, among others (Wu, Chang, Bina, Lam, & Xu, 2011). However, the lack of requirements on how to effectively conduct an EIA on trade policy in the existing provisions of the EIA Law and in the relevant regulations, leaves China's strategic environmental assessment system incomplete and imperfect (Mao et al., 2015).

There are more than 10 guidelines for EIAs on trade policy published by various countries such as the US, Canada, Japan, EU countries and international organizations such as WTO, ADB, and the United Nations Environment Programme (UNEP). Ultimately, the main purpose of an EIA on trade policies is to integrate environmental considerations into the trade negotiation process by screening and providing information on the environmental impacts of the proposed trade articles (if any). The EIA on trade policy also ensures that environmental concerns are being considered publicly in the course of trade negotiations (GoC, 2009).

For EU countries, the EIA method is designed to provide trade negotiators and policy-makers with an evidence-based assessment of the potential economic, social and environmental impacts of alternative trade liberalisation scenarios. For example, in the context of the EU-Chile FTA, the production of wine in Chile has been improved, leading to the expansion of grapes and other fruit in Atacama, Chile, a dry region. Consequently, the EU-Chile FTA brought about a shortage of water sources for irrigation and urban usage purposes in Atacama (EU-Chile report, 2012).

Vietnam's legal requirements on the environment have been established to conserve the environment in a harmonious relationship with economic and social development. The Law on

Environmental Protection was issued in 1993, revised in 2005 and 2014. However, there is no legal requirement to assess the impact of a proposed trade policy on the environment in Vietnam. This limits the consideration of possible environmental impacts as a result of free trade policy in Vietnam.

2.4 Chapter Summary

This chapter discusses the comparative advantages of Vietnam in international trade. Vietnam became a competitive country in trade activities owing to its abundance of natural resources, low labour costs, favourable geographic conditions and the political motivation of the government of Vietnam. However, economic activity sourced from natural resources may cause a negative impact on the environment. Particularly, the extensive consumption of energy sourced from fossil fuel in production is the main source of CO_2 emissions. Vietnam has gained remarkable achievements in trade activities, which contribute to the economic development and increase the per capita income of Vietnam.

The concern for environmental protection is regulated by the Law on the Environment, which requires protecting the environment during production. However, there is a lack of legal requirements and specific guidelines to conduct environmental impact assessment on trade policy in Vietnam. There is also a lack of incorporation of environmental concerns into the free trade agreements; and the CPTPP is the first free trade agreement Vietnam has negotiated which integrates the requirements and commitments to protect the environment.

Chapter 3

Review of Literature

This chapter reviews the literature on the theoretical approaches and practical applications of environmental impact estimation of trade openness. Section 3.1 presents an overview of the linkage between trade activities and environmental consequences. Section 3.2 analyses the effects of the determinants of trade openness on the environment, including scale effect, composition effect, technique effect and regulatory effect. Section 3.3 describes the Environmental Kuznets Curve hypothesis and reviews selected studies on EKC theory on developing countries. Section 3.4 presents the impact of economic development and trade liberalisation on environmental quality. Section 3.5 reviews studies on how environmental issues have been integrated into trade openness in Vietnam, followed by a summary of the chapter.

3.1 Trading Activities and Environmental Consequences

The discussion on the impact of trade openness on the environment started in the late 1970s and became an emerging and debatable issue particularly for developing countries (Jayadevappa & Chhatre, 2000; Muradian & Martinez-Alier, 2001). Theoretically, the environment system, which includes the natural resources, is linked to the economic system by two main functions. First, the environment provides natural resources as an input for production, and second the environment dissolves the wastes from production (Pearce & Turner, 1990), in which CO_2 is the main gas discharged.

Pearce & Turner (1990) claimed that the amount of waste discharge should be less than the environment's absorptive ability. This generates a harmonised relationship between economic activities and the environmental consequences. If the waste from production processes can be dissolved by the environment, the environment will not be damaged by the economic activities.

The impact of trade liberalisation on the environment has been increasingly investigated by both researchers and policy makers (Cole & Elliott, 2003). The debate on how to protect the environment, when free trade agreements are negotiated bilaterally and regionally, is of particular concern (Mukhopadhyay & Thomassin, 2010). Similarly, Baghdadi et al. (2013) argued that the relationship between trade liberalisation and the environment is complex, and the effect of trade liberalisation on the environment is the most debated issue in trade policy.

Environmental supporters argue that freer trade can be seen as environmentally-unfriendly, as freer trade expands the production activities that increase the exploitation of natural resources and discharges pollutants into the environment. If the discharge from production into the environment overcomes the dissolving ability of the environment, the environment will be degraded and free trade harm the environment. Besides, trade openness may deplete natural resources and negatively affect the environment. This is exemplified by a typical case of a free trade agreement between the US and Mexico. The low environmental standards and regulations in Mexico played a critical role in the reallocation of maquiladoras to the border area between the US and Mexico. This brought about job losses in the US and serious environmental damage and health problems in Mexico (Steininger, 1994 and Wallach & Naiman, 1998, as cited in Muradian & Martinez-Alier, 2001, p.5).

On the other hand, the supporters of a trade openness policy counter that trade liberalisation is environmentally-friendly as trade openness benefits the environment in various ways. First, trade liberalisation creates a transparent business environment in trade. This helps to reduce distortion in the market resulting from the protectionism of the domestic industries. Therefore, the domestic polluted industries and excessively intensified production will not be encouraged by trade liberalisation, consequently trade openness would benefit the environment.

Second, capital and technology can move and transfer freely within the free trade area. This enables the developing countries to access environmental-friendly technology during their production activities (Muradian & Martinez-Alier, 2001). Similarly, Mukhopadhyay and Thomassin (2010) argued that as a result of free trade agreements, capital and technology can be transferred freely within the free trade area. They further claimed that strict regulations on environmental protection in free trade agreements help to improve the competitiveness of the domestic firms. Thus the domestic firms become more innovative in their industrial processes.

Third, countries benefit financially from trade openness. This is considered as one of the most convincing arguments raised by the supporters of trade liberalisation (Carrapatoso, 2008). As a result of trade liberalisation, the per capita income and national revenue will increase considerably. Consequently, with higher income levels people will demand a better environment and be willing to pay higher prices for environmental protection as well as environmentally friendly products (Porter & van der Linde, 1995, as cited in Baek, Cho, & Koo, 2009). Repetto (1994) argued that the economic benefit from trade openness is greater than the environmental impacts as developing countries can factor the cost of environmental protection measures into the prices of products. This includes the costs to pursue high environmental standards or invest in environmental protection measures. The terms of trade will increase as the northern consumers are willing to pay more for products that are environmentally friendly (Repetto, 1994, as cited in Muradian & Martinez-Alier, 2001).

3.2 Determinants of Trade Openness and the Environment

The manner in which a trade openness policy affects the environment is summarised in Figure 3.1. Specifically, a trade openness policy is expected to influence an economy in several ways such as changes in scale, technical, composition and/or regulatory. In turn, the economic changes will affect the environment through three main activities, namely production, consumption and transportation (Fauchald & Vennemo, 2011). Consequently, a trade openness policy or trade liberalisation can affect the environment, which may cause environmental pollution or natural resources depletion. However, it is difficult to define the overall impact of trade openness on the environment whether it is good or bad and there is no simple pattern of good or bad effect. In fact, "they are both – good in some ways, bad in others" (UNEP, 2005, pp. 45).

The complexity of a trade openness impact on the environment is a cumulative combination of the country under study, the level of economic development, and the domestic requirements on environmental protection. Therefore, the overall impact of trade liberalisation on the environment is still a debatable topic. It is, however, plausible in the literature that this impact is conventionally divided into three components known as scale, composition and technique effects (Antweiler et al., 2001; Coxhead & Jayasuriya, 2003; Cole & Elliott, 2003; Fauchald & Vennemo, 2011; Managi et al., 2009; UNEP, 2000, 2005). Also, the regulatory effect has been recently considered when assessing the impact of a trade policy on the environment. The division of the overall impact of trade on the environment into scale, composition and technique effects was pioneered by Grossman and Kruger (1991).

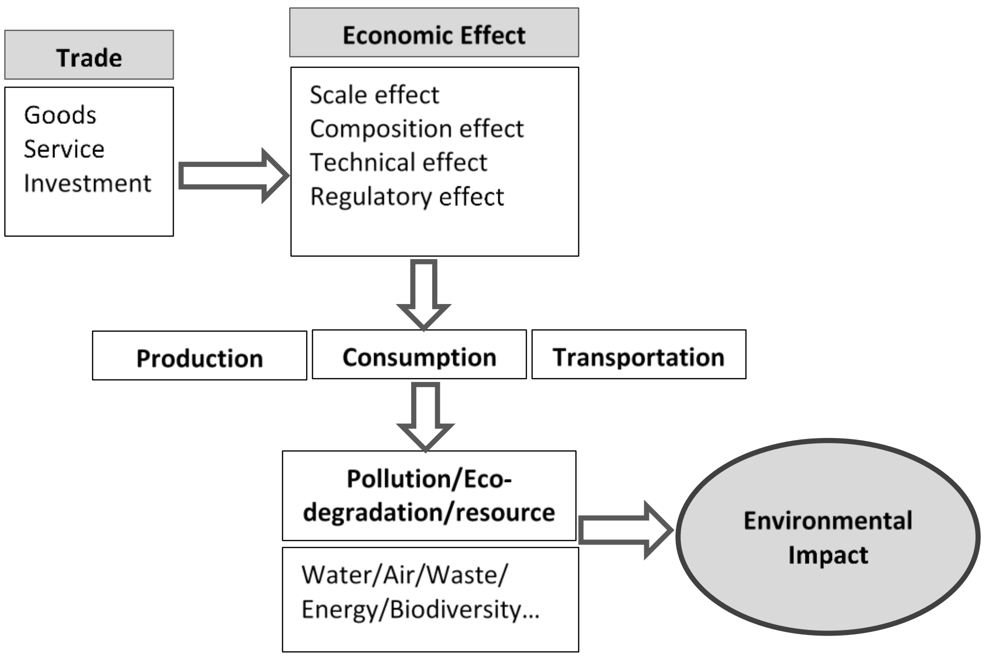


Figure 3-1: Impact of Trade on the Environment

Source: Adapted from Fauchald & Vennemo (2011)

3.2.1 Scale Effects

The scale effect occurs if there is a change in economic activity that leads to a change in the environment through the total level of contaminants, energy use and CO_2 emissions (Stern, 2003). The impact of the scale effect from trade liberalisation on the environment could either be negative or positive.

As the environment provides input for the production activities, then trade openness and economic expansion increase natural resources exploitation and CO_2 emissions into the environment, which lead to more pollution and more pressures on the environment (Antweiler et al., 2001). To this end, the scale impact of trade openness on the environment would be negative. Grossman and Krueger (1991) explained that even if the structure of the economy does not change and the technology has not improved, the scale effect of a trade policy can still be defined as the production activities that generate environmental pollution. An increase in production will result in an increase in pollution and environmental degradation. Thus the scale effects of economic activities on the environment would be negative (Akbostanci, Türüt-Aşık, & Tunç, 2009).

On the other hand, the nation can expand its production activities more effectively as a result of trade openness. Given the same set of natural resources, labour, machines and technology allocation, the economic activities can more effectively improve the efficiency of production activities (UNEP, 2005). This is because as a result of trade openness, countries become more specialised in their productions and more expert in terms of labour division. As a consequence, the scale effect of trade openness on the environment is likely to be positive. Coxhead and Jayasuriya (2003) argued that at first glance, it may appear that the scale effect will be the dominant determinant of long-run environmental outcomes. However, the long-run environmental outcomes are also influenced by other conditions such as the assimilative ability of the environment or the application of environmentally friendly technology in production. Therefore, the growth of economic rates cannot be seen as a negative indicator for environmental quality.

A study by UNEP (2005) showed that the expansion of the economy can affect the environment in both ways, negatively and positively. When production of a firm increases, the firm tends to use advanced technology to save production input originating from natural resources and to decrease waste discharge into the environment. The firm consequently tries to apply international standards and regulations that are usually high and strict, so as to improve its competiveness in the international market.

In terms of empirical works, Antweiler et al. (2001) explored the effect of international trade on environmental pollutants by using data on SO_2 concentrations and found a positive scale effect.

However, Managi et al. (2009) claimed that Antweiler et al.'s (2001) study did not consider the endogeneity problem in production (or income). This implies the authors' study did not treat the effect of trade openness on production (or income) explicitly (Managi et al., 2009). Antweiler and his colleagues divided the effects of trade openness on emissions by scale, composition and technology and the endogeneity problem of scale effects has not been properly calculated. Thus the overall environmental impact of trade cannot be inferred from the summation of these effects which makes the estimated results biased. In another study, Ling, Ahmed, Muhamad and Shahbas (2015) also found that trade openness has positive scale effects on the environment in Malaysia.

3.2.2 Composition Effects

Composition effect refers to the impact on the environment as a result of a change in the structure of production and consumption (Coxhead & Jayasuriya, 2003). This effect happens when there is a change in the industrial structure of the economy that leads to a change in emissions and depletion of the environment (UNEP, 2005).

Coxhead and Jayasuriya (2003) explained that one of the main effects associated with trade is the influence of international markets on relative prices. Specifically, resources are allocated to production in different sectors so as to equalize their marginal product value in all uses. A change in relative prices induces a reallocation and redistribution of natural resources which are used in the production processes of the sectors. Meanwhile, the propensity of the production of each sector to pollute the environment and to consume natural resources differs. Thus, the emissions and exploitation of natural resources will also change as a result of a change in production patterns.

When a country commits itself to a trade openness policy, it then tries to expand the economic activities to a greater extent in the sector or production area in which the country has an abundance or comparative advantages (Halicioglu, 2009). The change in economic structure leads to the change and adjustment in the levels of pollution, water use, resource use and energy use, consequently leading to change in the environment. Therefore, the impact of the composition effect of the production changes on the environment depends on the comparative advantage in production of a country under study (Cole & Elliott, 2003) and structural parameters, such as the elasticity of factor supply with respect to price. To this end, the composition effects of trade openness on the environment can vary across economies (Coxhead & Jayasuriya, 2003).

The local environmental position could be positively improved after a nation implements a trade openness policy when the country attempts to promote the less environmentally-intensive and greener sectors. Or the country trades with partners which have strong requirements on environmental protection that will benefit the environment. Antweiler et al. (2001) found that a change in production patterns as a result of trade openness generates a marginal effect on pollution. Similarly, Ling et al. (2015) investigated the impact of trade openness on CO_2 emissions in Malaysia using time series data over the period 1970QI-2011QIV. They found that the environmental quality can be improved as a result of trade openness and particularly by the composition effect as the empirical results show a lowering concentration of CO_2 emissions.

If a country has favourable advantages in pollution-intensive sectors, then trade openness may worsen the environment further. In this case, the country might have to exploit more natural resources for production to expand the economy. Consequently, the country may emit more air pollutants and discharge more waste into the environment. According to Stern (2003) this situation parallels the early stage of the EKC curve, and developing economies tend to follow this direction in their development practices. Honma and Yoshida (2011) argued that the composite effect on the environment of trade openness is only consistent with the pollution haven hypothesis on the export side. By this, they predict that developing countries export more of the dirtier industries and import more of the cleaner industries as a result of a free trade agreement.

3.2.3 Technique Effects

The technique effect refers to the effect generated by a change in the flow of technology applied in the production chain. The technique effect transpires when there is a change in production methods induced by a free trade agreement (Cole & Elliott, 2003). According to a study by UNEP (2000, 2005), it is highly likely that technological evolution takes place during the implementation of trade openness policies. The technique effects of trade openness helps to save input sources and minimize the cost of discharging waste into the environment (UNEP 2000, 2005). The advanced technology helps to increase production yield and promote environmental protection. Therefore, the technique effects of trade openness are assumed to positively impact the environment (Cole & Elliott, 2003).

3.2.4 Regulatory Effects

The regulatory effect has been commonly used in recent practices of environmental impact assessment on trade policy. While the scale, composition and technology effects are widely assessed/included in empirical models, the regulatory effects are usually examined and discussed by applying the environmental impact assessment method (Fauchald, 2000; Fauchald & Vennemo, 2011).

Regulatory effects refer to the policy effects of trade agreements on domestic environmental regulations, standards and other measures that are introduced to address the changes in trade policy. The regulatory effects of trade openness on the environment would be positive if the measures to protect the environment are introduced along with the changes in trade policies. To this end, the environmental advocates expect that stricter requirements to protect the environment would be regulated as a result of establishing a new trade policy among trade agreement partners (Faulchald, 2000). On the contrary, the regulatory effects would be negative if the environmental protection measures are not introduced, or encouraged during trade openness activities. An assessment on environmental protection regulations should be carried out before, during and after the negotiation of each free trade agreement (Fauchald, 2000).

In summary, the impact of a trade openness policy on the environment can be categorised into four main types of effects. These include the scale effect which can be negative or positive, the composition effect which is inconclusive depending on the country under study, and the technique effect which generates positive impacts on the environment. The overall impact of trade, thus, depends on the magnitude of each of the three effects based on a single free trade agreement (Antweiler et al., 2001; UNEP, 2000, 2005). Another important effect of trade openness on the environment is the regulatory effect which can hardly be assessed by empirical models and should be carried out separately for each free trade agreement.

3.3 Environmental Kuznets Curve Hypothesis

The hypothesis on the Environmental Kuznets curve is a theoretical tool which has been extensively used to examine the effect of economic variables on the environment (Tan et al., 2014; Ren et al., 2014). It is based on the Kuznets' hypothesis proposed by Kuznets (1955) that the relationship between GDP per capita and environment pollutants, or the long-run relationship between economic growth and environmental damage can be expressed in a parabolic function or an inverted U-curve (Grossman & Krueger, 1995; Stern, 2003; Baek & Kim 2013) as plotted in Figure 3.2.

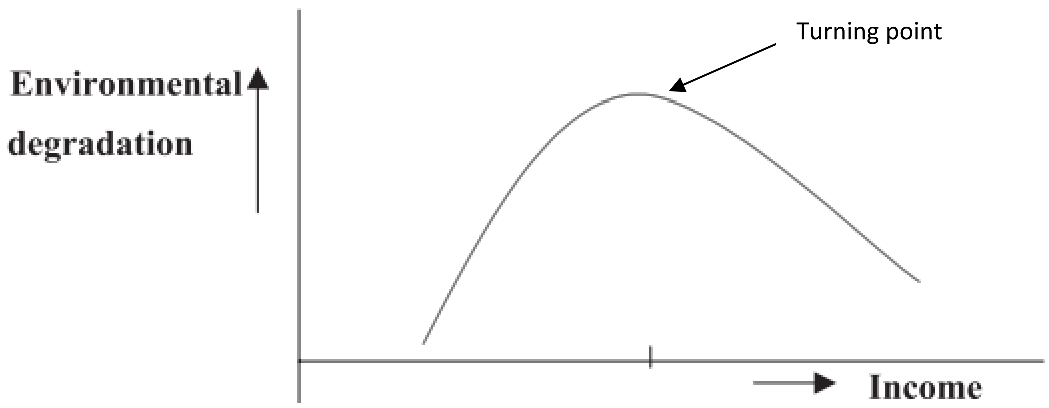


Figure 3-2: Environmental Kuznets Curve

Source: Dinda, 2004

In general, the EKC curve describes that in order to maintain and develop the economy and promote GDP per capita, the economy has to exploit and consume natural resources and discharge wastes into the environment, and these subsequently lead to the deterioration of the environment. This process will continue until it reaches a certain level, and from that point the promotion of GDP per capita and environment damage move in an inverse direction (Dinda, 2004). The hypothesis underlying the EKC theory is that the environmental quality will decrease at the first stage of economic development and this process continues until it reaches a turning point. After the turning point, the economic development is hypothesized to reduce the environmental degradation, or the environmental quality will be restored and increased together with the increase in per capita income (Begum, Sohag, Abdullah, & Jaafa, 2015; Halicioglu, 2009; Paudel & Zapata, 2004; Tan et al., 2014).

To be more specific, at the beginning stage of economic development, a nation focuses on growth rather than protecting the environment. At the low income level, people tend to spend the limited amount of money on their essential private purposes rather than to pay for environmental protection costs. When people's incomes increase, they start to think about the surrounding environment and are likely consider a choice between environmental quality and product consumption. However, this behaviour also leads to an increase in environmental damage at a slower pace than in the previous stage. After reaching a certain level of income, people will spend more money on environmental rehabilitation since they want to have a cleaner environment. This level is called the threshold level or turning point.

Generally, an amplified number of studies on EKC theory can be divided into two main categories. The first category studies the dynamic relationship between economic growth and environmental pollutants, or between economic growth, energy consumption and environmental pollutants. This classification can be marked by the pioneering work of Grossman and Krueger (1991) who examined the impact of the NAFTA on the environment. Since then researchers such as Gale and Mendez (1998); Grossman and Krueger (1995); Selden and Song (1994); Stern, Common and Barbier (1996), etc. have contributed to the literature on EKC theory.

The second category comprises recent studies that examine the dynamic relationship between economic growth, energy consumption, environmental pollutants and trade. These studies include Ang (2008); Baek and Kim (2013); Hossain (2012); Jalil and Mahmud (2009); Ren et al. (2014); and Zambrano-Monserrate, Garcia-Alban, and Henk-Vera (2016) which employed other variables such as foreign direct investment (FDI), export, import, trade openness, population density, and urbanization ratio to better capture the impact of economic development on the environment. The authors employed CO_2 emissions as a proxy of environmental degradation. Recent studies such as Baek and Kim (2013), and Zambrano-Monserrate et al. (2016) examined the energy consumption, GDP and trade under the same framework to assess the impact of economic development on the environment. Per capita income is used as a proxy of scale and technique effects of economic development on the environment (Grossman & Kruger, 1995). Meanwhile, energy use and trade intensity variables (Gale & Mendez, 1998) reflect the composition of the production pattern of a nation.

The empirical result of the EKC hypothesis is, however, inconclusive and the EKC theory is still a controversial issue (Begum et al., 2015; Halicioglu, 2009; Ren et al., 2014). There is a dissimilarity in the results of EKC theory for group country studies as well as studies on a single country, and for typical pollutants such as CO_2, BOD (biochemical oxygen demand), and SO_2 (Cole, 2003). Reviews of EKC theory study have been extensively surveyed in the literature since the pioneering work of Grossman and Krueger (1991), and significantly followed by Cole (2003), Dinda (2004), Jayadevappa and Chhatre (2000), and Stern (2003). Particularly, the EKC theory has been updated comprehensively by recent studies such as Al-Mulali, Saboori, & Ozturk (2015), Farhani, Chaibi & Rault (2014), Ren et al. (2014), and Tan et al. (2014). In a most recent work, Al-Mulali et al. (2015) reviewed 48 studies from 2003 to 2014 in order to examine the existence of the EKC. They found that around 70% of these studies are consistent with the EKC theory and most are conducted for developed countries.

On the rejection of the EKC hypothesis, Shafik (1994) showed that emissions of pollutants increase as a result of an increase in per capita income in a linear form. Gale and Mendez (1998) analysed the impact of trade openness and economic growth on the environment, and showed that the environment is negatively affected by the expansion of economic activities. They also found that higher per capita income leads to an improvement in the quality of the environment; meanwhile the impact of trade openness on the environment is insignificant.

Specifically, Gale and Mendes argued that using only one variable such as per capita income to capture the technique and scale effects of trade on the environment is inadequate. They calculated a city-specific measurement of scale effect and retained GDP per capita at the national level in their study. Their result shows that when the scale effect of trade openness on the environment is controlled then the relation between GDP per capita and environmental pollutants is found in a linear form instead of a parabolic form. However, statistically the coefficient of the trade variable is not significant, suggesting that impact of trade expansion on the environmental quality is likely to be ambiguous.

Similarly, Akbostanci et al. (2009) used time series and cross-sectional data for 58 prefectures in Turkey to examine the relationship between per capita income and the environment. The authors' research found that in the long-term there exists a linear function between CO_2 emissions and income variables and an N-curve function[10] between PM_{10}[11] and SO_2 emissions and per capita income. These results do not support the Environmental Kuznets Curve hypothesis.

In a review of previous researches on EKC, Ang (2008) shows that the findings of Hettige, Lucas, and Wheeler (1992), Cropper and Griffiths (1994), Selden and Song (1994), Grossman and Krueger (1995), and Martinez-Zarzoso and Bengochea-Morancho (2004) are consistent with the EKC hypothesis. However, it does not necessarily ensure that an increase in per capita income will lead to the emissions of pollutants. Among these studies, Martinez-Zarzoso and Bengochea-Morancho (2004) found the existence of EKC theory in an N-curve for most of the 22 OECD countries in their study.

In support of the EKC hypothesis, Baek et al. (2009) applied the Johansen co-integration analysis and cross-sectional data for 50 countries focusing on trade, income and environment to evaluate the dynamic impact of trade openness on the environment. In their study, SO_2 was selected to characterize environmental quality. Baek and his colleagues argued that before their work, previous researchers such as Gale and Mendez (1998), Dean (2002), and Frankel and Rose (2005) have mostly adopted a reduced-form model to examine the effect of trade openness and income growth on the environment, so the relationship is not comprehensively captured.

Further, Baek and his colleagues found that the environment benefits from trade liberalisation and economic development in developed countries while it is detrimentally affected in most developing countries, such as China, Sri Lanka and Turkey (Baek et al., 2009). To be more specific, for developed countries, the causality test shows that the causal relation appears in a direction from trade openness and economic growth to the environment. However, the causality is found in an inverse direction, from the environment to economic growth and trade liberalisation for most developing countries in their study.

Owing to the numerous studies on EKC theory, particularly cross country study (Akbostanci et al., 2009; Dinda, 2004), therefore we present in this study a review of the EKC theory for developing countries which employ CO_2 as an indicator for environmental degradation (see Table 3.1). We focus on studies that have been published recently, from 2006 to 2016, to examine the effect from trade openness on CO_2 emissions. Generally, the EKC theory for developing countries is inconclusive, which depends on the main variables of the study, such as the economic development, energy consumption, FDI, export, import; the estimation method; and the time period.

[10] The N-curve function describes the relationship between independent and dependent variables in a cubic form, which generally can be described as: $Y = aX^3 + bX^2 + cX + d$.
[11] PM_{10} is particular matter which is 10 micrometres or less in diameter.

Table 3-1: Selected Case Studies of EKC for Developing Countries

Authors	Case study	Time period	Modelling Technique	Trade (*)	Energy (**)	EKC (***)
(i) Case studies which do not give information on EKC theory						
Ang (2008)	Malaysia	1971-1999	Vector error-correction model; Johansen approach	No	Yes	NA
Hossain (2012)	Japan	1960-2009	Bounds and Johansen co-integration test	Yes	Yes	NA
(ii) Case studies which support EKC theory						
Tan, Lean, & Khan (2014)	Singapore	1975-2011	Johensen-Jusellius cointegration	No	Yes	+
Ren, Yuan, Ma, &Chen (2014)	China	2000-2010	Random-effects GLS regression and pooled OLS regression method	Yes	No	+
Saboori, Sulaiman, & Mohd (2012)	Malaysia	1980-2009	ARDL	No	No	+
Zambrano-Monserrate, Garcia-Alban, & Henk-Vera (2016)	Ecuador	1971-2011	ARDL	No	Yes	+
Jalil & Mahmud (2009)	China	1975-2005	ARDL	Yes	Yes	+
Baek & Kim (2013)	Korea	1971-2007	ARDL	No	Yes	+
(iii) Case studies which do not support EKC theory						
Halicioglu (2009)	Turkey	1960 - 2005	ARDL	Yes	Yes	-
Akbostanci et al. (2009)	Turkey	1968-2003	Johansen	No	No	-
Begum, Sohag, Abdullah, & Jaafar (2015)	Malaysia	1970-2009	ARDL	No	Yes	-

Notes: (*): Yes - The study captures the effect of trade openness on CO_2 emissions
No - The study does not capture the effect of trade openness on CO_2 emissions
(**): Yes - The study captures the effect of energy consumption on CO_2 emissions
No - The study does not capture the effect of energy consumption on CO_2 emissions
(***) (+) - The study supports the existence of EKC theory
(-) - The study does not support the existence of EKC theory
(NA) - The study does not conclude on the existence of EKC theory.

Ang (2008) examined the impact of economic development and energy consumption on CO_2 emissions in Malaysia, during the period from 1971 to 1999. The Johansen co-integration test reveals that at the 1% level of significance there is a long-run relationship between the independent and dependent variables. The author also found a weak causality running from CO_2 emissions to economic growth in the long-run. However, using a linear function to model the long-run relationship among the variables does not provide information on the EKC theory in Ang's (2008) study.

Similarly, Hossain (2012) explored the dynamic impact between CO_2 emissions, energy use, economic growth and foreign trade in Japan from 1960 to 2009. The author employed an urbanisation variable to capture the impact of population migration from rural to urban areas as a source of CO_2 emissions in Japan. The author argued that the EKC is not a flexible way to estimate the impact of economic development on CO_2 emissions, thus the long-run relationship among the variables is expressed in a linear logarithmic form. Hence, Hossain's study did not provide information on the existence of EKC theory. The author found an increase in CO_2 emissions because of higher energy use in Japan. In the long-run, trade openness has a negative impact on CO_2 emissions; however this impact is statistically insignificant. Meanwhile, the economic growth and the urbanisation have positive impacts on CO_2 emissions. This means that the environment benefits as a result of economic growth, urbanisation and trade liberalisation in Japan (Hossain, 2012).

Tan et al. (2014) conducted a study to examine the existence of EKC theory in Singapore for a period of 36 years, from 1975 to 2011. They used the VAR model and the Granger causality test to investigate the impact of energy consumption and per capita income on CO_2 emissions. The energy variable is examined by two proxies, total energy consumption and electricity production. The EKC theory is confirmed by this study. The authors further found a significant negative relationship between CO_2 emissions and economic growth, and a statistical significance of the relation between CO_2 emissions and GDP, as emissions increased when GDP rose over the 36 years in their study.

Saboori et al. (2012) attempted to establish a long-run relationship between economic development and CO_2 emissions in Malaysia from 1980 to 2009. Based on the ARDL (auto-regression distributed lag) method, the authors found an inverted U-curve for the long-run elasticity between GDP and CO_2 emissions. The authors, however, used a model based on EKC theory to capture the impact of economic development on the environment, without capturing the impact of energy use and trade openness. The exclusion of energy use and trade openness variables may have generated bias in their results as these variables help to explain the composition effect of economic development on the environment.

Ren et al. (2014) calculated the CO_2 emissions as a result of trade openness in China for a period of 10 years, from 2000 to 2010. They combined the impact of FDI, trade openness and export and import value as a proxy for the international trade variable. Their study confirmed the existence of EKC theory in China during 2000-2010 and foreign trade had a negative impact on CO_2 emissions in China.

A recent study by Zambrano-Monserrate et al. (2016) provides other evidence of EKC theory for Ecuador during 1971-2011. The authors estimated the effect of energy consumption for a better explanation of CO_2 emissions in Ecuador. They applied the modern ARDL technique in their estimation, and confirmed the existence of EKC theory in Ecuador in the long-term.

On the other hand, Halicioglu (2009) found evidence of the non-existence of EKC theory based on a case study in Turkey for the period 1960-2005. The author employed a quadratic functional form of EKC theory to describe the long-run relationship between CO_2 emissions and GDP per capita income, energy consumption and trade liberalisation. The long-run estimation revealed a negative sign for the GDP variable and a positive sign for the square of the GDP variable, which indicates the form of the EKC curve. However the author rejected the existence of EKC theory in his study as the graphical representation of per capita CO_2 emissions and per capita income is not plotted in a U-curve form (Halicioglu, 2009).

In another study, Akbostanci et al. (2009) found an N-shape relationship between economic development and CO_2 emissions in Turkey. Similarly, the authors' study rejected the existence of EKC theory for Turkey during the period 1968 to 2003. However, Akbostanci et al. (2009) did not capture the effect of trade openness and energy consumption variables which help to explain the composition effect of economic development on the environment. Therefore, this may lead to a biased estimation of the impact of economic development on CO_2 emissions in their study.

Likewise, Begum et al. (2015) also rejected the existence of EKC theory for Malaysia from 1970 to 2009. However, they concluded that the economic growth may have a detrimental effect on CO_2 emissions in Malaysia.

3.4 Effect of Trade Openness on Income and the Environment

The linkage between trade liberalisation and environmental quality is theoretically examined by integrating the EKC theory. This can be achieved by the inclusion of the trade openness ratio as an explanatory variable to capture the impact of economic growth on environmental quality under the EKC theory framework. International trade is one of the foremost factors in explaining EKC theory (Dinda, 2004) as freer trade is expected to lead to expansion in the size of the economy and an increase in per capita income. Since trade openness could increase production and income, it affects emissions through scale effect and technique effect (Antweiler et al., 2001 as cited in Managi et al., 2009). The overall complexity impact of trade openness on the environment is a cumulative combination of the country under the study, the level of economic development, the level of trade openness and the domestic requirements on environmental protection, among others.

The per capita income is expected to increase as a result of trade liberalisation, which then leads to the demand for environmental protection regulations (Baek et al., 2009; Cole & Elliott, 2003). Trade liberalisation policies may also aim at protecting the environment and reducing pollution, which leads to a positive effect on the demand for a good environment (Muradian & Martinez-Alier, 2001).

However, the increase in per capita income and expansion of the economy do not mean that environmental quality will be improved. It is strongly believed that the long-term relationship between environmental damage and trade openness or per capita income may be displayed in the form of a quadratic function and should be examined for an individual country (Akbostanci et al., 2009; Grossman & Krueger, 1991, 1995; Halicioglu, 2009; Jalil & Mahmud, 2009; Kohler, 2013;). Specifically, a nation experiences a common pattern of increasing pollution levels at the early stage of economic development, which exhibits a positive relationship between environmental degradation and trade openness. This pattern is then followed by a declining trend in the environmental degradation of freer trade. To this end, a country that moves beyond the turning point of the EKC curve experiences a higher level of trade openness. This may bring a change in the structure of the domestic production of the country towards less polluted or greener production (Kohler, 2013).

Theoretically, the relationships between trade openness, per capita income and environmental quality can be described by income (Y) as a function of trade openness (Tr) and other exogenous variables (Z_1). This can be expressed as $Y = f(Tr, Z_1)$. The pollution factor (E) can be formularized as a function of income (Y) and production technology (Z_2), that means $E = f(Y, Z_2)$ (Baek et al., 2009).

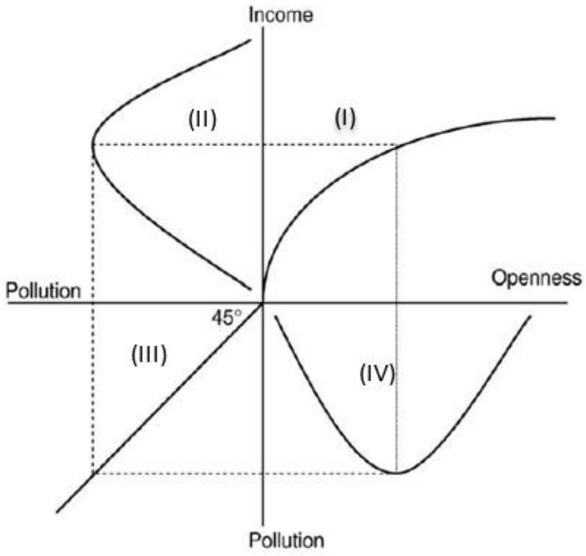


Figure 3-3: Effect of Trade Openness on Income and the Environment

Source: Baek et al. (2009)

Figure 3.3 shows the relationship between trade openness and per capita income is expressed in a positive linear function ($\frac{\partial Y}{\partial Tr} > 0$) (the first-quadrant of Figure 3.3). It is projected that the production of the main sectors will increase and the economy will be wealthier as a result of trade openness policy. Consequently, people can earn and save more money and finally their income will increase. However, if the economy cannot be developed through trade openness as projected, the national economy will be affected negatively and per capita income will be decreased.

The economy and the welfare of a country can be improved by trade openness in a way that the government may have to regulate new policies on tax and resources exploitation, as a result of the trade openness policy. These policies may be targeted at protecting the environment and reducing pollution, which lead to a positive effect on the demand for a good environment (Muradian & Martinez-Alier, 2001). Similarly, Cole and Elliott (2003) explained that per capita income is expected to increase as a result of trade liberalisation, which then leads to the demand for environmental protection regulations (Cole & Elliott, 2003).

During the first stage of economic development, the nation needs more natural resources for economic activities and income improvement that consequently cause severe damage to the environment, which means $\frac{\partial E}{\partial Y} > 0$. The process continues until a certain threshold level is reached, at that point the economy is still expanding but people will start to pay more attention to environmental protection, resulting in a decrease in damage to the environment, or $\frac{\partial E}{\partial Y} < 0$. The combination of these two inverse effects between the economy and the environment,

$\left(\frac{\partial E}{\partial Y} > 0\right)$ and $\left(\frac{\partial E}{\partial Y} < 0\right)$, generates a function of an inverted U-curve between income and pollution levels (the second-quadrant of Figure 3.3). Theoretically, economists call this relationship the Environmental Kuznets Curve (Baek et al., 2009). The quality of the environment will first be degraded and then improved with the increase in per capita income (Baek et al., 2009). Therefore, through the growth of income, trade liberalisation improves environmental quality.

Consequently, by combining the first and second quadrants, we obtained $E = g(Tr, Z_1, Z_2)$, where the environment is regarded as a normal good, and can be regarded as a function of trade openness, production technology, per capita income and other exogenous variables. Specifically, a nation will experience a common pattern of increasing pollution levels at the early stage of economic development, which exhibits a positive relationship between the environmental degradation and trade openness ($\frac{\partial E}{\partial Tr} > 0$). This pattern is then followed by a declining trend in environmental degradation of trade openness ($\frac{\partial E}{\partial Tr} < 0$). To this end, a country that moves beyond the turning point of EKC curve experiences higher levels of trade openness. This may bring a change in the structure of domestic production of the country towards less polluted or greener production. The country may promulgate stricter regulation to protect the environment during production activities, and the awareness of people also increases. This then leads to the improvement in environmental quality.

The combination of the trend between environmental degradation and the level of trade openness is generally expressed in an inverted U-shape curve as shown in the fourth-quadrant of Figure 3.3 (Baek et al., 2009). However, the overall effect of trade liberalisation on economic growth and environmental quality is essentially an empirical question for each individual country under study. The overall effect of trade liberalisation on environmental degradation varies for each country under study. The circumstances for each country include the stages of development and level of trade openness (Baek et al., 2009), as well as the domestic requirement to protect the environment under study (Kohler, 2013).

3.5 Review of the Literature on the Impact of Trade Liberalisation on the Environment in Vietnam

There is a limited number of published studies that specifically investigate the long-run impact of trade openness on the environment in Vietnam. Table 3.2 presents a summary of previous studies that examine the long-run relationship between trade liberalisation and environmental quality in Vietnam.

Table 3-2: Studies on the Link Between Trade Liberalisation and the Environment in Vietnam

Authors	Time period	Energy	GDP square	FDI	Trade	EKC (*) (+/-)	Main results
Linh & Lin (2014)	1980-2010	Yes	Yes	Yes	No	-	- GDP-FDI: bidirectional - Long-run causality among CO_2 emissions, energy use, economic growth and FDI
Tang & Tan (2015)	1976-2009	Yes	Yes	Yes	No	+	- Energy consumption and income positively affect CO_2 emissions - Long-run integration between CO_2 emissions, energy use, economic growth and FDI
Al-Mulali, Saboori, & Ozturk (2015)	1981-2011	Yes	No	No	No	-	- Export has no effect on pollution - Import increases pollution
Anwar & Alexander (2016)	1980-2011	Yes	No	No	Yes	NA	There is a statistically significant long-run relationship amongst pollution, trade openness, energy consumption and income

Authors	Main findings	Gaps
Phuong (1997)	Vietnam maximizes the benefits from AFTA membership that are associated with socioeconomic and environmental costs and consequences. Vietnam must promote trade liberalisation while ensuring its macroeconomic stability and develop its environmental policies.	- No detailed information on how the environment will be affected by AFTA. - Neither qualitative nor quantitative methods have been used in the study.
Mani & Jha (2006)	There is an increase in manufacturing and export activity in water and toxic pollution-intensive sectors compared to the less pollution-intensive sectors.	Time data ranges from 2000 to 2003 for output and FDI variable, and from 1997 to 2003 the exports variable is a relatively small to observe the changes in the composition of industries.

Notes: (*): (+): Support the EKC theory; (-): do not support the EKC theory;
(NA): no information available

The limited number of published studies that specifically investigate the long-run impact of trade openness on the environment in Vietnam are presented in Table 3.2. These studies consistently found a long-run causality between economic growth and CO_2 emissions. This implies that the development of Vietnam's economy is not accompanied by the necessary regulations to protect the environment. The studies used different variables to capture the effect of economic development on CO_2 emissions in Vietnam, such as FDI (Linh & Lin, 2014; Tang & Tan, 2015) and export and import (Halicoglu et al., 2015).

Linh and Lin (2014) assessed the relationship between CO_2 emissions, energy consumption, FDI, and economic growth in Vietnam using annual data from 1980 to 2010 from the UNCTAD statistic database and the World Bank Indicator database. Based on the EKC approach, the Johansen (1991) co-integration test and Granger causality tests, they found a dynamic relationship among CO_2 emissions, energy consumption, FDI and economic growth. A two-way direct relationship between income growth and FDI is confirmed by the causality test and reflects that increase in per capita income in Vietnam will attract more foreign investment and vice versa. This means that foreign direct investment also helps to improve the economic development in Vietnam. Further, Linh and Lin's (2014) results do not support the EKC hypothesis, indicating that there is not enough statistical evidence to confirm that the environment will be rehabilitated at a specific higher per capita income in Vietnam. Furthermore, the study found a long-run causality between CO_2 emissions, economic growth, energy use and FDI. The authors explained this finding in terms of environmental protection regulations in Vietnam. This implies that the development of Vietnam's economy is not accompanied by the required regulations to protect the environment.

Similarly, Tang and Tan (2015) employed the FDI variable to account for the impact of foreign trade on the environment in Vietnam. They used annual data from 1976 to 2009 from the World Bank Indicator and the CEIC databases. However, contrary to Linh and Lin (2014), Tang and Tan's result supports the existence of the EKC hypothesis in Vietnam indicating that the environment can be restored at a higher income level. The study also found a long-run co-integration between CO_2 emissions, energy use, economic growth and FDI in Vietnam. In terms of the relationship between FDI and CO_2 emissions, the study found a bidirectional causality among them. Thus it can be optimistically concluded that better controlling of FDI in Vietnam will benefit the environment. Specifically, a greener FDI is beneficial to the environment and helps to reduce the level of pollution by transferring environment friendly technologies and production techniques from developed countries to Vietnam.

In order to examine the existence of EKC theory in Vietnam, Al-Mulali et al. (2015) used time series data from 1982 to 2011 and GDP, capital, labour force, export and import and energy use. The energy use variable is captured by energy consumption from renewable sources and fossil fuel sources. Furthermore, the labour force and capital variables are considered as determinants of the energy use variable. Therefore, labour force and capital variables may generate indirect effects on the CO_2 emissions and are included in Al-Mulali et al.'s (2015) study. However, the authors did not employ the quadratic function, the well-known EKC function to check for the existence of EKC, due to the multi-collinearity problem when GDP and GDP squared variables are included in the same regression model. Their results do not support the existence of EKC theory in Vietnam for the period 1982 to 2011 as GDP positively impacts CO_2 emissions in the short-run and the long-run.

The above studies provide evidence of a close causality relationship between CO_2 emissions, energy consumption, economic growth and foreign direct investment in Vietnam. This indicates that the economic growth, energy consumption and foreign trade can be used to explain the environment in Vietnam. However, they did not capture the impact of trade openness on the environment in their studies. To the best of our knowledge, Anwar and Alexander's (2016) is the only study that includes a trade openness variable to assess the impact of trade openness on Vietnam's environment.

Specifically, Anwar and Alexander (2016) used time series data from 1980 to 2011 to estimate the long-run relationship between economic growth, electric consumption, trade and the environment. The authors' finding shows a statistically significant long-run relationship among pollution, trade openness, energy consumption and real national income in Vietnam. This is consistent with the findings of Al-Mulali et al., (2015), Linh and Lin (2014), and Tang and Tan (2015). Anwar and Alexander further found evidence that trade openness has minor effects on the level of pollution encouraging Vietnam to further open to trade. However, they did not capture the square value of GDP in their model so that the information on the EKC hypothesis cannot be provided.

Anwar and Alexander (2016) argued that the scaling of variables in natural logarithmic form and the inclusion of GDP squared in the regression model are problematic. They explained that the variable of interest is the total CO_2 emissions, not the per capita CO_2 emissions. They further argued that the estimated coefficients of GDP squared in Tang and Tan's study do not make sense as the estimated turning point is not within the range of data used in their study.

In our opinion, using per capita value for each variable enables us to avoid bias estimation for several reasons. First, the population of Vietnam has changed dramatically from 1980 to 2015 and scaling the annual data variables with the same measurement is necessary to interpret the magnitude of change. Second, the EKC theory is conventionally explained based on the willingness of people to pay to protect the environment. Thus, scaling the economic development variable from GDP to per capita income is necessary to understand the willingness of the people to pay to protect the environment. Third, the measurement variables in per capita terms have been widely and extensively applied in the literature. Therefore, using the per capita measurement for all variables enables us to compare the magnitude of the impact of trade openness on the environment in our study with previous studies.

In terms of the regulatory effect, to the best of our knowledge there is no published study which aims to assess the regulatory effect of trade liberalisation on Vietnam's environment.

3.6 Chapter Summary

This chapter discusses the linkage between trade activities and the environment. The environment system is linked to the economic system by two main functions and provides input, such as natural resources for economic activities. The environment is also a place to dissolve the wastes from economic activities.

It is highlighted in the literature that the impact of trade activities on the environment is complex and inconclusive. The impact may be good in some cases and may be bad in others and depend on the country and the pollutant under study. However, it is plausible to divide the impact of trade openness on the environment into the four main categories, namely scale effect, composition effect, technique effect and regulatory effect. The scale effect can be negative or positive depending on the level of economic development. The composition effect can be either negative or positive based on the production pattern of the country under study. However, the technique effect is commonly considered to be positive.

The EKC theory has been widely applied to examine the impact of economic development on the environment. According to EKC theory (Kuznets, 1955) at the beginning of economic development the environment will be degraded. However at the later stage of economic development, with a higher income level, people can spend more money to rehabilitate the environment. Consequently, the environmental quality will be improved along with economic development. This relationship is modelled in a quadratic function or in an inverted U-shape curve between per capita GDP and the concentration of pollutants. The EKC theory has been widely investigated in the literature, however the existence of EKC is still a debatable issue.

The linkage between trade liberalisation and environmental quality has been theoretically examined by integrating it into the EKC theory. To be more specific, the impact of trade openness on the environment depends on the country and time period studied. The overall complexity of the impact of trade openness on the environment is an empirical question that depends on the economic development, and domestic regulation to protect the environment in trade activities.

The literature also highlighted that Vietnam has comparable advantages in free trade based on the abundance of natural resources, geographic conditions and low labour cost. However, limited work has been carried out to examine the effects of trade liberalisation on the environment in Vietnam. To the best of our knowledge, there are only four published studies that examine the impact of economic development on CO_2 emissions in Vietnam and they reveal dissimilar results.

Linh and Lin (2014) and Al-Mulali et al.'s (2015) research did not support the existence of EKC theory in Vietnam. Meanwhile, Tang and Tan (2015) found statistical evidence of the existence of EKC theory in Vietnam. However, none of these studies takes into account the impact of trade openness on the environment. This may generate a biased estimation in their results due to the omitted variable. The trade openness variable explains the composition and technology effects from trade liberalisation on the environment.

A recent study conducted by Anwar and Alexander (2016) takes into account the effect of trade openness on the environment. However, the authors did not employ the EKC quadratic function in their estimation and did not scale the variables to per capita unit. This limits their findings in comparing the magnitude of the estimated results with other studies.

By and large, there exist various gaps in the literature on the linkage between economic development and the environment in Vietnam. First, none of the published studies has attempted to capture the specific environmental consequences or natural resources phenomena of trade openness in Vietnam. Second, the data set used in previous studies ranges from 1980 to 2011, before Vietnam actively engaged in free trade negotiations such as the CPTPP and the EVFTA. Third, the EKC hypothesis test results are divergent among the published studies especially in the case of Vietnam (see Table 3.2). Lastly, none of the published studies examines the regulatory effect of a trade openness policy on the environment.

Our study attempts to narrow these gaps by inclusion of the square of real per capita GDP to assess the EKC hypothesis as well as to avoid the potential non-linearity when applying time series data. This can be achieved by using a broader data set ranging from 1986 to 2013 to assess the impact of trade openness on the environment. A broader data set also enables us to capture the impact of important economic integration activities in Vietnam after 2010, for example, Vietnam's 2011-2020 socio-economic development strategy released in 2011 and the negotiation of the CPTPP in 2010.

Taking into consideration the economic integration of Vietnam after 2010 may generate a better evaluation of the link between trade openness and the environment. The inclusion of the squared value of the real per capita GDP variable in our empirical models will contribute to the limited evidence on the EKC hypothesis in Vietnam. Besides, our study takes into consideration the regulatory effect of the CPTPP on the environment which has never been considered in previous studies.

Chapter 4

Research Methodology and Data

This chapter presents the methodology and data used in the study. The scale, composition and technique effects of trade liberalisation on the environment are assessed using an empirical model. The regulatory effect of trade liberalisation is separately analysed by applying the environmental impact assessment method on trade policy. The first section presents the variables and research models, including: (i) the empirical model specification; (ii) the estimation methods; (iii) and a discussion of the secondary data used in the study. The second section describes the EIA method on trade policy, including (i) the necessity of using an EIA method on trade policy; (ii) the reasons the CPTPP is used as a case study; (iii) the general procedures to conduct the EIA method on trade policy; and (iv) the specific procedures to apply the EIA method on the CPTPP. The final section summarises the chapter.

4.1 Research Model - Assessing the Scale, Technique and Composition Effects of Trade Liberalisation on the Environment

The literature identifies several different modelling frameworks to examine the impact of trade liberalisation on the environment. Some of the models which have been widely applied include econometric approaches, gravity models, equilibrium economic models (partial and general equilibrium models) and environmental models such as the life cycle assessment, ecological and biological models, etc. Among these models, econometric empirical and simulation models are among the most popular methods (Martin, 2000).

The simulation method is dominated by the computable general equilibrium (CGE) model[12] based on the general equilibrium theory, and the CGE-GTAP model which integrates an environmental component into the CGE model (Strutt & Anderson, 2000). On the other hand, econometric models have been successfully used to examine the response of CO_2 emissions to economic growth (Hettige, Mani, & Wheeler, 1998). Further, econometric models are highlighted in the literature based on their statistics tests to verify the significance and robustness of the coefficient estimates (Beggs, 1988 as cited in Martin, 2000).

It is also widely documented by the literature that the research questions of each study are the main motivation for the choice of the model to use in the study (Martin, 2000). As discussed in Chapter 1, research question two of our study asks: "What are the effects of free trade openness on CO_2

[12] CGE models are based on the general equilibrium theory to analyse resources allocation and income distribution issues in market economies (Bergman, 2005).

emissions in Vietnam, quantitatively? To what extent, does trade openness impact on CO_2 emissions in Vietnam, in the short-run and long-run equilibrium". In order to answer this research question, our study employs the econometric empirical method, which has been extensively applied and suggested in the literature (Jalil & Mahmud (2009), Halicioglu (2009), Tan et al. (2014)). Using the econometric empirical method also helps our study to fill the gap in the linkage between the economic development, energy and pollution by putting the nexus of output-energy and output-pollution under the same framework.

To be more specific, the relationship between trade openness and CO_2 emissions in Vietnam is investigated in this current study using time series data from 1985 to 2013. As a result of the national policy on industrialisation and international economic integration, the economic development of Vietnam during the last 29 years has gained considerable achievements. Along with the economic development, there is also an observable trend of environmental degradation. The use of time series data enables our study to assess the short-run and long-run equilibrium between trade liberalisation and the environment. Moreover, time series data provide a better framework to study a single country case (Ren et al., 2014). Consequently, time series data from 1985 to 2013 allow our study to examine and capture the overall impact and trend of economic development, trade liberalisation and environmental protection during the last 29 years of the country's innovation process.

In our empirical model, CO_2 emissions are employed as a proxy of environmental degradation. Per capita income, energy use and trade intensity variables are used as proxies of scale, technique effects (Grossman & Kruger, 1995) and composition effect (Gale & Mendez, 1998) of economic development on the environment.

4.1.1 Empirical Model Specification

The relationship between the size of an economy and the intensity of CO_2 emissions was examined by Grossman and Krueger (1995) who reported that pollution tends to rise during the first stage of a country's development, and decreases after reaching a certain income level. The standard EKC regression model is given as:

$$\ln(E/P)_{it} = \gamma_i + \delta_t + \varphi_1 \, ln \, (\frac{GDP}{P})_{it} + \varphi_2 \, \{ln\left(\frac{GDP}{P}\right)\}_{it}^2 + \varepsilon_{it} \quad (4.1)$$

where E is emissions; P is population; GDP is gross domestic product; γ_i and δ_t are intercept parameters which may vary across countries or regions i and year t; ε_{it} is stochastic shock (Stern, 2003).

Empirically, the relationship between economic development and CO_2 emissions has been widely studied. It is plausible to establish the long-run relationship between CO_2 emissions, energy use, economic growth, and per capita income in a linear quadratic form (Stern, 2003). We specified a log linear quadratic equation to test the long-run relationship among CO_2 emissions, energy consumption, economic growth and foreign trade in Vietnam. The regression model is given as follows:

$$\ln C_t = \alpha_0 + \alpha_1 lnE_t + \alpha_2 lnTr_t + \alpha_3 lnY_t + \alpha_4 (lnY_t)^2 + \varepsilon_t \quad (4.2)$$

where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Tr_t is the openness ratio, Y_t is real per capita income, Y_t^2 is the square of real per capita income, and ε_t is the regression error terms. All variables in equation (4.2) are in their natural logarithmic form.

Generally, the higher level of energy consumption would result in greater economic activity and stimulate CO_2 emissions; therefore, α_1 is positive and significant in equation (4.2). Under the EKC hypothesis, the sign of α_3 is expected to be positive whereas a negative sign is expected for α_4. Linh and Lin (2014) found that α_4 is statistically insignificant, indicating that there is not enough statistical evidence to confirm that the environment will be rehabilitated at a time of specific higher per capita income in Vietnam. Tang and Tan (2015), in contrast, found that α_4 is statistically significant, reflecting that the environment can be restored at a higher level of income in Vietnam. The expected sign of α_2 is mixed depending on the stage of economic development of the country under study. For developed countries, α_2 is expected to be negative as the technology improvement allows them to produce less energy and pollution intensive goods, but this sign is expected to be positive for developing countries (Kohler, 2013). Therefore, in our study α_2 is expected to be positive.

However, the inclusion of the real per capita GDP variable and square of real per capita GDP under the same framework as equation (4.2) may cause collinearity problems. Beside, our primary purpose is to examine the impact of trade openness on CO_2 emissions, rather than the existence of EKC theory in Vietnam. Thus we also use equation (4.3) to avoid the potential collinearity between the variables of Y_t and Y_t^2.

$$ln\, C_t = \beta_0 + \beta_1 lnE_t + \beta_2 lnTr_t + \beta_3 lnY_t + \mu_t \quad (4.3)$$

where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Tr_t is the openness ratio, Y_t is real per capita income, and μ_t is the regression error terms. All variables in equation (4.3) are in their natural logarithmic form.

For equation (4.3), β_1 is expected to be positive and significant as the higher energy consumption would result in higher CO_2 emissions. The empirical estimation result of equation (4.3) can be compared with the results of Al-Mulali et al. (2015), and Anwar and Alexander (2016). The study conducted by Al-Mulali et al. (2015) found a positive relationship between GDP and CO_2 emissions in the short-run and long-run in Vietnam. Al-Mulali et al's (2015) study further found a significantly negative import impact and a positive export impact on CO_2 emissions, which indicates that Vietnam mainly imports highly polluted products (Al-Mulali et al., 2015). Anwar and Alexander (2016) found evidence that trade openness has minor effects on the CO_2 emissions in Vietnam.

The variables used in equations (4.2) and (4.3) are defined in Table 4.1.

Table 4-1: Variable Definitions for Equations (4.2) and (4.3)

Variable	Definition	Measurement
t	Year	From 1985 to 2013
C_t	CO_2 emissions per capita	CO_2 emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include CO_2 produced during composition of solid, liquid, and gas fuels and gas flaring
E_t	Energy used per capita	The energy use variable is measured in kilograms of oil equivalent per capita
Tr_t	Trade openness	The total value of exports and imports as a share of nominal GDP
Y_t	Real per capita GDP	The real per capita GDP is measured as a ratio of real GDP to total population.
$(Y_t)^2$	Square of the real per capita GDP	
ε_t	Regression error term	ε_t captures effects of other variables on CO_2 emissions rather than economic development, trade openness and energy use.

4.1.2 Empirical Model Estimation Methods

This study applies the autoregressive distributed lag model to test for the existence of the long-run relationship among the time series variables.

One of the main advantages of the ARDL technique is that it can be applied irrespective of whether the variable is I(0) or I(1) or fractionally co-integrated (Pesaran & Pesaran, 1997). The ARDL model takes a sufficient number of lags to capture the dynamics impacts of all dependent and independent variables as well as from the error term. Furthermore, the error correction model (ECM) is derived from ARDL through a simple linear transformation. ECM integrates short-run adjustments with long-run equilibrium without losing long-run information.

Perasan and Shin (1999) also demonstrated that the simultaneous estimation of long-run and short-run components and appropriate lags in the ARDL framework remove the problems that are associated with serial correlation and endogeneity problems. Another important advantage of ARDL procedure is that the estimation is possible even when the explanatory variables are endogenous

(Pesaran, Shin, & Smith, 2001). Finally, the ARDL model has proved to be suitable for a small sample size study (Farhani et al., 2014).

The estimation procedures are described next.

(i) Data Stationarity

In applying time series data in regression analysis, it is important to determine whether a time series is stationary or non-stationary to avoid the spurious regression problem. Although the ARDL techniques can be applied in time series data if the data is I(0) or I(1); however, ARDL estimation is not applicable if the data is I(2). This is because the computed F-statistics provided by Pesaran et al. (2001) are not valid for I(2) data. We apply three different unit root tests to check for the stationarity of data, namely: (i) the Augmented-Dickey-Fuller (ADF) test; (ii) the Dickey-Fuller GLS unit root test; and (iii) the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test.

The Dickey-Fuller GLS test is a simple modified version of the conventional ADF test that de-trends the series prior to the estimation of ADF test regression (Begum et al., 2015). The critical value of the Dickey-Fuller GLS unit root test is calculated for 50 observations by Elliot-Rotherberg-Stock (1996). The KPSS unit root test is conducted to complement the ADF and Dickey-Fuller GLS test, based on the argument that tests designed on the basis of the null that a series is I(1) has a low power of rejecting the null (Ang, 2008).

Besides, we conduct the Johansen co-integration test to check the existence of a long-run equilibrium among the variables at the levels, including: trade openness, GDP per capita, energy consumption and CO_2 emissions. The Johansen co-integration test provides information on the existence of co-integrations among the variables. However, the test does not calculate the magnitude of the possible long-run impact. Therefore, we further proceed to the Bounds test (or the F-test) to estimate the short and long-run co-integration among the variables.

(ii) Optimal Lag Length of Each Variable

In order to choose the optimal lag length for each variable, the ARDL method estimates $(p+1)^k$ number of regressions, where p is the maximum number of lags and k is the number of variables in the equation. The model can be selected based on Schawrz (SC) also known as the Bayes information criterion (BIC) and Akaike's information criterion (AIC). The BIC is a parsimonious model that selects the smallest possible lag length. AIC is used to select the maximum relevant lag length.

The Akaike information criterion is given as (Hill, Griffiths, & Lim, 2011):

$$AIC = \ln\left(\frac{SSE}{T}\right) + \frac{2K}{T} \quad (4.4)$$

where K is the number of coefficients that are estimated; T is the sample size.

The Schwarz criterion, or the Bayes information criterion (Hill et al., 2011), is given as:

$$BIC = \ln\left(\frac{SSE}{T}\right) + \frac{Kln(T)}{T} \tag{4.5}$$

where K is the number of coefficients that are estimated; T is the sample size.

(iii) Co-integration among Variables

The ARDL framework for equation (4.2) is given as follows:

$$\Delta C_t = \lambda_0 + \sum_{i=1}^{pi} \delta_i \, \Delta C_{t-i} + \sum_{i=0}^{pi} \varphi_i \, \Delta E_{t-i} + \sum_{i=0}^{pi} \omega_i \, \Delta Trt_{t-i} + \sum_{i=0}^{pi} \gamma_i \, \Delta Y_{t-i} + \sum_{i=0}^{pi} \theta_i \, \Delta Y_{t-i}^2 + \lambda_1 C_{t-1} + \lambda_2 E_{t-1} + \lambda_3 Trt_{t-1} + \lambda_4 Y_{t-1} + \lambda_5 Y_{t-1}^2 + U_t \tag{4.6}$$

where: λ_0 is the drift component and U_t is white noise. The terms with summation signs represent the error correction dynamics. λ_i (i=1-5) corresponds to the long-run relationship. p_i (i=1-5) is maximum lag levels of each variable.

The ARDL framework for equation (4.3) is given as follows:

$$\Delta C_t = \beta_0 + \sum_{i=1}^{pi} \delta_i \, \Delta C_{t-i} + \sum_{i=0}^{pi} \varphi_i \, \Delta E_{t-i} + \sum_{i=0}^{pi} \omega_i \, \Delta Trt_{t-i} + \sum_{i=0}^{pi} \delta_i \, \Delta Y_{t-i} + \lambda_1 C_{t-1} + \lambda_2 E_{t-1} + \lambda_3 Trt_{t-1} + \lambda_4 Y_{t-1} + \mu_t \tag{4.7}$$

where: β_0 is the drift component and μ_t is white noise. The terms with summation signs represent the error correction dynamics. λ_i (i=1-4) corresponds to the long-run relationship. p_i (i=1-4) is maximum lag levels of each variable.

The F-test (or the Bounds test) tests the existing long-run relationship among the variables.

For equation (4.6): the null hypothesis $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$ (the non-existence of long-run relationships); the alternative hypothesis $H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq 0$.

For equation (4.7): $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$; $H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$.

The calculated F-statistic value is compared with two sets of critical values provided by Pesaran et al. (2001). One set assumes that all variables are I(0) and the other assumes they are I(1). If the calculated F-statistics exceed the upper critical value, then the null hypothesis of no co-integration will be rejected irrespective of whether the variable is I(0) or I(1). If it is below the lower critical value then the null hypothesis of no co-integration cannot be rejected. If it falls inside the critical value band, the test is inconclusive.

(iv) Estimation of the Long-run and Short-run Elasticities

It has been proven that if a set of series is cointegrated then there exists an error correction mechanism. The error correction mechanism helps the variables move closely together over time, while allowing for a wide range of short-run dynamics (Engle & Granger, 1987, as cited in Baek & Kim, 2013, p. 746). This dynamic relationship is described by the error correction model demonstrating the short-run and long-run adjustment parameters. The results of the ECM allow us to measure the speed of adjustment required to adjust to long-run equilibrium after a short-term shock. The coefficient of the ECM term is expected to be negative and statistically significant.

Following the selection of the ARDL model by the AIC or BIC criterion, the long-run relationship among the variables can be estimated by the ordinary least square (OLS) method for equations (4.6) and (4.7), then the ECM frameworks for equations (4.6) and (4.7) are estimated using equations (4.8) and (4.9), respectively.

$$\Delta C_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=0}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=0}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i}^2 + \alpha ECM_{t-1} + U_t \quad (4.8)$$

$$\Delta C_t = \beta_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=0}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=0}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i} + + \alpha ECM_{t-1} + \mu_t \quad (4.9)$$

where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Y_t is real per capita GDP, Y_t^2 is the square of per capita real GDP, Tr_t is the openness ratio which is used as a proxy for foreign trade, and U_t and μ_t are the regression error terms. Δ stands for the first difference of the variable. ECM is the Error Correction Model that is derived from the ARDL model.

All variables in equations (4.8) and (4.9) are in their natural logarithmic form.

(v) Diagnostic Tests and Stability of the Estimated Model

Lastly, the selected ARDL specification is checked for robustness, including the tests to check the normality, the heteroscedasticity, the freedom from serial correlation and the stability.

The estimation procedures are summarised in Figure 4.1.

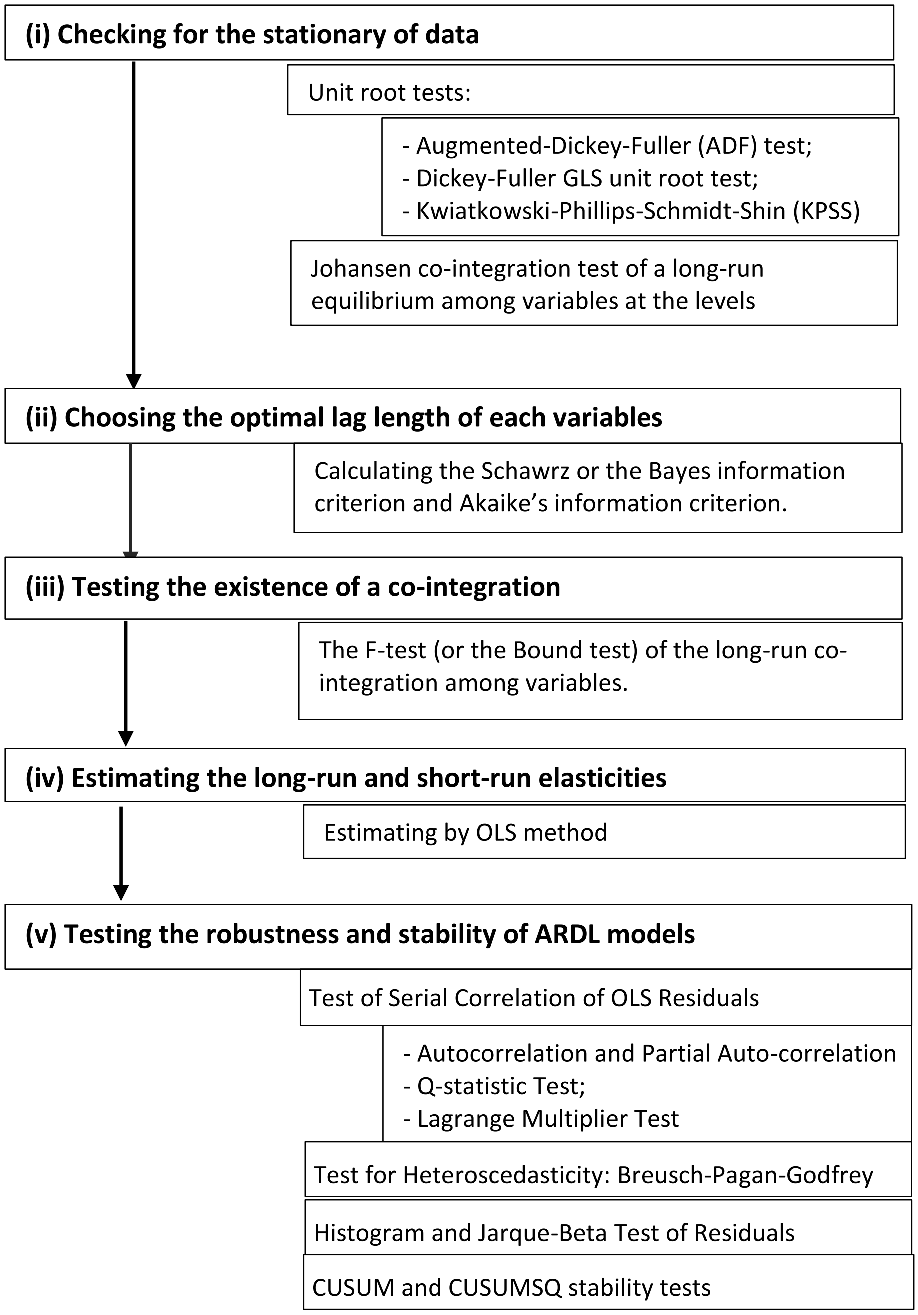


Figure 4-1: Estimation procedures for empirical models

4.1.3 Data

In order to apply the estimation techniques, time series data is collected from the official source of the Vietnam government and the World Development Indicators from 1985 to 2013, including:

(i) Per capita CO_2 emissions (C_t);

(ii) Energy consumption (E_t);

(iii) Real per capita GDP (Y_t). The real per capita GDP is measured as a ratio of real GDP to total population.

(iv) Trade openness ratio Tr_t is the total value of exports and imports as a share of nominal GDP.

The data used in the study cover a 29 year period, from 1985 to 2013 and are obtained from the World Bank's World Development Indicators[13]. The variables in our empirical models are measured by different units. For example, GDP is in current $US, energy is in kg of oil, CO_2 is in metric tons and trade openness ratio is the sum of exported and imported goods and services as a share of GDP. All data are converted into the natural log values as a common scale to enable comparison among the variables.

4.2 EIA Method on Trade Policy - the Regulatory Effect of CPTPP on the Environment

The empirical econometric model helps us to quantitatively assess how trade liberalisation affects the environment in Vietnam. The three main effects (scale, composition and technology) of trade liberalisation on the environment are assessed by the inclusion of independent variables (such as trade openness ratio, energy use and real GDP per capita) into the empirical model (equations (4.2) and (4.3)).

However, the results of the empirical model do not help our study to answer the question of which way a trade openness policy affects Vietnam's environment and what are the regulatory effects (see research questions 3 and 4). Thus we further apply an environmental impact assessment method on trade policy. The CPTPP is used as a case study to consider how it could potentially change the production pattern in Vietnam. In addition, we consider how that change could lead to the changes in energy use and CO_2 emissions; and subsequently what Vietnam can do to reduce the CO_2 emissions as a result of trade liberalisation.

The following sections describe (i) the necessity of conducting an EIA on trade policy; (ii) the reasons the CPTPP is selected as a case study; and (iii) specific procedures in applying the EIA method on the CPTPP in this present study.

4.2.1 The Necessity of Using the EIA Method on Trade Policy

The environmental impact assessment on trade policy is carried out in our study for two main purposes. First, there is a lack in the legislative system in Vietnam to require its bodies to conduct an EIA before, during and after the negotiation of a trade policy, which is being widely conducted in developed countries such as the US, EU countries, Japan, and Canada. If our study shows the significance and efficiency of an EIA on trade policy then a set of legal requirements and procedures

[13] http://wdi.worldbank.org/table/3.8

on environmental protection during trade openness negotiation could be developed and implemented in Vietnam.

Second, the results of an EIA on the CPTPP case study can be used to explain the long-term impact of trade openness on the environment in Vietnam. Specifically, an EIA on trade policy helps us to understand the possible impacts of trade agreements on the environment, how these impacts happen and the possibility of mitigating the adverse effects of trade openness on the environment. The application of an EIA on trade policy can also help our study to assess the regulatory effect of trade liberalisation on the environment.

In terms of regulatory effects, the literature highlighted that study and guidelines on assessment of the regulatory effects of trade policy on the environment are limited and the methodologies for assessing the regulatory effects of trade policy on the environment are not commonly agreed. The reasons may be due to the fact that it is often hard to analyse and depict with a high level of certainty the outcomes of domestic regulation of a country (Fauchald & Vennemo, 2011). The OECD (2000) summarised two methodologies that can be used to assess the regulatory effect of trade policy on the environment. One of these methods is the "sectoral method", which is carried out separately for each free trade agreement and "an FTA rule-by rule" approach, which examines the constraints on environmental policy posed by the FTA (Fauchald & Vennemo, 2011).

In our study, we used a statistical data analysis combined with a descriptive analysis of the environmental impact assessment method on trade policy. Statistical data which include export partner shares, export product shares, and Revealed Comparative Advantages index (RCA) in exports from Vietnam to CPTPP member countries are analysed in order to examine the potential changes in trade flows and production patterns of some main energy-intensive products in Vietnam as a result of the CPTPP. The descriptive analysis examines whether the integration of environmental commitments into the CPTPP is beneficial for the environment in terms of the regulatory effects. A set of questions used to examine the regulatory effect is adapted from the EIA method on trade policy (OECD, 2000; GoJ, 2004; McCormick et al., 2006; Mao et al., 2015).

4.2.2 Reasons to Use the CPTPP as a Case Study on Trade Policy

The EIA method on trade policy assesses the impact of individual free trade agreements on the environment. This is due to the differences in the level of openness of each free trade agreement. The CPTPP is used as a case study to assess the possible impact of trade agreements on the environment in Vietnam. The wide scope of the CPTPP [14] and the possible impact of the CPTPP on

[14] The CPTPP document released in 2017 is used in this study.

Vietnam's domestic production pattern and environment are the main motivations for selecting the CPTPP as a specific case study. To be more specific:

(i) CPTPP member countries collectively account for 24% of exports from Vietnam;

(ii) The CPTPP offers the widest level of trade openness for Vietnam; it reduces and eliminates tariff and non-tariff barriers for goods and services that may promote the production of, for example, textiles and garments, and subsequently could lead to an increase in the energy use in the production activities in Vietnam;

(iii) The CPTPP is the first-ever trade agreement which has integrated environmental commitments into its contents that Vietnam has negotiated so far.

The EIA on the CPTPP does not replace the statistical assessment of the linkage among the variables, however, it is useful to understand the specific environmental consequences of recently proposed FTAs in Vietnam. The framework to assess the regulatory impact of the CPTPP on the environment is integrated in the environmental impact assessment on trade policy, and presented in the following section.

4.2.3 General Procedures of the EIA Method on Trade Policy

Considering the existing guidelines on an EIA on trade policy, it is recognisable that the guidelines on conducting EIAs on trade policies differ in countries and international organisations in terms of purposes, situation, location, culture, etc. The guidelines published by international organizations such as the World Trade Organization (WTO, 1999), the European Union (SECSO, 2006), the Organization for Economic Co-operation and Development (OECD, 1994), and the United Nations Environment Programme (UNEP, 2005) usually cover not only the environmental impact but also economic and social impacts (Mao et al., 2015). Ultimately, the main goal of an EIA on trade policy is to minimise the harmful effects of trade on the environment in a sustainable manner (UNEP, 2000; OECD, 2000; GoC, 2009; GoJ, 2004).

The environmental impact assessment can be performed at two levels. The first level is commonly called "sectoral assessment" and examines the environmental effects of the economic changes resulting from a FTA. The second level is a "regulatory assessment" that attempts to analyse the text of the FTA, which could potentially affect the ability of a country to enact, maintain, or enforce its regulations on environmental protection (Gallagher et al., 2002).

In developed countries such as the US and Canada, conducting an environmental assessment on a proposed policy includes four distinct stages (Gallagher et al., 2002). These stages include: (i)

Identification of the economic effects of a proposed free trade agreement; (ii) Identification of the likely environmental impact of economic changes; (iii) Consideration of the significance of the identified likely environmental impacts; and (iv) Identification of enhancement or mitigation options. The contents of each stage are described below.

Step 1 - Identification of the Economic Effects of a Proposed Free Trade Agreement

This step determines the potential economic results of a proposed trade policy, including potential changes to trade flows and economic activity arising from the proposed policy. This procedure also helps to identify the sectors/product groups that will increase or decrease through appropriate trade policy. Particular consideration focuses on environmentally intensive products/industries. This step also can be named "screening" that helps to narrow trade agreements and needs further consideration in terms of environmental impacts (GoJ, 2004).

In order to identify sectors/product groups that can be increased or decreased via a free trade agreement, there are three main methods identified in the literature: trade indicator, the SMART-WITS model[15], and the CGE-GTAP model (Global Trade Analysis Project) (Plummer et al., 2010). These methods differ mainly in terms of the questions about a proposed FTA. Trade indicator is the simplest and most direct method to examine the trend (increasing or decreasing) in the production pattern of a country in terms of a specific product group. Trade indicator is an index or a ratio that can be used to describe and assess the state of trade flows and trade patterns of a particular economy (Mikic & Gilbert, 2007).

In some studies, the CGE model is conducted to predict the change in domestic production as a result of a trade openness policy (such as the EIA on FTA reports conducted by the Canadian and US governments). The main benefits of CGE models include: (i) the CGE model can quantitatively capture effects of the changes from an FTA on all markets/countries, rather than just the changes on one market/country; (ii) the CGE model is an economy-wide specification and a full system approach; thus the welfare changes as a result of trade liberalisation can be comprehensively assessed by the CGE model (Martin, 2000); (iii) the CGE model is extensively developed and widely applied by developed countries such as the US and Canada to examine the changes in the whole economy as a result of a trade policy change.

Having recognizing the benefits of CGE models, however, the CGE model is not appropriate for our study because it is a simulation and calibration model and not an estimation model. CGE models are often developed and presented in the context of formal, highly mathematical economic theories

[15] SMART-WITS stands for the software for market analysis and restrictions on trade in the world integrated trade solution.

such as the inclusion of the input-output structure of each country and the calibration equations that claimed to be of great mathematical sophistication (Martin, 2000). Furthermore, the theory on general equilibrium, which is the core foundation of the CGE model, is often argued to be problematic in applied economics (Ackerman, 1999). CGE models are calibrated models that are based on the validity of the general equilibrium theory, thus CGE models can only be used for simulation purposes but not for testing purposes (Rauscher, 2005; Berman, 2005). The required data set is enormous which includes the input-output, SAM data, labour, etc.

Thus we use the RCA index instead of the CGE model to predict the change in domestic production in Vietnam as a result of the CPTPP. The advantage of using the RCA index is that it considers the intrinsic advantage of a particular export commodity and is consistent with changes in an economy relative to factor endowment and productivity (Nguyen, 2011). The RCA index is a simple useful tool and the most widely used in the literature despite its own shortcomings (Grigorovici, 2009; Le, 2010). Although the method is simple, using trade indicator analysis is adequate to answer research question three and research question four of our study. Furthermore, the trade indicator analysis method is also suitable in our study in terms of the data availability as well as time and budget allocation and efficiency.

Step 2 - Identification of the Likely Environmental Impact of Economic Changes

This is an assessment of the likelihood or probability of environmental impacts of the economic changes determined in step 1. This step helps to answer questions such as what are the environmental impacts of economic changes. How did they occur and the extent of their impacts by scale effect.

This step can be named as “scoping” which focuses on the main fields and sectors that have a substantial impact on the environment from changes in the economic and industrial structures. 'Scoping' is a critical step in the preparation of an EIA. It helps to identify the most important environmental issues that are likely to arise and the information requirements necessary for further analysis. It presents a qualitative measurement in terms of (i) Not likely; (ii) Increasing Likelihood; (iii) Certain with a probability of 0% or 100%.

For instance, from our preliminary analysis of the CPTPP, the CPTPP (which is the Initial Provisions and General Definitions) provides general definitions and provisions that will be applied in understanding and interpreting the text of the agreement (Section 1, CPTPP, 2017, pp. 1-11). However, there is no relevant possible environmental impact in this section of the CPTPP. Consequently, neither further analysis nor environmental consequences consideration is required. Meanwhile, Chapter 7 of the CPTPP on Sanitary and Phytosanitary measures (SPS), aims at enhancing animal and plant health and food safety among the CPTPP member countries (CPTPP, 2017). The increased use of SPS measures in trade activities may mitigate risks in the environment in terms of ensuring the biosafety and quality of the products traded. As a result, the SPS chapter may generate a positive effect on the environment.

Step 3 - Assessment of the Significance of the Identified Likely Environmental Impacts

The positive and negative environmental impacts determined in step 2 are subjected to further consideration about their nature, geographical scale, magnitude, frequency and duration, timing, severity of the environmental impacts and possible synergies between them in order to identify their levels of significance.

Step 4 – Identification of Enhancement or Mitigation Options

This step helps to identify the solutions to improve the positive impacts and to mitigate the negative impacts of a trade policy on the environment. The solutions are a set of proposed laws, regulations, and policies initiatives.

4.2.4 Application of Specific Procedures to Conduct an EIA on the CPTPP in Vietnam

In order to answer the third and fourth research questions of our study, we apply the first and the second stages of the EIA method on the trade policy described above. The main purposes of this work are to examine: (i) a product group/sector whose production will likely increase as a result of the CPTPP in Vietnam, (ii) how the change in the sector production leads to the change in energy consumption and CO_2 emissions, and (iii) opportunities to reduce and control energy consumption and CO_2 emissions as a result of the production change in Vietnam.

(i) Identification of the Product Group that is Likely to Increase as a Result of CPTPP in Vietnam

Revealed Comparative Advantage Index

The traditional trade indicators including export partner share, export product share, and the RCA index will be analysed to provide information on the product groups that Vietnam has comparative advantage in exporting to other CPTPP member countries. The RCA index is defined as the share of a product group in one country's exports divided by that product group's share in world trade. The RCA index is a useful indicator in determining countries' comparative advantages (Nguyen, 2011). The standard RCA index is calculated as:

$$RCA_{ij} = \left(x_{ij} / x_{wj}\right) / \left(\sum x_{ij} / \sum x_{wj}\right) \qquad (4.10)$$

where x_{ij} is the country i's export of commodity j;

x_{wj} is the world's exports of commodity j;

$\sum x_{ij}$ is country i's total exports;

$\sum x_{wj}$ is the world's total exports.

A value of RCA greater than 1 broadly suggests a revealed comparative advantage for the country in sector j. This occurs when the share of that commodity in the country's exports exceeds its share in the reference group exports. The factors that contribute to the movement in RCA are economic, structural change, improved world demand and trade specialisation (Le, 2010; Nguyen, 2011).

An RCA index can be calculated for a specific sector or for a group of countries (Irshad & Xin, 2017). The RCA index in our study is calculated as:

$$RCA_{j;t} = \frac{\left(x_{j;t}/x_{j;t;CPTPP}\right)}{\left(\sum x_{j;t}/\sum x_{j;t;CPTPP}\right)} \tag{4.11}$$

where $RCA_{j;t}$ is the comparative advantage index in the export of commodity j from Vietnam to CPTPP member countries in year t; $x_{j;t}$ is Vietnam's export of commodity j in year t; $x_{j;t;TPPA}$ is the export of CPTPP member countries of commodity j in year t; $\sum x_{j;t}$ is Vietnam's total exports in year t; $\sum x_{j;t;TPPA}$ is CPTPP's total exports in year t.

Based on Hinloopen and van Marrewijk's (2001) study, the RCA index is classified into four categories (Nguyen, 2011):

- 0 < RCA < 1: Products without comparative advantage.

- 1 < RCA < 2: Products with weak comparative advantage.

- 2 < RCA < 4: Products with medium comparative advantage.

- 4 < RCA: Products with strong comparative advantage.

Regional Orientation Index

After determining the product group in which Vietnam has comparative advantage in exports, we then calculate the regional orientation index for that product. The regional orientation index helps to determine whether Vietnam's export of that product is more oriented toward the CPTPP region than other destinations. This index can be combined with the RCA index to examine which product group experiences trade diversion as a result of the CPTPP in Vietnam (Plummer et al., 2010).

The regional orientation index is calculated as follows:

$$Regional\ Orientation_{cgr} = \frac{X_{cgr}/X_{cr}}{X_{cg-r}/X_{c-r}} \quad (4.12)$$

where $\mathrm{X_{cgr}}$ = exports of good g by country c to region r;
$\mathrm{X_{cr}}$ = total exports of country c to region r;
$\mathrm{X_{cg-r}}$ = exports of good g by country c to countries outside region r;
$\mathrm{X_{c-r}}$ = total exports of country c to countries outside region r.

The orientation index of textile exports from Vietnam to CPTPP member countries is calculated as follows:

$$Regional\ Orientation_{VN-textile-CPTPP} = \frac{X_{VN-textile-CPTPP}/X_{VN-CPTPP}}{X_{VN-textile-RoW}/X_{VN-RoW}} \quad (4.13)$$

where

$\mathrm{X_{VN-textile-CPTPP}}$ = exports of textiles from Vietnam to CPTPP member countries;
$\mathrm{X_{VN-CPTPP}}$ = total exports of Vietnam to CPTPP member countries;
$\mathrm{X_{VN-textile-RoW}}$ = exports of textiles from Vietnam to the rest of the world;
$\mathrm{X_{VN-RoW}}$ = total exports of Vietnam to the rest of the world.

The data on export partner shares from Vietnam to CPTPP member countries from 1990 to 2015 are obtained from the World Integrated Trade Solution. The data on the RCA index from Vietnam to CPTPP member countries from 2000 to 2015 are retrieved from the World Bank's World Trade Indicators.

(ii) Identification of the Likely Environmental Impacts due to Economic Changes

The second stage of the analysis is identification of possible environmental impacts due to the economic changes of product group from the CPTPP in Vietnam identified in Stage 1. For this purpose, our study follows the procedure that is proposed by EIA procedures of the Canadian trade policy guideline[16] . A set of questions based on the descriptive method is modified according to the proposed EIA guideline procedures of Canada for the specific purposes of our study (the impact of the CPTPP on Vietnam's environment), including:

Question 1: Will the CPTPP lead to an increase or decrease in the production of a specific product in Vietnam?

Question 2: How will the increase in the production of the product as a result of the CPTPP affect input requirements (energy consumption) and outputs (CO_2 emissions) in Vietnam?

[16] The Canadian trade policy EIA framework and guideline are retrieved from: http://www.international.gc.ca/trade-agreements-accords-commerciaux/env/framework-cadre.aspx?lang=eng

Question 3: What does the literature identify about the energy demand and CO_2 emissions of the economic change of the product in Vietnam?

Question 4: Is there any movement in technology transfer among CPTPP member countries? Are these environmentally friendly or unfriendly technologies?

Question 5: How does the CPTPP regulate environmental protection during the production of the product?

In order to answer these questions, we follow the “sectoral approach” by analysing the statistical data for the product group that is more likely to increase in production as a result of the CPTPP; then we use the descriptive method to analyse the text of the CPTPP, and examine the existing domestic regulations to protect the environment during the production activities in Vietnam.

4.3 Chapter Summary

The chapter presents the data specification, the empirical model estimation method and the EIA method on trade policy to answer the research questions of our study.

We use an empirical model in Research question two to address the short-run and long-run impacts of trade openness, economic development and energy use on CO_2 emissions. This empirical model has been applied by researchers such as Ang (2008), Halicioglu (2009), Jalil and Mahmud (2009), Tan et al. (2014) for the cases in Malaysia, Singapore and China. Our model will provide a comprehensive quantitative assessment on the short-run and long-run relationships between economic development, trade openness, energy consumption and environmental impact in Vietnam. The advanced estimation technology, ARDL, is applied to avoid the spurious interaction among the variables and to overcome the stationarity of the time series data in the study model. Further, the ARDL and ECM models help to capture the dynamic effects of trade openness on CO_2 emissions.

To answer research questions three and four, we first analyse trade statistical data, including export partner shares, export product shares and the Revealed Comparative Advantage index to examine the export pattern of Vietnam to CPTPP member countries. Next, we apply the Environmental Impact Assessment method on trade policy to screen and scope potential effects of trade openness on Vietnam’s environment.

The data on export partner shares and export product shares from Vietnam to CPTPP member countries from 1990 to 2015 are obtained from the World Integrated Trade Solution. The data on the RCA index from Vietnam to CPTPP member countries from 2000 to 2015 are retrieved from the World Bank’s World Trade Indicators. Time series data which include real per capita GDP, energy use,

CO_2 emissions and the trade openness ratio are obtained from the World Bank's World Development Indicators from 1985 to 2013.

Chapter 5

Results and Discussions

This chapter presents the empirical model estimation results of the short-run and long-run impacts of economic development, trade openness and energy use on CO_2 emissions and the descriptive results of applying the EIA method to the CPTPP. Section 5.1 presents the empirical model estimation results, including the descriptive statistics of variables in ARDL models, the unit root test, the Johansen co-integration test, the selection of ARDL models, and the Bounds test. This section also presents the results of ARDL and ECM model estimation, followed by the diagnostic and stability tests. Section 5.2 presents the descriptive results of the EIA method on the CPTPP and discusses the possible impacts of the CPTPP on Vietnam's environment. The final section summarises the chapter.

5.1 Empirical Model Estimation Results

5.1.1 Data and Data Treatment

(i) Descriptive Statistics of Economic Development and Environmental Variables

The data used in the study cover a 29 year period, from 1985 to 2013, obtained from the World Bank's World Development Indicator. Table 5.1 presents the descriptive statistics for the economic development and environment variables used in the empirical models.

Real per capita GDP is measured in current US dollars and denoted as Y_t; CO_2 emissions are measured in metric tons per capita and denoted as C_t; trade openness ratio is measured by percentage of exports and imports of GDP, and denoted as Tr_t. The energy use variable is measured in kilograms of oil equivalent per capita and denoted as E_t. CO_2 emissions are used as the proxy for environmental degradation and trade ratio is used as the proxy for trade openness.

The reported descriptive statistics include the maximum, the minimum, standard deviation, the mean and the median of each variable for the period from 1985 to 2013.

Table 5-1: Descriptive Statistics of the Economic Development and Environmental Variables for ARDL Models (1985-2013)

Variable (notation)	Mean	Median	SD	Minimum	Maximum
CO_2 emissions per capita (C_t)	0.86	0.63	0.56	0.27	1.90
Energy use per capita (E_t)	412.87	356.59	145.33	269.30	677.67
Trade openness ratio (Tr_t)	98.94	102.00	44.84	18.13	165.09
Real per capita GDP (Y_t)	625.61	437.12	505.14	97.16	1,907.56

Table 5.1 reports the mean and standard deviations (SD) of the explanatory variables (E_t, Tr_t, Y_t). The high value of standard deviation indicates the variability of energy use, trade openness and real per capita GDP variables throughout the period 1985-2013. The large variation between the minimum and maximum values of real per capita GDP and trade openness ratio, together with high values of standard deviations of these variables indicate the development of the Vietnam economy during the period of 1985-2013.

On the other hand, the large variation and high value of standard deviations of energy use and CO_2 emissions may indicate the inefficiency of energy use in Vietnam. This implies that there could be a long-run relationship between economic development and environmental degradation in Vietnam (higher trade openness ratio may imply higher CO_2 emissions).

In applying time series data in regression analysis, it is important to determine whether a time series is stationary or non-stationary before performing any regression analysis. Firstly, the reason is the characteristic (nature feature) of time series data. For example, if time series data are non-stationary then they can be changed by time with a trend (increasing or decreasing). Therefore, the two unrelated series data may have the same trends and the regression relations among them may become significant. Consequently, this may cause a biased estimation if non-stationary data are used in regression analysis.

Secondly, although the ARDL techniques can be applied in time series data if the data are I(0) or I(1), however, ARDL is not applicable if the data are I(2). This is because the computed F-statistics, which are provided by Pesaran et al. (2001), are not valid for I(2) data. In our estimation procedures, we will apply the Bounds test to check for the co-integration among the variables, and the Bounds test is designed based on the assumption that the variable is I(0) or I(1) (Jajil et al., 2009). Therefore, we need to make sure that none of our variables is I(2) or beyond before conducting the regression estimation. All data are converted to the natural log values.

Visualised time trends of the variables in the levels and in the first differences are presented in Figure 5.1. The graphs on the left hand side describe the trend of data on the level, including C_t, E_t, Tr_t and Y_t. The data on the first differences, DC_t, DE_t, DTr_t and DY_t, are plotted and displayed on the right hand side of Figure 5.1

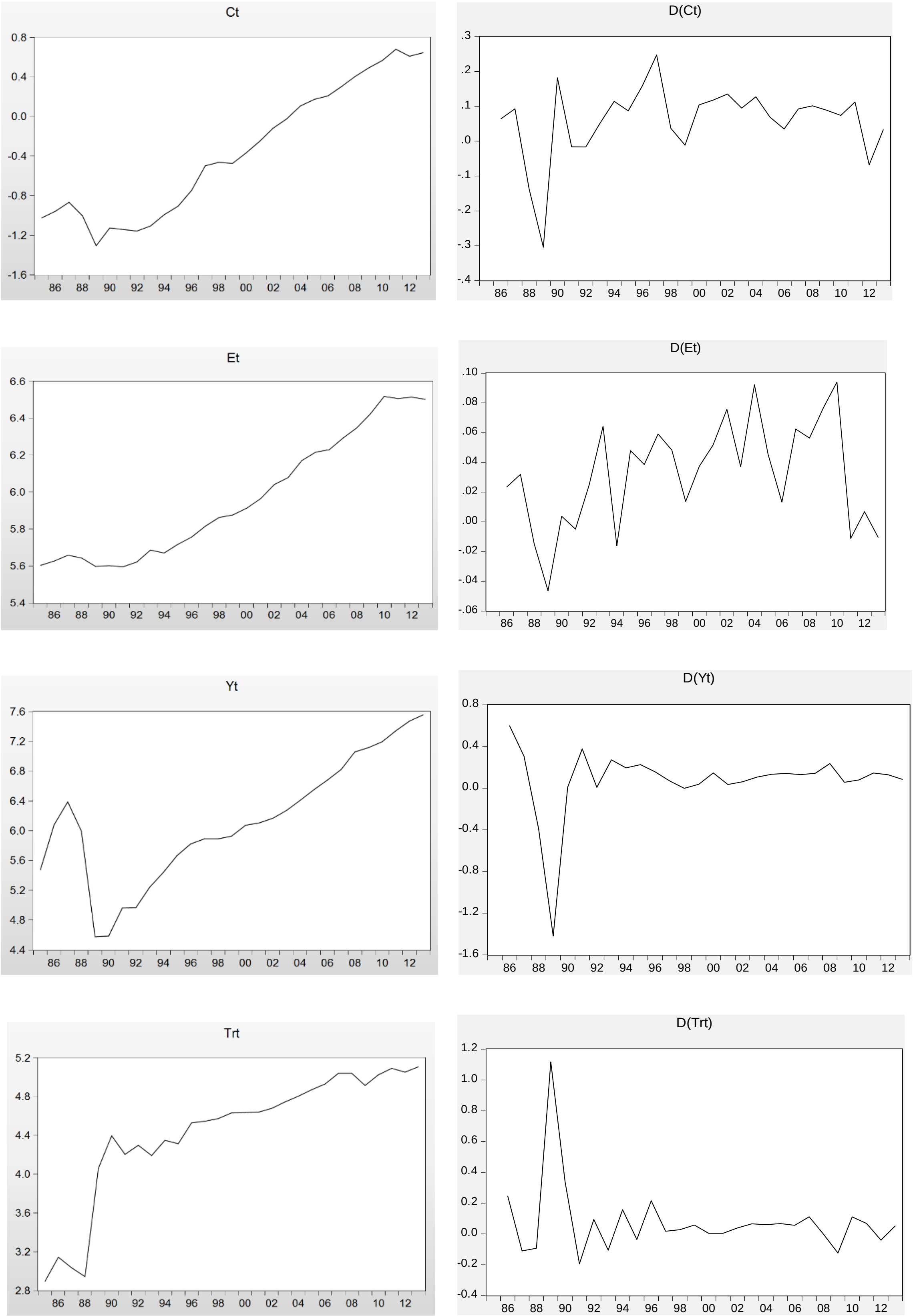


Figure 5-1: Plots Per Capita CO_2 Emissions, Real Per Capita GDP, Per Capita Energy Consumption and Trade Openness in the Level and the First Difference

Note: C_t - CO_2 emissions per capita; DC_t - the first difference of C_t; E_t - energy use per capita; DE_t - the first difference of E_t; Y_t - real per capita GDP; DY_t - the first difference of Y_t; Tr_t - trade openness ratio; DTr_t - the first difference of Tr_t.

It is noticeable that except for an extraordinary increase of Y_t in 1987, all the variables (C_t, E_t, Tr_t, and Y_t) seemed to move with the same increasing trend under the period from 1985 to 2013 (see Figure 5.1, left hand side). The similarity in upward trends of C_t, E_t, Tr_t and Y_t cautions us to be aware of spurious regression among variables. In terms of data on the first difference, it is observable that DC_t, DE_t, DTr_t and DY_t fluctuate around a straight line. This helps us to select a correct form for the Unit root test, which includes an intercept term and/or a trend term into the Augmented Dickey-Fuller test equation.

The correlation coefficients among the economic development and environment variables for the ARDL models are summarised in Table 5.2.

Table 5-2: Correlation Coefficients among Variables for ARDL Models

	Tr_t	Y_t	E_t	C_t	$(Y_t)^2$
Tr_t	1.00				
Y_t	0.49	1.00			
E_t	0.76	0.91	1.00		
C_t [(a)]	0.74	0.93	0.989	1.00	
$(Y_t)^2$	0.51	0.99	0.92	0.93	1.00

Notes: - Tr_t - natural log of trade openness ratio; Y_t - natural log of per capita income; E_t - natural log of energy use per capita; C_t - Natural log of CO_2 emissions per capita; Y_t^2 - square of natural log of per capita income.
- [(a)] C_t is a dependent variable;
- E_t, Tr_t, Y_t, and $(Y_t)^2$ are independent variables

There exists a high correlation among the independent variables (see Table 5.2), specifically, between trade openness ratio and energy use (0.76) and between capita income and energy use (0.91). This means they may cause multicollinearity in the regression model. If these variables are used in the regression model, then their coefficients may become unstable and difficult to interpret. However, the findings of such high correlation may prove useful if each of these indicators can capture more than one feature in explaining the CO_2 emissions.

Based on the empirical model specification that is widely used in the literature (see Chapter 3), energy consumption, trade or FDI, and income are the key determinants of CO_2 emissions in Vietnam (Tang & Tan, 2015), and there is no reason to drop any of the explanatory variables such as energy use, trade openness and per capita income to model CO_2 emissions (Ang, 2008; Halicioglu, 2009; Jajil & Mahmud, 2009; Tan et al., 2014). However, this cautions us to consider and check the collinearity of the selected models for a final conclusion.

Similarly, the per capita income and square of per capita income are highly correlated (the correlation coefficient value is 0.99, which is almost 1.00). As discussed in Chapter 4, it is widely suggested by the EKC theory to capture the squared value of per capita income as one of the explanatory variables for CO_2 emissions. However, the existence of EKC theory is still a controversial issue and the presence of the squared value of an independent variable in the regression model may cause multicollinearity in our model. Thus, we run two forms of model including and excluding the square of the real per capita GDP variable. These models are expressed in equations (5.1) and (5.2). Equation (5.1) describes the relationship between per capita income and pollution in a monotonic function. Equation (5.2) describes the relationship between per capita income and pollution in a quadric function.

The equation used to examine the relationship between CO_2 emissions (C_t), real per capita GDP (Y_t), square real per capita GDP (Y_t^2), energy consumption (E_t) and trade openness (Tr_t) in Vietnam is given as follows:

$$\ln C_t = \beta_0 + \beta_1 lnE_t + \beta_2 lnY_t + \beta_3 lnTr_t + \mu_t \qquad (5.1)$$

$$\ln C_t = \alpha_0 + \alpha_1 lnE_t + \alpha_2 lnTr_t + \alpha_3 lnY_t + \alpha_4 (lnY_t)^2 + \varepsilon_t \qquad (5.2)$$

where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Y_t is real per capita income, $(Y_t)^2$ is the square of real per capita income, Tr_t is the openness ratio, and ε_t and μ_t are the regression error terms.
All variables in equations (5.1) and (5.2) are in their natural logarithmic form.

Equation (5.2) is developed based on the EKC theory, which describes that the CO_2 emissions and real per capita GDP are related in an inverted U-curve. Thus, if α_4 is negative and statistically significant then there exists an inverted U-curve relationship among the variables. The results of equation (5.2) can be compared with the results of Linh and Lin's (2014) and Tang and Tan's (2015) case studies in Vietnam.

Linh and Lin (2014) found that α_4 is statistically insignificant, indicating that there is not enough statistical evidence to confirm that the environment will be rehabilitated at a specific higher per capita income in Vietnam. Tang and Tan (2015), in contrast, found that α_4 is statistically significant, reflecting that the environment can be restored at a higher income in Vietnam[17].

However, the existence of a real per capita GDP variable and a square of real per capita GDP under the same framework as equation (5.2) may cause collinearity problems. Beside, our primary purpose is to examine the impact of trade openness on CO_2 emissions, rather than the existence of EKC theory in Vietnam. Thus we used equation (5.1) to avoid the collinearity between the variables of Y_t and Y_t^2 and the result can be compared with the results of Al-Mulali et al. (2015), and Anwar and Alexander (2016).

[17] : Details on these studies can be found in Chapter 3

The study conducted by Al-Mulali et al. (2015) found a positive relationship between GDP and CO_2 emissions in the short-run and long-run in Vietnam. Al-Mulali et al's (2015) study further found a significantly negative import impact and a positive export impact on CO_2 emissions, which indicates that Vietnam mainly imports highly polluted products (Al-Mulali et al., 2015). Anwar and Alexander (2016) found evidence that trade openness has minor effects on the CO_2 emissions in Vietnam[18].

(ii) Unit Root Test for Stationarity

It is well-known that different unit root tests can lead to different results (Anwar & Alexander, 2016), therefore we used three different unit root tests, namely: (i) the Augmented-Dickey-Fuller (ADF) test; (ii) the Dickey-Fuller GLS unit root test; and (iii) the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) for the time series data of the variables in equations (5.1) and (5.2).

The Dickey-Fuller GLS test is a simple modified version of the conventional ADF test that de-trends the series prior to the estimation of ADF test regression (Begum et al., 2015). The critical value of the Dickey-Fuller GLS unit root test is calculated for 50 observations by Elliot-Rotherberg-Stock (1996). Because our sample size is quite small (29 observations), the result of the DFGLS test for our sample size may not be accurate. Therefore, we conducted three unit root tests to have a robust result on the stationarity of variables in the ARDL models. The KPSS unit root test is conducted to complement the ADF and Dickey-Fuller GLS test, which is motivated by the argument that tests designed on the basis of the null that a series is I(1) have low power of rejecting the null (Ang, 2008).

The forms of Unit root test for the level data were chosen based on visual inspection of the data plot in Figure 5.1, a constant term and a trend term were taken into consideration to choose the form of the ADF test. The data series at the levels of C_t, E_t, Y_t, Y_t^2 and Tr_t appeared to fluctuate around a linear trend (see Figure 5.1). Therefore, the third form of the ADF test, which includes constant and trend terms, was chosen to perform the unit root test for all variables at level[19]. Meanwhile, the second form of the ADF test, which includes a constant term, was selected to perform the Unit root test for the first difference of variables DC_t, DE_t, DY_t, DY_t^2, DTr_t, as the visual plots of these variables (see Figure 5.1) appear to drift around a constant, without a trend (Hill et al., 2011).

The lag length was automatically selected by Eviews 9 software based on the Schawrz information criterion. The results of the Unit root tests are presented in Table 5.3.

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[18]: Details on these studies can be found in Chapter 3

[19]: There are 3 forms of the ADF test in Eviews 9 software. The first ADF function form does not include constant or trend terms. The second ADF function form includes a constant but does not include a trend term. The third ADF function form includes both constant and trend terms.

Table 5-3: Unit Root Test Results of Equations (5.1) and (5.2)

t-statistic		lnC_t	lnE_t	$LnTr_t$	LnY_t	$(LnY_t)^2$
ADF test	Level	-2.355	-2.198	-2.518	-0.48	-1.806
	1st dif.	-4.358***	-3.44**	-3.978***	-4.012***	-3.86***
Dickey-Fuller GLS[(a)]	Level	-1.874	-1.861	-2.25	-0.81	-1.81
	1st dif.	-4.339***	-3.46***	-4.93***	-2.45**	-3.52***
KPSS[(b)] (LM-statistic)	Level	0.128*	0.165**	0.16*	0.14*	0.15*
	1st dif.	-	-			

Notes: *, ** and *** denotes 10%, 5% and 1% levels of significance, respectively.
[(a)]: Mackinnon (1996) one-sided p-values; [(b)]: LM-statistic
For the ADF and GLS tests: The null hypothesis (Ho) states a unit root (non-stationary), which will be rejected if $\tau < \tau$ -statistic (τ - *tau*).
For the KPSS test: The null hypothesis (Ho) states stationary, which is rejected if LM-statistic < critical values. The LM-statistic is calculated by Kwiatkowski-Phillips-Schmidt-Shin (1992). The LM-critical values for KPSS test are 0.216, 0.146 and 0.119 at 1%, 5% and 10% levels, respectively.

As can be seen from Table 5.3, the results of the ADF, Dickey Fuller GLS and KPSS tests for unit root and stationarity on all the variables at the levels and the first difference show that C_t, E_t, Tr_t, Y_t and Y_t^2 appear to contain a unit root in their levels but are stationary in their first differences. The variables have a unit root which implies that they are not stationary at their levels. However, the first differences of the variables have no unit root and the null hypothesis is rejected at the 5% level of significance (for C_t, E_t and Y_t^2) and at the 1% level of significance (for Tr_t) indicating that the variables are integrated of the same order 1. Hence, we can conclude that we have a mix of stationary and non-stationary data, but none of the variables is I(2) or beyond that which is eligible for the ARDL estimation technique and the Bounds Integration test (Jajil & Mahmud, 2009). Besides, when the variables are integrated at the same level, we can run the Johansen co-integration test for possible cointegration relationships.

(iii) Johansen Cointegration Test

From the Unit root test for stationarity of data, the variables (C_t, E_t, Tr_t, Y_t, Y_t^2) are non-stationary but become stationary after taking the first difference. Next, we used the Johansen co-integration test to identify the existence of a long-run relationship among the variables at the level before estimation by the ARDL approach. The Johansen co-integration tests were carried out twice for the four variables (C_t, E_t, Tr_t, Y_t) in equation (5.1) and for the five variables in equation (5.2) (C_t, E_t, Tr_t, Y_t, Y_t^2). The results of the Johansen cointegration test are shown in Table 5.4.

Table 5-4: Johansen Co-integration Test Results for Equations (5.1) and (5.2)

Ho	H1	**Trace statistic**	95% Critical value	Prob.[(a)]	Ho	H1	**Max-Eigen statistic**	95% Critical values	Prob.[(a)]
Equation (5.1) Variables: C_t, E_t, Tr_t, Y_t (all variables are in their natural logs)									
r=0*	r>0	73.45	47.85	0.000	r=0*	r<1	44.23	27.58	0.000
r<1	r=1	29.22	29.79	0.058	r<1	r=2	21.04	21.13	0.051
r<2	r=2	8.17	15.49	0.446	r<2	r=3	7.78	14.26	0.391
r<3	r=3	0.302	3.84	0.582	r<3	r=3	0.302	3.84	0.582
Equation (5.2) Variables: C_t, E_t, Tr_t, Y_t, Y_t^2 (the variables are in their natural logs)									
r=0*	r>0	138.94	69.81	0.000	r=0*	r>0	56.18	33.87	0.000
r<1*	r=1	87.75	47.85	0.000	r<1*	r=1	46.72	27.58	0.000
r<2*	r=2	36.03	29.79	0.008	r<2	r=2	21.03	21.13	0.051
r<3	r=3	15.00	15.49	0.059	r<3	r=3	10.39	14.26	0.187
r<4	r=4	4.60	3.84	0.031	r<4	r=4	4.06	3.84	0.039

Note: [(a)] - MacKinnon-Haug-Michelis (1999) p-values
* Denotes rejection of the null hypothesis at the 5% significance level
Ho: Series are not co-integrated; H1: There is at most or more co-integration equations

For equation (5.1), the Trace statistic and Max-Eigen statistic are both significant at the 5% level for the null hypothesis r=0 (see Table 5.4). This implies that the null hypothesis r=0 is rejected at the 5% level of significance. Therefore, we can conclude that there is an underlying long-run relationship among the variables C_t, E_t, Tr_t, Y_t in equation (5.1).

For equation (5.2), the Trace statistic results (see Table 5.4) show that the p-value of the null hypothesis that the number of cointegration equations is at most 2, ($r \leq 2$), is lower than 0.05. This indicates that the null hypothesis $r \leq 2$ is not rejected at the 5% significance level according to the Trace statistic. However, the null hypothesis $r \leq 2$ is rejected at the 5% significance level based on the Max-Eigen statistic. Besides, both the Trace statistic and the Max-Eigen statistic are significant at the 5% level for the null hypothesis $r \leq 1$. Therefore, we can conclude that there is at least one cointegration equation among the variables C_t, E_t, Tr_t, Y_t, Y_t^2 in equation (5.2). Alternatively, using a 95% confidence level, we can conclude that the variables in equation (5.2) exhibit a long-run equilibrium relationship.

5.1.2 Selection of ARDL Models

The variables (C_t, E_t, Tr_t, Y_t, and Y_t^2) are integrated at I(1) and have a long-run relationship, thus we can proceed to develop the ARDL model.

The ARDL framework for equation (5.1) are given as follows:

$$\Delta C_t = \beta_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=1}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \lambda_1 C_{t-1} + \lambda_2 E_{t-1} + \lambda_3 Trt_{t-1} + \lambda_4 Y_{t-1} + \varepsilon_t \quad (5.3)$$

The ARDL framework for equation (5.2) is given as follows:

$$\Delta C_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=1}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \delta_i \Delta (Y_{t-i})^2 + \lambda_1 C_{t-1} + \lambda_2 E_{t-1} + \lambda_3 Trt_{t-1} + \lambda_4 Y_{t-1} + \lambda_5 (Y_{t-1})^2 + \varepsilon_t \quad (5.4)$$

Where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Y_t is real per capita GDP, Y_t^2 is square of real per capita GDP, Tr_t is the trade openness ratio, and ε_t and μ_t are the regression error terms.
Δ stands for the first difference of the variable.
All variables in equations (5.3), (5.4) are in their natural logarithmic form.

It is proven that if a set of series is cointegrated then there exists an error correction mechanism. The error correction mechanism helps the variables move closely together over time, while allowing a wide range of short-run dynamics (Engle & Granger, 1987, as cited in Baek & Kim, 2013, p. 746). This dynamic relationship is described by the Error Correction Model demonstrating the short-run and long-run adjustment parameters. The results of the ECM allow us to measure the speed of adjustment required to adjust to long-run equilibrium after a short-term shock. The coefficient of the ECM term is expected to be negative and statistically significant. The ECM frameworks for equations (5.3) and (5.4) are estimated using equations (5.5) and (5.6), respectively:

$$\Delta C_t = \beta_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=1}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + + \alpha ECM_{t-1} + \mu_t \quad (5.5)$$

$$\Delta C_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta C_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta E_{t-i} + \sum_{i=1}^{p} \omega_i \Delta Trt_{t-i} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \delta_i \Delta (Y_{t-i})^2 + \alpha ECM_{t-1} + \varepsilon_t \quad (5.6)$$

where C_t is CO_2 emissions per capita, E_t is commercial energy use per capita, Y_t is real per capita GDP, Y_t^2 is the square of per capita real GDP, Tr_t is the trade openness ratio which is used as a proxy for foreign trade, and ε_t and μ_t are the regression error terms.
Δ stands for the first difference of the variable.
ECM is the Error Correction Model that is derived from the ARDL model.
All variables in equations (5.5) and (5.6) are in their natural logarithmic form.

The selection of ARDL models (equations (5.3) and (5.4)) is estimated using the software Eviews 9. Eviews allows the user to set a particular lag level or automatically select the lag level within the maximum lags of dependent and independent variables. Besides, the levels of lag can be selected differently for each variable. The model selection criterion is impacted strongly by the selection of lag order (Hill et al., 2011). As the selection of lag order affects the number of observations included in the model, increasing the length of lag order leads to the increase in the number of parameters.

With a view to capturing the essential lag effects without introducing an excessive number of parameters, we set the maximum number of lags to 4 then ran the model selection downward from 4. Since our sample size is small (29 observations) this helps to minimise the loss of degrees of freedom in estimating equations (5.3) and (5.4). The results of the model selection criterion for the ARDL models are reported in Table 5.5.

Table 5-5: Model Selection Criterion

C_t=f(C_t, E_t, Tr_t, Y_t)						ARDL(C_t, E_t,Tr_t,Y_t)
Equation	LogL	AIC	BIC	HQ	Adj. R-sq	Specifications
(5.7)	49.92	-3.148	**-2.712**	-3.022	**0.995**	**ARDL(1,2,2,0)**(*1)
(5.8)	64.55	**-3.80**	**-2.975**	-3.57	0.997	**ARDL(1,4,4,4)**(*2)
Ct=f[C_t, E_t, Tr_t, Y_t, $(Y_t)^2$]						ARDL(C_t, E_t, Tr_t, Y_t, Y_t^2)
Equation	LogL	AIC	BIC	HQ	Adj. R-sq	Specifications
(5.9)	58.50	-3.222	-2.503	-3.008	**0.9960**	**ARDL(2,2,2,2,2)**(*3)
(5.10)	53.54	**-3.225**	-2.745	-3.082	0.9956	**ARDL(1,2,2,0,0)**(*3)
(5.11)	49.58	-3.1987	**-2.811**	-3.087	0.9958	**ARDL (1,0,2,0,0)**(*4)

Notes: AIC - Akaike Information Criterion; BIC - Schwarz Bayesian Criterion; HQ - Hannn-Quinn Information Criterion; LogL – Log likelihood
See Table 5.6 for model specification
(*1) - Model is chosen when maximum lags for model selection are set to 3
(*2) - Model is chosen when maximum lags for model selection are set to 4
(*3) - Model is chosen when maximum lags for model selection are set to 2
(*4) - Model is chosen when maximum lags for model selection are set to 2 or 3

According to Pesaran and Shin (1999), the AIC and BIC criteria have very similar small-sample performances, with the BIC criterion performing slightly better in the majority of the experiments. Therefore, in our study, the ARDL model has been selected based primarily on the smallest value of BIC criterion, smallest value of AIC and highest value of adjusted R-squared which are reported in Table 5.5.

Equation (5.3) expresses the relationship among the variables in a monotonic function, which is C_t=f(C_t, E_t, Tr_t, Y_t). A total of 54 models were evaluated for the maximum lag 2; 192 models evaluated for the maximum lag 3; 500 models evaluated for the maximum lag 4. Table 5.5 reports the minimum AIC (-3.148) and minimum BIC (-2.712) are evaluated for ARDL specification (1.2.2.0) (equation 5.7) when the maximum lag 3 is used for the model selection. In the case of maximum lag 4, the minimum value AIC (-3.80) and minimum value BIC (-2.975) are calculated for ARDL specification (1.4.4.4) (equation 5.8). Therefore, the ARDL specifications (1.4.4.4) and (1.2.2.0) were selected for further analysis in our study.

For equation (5.4) [C_t=f(C_t, E_t, Tr_t, Y_t, Y_t^2)], a total of 162 models were evaluated for the maximum lag 2 and 768 models evaluated for the maximum lag 3, consecutively. Table 5.5 shows that the highest adjusted R-squared value, 0.996, is reported for equation (5.9); the AIC value (-3.225) is smallest for equation (5.10); and the smallest value of BIC is -2.811 for equation (5.11). Consequently, the ARDL specifications (1.0.2.0.0), (1.2.2.0.0) and (2.2.2.2.2) were selected to proceed for further analysis.

Accordingly, the estimation equations for long-run relationships among CO_2 emissions, trade openness, energy use and per capita income are specified in Table 5.6.

Table 5-6: ARDL Model Specifications

ARDL (Ct. E_t. Tr_t. Y_t)		
ARDL(1.2.2.0)	$LnC_t = \alpha_0 + \alpha_1*LnC_{t-1} + \alpha_2*LnE_t + \alpha_3*LnE_{t-1} + \alpha_4*LnE_{t-2} + \alpha_5*Tr_t + \alpha_6*LnTr_{t-1} + \alpha_7*LnTr_{t-2} + \alpha_8*LnY_t + \epsilon$	**Equation (5.7)**
ARDL(1.4.4.4)	$LnC_t = \alpha_0 + \alpha_1*LnC_{t-1} + \alpha_2*LnE_t + \alpha_3*LnE_{t-1} + \alpha_4*LnE_{t-2} + \alpha_5*LnE_{t-3} + \alpha_6*LnE_{t-4} + \alpha_7*Tr_t + \alpha_8*LnTr_{t-1} + \alpha_9*LnTr_{t-2} + \alpha_{10}*LnTr_{t-3} + \alpha_{11}*LnTr_{t-4} + \alpha_{12}*LnY_t + \alpha_{13}*LnY_{t-1} + \alpha_{14}*LnY_{t-2} + \alpha_{15}*LnY_{t-3} + \alpha_{16}*LnY_{t-4} + \epsilon$	**Equation (5.8)**
ARDL [C_t. E_t. Tr_t. Y_t. $(Y_t)^2$]		
ARDL (2.2.2.2.2)	$LnC_t = \alpha_0 + \alpha_1*LnC_{t-1} + \alpha_2*LnC_{t-2} + \alpha_3*LnE_t + \alpha_4*LnE_{t-1} + \alpha_5*LnE_{t-2} + \alpha_6*Tr_t + \alpha_7*LnTr_{t-1} + \alpha_8*LnTr_{t-2} + \alpha_9*LnY_t + \alpha_{10}*LnY_{t-1} + \alpha_{11}*LnY_{t-2} + \alpha_{12}*LnY_t^2 + \alpha_{13}*(LnY_{t-1})^2 + \alpha_{14}*(LnY_{t-2})^2 + \epsilon$	**Equation (5.9)**
ARDL (1.2.2.0.0)	$LnC_t = \alpha_0 + \alpha_1*LnC_{t-1} + \alpha_2*LnE_t + \alpha_3*LnE_{t-1} + \alpha_4*LnE_{t-2} + \alpha_5*Tr_t + \alpha_6*LnTr_{t-1} + \alpha_7*LnTr_{t-2} + \alpha_8*LnY_t + \alpha_9*(LnY_t)^2 + \epsilon$	**Equation (5.10)**
ARDL (1.0.2.0.0)	$LnC_t = \alpha_0 + \alpha_1*LnC_{t-1} + \alpha_2*LnE_t + \alpha_3*LnTr_t + \alpha_4*LnTr_{t-1} + \alpha_5*Tr_{t-2} + \alpha_6*LnY_t + \alpha_7*(LnY_t)^2 + \epsilon$	**Equation (5.11)**

Notes: α_i (i=1-16) denotes the coefficient;

LnC_t - natural logarithm of CO_2 emissions; LnC_{t-1} - one lag of LnC_t; LnE_t - natural logarithm of Energy use per capita; $LnTr_t$ - Natural logarithm of trade openness ratio; $LnTr_{t-1}$ - one lag of $LnTr_t$; $LnTr_{t-2}$ - two lags of $LnTr_t$; LnY_t - natural logarithm of per capita income; LnY_t^2 - square value of LnY_t

ϵ is the error term which captures all the factors that may affect the CO_2 emissions in Vietnam rather than the energy use, trade openness, GDP per capita and their lags.

5.1.3 The Bounds Tests for Co-integration of ARDL Models

The results of the Johansen cointegration test (see Table 5.4) for the variables (C_t, E_t, Tr_t, Y_t, Y_t^2) at the level have confirmed the existence of a long-run relationship among the variables at the level. According to Pesaran and Shin (1999), the small sample size properties of the ARDL approach are far superior to those of the Johansen and Juselius's cointegration technique (Jalil & Mahmud, 2009).

Besides, the Bounds Test in the ARDL approach has been widely employed in recent studies, such as Anwar and Alexander (2016), Halicioglu (2009), Hossain (2012), Jalil and Mahmud (2009), Ozturk and Acaravci (2010) to check for the cointegration among variables of the ARDL model. Therefore, in our study we further proceed to check the cointegration among variables at the level and their lag for each ARDL model (see Table 5.6 for model specifications).

The Bounds tests were performed to check for the existence of co-integration among the variables of each ARDL model. Equations (5.7; 5.8; 5.9; 5.10 and 5.11) were estimated by the ordinary least square method. The F-test was conducted to check the long-run relationship among the variables. The results of the Bounds tests are presented in Table 5.7.

Table 5-7: Bounds Test Co-integration Results

Equation	Specifications	F-statistic	ECT_{t-1}
(5.7)	ARDL(1.2.2.0)	4.92***	-0.35***
(5.8)	ARDL (1.4.4.4)	7.51***	-0.555***
(5.9)	ARDL(2.2.2.2.2)	5.128***	-0.320***
(5.10)	ARDL(1.2.2.0.0)	5.396***	-0.480***
(5.11)	ARDL(1.0.2.0.0)	11.05***	-0.585***

Notes: ** and *** denotes 5% and 1% levels of significance, respectively.
Ho: No long-run relationship exists
H1: Long-run relationship exists

Statistically, there is strong evidence to suggest the existence of a long-run relationship between the variables in five reported ARDL model specifications (Equations 5.7; 5.8; 5.9; 5.10; 5.11) (see: Table 5.7). At a 1% level of significance, the computed F-statistic is larger than the upper bound of the F-test at the 1% level of significance, thus we reject the null of no long-run relationship. The significance of the F-statistic indicates that the independent variables jointly affect the dependent variables in Equations (5.7) to (5.11). This implies the CO_2 emissions are jointly affected by the per capita income, energy use and trade openness.

The next sections describe the estimation results of each ARDL model. The reported information includes the coefficients for the CO_2 emissions variable and trade openness, economic development, energy use variables; t-values and p-values of coefficients of the long-run elasticities, short-run elasticities and diagnostic tests of each equation. The significance of the variables is evaluated based on the reported t-values at 1%, 5% and 10% levels of significance. It is expected that the energy use coefficient is positive and significant since the more energy is consumed the higher the CO_2 emissions (Ang, 2008; Hossain, 2012; Tan et al., 2014).

The results of the ECM models are also reported for each ARDL model. The coefficient ECM_{t-1} gives information on the speed of adjustment from a short-run to a long-run relationship. The coefficient ECM_{t-1} is expected to be negative and significant.

5.1.4 Estimation Results of Equation (5.7) - ARDL(1.2.2.0)

Equation (5.7) was selected when the maximum lag is set to 3. The estimation results for equation (5.7) are summarised in Table 5.8.

Table 5-8: Long-run and Short-run Estimation Results of Equation (5.7)

Normalised cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	-0.217	-0.306	DE_t	0.902	3.982***
Tr_t	0.513	2.716**	DTr_t	0.193	3.170***
Y_t	0.657	3.064***	DY_t	0.223	4.48***
Intercept	-5.50	-2.580**	Intercept	-1.935	-4.82***
			ECM_{t-1}	-0.351	-4.731***
R-squared: 0.997; F-statistic: 783.665***; DW stat: 2.421; RSS: 0.032					

Notes: See Table 5.6 for model specification; RSS stands for the residual sum of squares.
*,**,*** represent 10%, 5% and 1% levels of significance, respectively

Table 5.8 shows that the coefficient of ECM which is derived from equation (5.7) - ARDL (1.2.2.0) is negative and significant. This means there is an adjustment from the short-run to long-run equilibrium in equation (5.7) as our expectation. The estimated coefficient of ECM_{t-1} is -0.351 and this indicates that the deviation from the long-run equilibrium level of CO_2 emissions in one year is corrected by 35.1% over the following year in equation (5.7).

Regarding the impact of trade openness on CO_2 emissions, the estimation results of equation (5.7) show that Tr_t (0.513) is significant at the 5% level and DTr_t (0.193) is significant at the 1% level. This implies a negative impact of trade openness on CO_2 emissions. Specifically, a 1% increase of trade openness leads to an increase in CO_2 emissions by 0.513% in the long-run elasticity and by 0.193% in the short-run elasticity.

In terms of the impact of the real per capita GDP variable, Table 5.8 shows that Y_t (0.657) and DY_t (0.223) are significant at the 1% level, which indicates that a 1% increase in real per capita GDP will increase CO_2 emissions by 0.657% over the long-run elasticity and 0.223% over short-run elasticity.

With regard to impact of energy consumption on the CO_2 emissions, Table 5.8 reports that the coefficient of E_t has a negative sign (-0.217), which means that a 1% increase in energy use leads to a decrease in CO_2 emissions by 0.217%. However, the E_t variable is statistically insignificant. This indicates that equation (5.7) [ARDL (1.2.2.0)] does not statistically support the long-run impact of energy use on CO_2 emissions.

5.1.5 Estimation Results of Equation (5.8) - ARDL(1.4.4.4)

Equation (5.8) - ARDL specification (1.4.4.4) was selected when the maximum lag is set to 4. The estimation results for equation (5.8) are summarised in Table 5.9.

Table 5-9: Long-run and Short-run Estimation Results of Equation (5.8)

Normalised cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	0.179	0.284	DE_t	1.135	5.039***
Tr_t	1.232	3.662***	DTr_t	0.54	5.781***
Y_t	0.273	0.996	DY_t	-0.107	-1.37
Intercept	-8.61	-4.27***	Intercept	-4.784	-6.38***
			ECM_{t-1}	-0.555	-6.43***
R-squared: 0.999; F-statistic: 632.17***; DW stat: 1.99; RSS: 0.008					

Notes: See Table 5.6 for model specification; RSS stands for residual sum of squares.
*,**,*** represent 10%, 5% and 1% levels of significance, respectively

As reported in Table 5.9, the coefficient of ECM which is derived from equation (5.8) - ARDL (1.4.4.4) is negative and significant. This means there is an adjustment from the short-run to long-run equilibrium in the ARDL specification (1.4.4.4). The coefficient of ECM_{t-1} for equation (5.8) is -0.555. This indicates the deviation from the long-run equilibrium level of CO_2 emissions in one year is corrected by 55.5% over the following year in equation (5.8).

Regarding the impact of trade openness on CO_2 emissions, the estimation results of equation (5.8) show that Tr_t (1.232) and DTr_t (0.54) are both significant at the 1% level, which implies that an increase of 1% in trade openness leads to an increase of 1.23% in CO_2 emissions in the long-run equilibrium and an increase of 0.54% in CO_2 emissions in the short-run equilibrium.

With regard to the real per capita GDP variable, Table 5.9 shows that Y_t (0.273) and DY_t (-0.107) are insignificant. This indicates that the long-run and short-run elasticities of economic development on CO_2 emissions are not statistically supported by equation (5.8).

In terms of the impact of energy consumption on the CO_2 emissions, the coefficient of E_t (0.179) in equation (5.8) is insignificant. This indicates that equation (5.8) - ARDL specification (1.4.4.4) does not statistically support the long run relationship between energy use and CO_2 emissions in our study.

The finding of an insignificant impact of energy consumption on CO_2 emissions in equations (5.7) and (5.8) contradicts the energy literature that fossil fuel energy consumption is the main source of greenhouse gas emissions (Mulali et al., 2015); and we would expect that the increase in energy use causes the increase in pollution (Anwar & Alexander, 2016); or the higher energy consumption, the greater the CO_2 emissions (Linh & Lin, 2014). The insignificant impact of energy use on CO_2 emissions may be because of the omission of explanatory variables in equations (5.7) and (5.8) that leads to biased estimation results. Another reason could be that the monotonic function form, which is used in equations (5.7) and (5.8) is not appropriate to capture the effect of economic development, trade openness and energy usage on CO_2 emissions. To overcome this, we further examine the impact of trade openness, energy use and economic development on CO_2 emissions by including the square of real per capita GDP variable (Y_t^2).

5.1.6 Estimation Results of Equation (5.9) - ARDL (2.2.2.2.2)

Equation (5.9) - ARDL specification (2.2.2.2.2) was selected based on the highest R-square value when the maximum lag is set to 2. The estimation results for equation (5.9) are summarised in Table 5.10.

Table 5-10: Long-run and Short-run Estimation Results of Equation (5.9)

Normalised cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	-0.028	-0.017	DC_{t-1}	-0.395	-3.030**
Tr_t	0.656	1.36	DE_t	1.07	4.97***
Y_t	0.842	1.92*	DE_{t-1}	1.171	4.042***
Y_t^2	-0.068	-0.786	DTr_t	0.300	3.349**
Intercept	-10.55	-1.55	DY_t	2.264	4.60***
			DY_{t-1}	1.37	3.077**
			DY_t^2	-0.19	-4.38***
			DY_{t-1}^2	-0.141	-2.656**
			$ECM_{(t-1)}$	-0.320	-6.60***
R-squared: 0.998; F-statistic: 472.18***; DW stat: 2.14; RSS: 0.020					

Notes: See Table 5.6 for model specification; RSS stands for residual sum of squares
*, **, *** represent 10%, 5% and 1% levels of significance, respectively.

In terms of the ECM model, the coefficient of ECM, which is derived from equation (5.9) - ARDL specification (2.2.2.2.2), is negative and significant at the 1% level. This indicates the existence of an adjustment from the short-run to long-run equilibrium between economic growth, trade openness, energy use and CO_2 emissions. Specifically, at the 1% level of significance CO_2 emissions can return to their equilibrium at the ratio 0.32 in the equation (5.9).

Regarding the impact of trade openness on CO_2 emissions, the estimation results of equation (5.9) show that Tr_t (0.656) is insignificant, but DTr_t (0.3) is significant at the 5% level. This implies that in the short-run elasticity a 1% increase in trade openness leads to a 0.3% increase in CO_2 emissions; however, in the long-run elasticity trade openness does not affect the CO_2 emissions in equation (5.9).

With regard to the impact of economic development on CO_2 emissions, Table 5.10 shows that the per capita income, Y_t (0.842), is significant at the 10% level; DY_t (2.264) is significant at the 1% level; DY_{t-1} (1.37) is significant at 5%. This means that an increase of 1% in real per capital GDP leads to an increase of 0.842% in CO_2 emissions in the long-run equilibrium. The short-run impact of economic growth on CO_2 emissions has a lag effect. The short-run elasticity impact of economic growth on CO_2 emissions in the first year and the second year is 2.264 and 1.37, respectively. The square of real per capita GDP (Y_t^2) is insignificant in equation (5.9). The insignificance of the Y_t^2 variable indicates that the inverted U-curve relationship between CO_2 emissions and per capita income is not statistically supported by equation (5.9).

Particularly, it is worth noting that in the equation (5.9) the energy use (E_t) in the long-run relationship with CO_2 emissions is insignificant (see Table 5.10).

Again, the finding of the insignificance of the energy use variable on CO_2 emissions contradicts the literature of energy use, indicating that equation (5.9) is not appropriate to model the impact of energy use, trade openness and economic development on CO_2 emissions. This may be because of lag effects at level 2 of C_t, E_t, Tr_t, Y_t, Y_t^2 variables into the equation (5.9). Increasing the length of lag order leads to the increase in the number of parameters. The including of an excessive number of parameters may lead to the biased least square estimation.

5.1.7 Estimation Results of Equation (5.10) - ARDL (1.2.2.0.0)

Equation (5.10) - ARDL specification (1.2.2.0.0) was selected based on the minimum value of the AIC criterion when the maximum lag is set to 2. The estimation results for equation (5.10) are summarised in Table 5.11.

Table 5-11: Long-run and Short-run Estimation Results of Equation (5.10)

Normalised cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	0.789	1.151	DE_t	0.900	4.019***
Tr_t	0.308	1.95*	DE_{t-1}	0.661	2.88**
Y_t	1.442	2.611**	DTr_t	0.174	2.606**
Y_t^2	-0.087	-1.606	DTr_{t-1}	0.229	5.317***
Intercept	-12.01	-3.07**	DY_t	0.743	2.088*
			DY_t^2	-0.47	-1.532
R-squared: 0.997, F-statistic: 719.54***			Intercept	-5.84	
DW stat: 2.37, SSR: 0.029			ECM_{t-1}	-0.483	-5.69***

Notes: See Table 5.6 for model specification; RSS stands for residual sum of squares
*,**,*** represent 10%, 5% and 1% levels of significance, respectively

In terms of the ECM model, the coefficient of ECM, which is derived from equation (5.10) - ARDL specification (1.2.2.0.0), is negative and significant at the 1% level. This indicates the existence of an adjustment from the short-run to long-run equilibrium in the ARDL specification (1.2.2.0.0). Specifically, at the 1% level of significance CO_2 emissions can return to their equilibrium at the ratio of 0.483 in equation (5.10).

The per capita income, Y_t (1.442), is significant at the 5% level and DY_t (0.743) is significant at the 10% level in equation (5.10), which indicates that a 1% increase in the real per capita GDP leads to an increase of 1.442% in CO_2 emissions in the long-run elasticity and 0.734% in the short-run elasticity. However, the square of per capita income (Y_t^2) is insignificant in equation (5.10). The insignificance of the Y_t^2 variable indicates that the inverted U-curve relationship between CO_2 emissions and per capita income is not statistically supported by equation (5.10).

In terms of the impact of trade liberalisation on CO_2 emissions, Table 5.11 shows that Tr_t (0.308) is significant at the 10% level; DTr_t (0.174) is significant at the 5% level; and DTr_{t-1} (0.229) is significant at the 1% level. This indicates that trade openness has a negative impact and lag effect on CO_2 emissions. Specifically, a 1% increase in trade openness is associated with 0.308% in CO_2 emissions in the long-run elasticity, 0.174% in the first year and 0.229% in the second year of short-run elasticity.

Similarly to the estimation results of equation (5.9), the energy use (E_t) in the long-run relationship with CO_2 emissions is insignificant in equation (5.10) (see Table 5.11). The finding of insignificance of energy use on CO_2 emissions is contradicted by the literature of energy use, indicating that equation (5.10) is not appropriate to model the impact of energy use, trade openness and economic development on CO_2 emissions. This may be because the inclusion of lag effects at level 2 of C_t, E_t, Y_t, Y_t^2 variables into the equation (5.10) leads to the increase in the number of parameters and the biased least square estimation.

The above findings are supported by Pesaran and Shin (1999) that the ARDL-BIC performance is slightly better in their study. This may indicate that the Schwarz criterion is a consistent model-selection criterion in the ARDL technique (Pesaran & Shin, 1999, p.347). Similarly, Jajil and Mahmud (2009) argued that the BIC is known as a parsimonious model, since it selects the smallest possible lag length and minimises the loss of degrees of freedom. Meanwhile, the AIC[20] is known for selecting maximum lag length (Jajil & Mahmud, 2009), which may lead to excessive lag effects of energy use on CO_2 emissions in equations (5.9) and (5.10).

[20] BIC = ln(SSE/T) + Kln(T)/T; AIC = ln (SSE/T) + 2K/T; (SSE: sum of sample errors; T is sample size; K is number of coefficients). As Kln(T)/T>2K/T (when T>=8) then BIC penalizes additional lags more heavily than the AIC.

5.1.8 Estimation Results of Equation (5.11) - ARDL (1.0.2.0.0)

The equation (5.11) - ARDL specification (1.0.2.0.0) was selected based on the Schwarz criterion, BIC. The long-run and short-run estimation results of equation (5.11) are reported in Table 5.12.

Table 5-12: Long-run and Short-run Estimation Results of Equation (5.11)

Normalised cointegration - Long-run elasticities			Error-correction model - Short-run elasticities		
Dependent variable: C_t			Dependent variable: DC_t		
Regressors	Coefficient	t-Values	Regressors	Coefficient	t-Values
E_t	1.391	4.861***	DE_t	0.918	3.441***
Tr_t	0.191	2.412**	DTr_t	0.150	1.95*
Y_t	1.916	5.210***	DTr_{t-1}	0.209	4.805***
Y_t^2	-0.139	-4.578***	DY_t	1.136	2.81**
Intercept	-15.92	-9.708***	DY_t^2	-0.082	-2.33**
R-squared = 0.996, F-statistic = 888.5***			Intercept	-9.26	-5.12***
DW = 2.23, SSR = 0.034			ECM_{t-1}	-0.581	-5.36***

Notes: *,**,*** represent 10%, 5% and 1% levels of significance, respectively
DW indicates Durbin-Watson statistics; SSR stands for sum squared residuals.

In terms of the long-run elasticity, E_t, Y_t and Y_t^2 are significant at the 1% level, and Tr_t is significant at the 5% level. In the short-run, the error correction term is negative and significant at the 1% level. The adjusted R-square (0.997) and the F-statistic (significant at the 1% level) indicate that equation (5.11) - ARDL specification (1.0.2.0.0) can be used to examine the impact of trade openness on the CO_2 emissions.

The substituted coefficients for equation (5.11) are reported in equations (5.12), (5.13), and (5.14). Equation (5.12) presents the long-run relationship between CO_2 emissions and energy use, trade openness and real per capita GDP in the ARDL framework. Equation (5.13), which is a different form of equation (5.12), incorporates the information on the long-run and short-run into the same model. Equation (5.14) presents the estimated ECM model.

- Substituted-coefficient ARDL Model

$$C_t = 0.39\ C_{t-1} + 0.836 * E_t + 0.149 * Tr_t + 0.177 * Tr_{t-1} – 0.2117 * Tr_{t-2} + 1.151 * Y_t – 0.084 * Y_t^2 – 9.575 \quad (5.12)$$

- Cointegration Equation:

$$DC_t = 0.918*DE_t + 0.150*DTr_t + 0.209*DTr_{t-1} + 1.136*DY_t - 0.082*DY_t^2 – 9.261*(C_t – (1.391*E_{t-1} + 0.191*Tr_{t-1} + 1.916*Y_{t-1} - 0.139*Y_{t-1}^2) - 0.581*CointEq_{(-1)}) \quad (5.13)$$

- The Error Correction Model

$$ECM = C_t – (1.391*E_t + 0.191Tr_t + 1.916Y_t – 0.139Y_t^2) \quad (5.14)$$

The empirical model estimation results of equations (5.11), (5.12), (5.13) and (5.14) on the impact of economic development, trade openness, and energy use on CO_2 emissions in the short-run and long-run elasticities are described below.

(i) Impact of Per Capita Income on CO_2 Emissions

Y_t and DY_t are significant at the 1% and 5% levels, respectively (see Table 5.12), which indicates that per capita income has a long-run and short-run negative impact on CO_2 emissions. This reflects that economic development is accompanied by the increasing of CO_2 emissions. Alternatively, the economic development generates adverse long-term and short-term effects on the environment (measured by CO_2 emissions). The long-run elasticity of CO_2 emissions with reference to economic growth is 1.916, which implies that a 1% increase in per capita income is associated with a 1.916% increase in CO_2 emissions. The short-run elasticity of economic growth on CO_2 emissions is 1.136, which means a 1% increase in per capita income leads to a 1.136% increase in CO_2 emissions.

The accumulative characteristic of pollutants is one of possible explanations for the greater impact of economic development on CO_2 emissions in the long-run elasticity than that in the short-run elasticity. The environmental quality will be worsened if the pollutants from production activities cannot be treated efficiently. Another reason could be the poor technology available to treat the production pollutants in Vietnam. Consequently, over time larger CO_2 emissions are accumulated in the environment. Tang and Tan (2015) explained that it is hard or almost impossible for Vietnam to immediately learn and adopt the advanced environmentally friendly technology or new production techniques that Vietnam benefits from in terms of technology transfer from her trading partners.

In the long-run equilibrium (see Table 5.12), Y_t and Y_t^2 are significant at the 1% level. Besides, Y_t has a positive sign, and Y_t^2 has a negative sign which shows that the per capita income affects CO_2 emissions in an inverted U-curve function. This finding supports the EKC hypothesis that pollution emissions initially increase with income then decrease after the income reaches a certain level (Jalil & Mahmud, 2009; Saboori et al., 2012; Baek & Kim, 2013; Ren et al., 2014; Tan et al., 2014). More precisely, a 1% increase in real per capita GDP increases CO_2 emissions by 1.916% over the long-run and 1.140% over the short-run. On the other hand, a 1% increase in real per capita GDP square decreases CO_2 emissions by 0.139% over the long-run and 0.083% over the short-run, both of which are significant at the 5% level. We further calculated that the relationship between CO_2 emissions and per capita GPD which could be reversed from negative to positive when per capital GDP 982.401 (US$)[21]. This value is approximately equal to per capital GDP of Vietnam in 2009 and 2010. However,

[21] The turning point is calculated based on the estimation results of Table 5.12:
We have: $C_t = -15.92 + 1.391E_t + 0.191Tr_t + 1.916Y_t – 0.139Y_t^2$

the CO_2 emissions in Vietnam still increased from 1985 to 2012 (see Figure 2.1). One of the possible ways to understand the low value of the turning point in Vietnam could be the growing public concern and research knowledge about environmental protection. Vietnam's economy may continue to develop from low levels of per capita income with little degradation in environmental quality (measured by CO_2 emissions) (Taguchi, 2012). Another possible explanation for the value of the turning point could be that the CO_2 emissions cannot fully capture the impact of the economic development on the environment. Therefore, future studies need to consider other environmental pollutants as a proxy for environment degradation, such as SO_2, BOD and ecosystem services.

Our finding is similar to Tang and Tan's (2015) finding. Using Foreign Direct Investment as one of the main determinants of CO_2 emissions, Tang and Tan also found the existence of an inverted U-curved relationship between CO_2 emissions and economic growth in Vietnam. With 33 annual observations, from 1976 to 2009, Tang and Tan (2015) found that the long-run impact of CO_2 emissions as a result of economic growth is 15.851 - 0.918 lnGDP[22].

On the contrary, when employing time series data from 1980-2010 for Vietnam which are retrieved from the World Bank data and the UNCTAD statistics database, Linh and Lin (2014) found that Y_t is positive and Y_t^2 is negative, however both Y_t and Y_t^2 are statistically insignificant, thus their results did not support the EKC theory in Vietnam.

Al-Mulali et al. (2015) also rejected the existence of EKC theory in Vietnam when the authors assessed the impact of energy use, GDP, capita and labour force, export and import on CO_2 emissions. Al-Mulali et al's (2015) study examined the EKC theory by comparing the short-run and long-run coefficients of GDP impact on CO_2 emissions. They claimed that following Narayan and Narayan's (2010) approach if the long-run income elasticity is smaller than the short-run income elasticity then over time income leads to less CO_2 emissions. However, in our opinion the linear function in Al-Mulali et al.'s study, which is examined by our study in equations (5.7) and (5.8), is inadequate to model the relationship between economic development and environmental pollution.

(ii) Impact of Energy Consumption on CO_2 Emissions

In terms of the impact of energy consumption on CO_2 emissions, the results from Table 5.12 show that E_t (1.391) and DE_t (0.918) are statistically significant at the 1% level. This implies that per capita energy consumption has a significant long-run and short-run impacts on CO_2 emissions. The positive signs of E_t and DE_t indicate a negative impact of energy consumption on CO_2 emissions, as

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Take the first difference of dC_t/dY_t, *we get:* dC_t/dY_t=1.916-0.278Y_t
When 1.916-0.278Yt = 0 then ln(Yt)= 6.89; Yt = $e^{6.89}$ = 982.401

[22] Tang and Tan (2015) found that the long-run elasticity of GDP on CO_2 emissions is 15.851 and the long-run elasticity of the square of GDP on CO_2 emissions is -0.459. We take the first difference to calculate the long-run impact of economic growth on CO_2 emissions is 15.851 - 0.918 lnGDP.

hypothesized, which implies that the more energy that is used the higher the CO_2 emissions. Specifically, a 1% increase in per capita energy use leads to an increase of 1.391% in CO_2 emissions in the long-run and 0.918% in CO_2 emissions in the short-run (see Table 5.12). The highly significant long-run and short-run relationships between energy consumption and CO_2 emissions strongly suggest the inefficiency of CO_2 treatment of energy use in Vietnam.

Similarly, Linh and Lin (2014) also found that CO_2 emissions are elastic with energy consumption in Vietnam. More specifically, a 1% increase in energy use leads to a 1.954% increase in CO_2 emissions. Linh and Lin further found bidirectional causalities between CO_2 emissions, energy use with income, which indicates the economic development in Vietnam has been coupled with the increase in energy consumption. Tang and Tan (2015) found the long-run elasticity of CO_2 emissions with reference to energy consumption is 1.745, meaning a 1% increase in energy use leads to a 1.745% increase in CO_2 emissions. In the short-run their result suggests that a 1% increase in energy use leads to a 3.614% increase in CO_2 emissions. The magnitude of the impact of energy on CO_2 emissions from Tang and Tan's findings is almost double that of our findings. This might be because their study was conducted for a longer period from 1976 to 2009. Besides, the combination of different data sourced from the World Bank and the CEIC database in Tang and Tan's study (2015) may also lead to different results.

Using a monotonic linear function to describe the relationship between CO_2 emissions and real national income, Anwar and Alexander (2016) also found that energy consumption has a negative and significant effect on pollution in Vietnam. The magnitude of impact is 0.747 in the short-run and 0.804 in the long-run, which indicates that a 1% increase in energy use leads to an increase of 0.747% in the short-run and 0.804% in the long-run of CO_2 emissions.

(iii) Impact of Trade Openness on CO_2 Emissions

Regarding the impact of trade openness on CO_2 emissions, the estimation results (see Table 5.12) show that Tr_t (0.191) is significant at the 5% level, DTr_t (0.15) is insignificant at the 5% level but significant at the 10% level. This reflects a significant impact of trade openness on the CO_2 emissions in the long-run and short-run elasticities. The positive signs of Tr_t and DTr_t coefficients (see Table 5.12) indicate a negative impact of trade openness on CO_2 emissions which means the higher the level of trade openness the stronger the negative impact on the environment (measured by CO_2 emissions). However, the magnitude of the trade openness impact on CO_2 emissions is quite small (marginally). In the short-run, a 1% increase in trade openness leads to a 0.15% increase in CO_2 emissions, in the long-run a 1% increase in trade openness leads to a 0.196% increase in CO_2 emissions (see Table 5.12).

In terms of the lag effects, the lag one of Tr_t (or Tr_{t-1}) and lag two of Tr_t (or Tr_{t-2}) are significant at the 5% level (see Table 5.12). This implies a statistically significant impact of trade openness on the CO_2

emissions in a period of 2 lags. Or, the impact of trade openness on the CO_2 emissions does not occur instantaneously but is distributed over two future time periods. The long-run impact of trade openness on CO_2 emissions is further broken down into lag effects in Table 5.13.

Table 5-13: Estimated Results of Equation (5.11) - ARDL Model (1.0.2.0.0)

C_{t-1}	E_t	Tr_t	Tr_{t-1}	Tr_{t-2}	Y_t	Y_t^2	Є
0.399 *(0.001)*	0.836 *(0.005)*	0.149 *(0.03)*	0.177 *(0.005)*	-0.211 *(0.000)*	1.151 *(0.000)*	-0.08 *(0.000)*	-9.575 *(0.000)*

Notes: () the number in the parenthesis is the reported p-value;
C_t - natural logarithm of CO_2 emissions; C_{t-1} - one lag of C_t; E_t - natural logarithm of Energy use per capita; Tr_t - Natural logarithm of trade openness ratio; Tr_{t-1} - one lag of Tr_t; Tr_{t-2} - two lags of Tr_t; Y_t - natural logarithm of per capita income; Y_t^2 - square of Y_t;
Є is the error term.

More specifically, in terms of the lag effect, a 1% increase in trade openness leads to a 0.149% increase in CO_2 emissions in the same year, a 0.209% increase in CO_2 emissions one year later, and a 0.212% decrease in CO_2 emissions two years later. The coefficient of the lag two of trade openness has a negative sign (-0.212) and is significant at the 1% level indicating that the impact of trade openness on CO_2 emissions is estimated to be reversed from negative to positive after a two year period.

In a different specification of trade openness using FDI (that could be seen as another proxy of trade openness), Tang and Tan (2015) however found a negative elasticity of FDI on CO_2 emissions, even though the magnitude of impact is very small (-0.065%). Besides, they failed to find any significant evidence of the impact of FDI on CO_2 in the short-run. Similarly, Linh and Lin (2014) also found a negative and insignificant value of the FDI coefficient (-0.008%) which implies there is no evidence to show FDI is elastic in reducing CO_2 emissions.

To the best of our knowledge, the only published study for the same topic which employed trade openness ratio as a proxy of trade liberalisation in Vietnam is conducted by Anwar and Alexander (2016). They also found a long-run impact of trade openness on CO_2 emissions at a rate of 0.374%. Thus a 1% increase in trade openness leads to a 0.374% increase in CO_2 emissions in the long-run. However, Anwar and Alexander applied a monotonic function to describe the relationship between CO_2 emissions and real national income. The monotonic function based models are excluded from our study (equations (5.7) and (5.8)) due to the insignificance of energy impact on the CO_2 emissions.

(iv) Adjustment Speed from a Shock to Long-run Equilibrium

In terms of the ECM model (see Table 5.12), the estimated result of the ARDL model in Table 5.12 reports the coefficient of ECM, -0.581, is negative and significant at the 5% level, which suggests that a deviation from the long run equilibrium level of CO_2 emissions in one year is corrected by 58.1%

over the following year. The high value of R-square for the ECM-ARDL model shows that the adjustment of the ARDL model is extremely good.

Our finding on speed adjustment to a long-run equilibrium is consistent with Tang and Tan (2015). They found the speed of convergence is considered fast as their results showed the coefficient of ECM is -0.641. This is explained by Tang and Tan that if the system is exposed to a shock, it takes about one and a half years to return to the long-run equilibrium. The finding of Anwar and Alexander (2016) is far higher than our finding, which shows that at a 1% level of confidence the pollution in Vietnam can return to its equilibrium at the ratio of 0.923. This means the pollution in Vietnam responds quickly to any shocks and about 92.3% of the adjustment can be made within a year.

5.1.9 Granger Causality Test

The presence of cointegration reveals the existence of causality only (Tang, 2011). However, the direction of the impact has not been established. Therefore, we proceed to examine whether CO_2 emissions have an impact on trade openness and per capita income or vice versa. In order to test the direction of the relationship, we employed the Granger causality test. F-statistic and probability of the Granger causality test (see Table 5.14) are constructed under the null hypothesis of no causality.

If p > 0.05 (or 5%) then we cannot reject the Null hypothesis that means there is no Granger causality between variables. If p<0.05 then we can reject the Null, indicating there is Granger causality between variables. The results of the Granger causality test are presented in Table 5.14.

Table 5-14: Pair Wise Granger Causality Test

Null hypothesis	F-statistic	Prob.
Tr_t does not Granger cause C_t	10.034	0.0008
C_t does not Granger cause Tr_t	5.718	0.01
Y_t does not Granger cause C_t	4.55	0.04
C_t does not Granger cause Y_t	7.014	0.01

Notes: - Ho: There is no Granger causality
- H1: There is Granger causality

In terms of the relationship between trade openness and CO_2 emissions, under the Null hypothesis "Tr_t does not Granger cause C_t", the reported F-statistic is 10.034 and the corresponding probability is 0.0008 and that means the Null hypothesis can be rejected. Similarly, the Null hypothesis for the adverse trend, which is "C_t does not Granger cause Tr_t", can also be rejected (F-statistic: 5.718; prob.: 0.01). Consequently, there is existence of bi-direction between trade openness and CO_2 emissions in Vietnam under the 29 year period of our study.

In terms of the relationship between per capita income and CO_2 emissions, F-statistic (4.55) and probability (0.04) are calculated for the Null hypothesis "Y_t does not Granger cause C_t". This indicates that the Null hypothesis can be rejected. Similarly, the same decision can be made for the Null hypothesis "C_t does not Granger cause Y_t". The F-statistic and the corresponding probability are 7.014 and 0.01, respectively (Table 5.14). Therefore, the impact of per capita income on CO_2 emissions in Vietnam is a bi-directional relationship.

5.1.10 Test of Goodness of Fit for ARDL Specification (1.0.2.0.0) - Equation (5.11)

(i) Test of Serial Correlation of OLS Residuals

Theoretically, time series data are likely to be correlated as the effect of a change in a dependent variable at the present can be spread over the future. Hill et al. (2011) explained that autocorrelation in the error term can happen in many ways. It may come from an auto-correlated omitted variable, which means the error term at time period t, $e_{(t)}$, is auto-correlated to error term at time period t+1, $e_{(t+1)}$, for example. Or it can arise if a dependent variable is auto-correlated and this auto-correlation is not adequately explained by the independent variables and their lags that are included in the equation (Hill et al., 2011, p.347).

There are many ways to test the problem of serial correlation. As our selected equation (5.11) – ARDL specification (1.0.2.0.0) contains a lagged dependent variable hence we cannot apply the Durbin-Watson (DW) test. This is because the DW distribution no longer holds when the equation contains a lagged dependent variable (Hill et al., 2011, p.365). In our case, we strongly believe the selected ARDL model is free from serial correlation. This result is confirmed by the correlogram, Q-statistic, and the Lagranger Multiplier tests as below.

Correlogram Results

To test for serial correlation, the residuals from equation (5.11) are used as the dependent variable. Table 5.15 presents the auto-correlation results and partial auto-correlation for the first 12 lags of the residuals. The correlogram can visually aid the decision of free of serially correlation (see Figure 5.2). If the spikes of the auto-correlation coefficients in Figure (5.2) are well within the two border lines, $+1.96/\sqrt{T}$ and $-1.96/\sqrt{T}$, in which T is sample size then the model is free of auto-correlation.

Table 5-15: Autocorrelation and Partial Auto-correlation of the Residuals

Lags	1	2	3	4	5	6	7	8	9	10	11	12
AC	-0.14	-0.03	-0.302	-0.043	0.096	0.052	-0.034	-0.217	-0.14	0.06	0.115	0.97
PAC	-0.14	-0.05	-0.321	-0.16	0.023	-0.044	-0.096	-0.243	-0.28	-0.15	-0.14	-0.14

Note: AC - Auto correlation
PAC - Partial Auto-correlation.

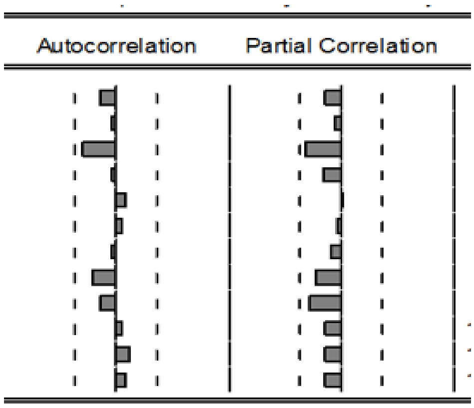


Figure 5-2: Correlogram of the Residuals

It can be seen from Table 5.15 that the values of the auto-correlation coefficients of AC and PAC for the first 12 lags of the residuals from equation (5.11) are very close to zero or almost zero, hence we can say there is likely no auto-correlation in the residuals of equation (5.11). In terms of the correlogram (see Figure 5.2), with a sample size of 29, it is also visible that the spikes of the auto-correlation value are very well within the line of $\pm 1.96/\sqrt{29}$; consequently there is no auto-correlation in the equation (5.11) – ARDL (1.0.2.0.0).

Q-statistic Test

The Q-statistic can be automatically calculated by E-views that provides us with another test to test the autocorrelation in residuals. The null hypothesis of the Q-test implies that there is no serial correlation in the residuals of the corresponding P-value for the Q-statistics are larger than 0.05, or the Q-statistics are not significant at the 5% level. The results of the Q-statistic tests are presented in Table 5.16.

Table 5-16: Q-statistic Testing

Lags	1	2	3	4	5	6	7	8	9	10	11	12
Q-statistic	0.587	0.616	3.593	3.657	3.986	4.087	4.132	6.076	6.923	7.121	7.765	8.26
Prob.	0.443	0.735	0.309	0.454	0.551	0.665	0.764	0.63	0.645	0.71	0.73	0.76

The Q-statistic values were calculated for the first 12 lags of the residuals of equation (5.11). It can be seen that the corresponding probabilities which were calculated for Q-statistics are larger than 0.05. This means at a 5% level of significance, the Q-statistic is not significant, thus we cannot reject the null hypothesis. Thus there is no serial correlation in our model residuals.

Lagrange Multiplier Test

The Lagrange Multiplier (LM) test is a joint test of correlations with more than one lag. The LM test can be used to test for more complicated auto-correlation structures involving higher order lags (Hill et al., 2011). The LM test was conducted to test the joint significance of least square estimated residuals and the lagged residuals from the selected model. The lag order of 2 has been chosen for the LM test based on the maximum lag of equation (5.11) - ARDL (1.0.2.0.0). The LM test result is shown in Table 5.17.

Table 5-17: Lagranger Multiplier Test

F-statistic	0.4017	Prob. F(2,17)	0.6754
Obs R-squared	1.218	Prob. Chi-Square	0.5438

Note: Ho: there is no serial correlation in the residuals up to lag 2.

Table 5.17 shows the F-statistic is not significant as the P-value is larger than 0.05 and we cannot reject the null hypothesis of no serial correlation. This implies no serial correlation in our model residuals up to lag 2.

(ii) Test for Heteroscedasticity

To check for heteroscedasticity, we look at the plot of the estimated least square residuals from equation (5.11) - ARDL (1.0.2.0.0). There is no pattern of any sort in the residuals of our estimated equation (5.11) indicating the homoscedasticity of the residuals (see Figure 5.3). If the errors are heteroscedastic, they then exhibit greater variation in some systematic ways (Hill et al., 2011, p.303).

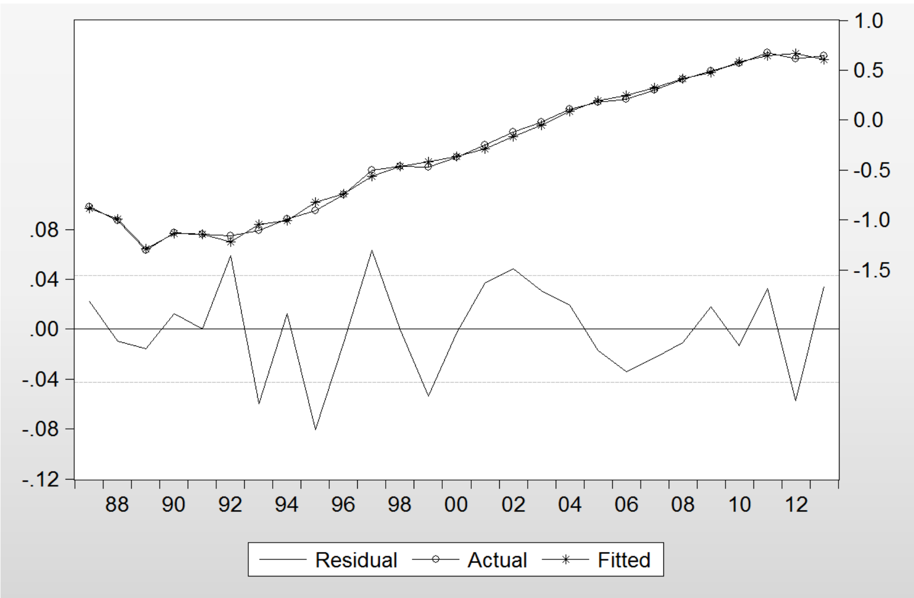


Figure 5-3: Plot of Estimated Model Residual

The plot of the residual is usually used in a simple regression model[23]. Therefore, we further checked for the existence of heteroscedasticity using the Breusch-pagan-Godfrey test. The Breusch-Pagan-

[23]The homoscedasticity of equation (5.11) is checked by 2 methods, including the plot of the estimated least square residuals and the Breusch-Pagan-Godfrey Heteroscedasticity test. The Breusch-Pagan-Godfrey Heteroscedasticity test was performed to take into account the dynamic effect because the residual plot is usually used for simple regression models such as linear and static models.

Godfrey test regresses the squared residuals, which are obtained from equation (5.11), on the independent variables [C_{t-1}, E_t, Tr_t, Tr_{t-1}, Tr_{t-2}, Y_t, Y_t^2] and the intercept. The result of the test is presented in Table 5.18.

Table 5-18: Breusch-Pagan-Godfrey Heteroscedasticity Test

F-statistic	0.619	Prob.F(7.19)	0.7334
Obs. R-squared	0.5018	Prob. Chi-Square(7)	0.6577
Scaled explained SS	1.9490	Prob. Chi-Square(7)	0.9626

Note: Ho: There is no heteroscedasticity

The Breusch-pagan-Godfrey test shows the p-value of the F-statistic test is insignificant so we do not reject the null of homoscedasticity. Consequently, our model is free from heteroscedasticity.

(iii) Histogram and Jarque-Beta Test of Residuals

We performed the Jarque-Bera test to check for the normality of the residuals of equation (5.11) - ARDL (1.0.2.0.0). The null hypothesis of the Jarque-Bera test hypothesises there is normal distribution against the alternative hypothesis of non-normality. The result of the Test is shown in Figure 5.4.

The Jarque-Bera is 0.67 and the corresponding p-value 0.71 which is larger than 0.05, thus the Jarque-Bera statistic is not significant, and we cannot reject the null. Hence, we can conclude that the residuals of our model are normally distributed.

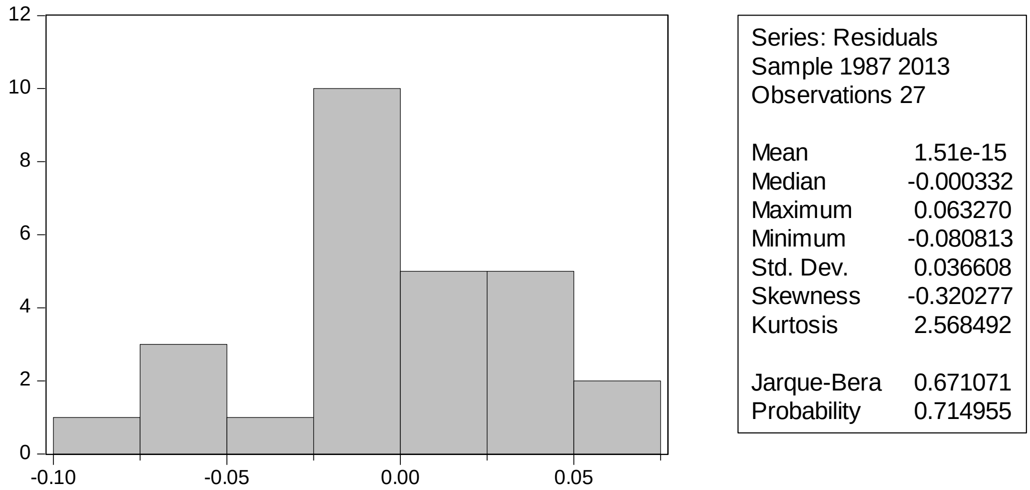


Figure 5-4: Histogram and Result of the Jarque-Bera Test for Normality

(iv) Stability Test of the Regression Model

Finally, we performed the test on the stability of the short-run movement and the long-run equilibrium for the selected equation (5.11) - ARDL (1.0.2.0.0). The stability is tested by using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests. The results are presented in Figure 5.5, in which the straight lines represent critical bounds at the 5% level of significance.

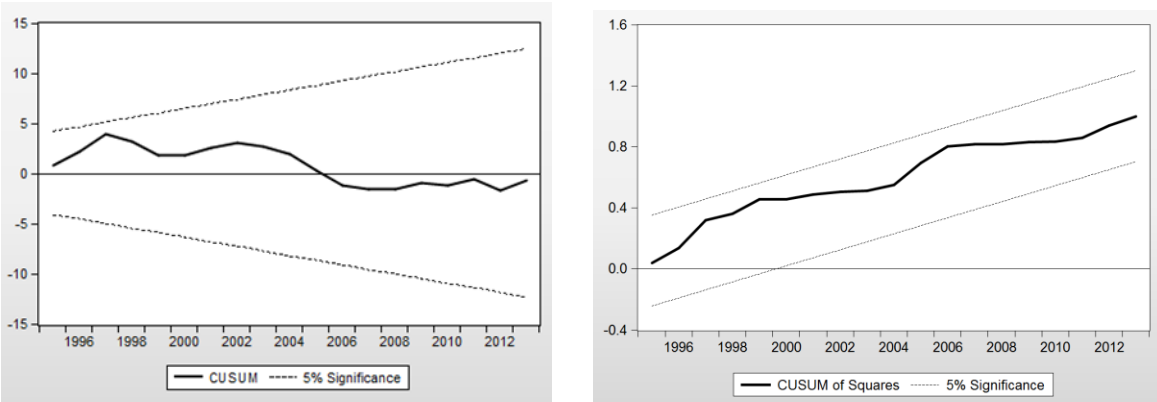


Figure 5-5: Plot of the Cumulative Sum of Recursive Residuals and Square Recursive Residuals

Notes: CUSUM - Cumulative sum of recursive residuals
CUSUM of Squares - Cumulative sum of square recursive residual

The plots of CUSUM and CUSUMSQ statistics from the ECM model are well within the 5% significance level lines. This means the cumulative sum of residuals is larger than negative 5% (-0.05) and smaller than positive 5% (+0.05). Visually, the curve that describes the cumulative sum of residuals is within the lines of +/-5% level. This indicates the stability of the model and the equation (5.11) - ARDL specification (1.0.2.0.0) can be used to model the effect of trade openness on CO_2 emissions in Vietnam.

5.2 EIA Analysis on the CPTPP - Some Policy Implications

The results of empirical model estimation (Section 5.1) show a significant negative long-run relationship between economic development, trade openness and energy use on CO_2 emissions in Vietnam. Trade liberalisation statistically has a negative impact on CO_2 emissions. A 1% increase in trade openness leads to an increase in CO_2 emissions of 0.191% in the long-run and 0.15% in the short-run. The empirical model estimation results also show a possibility to rehabilitate the environment along with the economic development. However, the results of the empirical model do not enable our study to answer the questions of what are the regulatory effects and in which way a free trade policy affects Vietnam's environment.

In this section, we examine the regulatory effect of the CPTPP on Vietnam's environment. In particular, this work helps to explore whether the incorporating of enforceable environmental requirements into the CPTPP benefits Vietnam's environment.

5.2.1 Vietnam's Export Pattern to CPTPP Member Countries

(i) Vietnam's Main Export Partners

Among the eleven member countries of the CPTPP, Vietnam's main export partners are Japan, Singapore, Australia and Malaysia. In particular, Japan is the predominant exporting destination of Vietnam; the export partner share from Vietnam to Japan was 18% in 2000 and relatively stable at 10% during the last 5 years, from 2010 to 2015. The export partner share from Vietnam to Australia accounted for roughly 9.26% of Vietnam's total exports in 2006, then decreased thereafter.

Other CPTPP member countries, namely: Brunei, Canada, Chile, Mexico, New Zealand and Peru are not the main export partners of Vietnam. The export partner share from Vietnam to each of these countries individually ranged between 0% and 1% from 2000 to 2015.

Overall, during the period from 2000 to 2013, the total export partner share of CPTPP member countries from Vietnam has steadily reduced (see Figure 5.6). The number peaked at 36.62% in 2000, followed by a relatively stable period, before falling to around 24% in 2009. The total export partner share from Vietnam to CPTPP member countries was around 20% from 2013 to 2015 (see Table 5.19). The main export products from Vietnam to CPTPP member countries include textiles, footwear, fuel, minerals, etc.

Table 5-19: Sum of Export Partner Share (%) from Vietnam to CPTPP Partners from 2000 to 2015

Partners	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	8.79	6.93	7.95	7.05	7.12	8.39	9.26	7.83	6.94	4.18	3.74	2.69	2.8	2.64	2.65	1.79
Brunei	0.01	0.01	0.01	0.0	0.0	0.0	0.01	0.0	0.01	0.01	0.02	0.02	0.01	0.01	0.03	0.02
Canada	0.68	0.71	0.83	0.85	1.02	1.1	1.11	1.11	1.05	1.12	1.11	1.0	1.01	1.18	1.38	1.49
Chile	0.07	0.06	0.06	0.05	0.08	0.1	0.12	0.1	0.11	0.19	0.13	0.14	0.15	0.17	0.35	0.4
Japan	17.78	16.7	14.59	14.44	13.37	13.3	13.16	12.54	13.5	11.1	10.7	11. 5	11.4	10.3	9.77	8.7
Malaysia	2.86	2.24	2.08	2.25	2.36	3.17	3.05	3.2	3.24	3.11	2.9	2.86	3.93	3.78	2.61	2.21
Mexico	0.17	0.29	0.36	0.39	0.48	0.59	0.72	0.74	0.7	0.63	0.68	0.61	0.6	0.68	0.69	0.95
New Zealand	0.13	0.12	0.13	0.12	0.18	0.15	0.14	0.14	0.12	0.12	0.17	0.16	0.16	0.21	0.21	0.95
Peru	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.06	0.04	0.05	0.08	0.09	0.08	0.12	0.15
Singapore	6.12	6.94	5.75	5.09	5.61	5.91	4.17	4.6	4.33	3.64	2.94	2.22	2.07	2.04	1.96	2.01
CPTPP **-Total**	**36.6**	**34.0**	**31.77**	**30.25**	**30.24**	**32.8**	**31.8**	**30.3**	**30.1**	**24.1**	**22.4**	**21.2**	**22.2**	**21.0**	**19.8**	**20.7**

Source: The World Bank's WITS, 2016

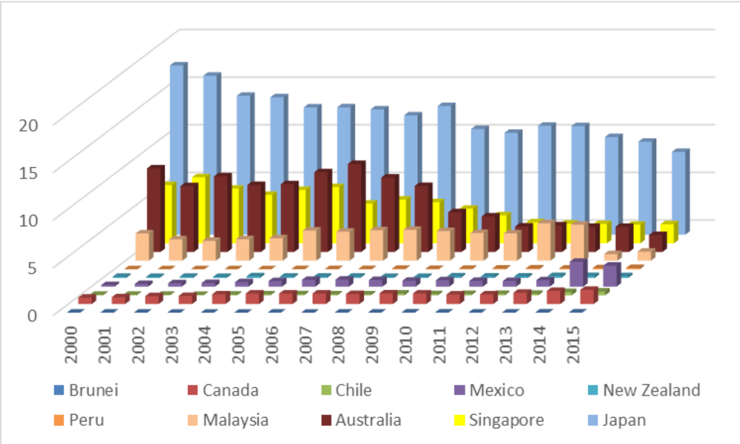


Figure 5-6: Export Partner Shares (%) from Vietnam to CPTPP Member Countries from 2000 to 2015

Source: The World Bank's WITS, 2016

The type of goods currently traded between Vietnam and CPTPP member countries is highlighted in the following section. Based on the current trend of exporting from Vietnam to CPTPP member countries, we subsequently identify the sector that is more likely to increase in trade as a result of the CPTPP. If the tariff of this sector is proposed to be reduced or eliminated by the CPTPP then it would likely result in an increase in production of the sector.

Owing to greater demand in CPTPP member countries for Vietnamese exports, it is anticipated that most of the environmental impacts in Vietnam would be related to the increase in production of the sector in which Vietnam has the comparative advantage. Honma and Yoshida (2011) predicted that the developing countries export more of their dirtier industries as a result of free trade agreements as they found that the composition effect on the environment of trade openness is only consistent with the pollution haven hypothesis on the export side. Further detailed analysis on the main sector in which Vietnam has a strong comparative advantage in exports to the CPTPP member countries is presented in the following section.

(ii) Vietnam's Revealed Advantages Pattern

We calculated the RCA index for the main product groups of Vietnam's exports to CPTPP member countries, namely: textiles, fuel and raw materials to determine the patterns and dynamics of Vietnam's comparative advantages to CPTPP member countries. All the data were retrieved from the World Bank (2016). The product groups were classified according the Harmonised system 1988/1992. The product codes of textiles include 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, and 63.

Figure 5.7 describes the change of RCA indices from 2010 to 2015 for textiles, fuel and raw material products. The RCA-textile line is always above the most comparative base line (see Figure 5.7). This means that the RCA index of textile products is always greater than 4, which is the baseline level indicating the most comparative advantage product. The RCA index of textiles is around 15.5 in 2010 and increases to 18.0 in 2015; meanwhile the RCA indices of fuel and raw materials are higher than 1 but lower than 4. According to the classification suggested by Hinllopen and Van Marrewijk (2001), this indicates that Vietnam has strong comparative advantage in exporting textile products to CPTPP member countries.

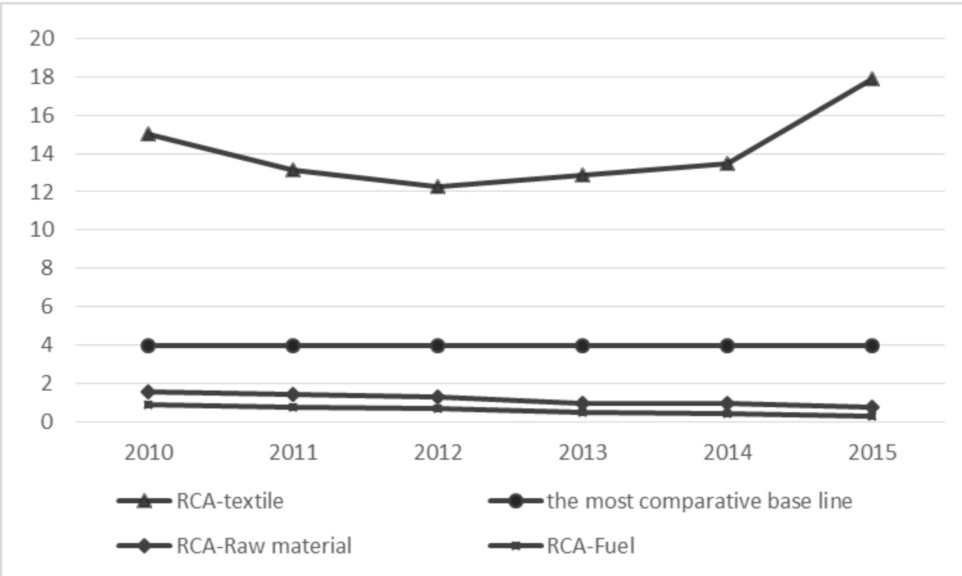


Figure 5-7: Trend in RCA-Textiles of Vietnam to CPTPP Member Countries

The details on the RCA index and export product share of textiles from Vietnam to each CPTPP member countries were collected and described in Table 5.20. Textiles are Vietnam's main export product to Japan, Canada, Chile, Mexico, and Peru. In particular, the textile export product share from Vietnam to Canada accounted for 26.82% on average, followed closely by Japan (18.14%), and Chile (18.25%) from 2000 to 2015. Further, Vietnam's textile products have a high RCA index to each of the CPTPP markets. The average RCA index of textiles from Vietnam to Canada is 7.54, and 3.39 to Japan (see Table 5.20). This indicates that textile exports would be more likely to increase as a result of the CPTPP in Vietnam.

Table 5-20: RCA Index and Export Product Share of Textiles from Vietnam to Each CPTPP Member Countries from 2000 to 2015

Textile		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean	Var.
Japan	RCA	3.98	3.52	3.33	2.97	2.93	2.95	2.84	2.88	2.68	3.05	3.6	3.78	3.47	3.97	4.28	3.95	**3.39**	0.25
	%	26.11	25.86	21.96	17.8	16.52	15.72	13.87	13.49	11.29	16.48	16.79	16.83	16.44	19.23	19.89	22.0	**18.14**	17.43
Malaysia	RCA	2.6	2.96	3.94	3.92	3.4	2.65	3.04	3.24	2.56	2.3	2.86	2.05	1.33	1.74	2.84	2.08	2.72	0.52
	%	6.83	8.78	10.28	8.77	6.92	4.46	5.03	4.59	3.47	3.24	4.0	3.51	1.91	2.08	3.1	3.93	5.06	6.35
Australia	RCA	0.44	0.44	0.42	0.42	0.33	0.32	0.23	0.26	0.31	0.47	0.55	0.73	0.87	0.91	1.0	1.38	0.57	0.10
	%	1.77	2.33	1.99	1.71	1.5	1.23	0.87	0.9	0.92	1.63	2.01	2.61	2.67	3.14	3.92	5.62	2.18	1.55
Canada	RCA	6.19	6.17	6.65	5.51	5.12	6.5	7.53	8.07	9.26	8.65	8.51	9.31	9.06	8.89	8.46	6.69	**7.54**	1.99
	%	27.69	29.51	32.32	22.91	19.3	24.3	23.67	27.18	28.36	29.98	28.88	29.21	28.35	27.0	25.52	24.94	**26.82**	10.43
Singapore	RCA	1.13	0.9	2.03	2.75	1.23	1.01	1.4	0.8	1.48	2.01	3.32	3.97	3.55	14.65	3.58	2.86	2.92	10.93
	%	2.99	2.05	2.38	1.66	1.11	0.81	1.54	1.3	1.18	2.35	1.61	1.85	1.8	1.86	2.07	2.51	1.82	0.33
Mexico	RCA	3.37	3.12	2.47	3.44	3.54	3.82	4.74	6.36	6.91	6.14	5.23	6.02	5.39	4.55	4.18	2.41	4.48	2.00
	%	23.47	21.52	21.24	17.67	16.2	15	15.11	15.25	14.65	15.52	13.75	14.54	12.65	10.29	11.01	7.1	**15.31**	17.90
New Zealand	RCA	NA	1.58	2.08	1.82	1.44	1.88	1.31	1.57	1.89	1.72	1.57	1.92	1.62	1.54	1.81	1.63	1.69	0.04
	%	NA	9.75	12.55	10.41	6.04	7.91	8.45	5.69	6.93	8.43	5.58	7.05	5.61	5.56	6.69	5.79	7.50	4.39
Chile	RCA	2.42	3.84	3.95	1.69	2.41	1.88	2.28	3.6	3.81	2.07	3.3	3.31	4.1	3.04	2.43	1.43	2.85	0.77
	%	20.91	25.05	21.95	11.07	19.82	16.2	19.56	18.5	19.11	10.15	16.49	19.06	18.75	17.98	21.7	15.76	**18.25**	14.37
Peru	RCA	NA	NA	NA	1.87	8.38	4.9	2.62	2.95	NA	3.76	3.72	1.9	2.71	2.57	1.69	1.55	3.22	3.62
	%	NA	NA	NA	8.06	42.88	26.35	13.52	15.95	NA	16.65	16.73	10.52	6.85	9.55	6.24	5.84	**14.93**	112.72
Brunei	RCA	NA	1.32	1.29	2.77	2.95	NA	NA	NA	NA	NA	NA	NA	0.65	0.96	1.33	0.41	1.46	0.86
	%	77.69	54.62	4.46	2.14	23.82	NA	NA	NA	NA	NA	0.41	NA	0.33	1.71	0.97	0.42	16.66	760.0

Notes: RCA: RCA index in export of textiles from Vietnam to CPTPP member countries
- %: The export product share of textiles from Vietnam to CPTPP member countries
- NA: Data are not available
- Mean: The average value
- Var.: Variance

Source: The World Bank's WITS, 2016

We further analysed the changes in the RCA index of textiles by calculating the regional orientation index of textiles from Vietnam to CPTPP member countries. The regional orientation indices of textiles from Vietnam to CPTPP member countries were calculated for a period of 5 years, from 2011 to 2015 (see Figure 5.8).

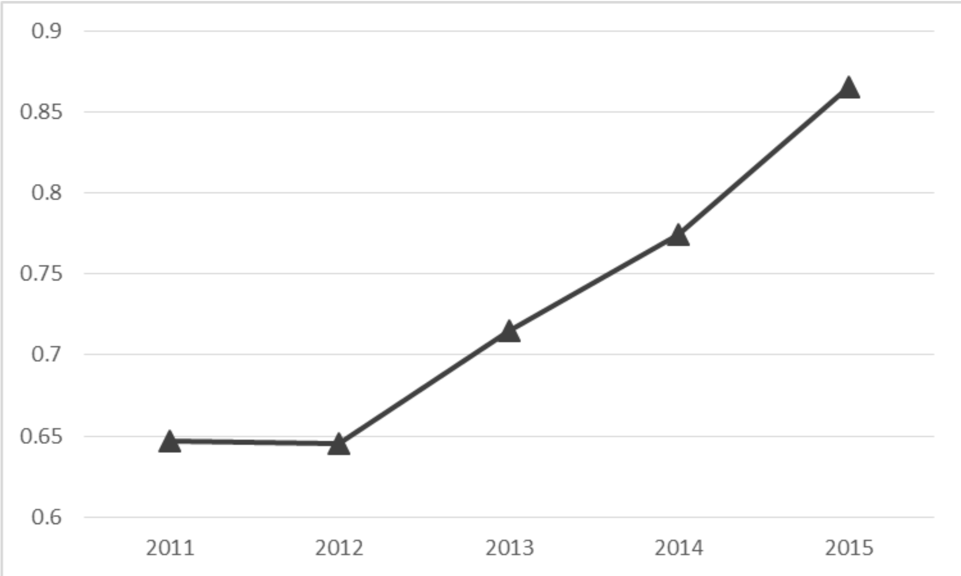


Figure 5-8: Regional Orientation Index of Textiles from Vietnam to CPTPP Member Countries

Figure 5.8 shows an upward trend of the regional orientation index of textiles, indicating that Vietnam's textile export is being oriented to the CPTPP markets. Therefore, the textile and apparel sector[24] was selected for further analysis to examine the impact of the CPTPP on Vietnam's environment.

More specifically, there are three main reasons that textiles were chosen for further analysis: (i) Textiles are one of the most comparative advantage export sectors from Vietnam to CPTPP member countries (see Figure 5.7 and 5.8); (ii) Availability of data and information on the development of the textile sector in Vietnam as well as the accessibility of domestic regulations related to textile production in Vietnam. Besides, the CPTPP has a separate chapter regulating specifically on textiles that provides us with more specific information on the sector's tariff elimination; (iii) According to the sectoral approach, a case study on the textile sector enables us to better understand the changes in the sector as a result of the CPTPP (Fauchald & Vennemo, 2011).

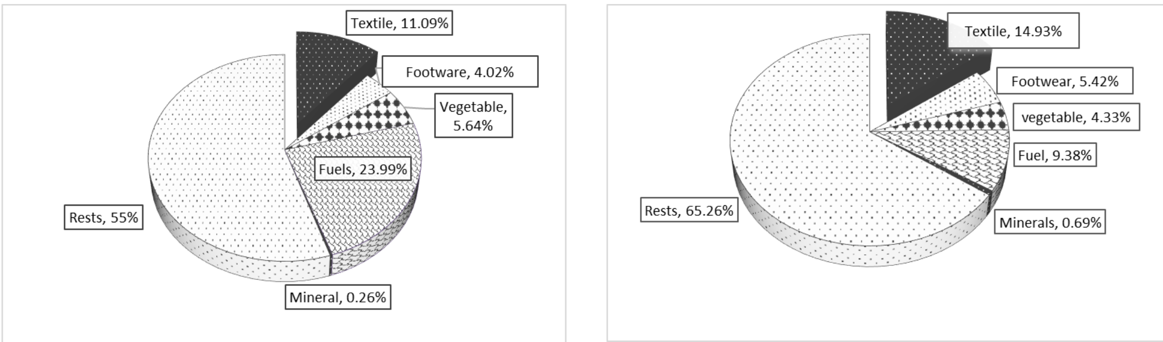
[24] Textiles and apparel include clothes, fabrics and yarns; the textile industry collectively refers to the production of clothes, fabrics and yarns.

5.2.2 Vietnam's Textile Production

(i) Textile Export Competitiveness

In terms of the RCA index, the RCA indices of textile exports from Vietnam to each CPTPP member countries are relatively high (see Table 5.20). For example, the RCA index of textile exports from Vietnam to Japan is 2.95 in 2005 and 3.97 in 2015, the textile export product share from Vietnam to Japan is 15.72% and 19.23% in 2005 and 2013, respectively. The RCA index of textile exports from Vietnam to the CPTPP region is increasing over time and higher than 4 (see Figure 5.7), indicating the strong competitiveness of textile exports from Vietnam to the CPTPP region (Hinloopen & van Marrewijk, 2001).

With regard to export product share, textiles are the most predominant export product from Vietnam to the CPTPP markets. The export product share of textiles from Vietnam to all CPTPP member countries increased gradually from 2010 to 2015, which accounts for 11.09% and 14.9% of total exports in 2010 and 2015, respectively (see Figure 5.9). This again indicates textiles as one of the main and important export sectors from Vietnam to CPTPP member countries.



(a) 2010 **(b) 2015**

Figure 5-9: Percentage in Export of Goods from Vietnam to CPTPP Member Countries in 2010 and 2015

Source: Authors' calculation from the World Bank's WITS, 2016

In terms of export turnover, data on export turnover of textiles from Vietnam to CPTPP member countries and to the world from 2011 to 2015 are presented in Table 5.21. Textiles are the main and most important export sector, accounting for more than 13% of total export turnover from Vietnam to CPTPP member countries (see Table 5.21, P2). Further, textiles are the largest export product of Vietnam to CPTPP member countries, with 14.37 billion US dollars in 2014 (represents 13.62% of total export turnover of Vietnam to CPTPP member countries), and 15.91 billion US dollars in 2015 which accounts for 14.93% of total export turnover (WITS, 2016).

The growth rate in textile exports from Vietnam to CPTPP member countries on average is 13.46% per year from 2011 to 2015. Japan is the biggest trading partner among CPTPP member countries in importing textile and apparel goods from Vietnam, accounting for 2.9 billion US dollars and 3.1 billion US dollars in 2014 and 2015, respectively (see Table 5.21).

Further CPTPP member countries are Vietnam's main textile export customers. On average, CPTPP member countries account for 16% of Vietnam's textile exports compared to Vietnam's textile exports to the rest of the world (see Table 5.21, P1). The high textile export product share reflects the existing dominance of textile exports from Vietnam to CPTPP member countries.

Table 5-21: Export Turnover of Textiles and Apparel of Vietnam (2011-2015)

(US$ Million)

Partner	2011	2012	2013	2014	2015	Growth rate (*)
Australia	67.981	85.651	109.402	156.532	163.169	25.26%
Brunei	0.048	0.055	0.299	0.482	0.107	109.71%
Canada	283.134	327.844	420.535	530.248	600.550	20.58%
Chile	26.218	31.625	39.490	112.989	102.382	55.56%
Japan	1866.973	2148.032	2604.585	2919.056	3102.050	13.66%
Mexico	85.750	86.351	91.747	114.075	109.715	6.87%
Malaysia	97.352	86.076	103.531	121.538	140.543	10.43%
New Zealand	10.671	10.319	15.231	21.118	18.823	18.02%
Peru	8.024	6.888	10.485	11.653	13.905	17.13%
Singapore	39.733	42.727	50.026	61.008	81.764	20.15%
CPTPP - Total	9616.238	10656.427	12516.304	14372.322	15913.614	13.46%
World	16760.021	18150.522	21535.484	25241.129	27270.078	
P1	14.83%	15.57%	16.00%	16.04%	15.89%	
P2	12.09%	11.10%	12.4%	13.62%	14.93%	

Source: Author's calculation from the World Bank's WITS, 2016

Notes: P1 is the percentage of textile exports from VN to CPTPP compared to the world
P2 is the percentage of textile exports compared to the total exports from VN to CPTPP
(*): Growth rate is calculated in average for each country from 2011 to 2015

(ii) CPTPP's Tariff Elimination on Textile Goods

The existing MFN on Vietnam textiles from CPTPP member countries is relatively high. More specifically, Vietnam has MFN of 17% from Canada, 30% from Mexico and 17% from Peru (MOIT, 2016). Japan is Vietnam's biggest textile export market. As a result of the Vietnam-Japan Economic Partnership Agreement - VJEPA signed between Vietnam and Japan in 2009, the existing MFN for Vietnam from Japan on textile and apparel goods is zero percent at minimum and 14 percent at maximum (MOIT, 2016).

With regard to market access, the CPTPP seeks to improve market access for goods based on tariff elimination and the rule of origin.

In terms of the CPTPP's tariff elimination schedule, Table 5.22 shows that 78.7 percent of tariff lines for textile goods are under the staging category "EIF" that shall be eliminated entirely (CPTPP, 2017, appendix 2D). Consequently, 78.7 percent of tariff lines of textile goods will be eliminated to zero percent on the date that the CPTPP is implemented. This means the market for Vietnam textile goods is widely opened from CPTPP member countries.

Table 5-22: CPTPP's Tariff Elimination on Textile Goods

Staging category	EIF	B3	B4	B5	B6	B7	B8	B10	B11	B16
Number tariff lines	9000	22	182	73	140	180	92	806	197	634
Percentage (%)	78.7	0.19	2.46	0.64	1.22	1.6	0.8	7.05	1.72	5.54

Source: Author's calculation from CPTPP, 2015, Appendix 2D.
Notes: EIF: tariff is eliminated when the CPTPP goes into effect; B3: tariff is eliminated after 3 years; B4: tariff is eliminated after 4 years; B5: tariff is eliminated after 5 years; B6: tariff is eliminated after 6 years; B7: tariff is eliminated after 7 years; B8: tariff is eliminated after 8 years; B10: tariff is eliminated after 10 years; B11: tariff is eliminated after 11 years; B16: tariff is eliminated after 16 years.

With regard to the rule of origin, the CPTPP requires at least 90% of materials to produce textile and apparel products must have originated within CPTPP member countries (CPTPP, 2017, chapter 4, p.1). This will help to improve the production of textiles and apparel within CPTPP member countries. Besides, this rule also positively affects Vietnam's environment as developed countries such as Japan, Canada, New Zealand, and Australia, among other CPTPP member countries, already have strict domestic regulations on sustainable production of cotton and man-made fabrics and serious concern about the environmental consequences of production activities.

To sum, Vietnam would gain in textile export as the result of tariff elimination from CPTPP member countries and the application of rules of origins for textiles. This result is in line with two published studies conducted by the World Bank using the CGE model for Vietnam (Lakatos, Maliszewska, Ohnsorge, Petri, & Plummer, 2016). The World Bank's study projected that Vietnam would benefit most in terms of GDP from the CPTPP, followed by Malaysia (10 percent and 8 percent, respectively). The countries would benefit from the CPTPP due to lower tariffs and national treatment measures in large export markets and from stronger positions in regional supply chains through deeper integration (World Bank, 2015b).

Textile is an energy-intensive sector and energy consumption is one of the most critical environmental issues in textile production (Martinez, 2010). In particular, the production of yarn formation, fabric formation and wet processing have been widely proved to be energy-costing in the literature (Adelaar et al., 2005; Chen, 2006; Hasanbeigi & Price, 2012; Ozturk et al., 2015; Resta, Gaiardelli, Pinto, & Dotti, 2016). Therefore, an increase in textile production would bring more pressure on energy consumption and CO_2 emissions.

5.2.3 Discussions on the Regulatory Impact of the CPTPP on Vietnam's Environment

(i) Vietnam's Environmental Requirements in Textile Production

Vietnam has a strict set of domestic regulations that regulate the production activities in general and production of textiles and apparel in particular. The development strategy of Vietnam's textile and apparel industry 2020 vision towards 2030 identified one of the key objectives of the sector as that the development of the sector has to be associated with the environmental protection and greening of the production. The strategy of Vietnam's textile development also takes into consideration the technological innovations for textile production. In addition, the production of textile goods tries to achieve a cleaner production, and effective use of chemical compounds, energy and water supply (GoV, 2016).

Further, the Environmental Protection Law (2014) requires the textile and apparel production firms to conduct an EIA study before commencing operation. To this end, the owners of the textile firms have to identify and forecast impacts of production activities on the environment and propose suitable mitigation measures, depending on the scale and scope of the firm (Nguyen, 2015b). Besides, during the operation process, the textile and apparel firms have to fulfil domestic legal requirements in protecting the environment (GoV, 2014b).

Despite strict regulations on environmental protection during production activities, the implementation of these regulations in Vietnam is usually considered to be weak (MONRE, 2015; 2016). Nguyen et al. (2015a) showed that, although 94% of the textile firms conduct an environmental protection study, the quality of these reports is not good. The textile firms even consider that the environmental protection report is a barrier to their businesses and did not see the benefits of having these documents. The environmental protection reports are only used to apply for an operation permit with the local authorities.

By and large, despite strict requirements on environmental protection, the implementation of these regulations in textile production is still weak. The integration of the environment into Vietnam's textile development strategy is a very important step that reflects the endeavours of Vietnam to protect the environment (GoV, 2016). This also indicates that the government of Vietnam will consider more seriously the environmental impact of any proposal to establish the textile firms, or before making a decision to trade-off between the environment and economic development related to the textile sector (GoV, 2014b). Therefore, it is expected that at the early stage of proactive engagement in free trade agreements, Vietnam has opportunities to proactively address the environmental impact of the textile manufacturing operations.

(ii) CPTPP's Enforceable Regulations on Environmental Protection

The CPTPP promotes the mutual support for the environment and trade policies, promotes high levels of environmental protection and effective enforcement of environmental law. The CPTPP sets out strict requirements to protect the environment during the production. Any non-environmental friendly products are not supposed to be legally traded with tax reduction policy within the CPTPP region.

The CPTPP also ensures that weakening or reducing of environmental regulation to promote trade and investment is not promoted or encouraged (CPTPP, 2017, chapter 20, p. 3). This accordingly benefits Vietnam's environment in terms of regulatory effects. Specifically, Vietnam cannot weaken the environmental requirements to promote the production of any sectors under the CPTPP. For example, it is ineligible for CPTPP's tax reduction in textile and apparel goods if the environmental requirements are weakened in the production process, such as lowering CO_2 emissions requirements in textile production.

The implementation efficiency of environmental requirements in Vietnam would be further strengthened by a cooperation mechanism among CPTPP member countries. According to the CPTPP, CPTPP member countries shall cooperate to address matters of joint or common interest in terms of energy saving and CO_2 emissions reducing, such as energy efficiency and low emissions technologies; clean and renewable energy sources; emissions monitoring, etc. (CPTPP, 2017, chapter 20, p. 13).

The willingness to protect the environment during production processes is reinforced by the CPTPP's regulations on a low carbon and climate change resilience economy. Accordingly, CPTPP member countries have to take measures to control the production and consumption of substances that deplete the ozone layer, including the control of CO_2 emissions (CPTPP, 2017, chapter 20, p.13).

Further, the CPTPP's dispute settlement mechanisms, which include trade sanctions, would improve the efficiency of environmental protection implementation in Vietnam. As discussed above, the Vietnamese government has already promulgated strict requirements to protect the environment during productions, however there is a lack of proper management and enforcement mechanism to ensure that production firms would effectively carry out these requirements. Therefore, the CPTPP's dispute settlement mechanisms are expected to improve the efficiency of environmental protection implementation (CPTPP, 2017, chapter 28, p. 2; CPTPP, 2017, chapter 20, pp. 23-24). Consequently, the adverse impact on Vietnam's environment as a result of the CPTPP can be minimised and controlled.

This finding is supported by Nguyen et al. (2015b) who studied a conceptual framework on the response to environmental requirements by Vietnam's textile and garment industry and found that the Vietnamese government's decisions on environmental management are greatly affected by international trade policy. To this end, trading partners' willingness would influence the textile firms' commitments and motivations to adopt and implement environmental policy.

Likewise, Nguyen et al. (2015c) showed that trade agreements are likely to be the most effective potential legislative tool in improving the efficiency of environmental implementation in Vietnam. In other words, environmental requirements should be formulated on a basis of a commercial reality. Similarly, Nguyen et al. (2014) found that trading partner requirements appear to be the most influential factor on the environmental protection capacity of Vietnam's textile firms.

(iii) Potential Environmental Impacts of the CPTPP in Vietnam

The CPTPP is a free trade agreement that highly considers the protection of the environment, towards achieving sustainable development. The CPTPP's requirements on greener production will lead to the regulatory and technology impacts on the production of textile and apparel in Vietnam. These changes are projected to be more beneficial to the environment as a result of installing advanced production technology and applying CO_2 emissions treatment technology. The government of Vietnam also has to reinforce the implementation of its environmental law in production activities since any arising environmental concerns related to the CPTPP are eligible for the CPTPP's dispute settlement mechanisms (CPTPP, 2017).

The major environmental concerns as a result of the CPTPP in Vietnam's textile sector are related to the broadening of the production scale and the changes in the production structure of weaving and dyeing activities to be eligible for the CPTPP's tax reduction and rule of origin involved with textile goods. Vietnam is expected to invest more in environmental protection measures in textile and apparel production processes such as investment on technology innovation and energy efficiency, and building of treatment plants (GoV, 2016). Vietnamese textile firms can gain long-term benefits from investment in environmental protection measures as Vietnam can internalise the costs of environmental measures into the prices of products. Following confirmation that the productions are environmentally friendly and fulfil other CPTPP's environment requirements, the products are eligible for tax reduction within the CPTPP region.

The CPTPP's dispute settlement mechanisms will be applied for unsuccessful cases and any improper activities to protect the environment during the textile and apparel productions. That would encourage Vietnam to improve the efficiency of implementing environmental regulations. Given the environmental management systems and government measures in place, a potential increase in textile and apparel exports to CPTPP member countries is not expected to have a negative and significant impact on the sustainability of Vietnam's natural resource and environment. This indicates a positive signal for Vietnam's continuing to negotiate FTAs that incorporated environmental provisions into its contents.

5.3 Chapter Summary

The chapter presents the regression model results of the impact of energy consumption, per capita income and trade openness on CO_2 emissions in Vietnam and discusses the possible environmental impact of the CPTPP.

In terms of empirical models, two functional form models were examined to assess the impact. Equations (5.7) and (5.8) capture the impact of explanatory variables (E_t, Tr_t and Y_t) on CO_2 emissions in a log-linear regression model. Equations (5.9), (5.10) and (5.11) describe the relationship among explanatory variables (E_t, Tr_t, Y_t and Y_t^2) on CO_2 emissions in quadratic functions. The ARDL estimation technique was applied to include the dynamic effect of the variables in these equations. The ARDL models were then selected based on the selection criterion such as BIC, AIC and adjusted R-square. Consequently, equation (5.11) - ARDL specification (1.0.2.0.0) was selected to be the best regression model among the variables, based on the smallest value of BIC criterion.

The estimation results of equation (5.11) - ARDL (1.0.2.0.0) show that trade openness has a negative impact on CO_2 emissions and the increase in free trade activities would bring more CO_2 emissions into Vietnam's environment. The impact is statistically significant at the 5% level but in a small scale (0.149%). The lag one of Tr_t (or Tr_{t-1}) and lag two of Tr_t (or Tr_{t-2}) are significant at the 5% level (Table 5.12). This implies a statistically significant impact of trade openness on CO_2 emissions in a period of 2 lags. In other words, the impact of trade openness on the CO_2 emissions does not occur instantaneously but is distributed over two future time periods. More specifically, a 1% increase in trade openness leads to a 0.149% increase in CO_2 emissions in the same year, a 0.177% increase in CO_2 emissions for one year later, and a 0.211% decrease in CO_2 emissions for two years later. The coefficient of the lag two of trade openness has a negative sign (-0.211) and is significant at the 1% level indicating that the impact of trade openness on CO_2 emissions is estimated to be reversed from negative to positive after a two year period.

The positive sign of per capita income and negative sign of squared per capita income indicate that the relationship between per capita income and CO_2 emissions in Vietnam can be expressed in an inverted U-curve that reflects the existence of EKC theory in Vietnam, where the CO_2 emissions increase at the initial stage of economic growth, and decrease thereafter.

The estimation results of the equation (5.11) confirm our view that economic development of Vietnam impacts the environment (measured by CO_2 emissions) negatively. In the long term, a 1% increase in real per capita GDP would result in a 1.915% increase in CO_2 emissions and a 1% increase in energy use would result in a 1.391% increase in CO_2 emissions (see Table 5.12). The EKC theory may help to explain the negative impact of economic development on the environment in Vietnam. This means in order to develop the economy, the country must rely heavily on nature, or trade off the environment with economic benefits.

The result also reflects the need to improve the efficiency of environmental protection measures in production in Vietnam. The result shows a high emissions indicator of CO_2 as a result of energy consumption. Hence, it is likely that the environmental quality in Vietnam can be improved by cleaner technology and improved regulations on protecting the environment during the production processes.

The Vietnam economy exhibits high resilience in responding to a shock, the ECM coefficient (-0.581), which is derived from equation (5.11) - ARDL (1.0.2.0.0) is significant at the 5% level (see Table 5.12), which suggests that a deviation from the long run equilibrium level of CO_2 emissions in one year is corrected by 58.5% the following year.

In terms of the goodness of fit, equation (5.11) - ARDL (1.0.2.0.0) passes the diagnostic tests. Equation (5.11) is free of serial correlation, and heteroscedasticity. Equation (5.11) also passed the stability test and can be used to model the impact of energy use, trade openness and per capita income on CO_2 emissions in Vietnam.

In terms of the regulatory effect of the CPTPP on Vietnam's environment, it is projected that the CPTPP's regulations would impact Vietnam's environment positively. Considering the RCA indices in export from Vietnam to CPTPP member countries, it is found that Vietnam has comparative advantages in the export of textiles. It is more likely that the production pattern of Vietnam's textile sector will change to be eligible for tax reduction benefits that are involved with textile goods under the CPTPP.

However, the potentially negative environmental impacts from the textile and apparel production activities could be offset by mitigation options such as technological innovations and industry best practices; or if the government of Vietnam sets strict regulations to protect the environment during production activities as required by the CPTPP. Consequently, environmental impacts as a result of increased trade in textile and apparel goods are more likely to be controlled by a proper management and enforcement of implementation of legal requirements.

The CPTPP is a free trade agreement that seriously considers the protection of the environment, towards achieving sustainable development. Furthermore, the CPTPP's dispute settlement mechanisms will be applied for unsuccessful cases and any improper activities to protect the environment during the production of textile and apparel products. This would benefit Vietnam in terms of improving the efficiency of implementing environmental regulations as stated in the domestic law. Consequently, environmental impacts as a result of increased trade in textiles and apparel are likely to be minor, and Vietnam has to be strict in the enforcing and implementing of environmental protection requirements during the textile and apparel production.

Chapter 6

Conclusions and Recommendations

This chapter summarises the study. Section 6.1 presents a summary on the significance of the study. Section 6.2 summarises the main findings of the study and suggests policy implications drawn from the findings. Section 6.3 provides the academic and practical implications of the study results. The limitations of the current study are presented in Section 6.4, followed by recommendations for the future studies in Section 6.5.

6.1 Summary of the Study

The literature enhanced our understanding of the link between the environment and trade openness. The link between economic growth and environmental quality was theoretically examined with the EKC theory. The EKC theory postulates that pollution tends to rise during the first stage of a country's development, and decreases after reaching a certain income level (Grossman & Kruger, 1995). International trade is one of the main factors contributing to economic growth and therefore it can be used to explain the EKC theory (Dinda, 2004), because freer trade is expected to increase the per capita income. The increase in per capita income then leads to the demand for environmental protection regulations (Baek et al., 2009; Cole & Elliott, 2003), or for a good environment (Muradian & Martinez-Alier, 2001).

However, few studies have examined the impact of trade openness on Vietnam's environment; in particular, there is a lack of empirical evidence on the possibility of rehabilitating the environment during trade liberalisation in Vietnam. Therefore, our study attempts to investigate the impact of trade openness on the environment (measured by CO_2 emissions) in Vietnam over the last 30 years. Taking into considerations the dynamic and overall effects (scale, composition, and technique effects) of economic development, trade liberalisation and energy consumption on CO_2 emissions in Vietnam, this study also provides evidence and recommendations to reduce CO_2 emissions as a result of economic development in Vietnam. Further, our study examines the regulatory effect of the CPTPP on Vietnam's environment, which has not been discussed previously.

6.2 Summary of the Findings for the Research Objectives

6.2.1 Research Objective One

The first research objective reviews and evaluates the current corpus of theory and practice in trade openness and environment degradation in Vietnam. This objective is achieved by examining the theory of trade liberalisation, and economic development and environmental concerns in Vietnam from 1985 to 2015.

A review of the comparative advantage theory revealed that low labour costs and abundance of natural resources are the main factors that contribute to Vietnam's comparative advantages in trade liberalisation. In addition, Vietnam's favourable geographic condition and the political motivation of Vietnam's government also contribute greatly to the country's rapid trade liberalisation.

With regard to trade liberalisation, Vietnam has actively accelerated its participation into international economic integration during the last 30 years. A variety of free trade agreements with developed countries has been concluded and/or has been being negotiated, such as the CPTPP, the EVFTA, the EVTA, the RCEP, etc. However, our study found that environmental protection has not been integrated into commitments of the FTAs. We further found that the CPTPP is the first free trade agreement Vietnam negotiated, which covers a broad-range of environmental concerns. In particular, the CPTPP's dispute settlement procedures are applied for unresolved environmental issues arising under the CPTPP.

In terms of the domestic requirement to protect the environment, although the concerns on environmental protection have been regulated by the Environmental Protection Law (GoV, 1993, 2005, 2014), there is no legal requirement that regulates the environmental impact assessment for the trade openness policy in Vietnam.

In terms of the main determinants of trade liberalisation on the environment, our study found that the impacts of trade openness on the environment are divided into four main categories: scale, composition, technique, and regulatory effects. The scale effect exists if there is a change in economic activity that leads to a change in the environment through the total level of contaminants, energy use and CO_2 emissions (Stern, 2003). Composition effect refers to the impact on the environment as a result of a change in the structure of production and consumption (Coxhead & Jayasuriya, 2003). The technique effect transpires when there is a change in production methods, which are induced by free trade agreements (Cole & Elliott, 2003). Regulatory effect refers to the policy effects of trade agreements on domestic environmental regulations, standards and other measures that address the changes in trade policy (Faulchald, 2000).

The identified effects can affect the environment negatively or positively. However, the overall complexity of the impact of these effects on the environment is an empirical question to be addressed separately for each of the countries under study. This is because the impact varies depending on the level of economic development, the level of trade openness, and the domestic requirements to protect the environment of each country (Halicioglu, 2009; Kohler, 2013). Of these four effects, the scale, composition and technique effects are examined with the inclusion of trade openness ratio, real per capita GDP and energy use variables in an empirical model. The regulatory effect, on the other hand, is examined separately for each free trade agreement due to the different levels of trade openness of each trade agreement (Antweiler et al., 2001; UNEP, 2000, 2005).

6.2.2 Research Objective Two

The second research objective aims to evaluate the long-run and short-run relationship between CO_2 emissions and per capital income, trade openness ratio, energy consumption over a period of 29 years from 1985 to 2013. In order to achieve the second objective of our study, we examined the impact of trade liberalisation on the environment by applying an empirical model. Our study follows the empirical methods of Halicioglu (2009), Jalil and Mahmud (2009), and Tan et al. (2014) by putting the nexus of output-energy and output-pollution under the same framework.

In our empirical model, the dependent variable is CO_2 emissions (C_t); the explanatory variables are trade openness ratio (Tr_t), real per capita GDP (Y_t), and energy consumption (E_t). The CO_2 emissions variable is employed as a proxy of environmental degradation. Per capita income, energy use and trade intensity variables are used as proxies of scale, technique, and composition effects of economic development on the environment (Grossman & Kruger, 1995; Gale & Mendez, 1998).

The relationship between the explanatory variables and the dependent variable was examined by two functional equation forms, including a log-linear and quadratic function. The ARDL estimation technique was applied to estimate the short-run and long-run impacts of the independent variables on CO_2 emissions. Time series data enabled our study to assess the dynamic impacts of each independent variable and provide a better framework to study a single country case (Ren et al., 2014). The data were obtained from the World Bank for a period of 29 years, from 1985 to 2013.

The research results on the overall impact of trade liberalisation on the CO_2 emissions in Vietnam are summarised below.

Firstly, the research result revealed that trade openness has a negative impact on CO_2 emissions and the increase in free trade activities would bring more emissions of CO_2 into the environment. In the short-run, a 1% increase in trade openness leads to a 0.150% increase in CO_2 emissions; and in the long-run a 1% increase in trade openness leads to a 0.191% increase in CO_2 emissions (see Table 5.12).

Further, our study found that the impact of trade openness on the CO_2 emissions does not occur instantaneously but is distributed over two future time periods. More specifically, in terms of the lag effect, a 1% increase in trade openness leads to a 0.149% increase in CO_2 emissions in the same year, a 0.209% increase in CO_2 emissions one year later, and a 0.2117% decrease in CO_2 emissions two years later. The coefficient of the lag two of trade openness has a negative sign (-0.2117) and is significant at the 1% level indicating that the impact of trade openness on CO_2 emissions is estimated to be reversed from negative to positive after a two year period. The positive effect of trade openness may occur due to the technology transfer from Vietnam's trading partners. Alternatively, trade liberalisation enables Vietnam to equip itself with advanced technology in its domestic productions and reduce CO_2 emissions. Our explanation can, in fact, be supported by some literature that the technological evolution is more likely to happen during the implementation of trade policy (Cole & Elliott, 2003; Tang & Tan, 2015; UNEP, 2005). This indicates a positive signal for Vietnam to continue opening to trade in a sustainable manner by integrating environmental protection requirements into free trade policy.

Vietnam is experiencing a thriving trend in negotiating free trade agreements, thus the country should take the advantages of trade openness to protect the environment. This could be achieved by efficiently adopting several measures, such as the promulgating of stricter requirements on environmental protection during trade and production activities; investing and adopting of environmentally friendly technology applied in the domestic production activities; and improving the implementing efficiency of environmental protection requirements.

Secondly, in the long-run equilibrium (see Table 5.12), Y_t and Y_t^2 are significant at the 1% level. Besides, Y_t has a positive sign, and Y_t^2 has a negative sign which shows that the per capita income affects CO_2 emissions in an inverted U-curved function. This reflects the existence of an EKC theory in Vietnam, where the CO_2 emissions increase at the initial stage of economic growth, and decrease thereafter. The EKC theory may help to explain the negative impact of economic development on the environment in Vietnam. This means at the beginning stage of economic development, the country relies heavily on nature, or trades off the environment for economic benefits.

Y_t and DY_t are significant at 1% and 5% levels, respectively (see Table 5.12), which indicates that per capita income has long-run and short-run negative impacts on CO_2 emissions. This reflects that economic development in Vietnam is accompanied by the increasing of CO_2 emissions. The long-run elasticity of CO_2 emissions with reference to economic growth is 1.916, which implies that a 1% increase in per capita income is associated with a 1.916% increase in CO_2 emissions. The short-run elasticity of economic growth on CO_2 emissions is 1.136, which means a 1% increase in per capita income leads to a 1.136% increase in CO_2 emissions.

While the study shows the applicability of EKC theory in Vietnam, it does not indicate that there exists a simple way to rehabilitate the environment by developing the economy further. Vietnam has comparative advantages in international trade due to its abundant natural resources, low labour cost and favourable geographic conditions; thus Vietnam may develop further the production of natural-intensive sectors as a result of trade openness. In other words, the domestic production pattern of Vietnam may change towards environmentally-intensive sectors. Therefore, in order to efficiently protect the environment, Vietnam needs to invest in energy efficient technology towards a low carbon economy as well as strictly monitor the implementation of environmental protection requirements in its production activities.

Lastly, the per capita energy consumption has a significant long-run and short-run impact on CO_2 emissions. The positive signs of E_t and DE_t indicate a negative impact of energy consumption on CO_2 emissions which implies the more energy that is used the higher the CO_2 emissions. Specifically, a 1% increase in energy use leads to an increase of 1.391% in CO_2 emissions in the long-run and 0.918% in CO_2 emissions in the short-run (see Table 5.12). This indicates the inefficiency of CO_2 treatment of energy consumption in Vietnam and suggests that Vietnam's CO_2 emissions will be reduced as a result of improving energy consumption efficiency. This result is supported by previous studies such as those of Anwar and Alexander (2016); Linh and Lin (2014); Tang and Tan (2015) which documented the inefficiency of energy use in Vietnam.

6.2.3 Research Objective Three

The third research objective explores the possible impact of the CPTPP on Vietnam's environment. In order to achieve this objective, we first analysed the trade indicators of Vietnam including export data and RCA index to determine the export pattern of Vietnam to CPTPP member countries. Next, we applied the EIA method on trade policy to analyse the regulatory effect of the CPTPP on textile production with reference to energy consumption and CO_2 emissions in Vietnam.

Our study found that Vietnam has comparative advantages in textile production and in the exporting of textile products to CPTPP member countries. More specifically, from 2010 to 2015, the RCA index of textiles to CPTPP member countries is higher than 4 (see Figure 5.7). In addition, Vietnam's textile products are increasingly exported to CPTPP member countries (see Figure 5.8). Further, we found that the main environmental concerns for Vietnam's textile sector relate to the production scale and the broadening of weaving and dyeing activities to be eligible for the CPTPP's tax reductions.

In terms of environmental impact, our study found that the impact on the environment due to the broadening of textile production could be minimised if Vietnam's textile firms effectively implement the requirements on environmental protection. One possibility to minimise the potential negative environmental impacts is due to the benefit of technology transfer as a result of the CPTPP. As a result, the CO_2 emissions can be reduced due to mitigation options in textile production, including technological innovation and industry best practices.

Our finding on the positive regulatory effects of the CPTPP is supported by additional evidence that the CPTPP considers environmental protection issues towards achieving sustainable development. The CPTPP's strict requirements and regulations on greener production are expected to benefit the environment during the production of Vietnam's textile and apparel sector. As a result, environmental impacts due to increased trade in textile and apparel goods are more likely to be controlled by proper management and enforcement of legal requirements relating to environmental protection. This finding is supported by the literature that trading partner requirements play a critical role in the environmental protection of Vietnam's textile firms (Nguyen et al., 2014; Nguyen et al., 2015c). Similarly, Mukhopadhyay and Thomassin (2010) claimed that strict regulations on the environmental protection of free trade agreements help domestic firms to become more innovative in their industrial processes.

Furthermore, we found that the CPTPP's dispute settlement mechanism is beneficial to the environment because the non-environmentally friendly products are not legally eligible for the CPTPP's tax reduction policy. The CPTPP's dispute settlement mechanism enables Vietnam to protect the environment and consider any arising environmental issues more seriously during the implementation phase of the CPTPP. That would encourage Vietnam to improve the efficiency in implementing environmental regulations. Therefore, a potential increase in trade in the textile sector is not expected to have a negative and significant impact on the sustainability of Vietnam's natural resources and environment.

6.2.4 Research Objective Four

The fourth research objective aims to draw policy implications from the findings and suggest recommendations to promote the "good" effect and to mitigate the "bad" effect of trade openness on Vietnam's environment. Our study results revealed the applicability of the EKC theory which provides important evidence for Vietnam to continue to develop its economy and to have a better chance to protect the environment. Although, the study result confirmed the existence of the EKC theory, it did not indicate a simple way for Vietnam to better protect the environment by developing its economy. This is due to the overall complexity impacts of the scale, composition, technique, and regulatory effects of trade liberalisation on the environment. Therefore, in order to protect the environment during trade openness activities, we propose the following policy measures to be implemented in Vietnam.

(i) Improving Environmental Law Implementation Efficiency

The study results indicated that improving the implementation efficiency of Vietnam regulations on environmental protection is critically important. The CPTPP's dispute settlement procedures and trade sanctions are applicable for unresolved environmental issues arising under the agreement.

Therefore the Vietnamese government should adopt or modify relevant international environmental laws and policies to protect the environment. These regulations should include the provisions to obligate the production firms to green their productions, and effectively implement the environmental protection requirements during their production activities.

In addition, the policy makers should consider the environmental requirements more seriously if the CPTPP goes into effect. The government of Vietnam also has to reinforce the implementation efficiency of its environmental law as any arising environmental concerns related to the CPTPP are eligible for the CPTPP's dispute settlement mechanism (CPTPP, 2017). The CPTPP also ensures that weakening or reducing environmental regulations to promote trade and investment is not promoted or encouraged (CPTPP, 2017, chapter 20, p. 3). Therefore, Vietnam cannot weaken the environmental requirements to promote the domestic production of any sectors under the CPTPP.

Besides, the government of Vietnam should take full advantage of trade liberalisation, particularly the technology transfer from the developed countries. Vietnam needs to invest in advanced and environmentally friendly technology in its domestic productions. Particular attention should focus on production that has comparative advantages such as the textile sector.

Another policy implication of this study is that Vietnam needs to raise the awareness of the environment on the part of Vietnamese production firms. In the context of trade liberalisation, Vietnamese production firms will have to fulfil the requirements on environmental protections regulated by free trade agreements in general and by the CPTPP in particular to be eligible for the tariff reduction. For example, if the products are environmentally friendly then they would be eligible for tax reduction regulated by the CPTPP. Therefore, if Vietnamese production firms understand these regulations, they will have a better chance for their businesses to flourish internationally.

(ii) Improving Energy Consumption Efficiency

Our study provided evidence of inefficient consumption of energy in Vietnam over the last 30 years. Specifically, a 1% increase in energy consumption leads to a 1.4% increase in CO_2 emissions. This suggests that there is a possibility for Vietnam to reduce CO_2 emissions by increasing the efficiency of energy consumption. Further, the empirical estimation result indicated the need to improve the efficiency of environmental protection measures in production in Vietnam, because of high emissions of CO_2 due to energy consumption.

Based on the forecasts of Vietnam's electricity production and the National Electricity Development Program for the 2006-2030 period (see Table 1.5), thermal and hydroelectricity remain Vietnam's main sources of electricity. Of these, coal thermal power accounts for 49.3% of the power infrastructure in 2020 (see Table 1.5). The exploitation of coal, crude oil (domestic and import sources) and gas will continue in the decades to come (GoV, 2017). With the heavy dependency on fossil fuel, it is likely that the environmental quality in Vietnam can be improved with cleaner and energy efficient technology, and improved implementation efficiency of environmental requirements during the production activities.

6.2.5 Research Objective Five

The fifth research objective proposes mechanisms to include environmental protection in international economic integration at the policy level in a mutually supportive and sustainable manner in Vietnam. Our study results revealed that the legalisation of environmental impact assessment on trade policy is beneficial to the environment. An environmental impact assessment on trade policy ensures that the environmental concerns are considered under a free trade agreement negotiation framework (GoC, 2009). Therefore, the harmful effects of trade openness on the environment could be minimised (GoC, 2009; GoJ, 2004; OECD, 2000; UNEP, 2001).

The lack of domestic legal requirements of an EIA on trade policy in Vietnam obstructs researchers and policy makers in assessing the impact of each FTA on the environment. Besides, this makes Vietnam's legal system in relation to environmental matters imperfect compared to other countries, such as Canada or Japan. Our study results indicated that the integration of cooperative measures into FTAs does not benefit the environment if it lacks an enforceable implementation mechanism. Therefore, the legalisation of an EIA on trade policies is critically important when Vietnam is under a rapid process of trade liberalisation.

An environmental impact assessment can be undertaken prior to the negotiation of a trade agreement, during the negotiation of the trade agreement, after the agreement is signed, and after the agreement is implemented (OECD, 2000). To this end, our study provides significant insights for Vietnam's policy makers about the EIA on a trade policy framework. Vietnam should apply the lessons learnt from developed countries, such as Japan, Canada and the US in promulgating of environmental impact assessment regulations on trade policy.

In the short term, Vietnam may develop a general check list for screening and scoping the potential impact of trade policies on the environment (Fauchald & Vennemo, 2011). In the long-term, the requirements to conduct environmental impact assessments on trade policies should be legalised to ensure that the environmental concerns are properly considered and environmental protection measures are timely proposed before the negotiation of a free trade agreement.

6.3 Research Implications

6.3.1 Academic Implications

Our study provided evidence of the applicability of EKC theory in Vietnam. This indicates that the long-term relationship between economic development and the concentration of CO_2 emissions in Vietnam can be expressed in an inverted U-shaped function. Alternatively, this can be stipulated that in order to maintain and develop the economy and promote GDP per capita, Vietnam has to exploit and consume natural resources and discharge wastes into the environment. This will subsequently lead to the deterioration of the environment. However, our study revealed a possibility that Vietnam's environment (measured by CO_2 emissions) will be rehabilitated in conjunction with its economic development.

With regard to the empirical estimation method, the selection of lag order is very important for studies which apply time series data and capture the dynamic effect of independent variables on the dependent variable. This is because increasing the number of lag orders leads to the increase in the number of parameters. Consequently, this leads to an increase in the sum of sample square errors and biased estimation results. Therefore, the model selection criterion plays a key role to minimise the loss of degrees of freedom in ARDL models. The empirical results of our study supported the Schwarz criterion which has more advantages in selecting the minimum lag order in ARDL models. The Schwarz criterion performs better in ARDL estimations compared to the Akaike information criterion and the R-squared value. This is because the BIC selects the smallest possible lag length and minimises the loss of degrees of freedom.

The use of an advanced estimation technique in our study, which is an auto-regression distributed lag model, contributes significantly to the field of econometrics. The ARDL estimation technique has advantages in estimating the short-run and long-run relationships among time series data variables. The ARDL estimation technique helps the current study to overcome the problems related to small sample size, and the auto-correlation of time series data variables. To this end, we recommend that the ARDL estimation technique is appropriate for future studies, particularly for the studies employing time series data of economic development and environment variables.

Another contribution of our study is providing a framework relating to the environmental impact assessment on trade policy in Vietnam. The environmental impact assessment method on trade policy has been widely conducted in developed countries such as the US, EU countries, Japan, and Canada. Particularly, the *ex-ante* and *ex-post* environmental impact reports are conducted for each free trade negotiation in these countries. Vietnam can learn from developed countries in terms of legalising the environmental impact assessment requirements on a proposed trade policy. The environment will be better protected if the potential environmental impacts are foreseen and can be assessed before, during and after the negotiation of each free trade policy. To this end, our study supports the benefit of applying the EIA method on trade policy and this method is appropriate in examining the regulatory effect of trade policy on the environment.

6.3.2 Practical Implications

The main policy implications emerging from the current study (see Section 6.2.4 and 6.2.5) are summarised as follows.

First, we found that energy consumption has a negative impact on CO_2 emissions, which implies that Vietnam needs to embrace more energy saving policies and apply energy efficient technology in its productions to reduce CO_2 emissions. In addition, the empirical results revealed that the real per capita GDP has negative impact on CO_2 emissions, indicating that as the per capita income grows, in the absence of energy saving and environmental protection policies, Vietnam will exacerbate the environment further.

However, the empirical results provided an applicability of EKC theory in Vietnam. This indicates that there is a possibility for Vietnam to improve the environmental quality in conjunction with its economic development process. In addition, the results showed that trade openness has a negative impact on CO_2 emission, however the magnitude of the impact is quite small (0.191%); and after two years the impact will be reversed from negative to positive. These findings indicate a possibility for Vietnam to better protect the environment. Therefore, Vietnam needs to adjust the domestic production pattern to ensure that the changes in production processes are environmentally sustainable. Besides, Vietnam needs to take full advantage of trade liberalisation to equip and adopt the advanced production technology to mitigate the negativity in the environment.

Second, on the part of Vietnamese production firms, the results showed that the Vietnamese government should educate these firms on the environmental regulations required by the CPTPP. This will help Vietnamese production firms to fulfil the environmental protection requirements regulated by the CPTPP and have a better chance to boost their businesses internationally. Furthermore, Vietnam needs to more strictly monitor the implementation of its environmental protection law as unresolved environmental concerns arising during the production activities are eligible for the CPTPP’s dispute settlement mechanisms and trade sanctions.

Third, Vietnam should actively participate in the negotiation of FTAs that incorporate enforceable environmental provisions. Further, Vietnam should learn from her trading partners such as Canada, Japan and the US to legalise the requirements on environmental impact assessment before, during and after the negotiation of free trade agreements.

6.4 Research Limitations

This study faces several limitations in terms of data availability, time and budget constraints. With regard to data availability, there is a difference between data on real per capita GDP, which is obtained from the Vietnam GSO and from the World Bank. Our study used data on CO_2 emissions, energy use and real per capita GDP from the World Bank data sources and data on trade liberalisation from the official websites of Vietnam's government.

Quantitative assessment of the impact of trade liberalisation on Vietnam's environment is undertaken based on the estimated impact of trade openness ratio, real GDP per capita and energy consumption on CO_2 emissions. Consequently, the empirical model estimation in our study encounters various limitations with reference to the economic modelling:

First, the economic modelling analysis is a useful estimation tool but it applies a simplification of reality and relies on numerous assumptions. Therefore, the results presented should be viewed as complementing the descriptive analysis for the impact of trade openness on Vietnam's environment.

Second, the economic assessment is best understood as estimates of the potential economic impacts of the trade openness on the environmental quality, not as forecasts of the actual results.

Third, the economic model captures only the changes of the trade openness ratio, and cannot predict the increased export and import flows as a result of trade openness. In addition, the model does not include the creation of trade in new product areas, which is potentially important when the tariff is reduced or eliminated as a result of trade liberalisation.

In terms of the environmental impact assessment method on trade policy, due to time constraints, our study only examines the impact of Vietnam's textile production on the environment as a case study when examining the environmental impact of the CPTPP. This limits our study in considering the potential impacts of the CPTPP on other industries and makes our research results less generalizable.

The assessment of the regulatory effect of the CPTPP on the environment is still limited in terms of the study's scope and the proxies of environmental quality. For the focus of our study, only CO_2 emissions were considered as the proxy for environmental degradation. Thus, our study is unable to assess the impacts of trade liberalisation on other environmental problems such as water pollution, land contamination and biodiversity degradation.

6.5 Recommendations for Future Research

In order to improve the generalisation of the research results, future studies can extend this present study by considering the environmental impact of various free trade agreements. Future studies may provide a more comprehensive assessment on the environmental impact of FTAs by taking into consideration the different levels of trade openness of various FTAs, as well as the different levels of environmental commitment regulated by each FTA. In particular, future studies can attempt to examine the environmental impact of the EVFTA and/or the VCUFTA, and compare the results with our research findings. Alternatively, future studies could compare the environmental impacts of the FTAs with and without enforceable environmental provisions.

In terms of the environmental consequences of production activities, our study limits its scope to the textile and apparel sector. The results of applying environmental impact assessment methods on trade policy could be generalised by taking into considerations other production sectors such as footwear, raw material, and fuel. Future studies could use the general and sectoral CGE models to comprehensively examine the impacts of a new free trade agreement on trade flows and the economy on the whole. The CGE model can quantitatively capture effects of the changes from a FTA on all markets/countries involve in the FTA, rather than just only the changes on one market/country.

With regard to the empirical model, our study limits the environmental degradation proxy to CO_2 emissions. Future studies could consider the environmental impact of trade liberalisation with reference to other environmental factors such as water, land, and ecosystem resources. Besides, future studies could attempt to include other environmental pollutants as a proxy of environmental degradation, such as BOD, SO_2, and NO_2.

Another drawback of our study is the lack of information on the difficulties that the Vietnamese government faces to achieve a mutual benefit between economic development and environmental protection. Future studies can consider applying a qualitative method to collect data and related information regarding environmental requirements in free trade policy. Further, future studies can also attempt to interview local/provincial government officials to obtain insightful information and better understand the specific difficulties which the local government encounters to ensure that production firms effectively implement environmental protection requirements.

Finally, in terms of the benefit in incorporating environmental commitments into free trade agreements, future studies could broaden their scope to compare the environmental impact of free trade agreements in developing countries (for example the FTAs of ASEAN countries) and developed countries (such as the FTAs of EU countries). A more comprehensive assessment contributes in assisting developing countries to better consider the environmental protection in trade liberalisation.

Appendix A

Statistical Data on Economic Development and the Environment

This section presents the statistical data on economic development and the environment in Vietnam for a period of 29 years from 1985 to 2013.

A.1 Vietnam's GDP by Economic Sectors (1986-2015)

Table A-1: Vietnam's GDP by Economic Sectors (1986-2015)

	Total (Billion Dongs)				Percentage (%)			
Year	Agriculture, forestry, and fishing	Industry and construction	Service	Total	Agriculture, forestry, and fishing	Industry and construction	Service	Total
1986	228	173	198	599	38.06	28.88	33.06	100
1987	1164	814	892	2870	40.56	28.36	31.08	100
1988	7139	3695	4586	15420	46.3	23.96	29.74	100
1989	11818	6444	9831	28093	42.07	22.94	34.99	100
1990	16252	9513	16190	41955	38.74	22.67	38.59	100
1991	31058	18252	27397	76707	40.49	23.79	35.72	100
1992	37513	30135	42884	110532	33.94	27.26	38.8	100
1993	41895	40535	57828	140258	29.87	28.9	41.23	100
1994	48968	51540	78026	178534	27.43	28.87	43.7	100
1995	62219	65820	100853	228892	27.18	28.76	44.06	100
1996	75514	80876	115646	272036	27.76	29.73	42.51	100
1997	80826	100595	132202	313623	25.77	32.08	42.15	100
1998	93073	117299	150645	361017	25.78	32.49	41.73	100
1999	101723	137959	160260	399942	25.43	34.5	40.07	100
2000	108356	162220	171070	441646	24.53	36.73	38.74	100
2001	111858	183515	185922	481295	23.24	38.13	38.63	100
2002	123383	206197	206182	535762	23.03	38.49	38.48	100
2003	138285	242126	233032	613443	22.54	39.47	37.99	100
2004	155992	287616	271699	715307	21.81	40.21	37.98	100
2005	176402	348519	389080	914001	19.3	38.13	42.57	100
2006	198797	409602	453166	1061565	18.73	38.58	42.69	100
2007	232586	480151	534032	1246769	18.66	38.51	42.83	100
2008	329886	599193	686968	1616047	20.41	37.08	42.51	100
2009	346786	676408	785955	1809149	19.17	37.39	43.44	100
2010	396576	693351	797155	2157828	18.38	32.13	36.94	100
2011	543960	896356	1021126	2779880	19.57	32.24	36.73	100
2012	623815	1089091	1209464	3245419	19.22	33.56	37.27	100
2013	643862	1189618	1388407	3584262	17.96	33.19	38.74	100
2014	696969	1307935	1537197	3937856	17.7	33.21	39.04	100
2015	712460	1394130	1665962	4192862	17.0	33.25	39.73	100

Source: GSO, 2017

A.2 Vietnam’s GHG Emissions (1985-2013)

Table A-2: GHG Emissions in Vietnam (1985-2013)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Methane emissions (a)	58648.10	58,737.80	58,382.20	58,867.20	59,785.60	60,473.80	61,759.80	63,403.40	63,890.90	63,964.70	66,075.90	67,543.80	68,456.20	72,807.40	72,666.30	75,429.70
Nitrous oxide emissions (b)	9731.80	10,472.90	10,553.60	11,158.00	10,935.10	11,614.00	12,735.70	13,248.90	13,329.70	15,376.10	15,424.10	16,514.10	16,284.60	21,762.00	20,142.50	19,746.10
Other (c)	4274.90	4,603.40	5,011.90	5,151.00	5,266.50	5,738.10	5,681.70	5,901.40	5,775.10	5,705.20	5,775.10	5,635.30	5,632.00	43,568.30	33,149.90	5,782.50
CO_2 emissions (kt)	21165.90	23,091.10	25,969.70	23,182.80	17,509.90	21,407.90	21,452.00	21,477.60	23,006.80	26,230.10	29,090.30	34,667.80	45,100.40	47,513.30	47,693.00	53,644.50
Total GHGs (d)	93820.7	96905.2	99917.4	98359	93497.1	99233.8	101629.2	104031.3	106002.5	111276.1	116365.4	124361	135473.2	185651	173651.7	154602.8

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Methane emissions (a)	75,926.20	80,623.30	80,775.50	88,418.10	94,344.90	99,338.40	103,899.00	106,450.00	110,278.00	111,337.00	112,450.40	113,563.70	NA
Nitrous oxide emissions (b)	18,438.30	21,944.50	20,912.70	21,960.20	22,806.20	22,803.90	23,715.40	24,207.40	29,479.00	33,817.90	34,156.10	34,494.30	NA
Other (c)	4,957.30	13,646.40	12,599.50	21,882.20	16,271.80	8,898.00	17,038.30	4,189.10	5,667.10	5,707.30	5,707.30	25,707.30	NA
CO_2 emissions (kt)	61,139.90	70,806.10	78,767.20	90,549.20	98,143.60	102,745.70	104,872.50	117,993.10	134,916.30	147,340.10	161,887.00	158,231.10	152,624.2
Total GHGs (d)	160461.7	187020.3	193054.9	222809.7	231566.5	233786	249525.2	252839.6	280340.4	298202.3	314200.8	331996.4	

Notes: (a) kt of CO_2 equivalent;
(b): thousand metric tons of CO_2 equivalent;
(c): HFC, PFC, and SF6 (thousand metric tons of CO_2 equivalent);
(d): kt of CO_2 equivalent;
NA: Data are not available.

Source: World Bank’s World Development Indicator, 2016

Table A-3: Vietnam's GHG Inventories in 2012

		Percentage
Methane Emissions (kt of CO_2 equivalent)	113,563.70	34%
Nitrous Oxide Emissions (thousand metric tons of CO_2 equivalent)	34,494.30	10%
Other Greenhouse Gas Emissions, HFC, PFC and SF6 (thousand metric tons of CO_2 equivalent)	25,707.30	8%
CO_2 Emissions (kt)	158,231.10	48%
Total greenhouse gas emissions (kt of CO_2 equivalent)	331996.4	100%

Source: World Bank's World Development Indicator, 2016

Table A-4: GHG Inventories by Sector from 1994 to 2013

Sector	1994	2000	2010	2013
Energy	25.6	52.8	141.1	151.402
Industrial Processes	3.8	10	21.2	31.767
Agriculture	52.4	65.1	88.3	89.407
Waste	2.6	7.9	15.4	20.686
Total	84.4	135.8	266	293.262

Unit: million tons of CO_2 equivalent
Source: MONRE, 2016

A.3 CO_2 Emissions Per Person in Vietnam Compared to CPTPP Member Countries and the World Average

Table A-5: Estimated CO_2 Emissions Per Person in Vietnam, CPTPP Member Countries and the World Average (1985-2013)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Vietnam	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.7
World	4.1	4.2	4.2	4.3	4.3	4.2	4.2	4.1	4	4	4.1	4.1	4.1	4	4	4
New Zealand	6.7	7.1	7.4	7.7	7.7	7.1	6.9	7.1	7.5	7.4	7.4	7.7	8.2	7.9	8.5	8.5
Mexico	3.7	3.7	3.8	3.7	4.3	3.7	3.7	3.7	3.6	3.8	3.5	3.6	3.7	3.8	3.8	3.7
Australia	15.3	15	15.7	15.8	16.5	15.5	15.1	15.3	15.7	15.6	15.6	16.5	16.5	16.9	17.2	17.2
Brunei	11.6	10	14.1	23.6	25.4	24.1	20.1	19.2	17.8	16.3	16.2	16.1	16.3	16.6	12.1	14.3
Chile	1.8	1.8	1.8	2.1	2.5	2.5	2.3	2.4	2.5	2.7	2.9	3.4	3.9	3.9	4.1	3.9
Canada	16.3	15.5	16.2	17	16.9	15.7	15.1	15.5	15.5	15.7	15.9	16.2	16.5	16.7	16.9	17.4
Japan	7.6	7.5	7.4	8.1	8.3	8.9	8.9	9	8.9	9.4	9.4	9.6	9.5	9.2	9.4	9.6
Malaysia	2.3	2.5	2.4	2.5	2.8	3.1	3.7	3.9	4.7	4.7	5.8	5.9	5.7	5.1	4.7	5.4
Peru	2.3	2.5	2.4	2.5	2.8	3.1	3.7	3.9	4.7	4.7	5.8	5.9	5.7	5.1	4.7	5.4
Singapore	12.2	12.8	11.7	12.7	14.3	15.4	15.1	15.6	16.5	19.1	13.4	15.1	18.2	14.6	12.6	12.2
United States	18.9	18.7	19.4	20	20.1	19.3	19.1	19.1	19.4	19.4	19.3	19.5	19.7	19.6	19.7	20.2

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Vietnam	0.8	0.9	1	1.1	1.2	1.2	1.2	1.4	1.6	1.7	1.8	1.8	1.7
World	4.1	4.1	4.3	4.4	4.5	4.6	4.7	4.7	4.6	4.8	5	5	5
New Zealand	8.9	8.4	8.5	8.5	8.3	8	8	8	7.5	7.3	7.2	7.8	7.6
Mexico	3.8	3.7	3.8	3.8	4	4	4.1	4.1	3.9	3.8	3.9	3.9	3.9
Australia	16.7	17.4	16.9	17	17.2	17.7	17.9	18.2	18.2	16.9	16.9	16.5	16.3
Brunei	13.4	12.8	13.1	14.1	13.8	13.2	22.5	24	20.3	20.9	24.3	23.8	18.9
Chile	3.5	3.5	3.5	3.8	3.8	4	4.4	4.3	4	4.2	4.6	4.7	4.7
Canada	17	16.6	17.5	17.3	17.1	16.5	16.4	16.2	14.8	14.5	14.5	13.9	13.5
Japan	9.5	9.6	9.7	9.9	9.7	9.6	9.8	9.4	8.6	9.2	9.3	9.6	9.8
Malaysia	5.7	5.5	6.4	6.5	6.8	6.4	6.9	7.5	7.2	7.8	7.7	7.5	8
Peru	5.7	5.5	6.4	6.5	6.8	6.4	6.9	7.5	7.2	7.8	7.7	7.5	8
Singapore	12	11.3	7.6	6.8	7.1	7	4.3	7.5	7.4	8.7	7.4	10.3	9.4
United States	19.7	19.6	19.6	19.7	19.6	19.1	19.2	18.5	17.2	17.5	17	16.3	16.4

Source: World Bank’s World Development Indicator, 2016

A.4 Data Used for ARDL Model Estimations

Table A-6: Data for Economic Development and Environment Variables for ARDL Models (1985-2013)

Years	Y_t	LnY_t	LnY_t^2	Tr_t	$LnTr_t$	C_t	LnC_t	E_t	LnE_t
1985	239.4287	5.478256	30.01128496	18.1274	2.8974244	0.359548889	-1.02290512	271.2254875	5.602950532
1986	437.1295	6.08023	36.96919186	23.21869	3.1449577	0.383261116	-0.95903876	277.652376	5.626369885
1987	593.6536	6.386296	40.78477583	20.79861	3.034886	0.420561846	-0.86616373	286.6572146	5.658287128
1988	401.8749	5.996141	35.95370538	18.95049	2.9418296	0.366450753	-1.00389114	282.4150609	5.643377836
1989	97.15789	4.576337	20.94286342	57.90446	4.0587945	0.270323355	-1.30813643	269.6105073	5.596978352
1990	98.03187	4.585293	21.02490841	81.3157	4.3983391	0.324280765	-1.12614558	270.6291438	5.600749411
1991	142.9659	4.962606	24.627459	66.94695	4.2039005	0.319024157	-1.14248845	269.3023449	5.595834707
1992	144.1487	4.970845	24.70930119	73.57689	4.2983309	0.313770455	-1.1590936	276.1308749	5.620874938
1993	189.2605	5.243124	27.49035408	66.21227	4.1928657	0.330345655	-1.10761573	294.4657654	5.68516275
1994	229.9548	5.437883	29.57056924	77.4732	4.349932	0.370352788	-0.99329925	289.766465	5.669075305
1995	288.0203	5.663031	32.06991883	74.72127	4.3137648	0.404057351	-0.90619845	303.9805821	5.716963825
1996	337.0501	5.820231	33.87509441	92.70575	4.5294305	0.473884388	-0.74679189	315.927263	5.755512007
1997	361.2545	5.889583	34.68718395	94.34448	4.5469528	0.606948117	-0.49931197	335.1705562	5.814639525
1998	360.6008	5.887772	34.66585352	97.00125	4.5747239	0.629679947	-0.46254361	351.7454474	5.862907753
1999	374.4764	5.925529	35.111892	102.7874	4.6326629	0.622650871	-0.47376932	356.5941353	5.876598259
2000	433.3337	6.071508	36.86321083	103.2444	4.6370993	0.691020496	-0.36958579	370.1625126	5.913942132
2001	448.8823	6.106761	37.29252588	103.6884	4.6413899	0.777658384	-0.25146795	389.7906907	5.965609905
2002	477.1059	6.167738	38.04099733	107.8287	4.6805434	0.89022065	-0.11628593	420.4468321	6.041318032
2003	530.8618	6.274502	39.36937305	115.1175	4.7459534	0.978870449	-0.02135597	436.3347393	6.078409699
2004	606.9044	6.408371	41.06722204	122.2613	4.8061603	1.111901201	0.106071344	478.5049929	6.170666645
2005	699.4998	6.550365	42.9072879	130.7148	4.8730182	1.191177164	0.174942031	500.6759507	6.215959087
2006	796.6716	6.680443	44.62831221	138.3136	4.9295237	1.233275634	0.209673747	507.3890905	6.229278146
2007	919.2093	6.823514	46.56034067	154.6054	5.040876	1.352790931	0.302169815	540.0819535	6.291720894
2008	1164.613	7.060144	49.84562926	154.3175	5.039012	1.497496085	0.403794437	571.3794031	6.348053443
2009	1232.37	7.116694	50.64733572	136.3107	4.9149371	1.636370776	0.492480848	616.8350015	6.424601567

2010	1333.584	7.195625	51.77701883	152.2174	5.0253096	1.76169543	0.566276658	677.6743911	6.518666923
2011	1542.67	7.34127	53.89424878	162.9145	5.0932255	1.971433571	0.678760979	670.1831202	6.507550989
2012	1754.548	7.469967	55.80040008	156.5539	5.0534006	1.842246636	0.610985825	674.7836485	6.514392119
2013	1907.564	7.553583	57.0566088	165.0942	5.1065165	1.904865931	0.644411629	667.6464664	6.503758792

Source: World Bank, 2016

Appendix B

Statistical Data on Vietnam's Textile Sector

This Appendix summarises the statistical data used to analyse the impact of the CPTPP on Vietnam's textile production.

B.1 Data on Vietnam's Textile Exports

Table B-1: RCA Index of Vietnam's Textile in Exporting to CPTPP Member Countries

	2010	2011	2012	2013	2014	2015
RCA-textile	14.97	13.16	12.26	12.85	13.45	17.87
The most comparative base line	4.0	4.0	4.0	4.0	4.0	4.0
RCA-Raw material	1.59	1.46	1.28	0.99	0.94	0.79
RCA-Fuel	0.86	0.78	0.67	0.49	0.41	0.29

Source: Author's calculation based on WITS, 2016

Table B-2: Textile Export Turnover and Total Export Turnover from Vietnam to CPTPP Member Countries (2011-2015)

(US$ thousand)

	2011	2012	2013	2014	2015
CPTPP - Total export turnover	20553421	25450598	27778885	29718246	29031031
CPTPP - Textile export turnover	2485890	2825573	3445335	4048703	4333013

Table B-3: Textile Export Turnover and Total Export Turnover from Vietnam to the Rest of the World

(US$ thousand)

Partner Name		2011	2012	2013	2014	2015
Textile export	World	16760021.12	18150522.65	21535484.1	25241129	27270078.3
	Rest of the world	14274131.18	15324949.32	18090148.7	21192427	22937065
Total export	World	96905673.96	114529171	132032854	150217139	162016742
	Rest of the world	76352252.87	89078572.79	104253969	120498893	132985711

Table B-4: Regional Orientation Index of Vietnam's Textile Exports to the CPTPP Region

	2011	2012	2013	2014	2015
Textile export from VN to CPTPP /Total exports from Vietnam to CPTPP	0.120948	0.111022	0.124027	0.136236	0.149254546
Textile export from VN to RoW/Total exports from Vietnam to RoW	0.186951	0.172039	0.17352	0.175872	0.172477665
Regional orientation index	0.65	0.65	0.71	0.77	0.87

Notes: RoW - Rest of the World

B.2 CPTPP Tariff Reduction Schedule for Textile Goods

Table B-5: CPTPP Tariff Schedule for Textile Goods

Staging category	EIF	B3	B4	B5	B6	B7	B8	B10	B11	B16
Australia	744	22	144							
Brunei	997					52				
Canada	1095		102		28					
Chile	826		35				92			
Japan	1934								24	
Malaysia	1011				5					
Mexico	343			15				806		81
New Zealand	850			58		132				
Peru	128				107				173	553
Singapore	1072									
Sum of number tariff lines	9000	22	182	73	140	180	92	806	197	634
Percentage (%)	78.7	0.19	2.46	0.64	1.22	1.6	0.8	7.05	1.72	5.54

Source: Author's calculation from CPTPP, 2017, Appendix 2D.
Notes: EIF: tariff is eliminated when the CPTPP goes into effect; B3: tariff is eliminated after 3 years; B4: tariff is eliminated after 4 years; B5: tariff is eliminated after 5 years; B6: tariff is eliminated after 6 years; B7: tariff is eliminated after 7 years; B8: tariff is eliminated after 8 years; B10: tariff is eliminated after 10 years; B11: tariff is eliminated after 11 years; B16: tariff is eliminated after 16 years.

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