THE EFFECTS OF IMPOSING AN EMISSON POLICY IN ASEAN AND CHINA UNDER THE TRADE LIBERALIZED CONTEXT IN THE ASEAN COMMUNITY AND ITS FREE TRADE AGREEMENTS: THE DYNAMIC CGE APPROACH

A THESIS

BY

KOMWIT SIRITORN

Presented in Partial Fulfillment of the Requirements for the

Doctor of Philosophy in Economics

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คมวิทย์ ศิริธร. (2557). *ผลกระทบจากการดำเนินนโยบายสิ่งแวดล้อมในกลุ่มประเทศอาเซียนและจีน ภายใต้บริบทการค้าเสรีในประชาคมอาเซียนและเขตการค้าเสรีร่วมกับหกประเทศคู่ค้าหลัก: ดุลยภาพทั่วไปแบบพลวัต*. ปริญญานิพนธ์, ปร.ด. (เศรษฐศาสตร์). กรุงเทพ: บัณฑิตวิทยาลัย ,มหาวิทยาลัยศรีนครินทรวิโรฒ. อาจารย์ที่ปรึกษา: รศ.ดร.ชมพูนุท โกสลากร เพิ่มพูนวิวัฒน์, Prof. Dr.Stephen E. Reynolds.

จากการที่ประเทศสมาชิกอาเซียนพัฒนาความร่วมมือในภูมิภาค โดยรวมตัวกันจัดตั้งเป็นประชาคมอาเซียนภายในปี 2558 อาจส่งผลให้เกิดการเคลื่อนย้ายมลพิษระหว่างประเทศสมาชิก อันเนื่องมาจากการแสวงหาผลประโยชน์ของผู้ประกอบการจากนโยบายสิ่งแวดล้อมที่แตกต่างกันในหมู่ประเทศสมาชิก (Pollution Haven Hypothesis) ในขณะเดียวกันประเทศจีนซึ่งกำลังประสบปัญหาระดับมลพิษสูงเกินกว่ามาตรฐานสากล (WHO Standard) ซึ่งก่อให้เกิดปัญหาสุขภาพและการดำรงชีพของประชาชนจีนอย่างรุนแรง เหตุการณ์ดังกล่าวอาจทำให้ทั้งอาเซียนและประเทศจีนแก้ปัญหาโดยบังคับใช้มาตรการทางสิ่งแวดล้อมอย่างจริงจัง โดยเฉพาะในภาคการเกษตร (Agriculture) ภาคอุตสาหกรรมหนัก (Capital-intensive manufacture) และ ภาคการคมนาคมขนส่งและการสื่อสาร (Transportation and Communication) ดังนั้นการวิจัยนี้จึงเกิดขึ้นเพื่อทำการศึกษาผลกระทบทั้งต่อภาคเศรษฐกิจและการปลดปล่อยก๊าซมลพิษ จากการนำนโยบายสิ่งแวดล้อมทั้งแบบหละหลวมและแบบเคร่งครัด มาใช้ในกลุ่มประเทศอาเซียนและจีน ภายใต้บริบทการค้าเสรีในประชาคมอาเซียนและเขตการเสรีที่อาเซียนทำร่วมกับหกประเทศหลัก ได้แก่ ออสเตรเลีย นิวซีแลนด์ จีน อินเดีย ญี่ปุ่น และเกาหลีใต้

การวิจัยนี้ใช้แบบจำลองดุลยภาพทั่วไปแบบพลวัต (Dynamic CDE Model) ร่วมกับฐานข้อมูล GTAP version 8.1 ในการคาดการณ์ผลกระทบดังกล่าวตั้งแต่ปี 2558 ถึง ปี 2573 โดยพบว่าหากกลุ่มประเทศอาเซียนและจีน นำนโยบายการลดก๊าซมลพิษมาใช้ จะส่งผลกระทบด้านลบต่อระบบเศรษฐกิจของประเทศที่มีรายได้ต่ำ เช่น กัมพูชา ลาว เวียดนาม และพม่า มากกว่าประเทศสมาชิกอื่น อีกทั้งในระยะยาวประเทศอินเดียเป็นประเทศที่ได้ประโยชน์จากนโยบายดังกล่าว ในเชิง GDP สูงสุด และเพื่อชดเชยความสูญเสียที่เกิดขึ้น กลุ่มประเทศอาเซียนและจีน ต่างต้องการเพิ่มการส่งออกสินค้าประเทศอุตสาหกรรมที่ใช้แรงงานเป็นหลัก (Labor-intensive manufacture) และสินค้ากลุ่มพลังงาน ดังนั้นจึงอาจมีการแข่งขันกันระหว่างอาเซียนและจีน เพื่อส่งออกสินค้าในกลุ่มดังกล่าว นอกจากนี้หากกลุ่มประเทศอาเซียนและจีนนำนโยบายลดก๊าซมลพิษแบบเคร่งครัดมาใช้ จะก่อให้เกิดประสิทธิผลทางด้านต้นทุนต่ำสูงกว่านโยบายแบบหละหลวม

Komwit Siritorn. (2014). *The Effects of Imposing an Emission Policy in ASEAN and China under the Trade Liberalized Context in the ASEAN Community and Its Free Trade Agreements: The Dynamic CGE Approach*. Dissertation, Ph.D. (Economics). Bangkok: Graduate School, Srinakharinwirot University.

Advisor Committee:

Assoc. Prof. Dr.Chompoonuh K. Permpoonwiwat, Prof. Dr.Stephen E. Reynolds.

As nations in South East Asia integrate into the ASEAN Community by 2015, this may lead to a pollution haven hypothesis problem among the members due to a disparity in their environmental policies. China as a main ASEAN trading partner is also facing a critical level of air emission by WHO standards. To avoid these problems, ASEAN and China need to issue an emission policy. The purpose of this dissertation was to examine all economic and emission effects of both lax and stringent emission policies imposed on the 3 main polluting sectors in ASEAN and China: agriculture, capital-intensive manufacture, and transportation and communication under the trade liberalized context of the ASEAN community and its FTAs with Australia, New Zealand, China, India, Japan, and South Korea. The Dynamic CGE model was obtained with GTAP database version 8.1 due to the ability to capture interactions of each region both in short-term and long-term. The findings illustrated that an emission policy imposed in ASEAN and China had more negative effects on the economies of low income countries, such as Cambodia, Lao, Myanmar, and Vietnam (CLMV) than other ASEAN members while India gained the most in GDP, especially, in the long-term. An increasing export in labor-intensive goods and energy products would be a key strategy for ASEAN and China in order to compensate the losses from an emission policy. A stringent emission policy would lead the two regions to an achievement of cost-effectiveness rather than a lax emission policy.

The dissertation titled

" The Effects of Imposing an Emission Policy in ASEAN and China under the Trade Liberalized Context in the ASEAN Community and Its Free Trade Agreements: The Dynamic CGE Approach "

by

Komwit Siritorn

has been approved by the Graduate School as partial fulfillment of the requirements for the Doctor of Philosophy in Economics of Srinakharinwirot University.

…………………………………………… Dean of Graduate School

(Assoc. Prof. Dr.Somchai Santiwatanakul)

....

Dissertation Committee	Oral Defense Committee
....Major-advisor	....Chair
(Assoc. Prof. Dr.Chompoonuh K. Permpoonwiwat)	(Dr.Danupon Ariyasajjakorn)
....Co-advisor	.... Committee
(Prof. Dr.Stephen E. Reynolds)	(Assoc. Prof. Dr.Chompoonuh K. Permpoonwiwat)
	.... Committee
	(Prof. Dr.Stephen E. Reynolds)
	.... Committee
	(Assoc. Prof. Dr.Renu Sukharomana)
	.... Committee
	(Dr.Tam Bui Thi Minh)

This dissertation was granted

by

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Komwit Siritorn

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GLOSSARY

ACFTA	ASEAN-China Free Trade Agreement
AEC	ASEAN Economic Community
AFTA	ASEAN Free Trade Agreement
AGE	Applied General Equilibrium
APSC	ASEAN Political-Security Community
ASCC	ASEAN Socio-Cultural Community
ASEAN	Association of Southeast Asian Nations
CDE	Constant Difference of Elasticity
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium model
EU	European Union
EC	European Community
GDP	Gross Domestic Product
GNI	Gross National Income
GTAP	Global Trade Analysis Project
ISIC	International Standard Industrial Classification
NAFTA	North American Free Trade Area
OECD	Office of Economic Cooperation and Development
PHH	Pollution Haven Hypothesis
UN	United Nations
WTO	World Trade Organization

CHAPTER 1

INTRODUCTION

Background

The world trade regime has radically changed over the last few decades. Since the world became globalized with the new technology of communication, trading across countries is not as difficult as it was in the past. Most economies around the world have been scaled up in terms of economic activity, and size of industry. Consequently, the value of trade has increased dramatically, over the last decade. For instance, in 2000, the world trade value was approximately 13,180 billion US dollars and grew rapidly to about 36,693 billion US dollars in 2011. In other words, the marked rise in world trade value tripled (WTO, 2013) between 2000 and 2011. This trend has been accelerated by several factors such as population growth, advancement of communication technology, and worldwide transportation. It is true that the world population has increased sharply from just over 6 billion to almost 7 billion from 2000 to 2011 and has been growing continually (World Bank, 2013). In fact, population growth may induce a large number of demands in goods and services which in turn generate more production activities. In addition, advanced technology and global transportation has also influenced trade activities due not only to reducing cost of production, but also expanding the scale of economy. Thus, it can be seen that the world economy has to expand sharply in order to serve human needs which are unlimited.

On the other hand, while people enjoy overconsumption supported by global trade, the world environmental degradation appears to be a serious problem. In fact, the pollution of air, water, land and waste has risen significantly as well. For example, the

CO_2 emissions were about 4 metric tons per capita in 2000, and rose to 4.7 metric tons per capita in 2009 (World Bank, 2013). This kind of degradation is soaring steadily as economic activities increase and world population growth rises steadily. Furthermore, natural resources, particularly nonrenewable, have been reduced dramatically because they can be used as input factors in production. One important thing to note is that the natural resource price does not internalize the environmental cost of extraction so it is used as overconsumption. For this reason, it can be seen that the shortage of natural resources in the future may lead to a reduction of the next generation's ability to consume. As a result, such trade and consumption presently cannot sustain the development.

Even though people recognize such problem, the improvement of the economy has gone faster than environmental policy development. However, many studies attempt to capture the relation between trade and environment in order to develop optimal environmental policy. It appears that these studies were suitable in specific cases. They could not be applied in general terms as it depends on what types of determinants are (Copeland and Taylor, 2004). For example, Grossman and Krueger (1991; & 1994), Reinert and Roland-Holst (2001) and Gamper-Rabindran (2006) tried to study the impact of the North American Free Trade Agreement (NAFTA) and found that in general, this agreement may not cause environmental problems in Mexico even though its environmental policies are relatively weaker than those in the US and Canada.

On the contrary, one of paradigms about the trade-environment nexus, namely the Pollution Haven Hypothesis, argues that when a country where has relatively stringent environmental policy trades with relatively lenient environmental policy country; it might lead the lax country to specialize in dirty-good production and the stringent country will specialize in clean-good production. This is supported by the study of Michid and

Nishikimi (2007). They expanded the common pollution model of Copeland and Taylor (1994) and indicated that pollution-intensive industry has moved from high income country (stringent environmental policy country) to low income country (lax environmental policy country). Hence, there is an increase in disutility in the lax country.

While the debate on trade and environment is still controversial, there are many attempts have been made to boom trade either in local or international border. The integration of countries has been developed to encourage trade between regions by eliminating trade and non-trade barriers. Like the European Union and NAFTA, South East Asian nations enhanced their cooperation and became the Association of Southeast Asian Nations (ASEAN) on 8 August 1967 with the signing of the ASEAN Declaration or the so-called “Bangkok Declaration” in Bangkok, Thailand (ASEAN, 2013). At the time, it consisted of six member states; Indonesia, Malaysia, Philippines, Singapore and Thailand. Currently, ASEAN is comprised of ten nations with the addition of Brunei Darussalam, Viet Nam, Lao PDR and Myanmar. The objectives of ASEAN were defined in order to accelerate economic growth, social progress and cultural development as well as enhance coalitions in the region.

The explicit progress of ASEAN would be the multilateral trade agreement; ASEAN Free Trade Area (AFTA) which was initiated in 1992 by ASEAN Head Leaders in order to push up trade in the region because there is a lower trade level among members as shown in Table 1. From 1998 to 2010, the intra ASEAN trade was between 21 and 25 percent whereas the extra ASEAN trade accounted for 74-79 percent over the same period. Therefore, this gap could be filled with increasing trade across ASEAN states. Moreover, the roadmap of reducing tariff and non-tariff barriers was defined. In fact, the first six members are expected to eliminate those two kinds of barriers to zero by 2015 and the other four nations will do so by 2018.

Table 1 ASEAN Total Trade in specific years

Indicator	Unit/Scale	1998	2000	2003	2008	2009	2010
Total Trade	Value (million US$)	576,108	759,101	824,539	1,897,127	1,536,878	2,045,731
	Growth (%)	-17.5	21.8	15.5	17.8	-19	33.1
Intra-ASEAN Trade	Value (million US$)	120,918	166,846	206,732	470,112	376,177	519,805
	Growth (%)	-19.4	25.8	29.3	17	-20	38.2
	Share to total trade (%)	21	22	25.1	24.8	24.5	25.4
Extra-ASEAN Trade	Value (million US$)	455,190	592,255	617,807	1,427,015	1,160,700	1,525,926
	Growth (%)	-17	20.7	11.5	18	-18.7	31.5
	Share to total trade (%)	79	78	74.9	75.2	75.5	74.6

Source: ASEAN Secretariat. (2012, April). *ASEAN Community in Figures 2011*. p. 9

Owing to the strong coalition and the diversity of natural resources in the region, ASEAN became interesting for other countries such as Japan, South Korea, India, China, Australia, and New Zealand. Hence, the bilateral free trade agreement between ASEAN and each of those counties are conducted after. Especially, the ASEAN-China Free trade agreement will be focused on this dissertation as a case of an extra-trade because China is a large country. In 2010, it had a population of approximately 1,341.4 million and a GDP of about 5,878 billion US dollars whereas ASEAN had a population of just 598.5 million and a GDP of 1,859 billion US dollars (see more detail in ASEAN Community in Figures 2011). Hence, ASEAN-China Free Trade (ACFTA) appears to be a big deal which was signed on November 4th, 2002 in Phnom Penh. In 2009, China was the largest trading partner of ASEAN accounting for 178.2 billion US dollars of trade value and the ASEAN market was the fourth largest trading partner of China with 9.7 percent of China's total trade value. Currently, ASEAN and China have eliminated their tariff barriers except for Cambodia, Laos, Myanmar and Vietnam will cut their tariff on the majority of products by 2015 and others will be eliminated by 2018 (see more detail in ASEAN Economic Community Fact Book 2011).

In addition, China, apart from the rapidly growing economy, now faces serious pollution in both air and water quality. China has tried to reduce these pollutions by putting pressure on manufacturing industries as well as implementing a pollution tax and fee, however; those attempts did not work well. This can be seen from China's greenhouse gas emission growth. It was about 10 percent of the world emissions in 1990 but recently it accounts almost 30 percent (Beijing, 2013 August 10^{st}). In addition, China launched new ambient air quality standards which are much more stringent than the previous ones shown in table 3. To meet these new standards, power generating companies have to spend about 41 billion US dollars to upgrade their abatement equipment (China FAQs, 2012). This may raise the price of electricity use in China but it could also help the Chinese to have better air quality.

Another outcome of the ASEAN coalition is the ASEAN Community. In fact, there are three pillars of this community; the ASEAN Political-Security Community (APSC), the ASEAN Economic Community (AEC) and the ASEAN Socio-Cultural Community (ASCC). These communities must be established by 2015 in order to serve the ASEAN slogan; One Vision, One Identity, One Community as well.

AEC was designed for shaping the ASEAN region into a single market and production base and focusing on trade both in and out of the region so that ASEAN could have a more competitive advantage in the global market context. With ASEAN single market and production base goal, five core elements were introduced; 1) free flow of goods, 2) free flow of services, 3) free flow of investment, 4) freer flow of capital and 5) free flow of skilled labor. These elements could enlarge the economic activities among member nations dramatically. Inputs and outputs would flow across countries as transaction costs from trade and nontrade barriers disappear. It would be more efficient in terms of resource allocation but what about other contexts such as environment in the region?

One of the concerns about AEC is environmental impacts. It is true that ASEAN countries are markedly different in many aspects, such as factor endowment, technology, per capita income, skilled and unskilled labor and environmental policy as shown in table 2 and table 3. These differences could cause a variety of effects on those countries like social problems, economic competition and environmental degradation, when they are in the community. Nevertheless, this dissertation will concentrate on environmental deterioration relative to an emission policy under trade liberalization either intra ASEAN or extra ASEAN.

Table 2 The ASEAN countries' profile in 2010

Country	Total land area (sq km)	Total population (thousand)	GDP per capita ($PPP)	Adult literacy rate 15 yrs old up	Unemployment rate (in percent)
Brunei Darussalam	5,765	415	46,811	95.3	2.7
Cambodia	181,035	15,269	1,898	77.6	-
Indonesia	1,860,360	234,181	4,403	92.9	7.1
Lao PDR	236,800	6,230	2,585	-	-
Malaysia	330,252	28,909	14,361	92.5	3.2
Myanmar	676,577	60,163	1,273	92	-
Philippines	300,000	94,013	3,741	95.4	7.5
Singapore	710	5,077	57,505	95.9	3.1
Thailand	513,120	67,312	8,701	-	-
Viet Nam	331,051	86,930	3,351	92.8	-

Source: ASEAN Secretariat. (2012, April). *ASEAN Community in Figures 2011*. p. 1, 56

Table 3 the Ambient Air Quality Standards in ASEAN countries and China

Country	PM_{10}		SO_2		NO_2	
	24-hr	1-yr	24-hr	1-yr	24-hr	1-yr
Brunei Darussalam	150	50	-	-	-	-
Cambodia	-	-	300	100	100	-
Indonesia	150	-	365	60	150	100
Lao PDR	120	50	300	100	-	-
Malaysia	150	50	105	-	10	-
Myanmar	-	-	-	-	-	-
Philippines	150	60	180	80	150	-
Singapore	150	-	-	-	-	99.6
Thailand	120	50	300	100	-	57
Viet Nam	150	50	125	50	-	40
China Current	150	100	150	60	120	80
China in 2016	150	70	150	60	80	40

Source: Kaye Patdu. (2012, March 28-30). *Compliance and Enforcement of Air Quality Standards in Asia Implications to Climate Change Mitigation*. p. 6

As the AEC blueprint was published due to the need to change ASEAN nations into a single market and production base, it does not take environmental problems induced from trade into consideration. Most of the AEC characteristics focus only on economic dimension e.g. how to increase their trade among ASEAN states and how to get a competitive advantage in the global economy. Thus, environmental degradation seems to be left behind. However, another community; namely the ASEAN Socio-Cultural Community, was constructed under the ASEAN human well-being concept. It aims to enhance the quality of human, cultural and natural resources for sustainable development. The leaders of member states then launched the ASEAN Socio-Cultural Community (ASCC) Blueprint on March 1st, 2009 in Cha-am/Hua Hin, Thailand.

The ASCC blueprint defined the characteristics of human-wellbeing into 6 pillars; A) Human Development, B) Social Welfare and Protection; C) Social Justice and Rights; D) Ensuring Environmental Sustainability, E) Building the ASEAN Identity and F)

Narrowing the Development Gap. Although the environmental aspect is described in section D of the blueprint, it seems a slow progress under those environmental strategies and actions. From this point of view, Middleton (2012) stated at the Second International Conference on International Relations and Development in Chiang-Mai, Thailand that the progress, in terms of political and economic has been moving faster than the cooperation in improving the environmental governance gap. As a result, there are the problems of taking advantage from this gap. Middleton also presented a case study describing the governance of Thailand's power sector. As the need for electricity consumption in Thailand has grown steadily, the Electricity Generating Authority of Thailand (EGAT) is working to find new sources of power from Thailand neighborhood: Lao PDR and Myanmar. This project was introduced and then the Environment Impact Assessment (EIA) was conducted. The point of this case study is that the EIA was implemented with a lower standard than previously conducted in Thailand due to a relatively weak environmental policy in LAO and Myanmar. This case study is quite similar to the case of Sukharomana (2013). She claimed that almost 40 female workers in the Northern Industrial Estates, Thailand are encountered with illness from air pollution contaminated with volatile organic compounds (VOCs) in the assembly lines of an electronic factory. Subsequently, twelve of them died and two infants died before reaching the age of one. These circumstances might be caused by two kinds of factors 1) external factors such as movement of production bases through FDI from developed nations, and international trade and environmental agreement 2) internal factors such as government policies on industrial development, and the lack of effective governance in the host country. In both cases, it is undeniable that good environmental policy preparation and effective governance are needed before facing trade liberalization as in AEC.

Turning to the ASCC blueprint, even though it appears to be difficult to accomplish all action plans in the blueprint, the ASEAN claimed that there were several positive outcomes, for example, a number of protected areas both on land and marine were established. However, the aim to harmonize environmental policies and databases has been made slow progress (Middleton, 2012). Actually, this aim is important because it would fill the environmental policy gap across ASEAN nations. Consequently, the pollution haven effect could not take place because in general, there will not appear a disparity in environmental regulation among ASEANs. Thus, the specialization in production might be determined by other factors.

Moreover, as mentioned, the severe air pollution in China at present may cause China to impose emission policies in particular area of dirty production such as agriculture, capital manufacture, and transportation and communication. This may lead to a significant increase in the import of these types of products from aboard by Chinese firms. Hence, the ASEAN market would be interesting for China in this point because ASEAN and China have signed the ASEAN-China Free Trade Agreement (ACFTA) so that tariff barriers between the two regions are removed. This could cause a problem as in the case of China-US trade during 1997-2003. Such trade could reduce CO_2 emissions in the US by 3-6 percent, whereas it has increased in China by 7-14 percent in order to produce goods for the US (Bin Shuia and Robert C. Harriss, 2006). For this reason, the ACFTA could harm ASEAN in terms of an environmental context if ASEAN does not enact strong environmental policies first.

On the whole, it appears that the coalition in South East Asia nations will be continually geared to be a single market and production base in order to drive trade in the region, and emerge in the global market with a competitive advantage from being ASEAN Economic Community, ASEAN Political-Security Community and ASEAN

Socio-Cultural Community. Even though a trade-environment nexus is still controversial in the world, the progress of economic integration seems to grow faster than the attempt to harmonize environmental policies and databases. As a result, ASEAN may confront the effects from either intra-trade or extra-trade. If those effects emerge from trade liberalization due to ASEAN community or FTA context, then there will be a need to establish a suitable emission policy in the region before going into trade liberalization. However, it is undeniable that an emission policy could impact on such region’s economy in particular the period of implementation but in the long-run, the benefit from reducing emission may offset that loss. From this point of view, it could be questioned that if the two regions: ASEAN and China are going to impose an emission policy on the 3 main polluting sectors, what will happen to the economies and emissions of ASEAN, China and also trading partners? As well as, what is the type of an emission policy that is good for ASEAN and China?

To answer these questions, this dissertation is conducted in order to grab all effects of the emission policy in ASEAN and China under the trade liberalized context of the ASEAN community and the FTAs between ASEAN and the 6 key partners: Australia, New Zealand, China, India, Japan, and South Korea on both economic and environmental views. The Computable General Equilibrium (CGE) will be used to estimate those effects. The study utilizes data from the Global Trade Analysis Project (GTAP) version 8.1, the most current update. It is comprised of 57 sectors and includes 134 regions around the world. Apart from an updated database, this study differs from others since it takes into consideration not only economic aspect, like Petri, Plummer, and Zhai (2012) but also an environmental context. For these reasons, the results of this study could illustrate both the positive and negative aspects of trade liberalization.

In addition, the study covers both intra-ASEAN trade and extra-ASEAN trade so that the effects of emission policies in the two regions are captured accurately. The findings of this paper will indicate the effects in both the short and long run as the dynamic approach is obtained in the study as well. Cost-effectiveness analysis is also added in order to analyze a suitable emission policy for both ASEAN and China. This analysis tool is a decision-making assistance tool since it can identify the most efficient way to meet an objective in terms of the effectiveness per unit of cost or the cost per unit of effectiveness. As a result, the findings will reflect the impacts of trade liberalization in the ASEAN Community and should be beneficial for ASEAN members and China in order to design appropriate emission policies which achieve the economically most efficient reduction of emissions.

Research objectives

This dissertation aims to examine the effects of emission policies under the trade liberalization in the form of ASEAN community and FTA between ASEAN and the 6 key partners: Australia, New Zealand, China, India, Japan, and South Korea. To do so, the simulation of all trade liberalized conditions based on the Global Trade Analysis Project (GTAP) database has to be conducted in order to investigate the objectives as follows;

1. To study the effects of imposing emission policies both lax and stringent in ASEAN nations, in particular, agricultural, capital manufacturing, and transportation and communication sectors under ASEAN community and Free trade Agreement conditions.
2. To study the effects of imposing emission policies both lax and stringent in China in particular agricultural, capital manufacturing, and transportation and communication sectors under ASEAN community and Free trade Agreement conditions.
3. To study the effects of imposing emission policies both lax and stringent in ASEAN and China together[1] in particular agricultural, capital manufacturing, and transportation and communication sectors under ASEAN community and Free trade Agreement conditions.

[1] ASEAN and China impose a same kind of an emission policy, i.e. a lax or a stringent emission policy in the same year (2015).

Significance of the study

As trade regimes tend to attach with an integration of countries, it could induce more economic activities and enhance the power of integrated regions in the global market. It is evident that national income in the region should rise from such integration but in the meantime, it could lead to a major environmental degradation problem as well. Additionally, there are a large number of infrastructure differences among integrated countries, for example endowment factors, income, labor and environmental policy. If a disparity in environmental policy plays a main role in determining trade patterns, it would seem to be a Pollution Haven Hypothesis. Thus, lax environmental policy countries are going to specialize in dirty-good production while stringent countries will specialize in clean-good production and import dirty-goods from lax countries instead.

However, the trend of trade liberalization embedding with integrated country regime has widely spread since it began by the Europe Community (EC) and followed by the North American Free Trade Agreement (NAFTA). ASEAN nations will now become the ASEAN Economic Community (AEC) by 2015. There are many concerns about the negative impacts of the AEC particularly, environmental impacts, however; few studies have been conducted. The study done by Howard Gumilang, Kakali Mukhopadhyay, and Paul J. Thomassin (2011) is a case in point. They claimed that Indonesia will enjoy the economic growth but it will be followed by a higher rate of environmental deterioration. Moreover, there was a study of CO_2 which embodied in US-China trade by Bin Shuia and Robert C. Harriss (2006). This study illustrates that the US can avoid emissions in its country by importing goods from China by 3-6 percent whereas China has increased their emissions due to producing export goods to the US by 7-14 percent. This can indicate a mobility of production composition between stringent countries and lax countries which also have lower levels of clean technology. As a result, lax countries are going to be pollution havens for stringent countries.

Regarding the ASEAN Community, it consists of ten member nations which have huge differences, for instance, income per capita, labor (skilled and unskilled), factor endowment, technology and environment regulation. These may contribute to a variety of trade patterns when they are joining to the community. However, in order to get a maximum benefit in terms of economy and environment, it should be come with environmental policy reform as well. As suggested in Dessus and Bussolo (1998), if free trade combined with an appropriated environmental policy, there should be an improvement in reallocation toward competitive industries and may also lead to becoming better off in both economic growth and environmental quality.

For this reason, there is a need to study what the effective environmental policy is, under conditions of trade liberalization both in the form of community and free trade agreement. Hence, this dissertation is conducted by focusing on both intra effects (among ASEAN member states) and inter effects (ASEAN and Rest of the World including China) caused by an emission policy imposed in the two regions. In fact, an emission policy could either be lax or stringent ones. Both kinds would have different impacts on each ASEAN member and non-ASEAN region. It is clear that an emission policy could hurt the economy in the initial period of implementation but in the long-run the benefit of decreasing emissions may offset the damage to the economy as well. For this reason, it is worthwhile to carry through this dissertation. It could indicate the effective emission policy for ASEAN nations and China rather than studying just the effects of the policy.

Moreover, the dissertation is different from others due to taking account of the impacts of ASEAN Community and the FTA conditions on both the economic and environmental aspects. It also uses a dynamic approach to be an analytical tool with an updated and wide data base. The important thing to note is that this dissertation takes a variety of air pollution indicators such as Green House Gas (GHG); Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O) and non-GHG air pollutants; Sulfur Dioxide ($S0_2$), Nitrogen Dioxide ($N0_2$), and Particulate matter (PM_{10}) into account in order to measure the effects on the environment.

As a result, it can be seen that this dissertation will reveal the key impacts of an emission policy on the economies and environment in both ASEAN nations and China under the ASEAN Community and FTA conditions. In addition, the cost-effectiveness analysis will reveal the better emission policy in terms of the emission change and GDP change ratio to policy planners so that they could use the findings to design the suitable policy for their regions by taking the effects of both the economy and emission into their consideration.

Scope and delimitation of the study

As the aims of this dissertation focused on the effects of emission policy both on economic and emission points under ASEAN community and the FTA conditions, in order to grab the main key findings, the scope of the study is defined as follows;

1. The data used in this study is obtained from the Global Trade Analysis Project (GTAP) version 8.1. Its input-output data comprises of 134 regions (covering 244 countries) and 57 commodities (referring to the International Standard Industry Classification (ISIC) and the Central Product Classification (CPC))

2. Environmental indicators used to indicate environmental damage can be divided into three groups. 1) Carbon dioxide Green House Gas such as CO_2 2) Noncarbon dioxide Green House Gas (non-CO_2 GHG) such as Methane (CH_4) and Nitrous oxide (N_2O) 3)

nonGHG Air emission pollutants for example, sulfur dioxide ($S0_2$), nitrogen dioxide ($N0_2$), and particulate matter (PM_{10})

3. To obtain the inter effects, this study used China to be representative of other key partners since it has been confronting serious air pollution recently and also China is one of the key trading partners of ASEAN accounting for an 11.7 percent share of ASEAN trade in 2011 (ASEAN, 2012).

4. As this paper has to estimate emission effects in terms of total emission change, it needs to use the emission intensity of each air emission indicator. Thus, the paper includes the emission intensity from three sources. 1) the cabondioxide emission intensity calculation from the GTAP CO_2 database included in GTAP Database version 8.1 2) the paper of Rose and Lee (2008) for non-CO_2 GHGs 3) the industrial pollution projection system (IPPS) for non-GHG air pollutant gases.

5. The emission data used in this paper shows that there are 3 main polluting sectors namely agriculture, capital intensive manufacture, and transportation and communication. Thus, the emission policy that ASEAN and China are going to impose is designed for only those 3 sectors. For this reason, the other sectors do not need to meet the emission conditions as written in that policy. However, they might be impacted from the changing of production structure as a whole due to the emission policy imposed on the 3 polluting sectors.

However, this dissertation also has delimitation as IPPS, the data source of non-GHG emission intensity, has provided the information for just only 3 main sectors namely, capital intensive manufacture, labor intensive manufacture, and transportation and communication. Thus, the dissertation could illustrate the estimated total emissions of non-GHG air pollutants caused by an emission policy for just such 3 sectors.

Theoretical framework

Owing to the purposes of this dissertation, ASEAN and China may impose an emission policy on its region in order to reduce their emission problem. There are three main situations which could happen. Firtly, ASEAN imposes a lax or a stringent emission policy alone while China does not impose it. Secondly, China imposes a lax or a stringent emission policy alone while ASEAN does not impose it. Thirdly, ASEAN and China impose a same type of an emission policy (i.e. a lax or a stringent emission policy) in the same year. Obviously, these three situations would bring different effects on both the two region and others.

For example, the first situation, firms, especially in the the 3 main polluting sectors: agriculture, capital intensive manufacture, and transportation and communication, could suffer dramatically from the emission policy imposed on. The policy could reduce the number of such 3 productions both in final goods and intermediate goods and lead to a decrease in exports of the products to China and other regions. In the meantime, emisisons in ASEAN could reduce as the 3 main polluting production decreases due to the emission policy imposed in ASEN.

However, this seems to benefit for other region as they can increase their export in such products but they may see an increase in their emissions as their polluting productions increase in order to serve thire export growth. In addition, the degree of circular effects like this would be stronger when ASEAN decides to impose a stringent policy instead of a lax one as the pressure on the productions cuased by a stringent policy is stronger than a lax one.

By contrast, if China imposes an emission policy while ASEAN dose not do so, China would see a significant drop in the 3 productions, and ASEAN and non-ASEAN nations may benefit from this situation in terms of increasing the exports in such goods as mention in the first situation. However, in the case of that ASEAN and China impose the same type of whether a lax or a stringent emission policy in the same time, the effects could be conveyed to the all trading partners and lead them to getting better or worse off depending on their structure of production and trade. Therefore, this kind of process could be drawn as a framework of the study indicated below.

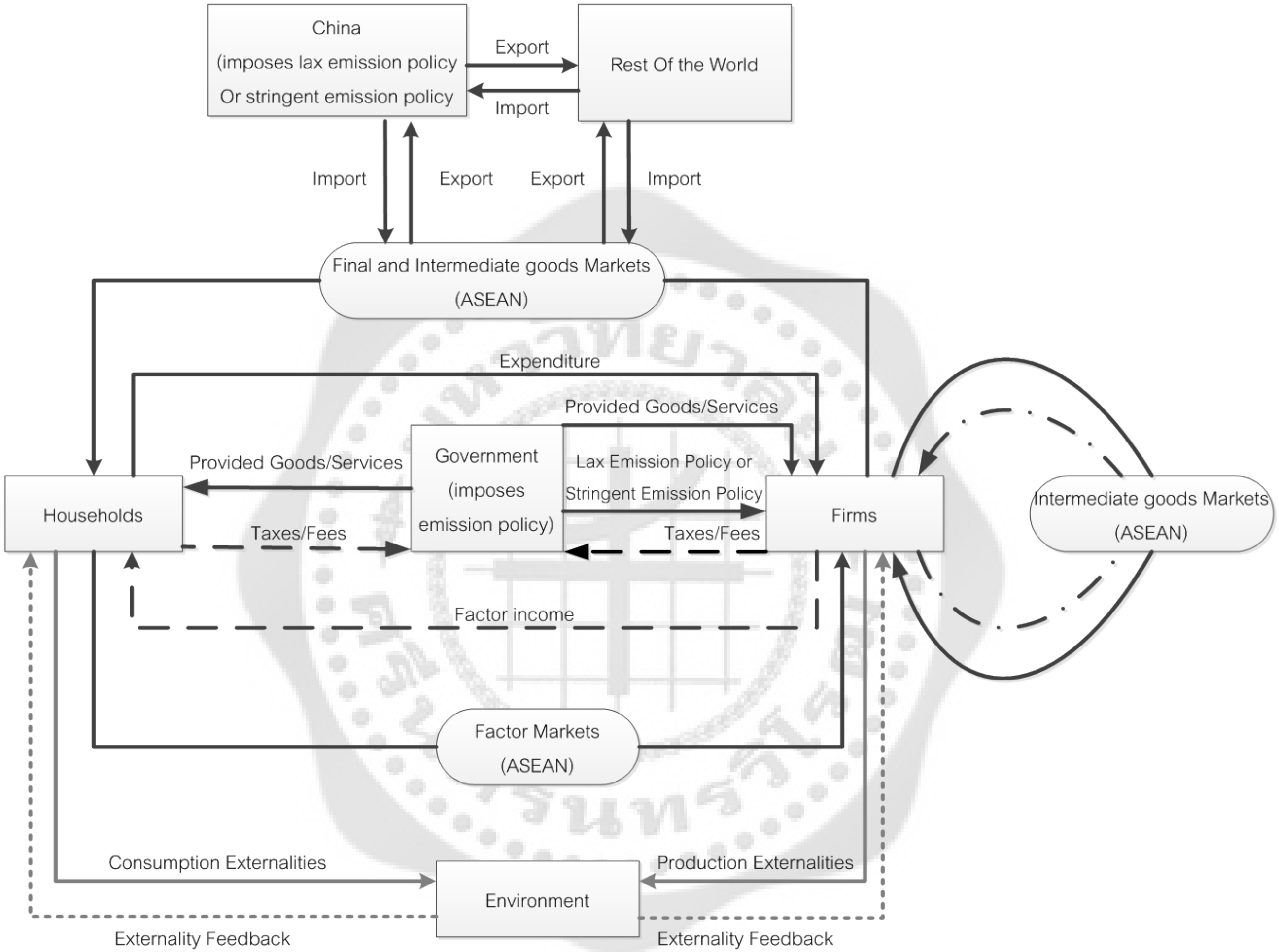

Figure 1 the theoretical framework of the dissertation

Source: Amitrajeet A. Batabyal; & Peter Nijkamp. (2011). *Research tools in natural resource and environmental economics*. World Scientific., Modified by Author

Definitions

In this study, many technical terms as well as specific words are used in the trade-environment nexus. The explanations of these terms are defined as follows;

1. Dirty-goods production or pollution-intensive industry is the production or industry that use more capital-intensive rather than labor-intensive production process (Copeland; & Taylor, 2004).

2. Clean-goods production or nonpolluting-intensive industry is the production or industry that use more labor-intensive rather than capital-intensive production process.

3. Pollution Haven Hypothesis is the circumstance that there is a movement of pollution-intensive industries from the relatively stringent environmental policy country to lax policy country due to the decrease in trade barriers (Copeland and Taylor, 2004).

4. Factor Endowment Hypothesis is the situation that there are factor endowment difference between trade partners and this determines such trade pattern. Thus, the capital-abundant countries will export capital-intensive goods (pollution–intensive goods) while capital-scare countries will export clean-goods (Copeland; & Taylor, 2004).

5. Race to the Bottom Hypothesis is the circumstance that the central government decentralizes the responsibility of environmental policy design to local governments which leads to local competition for investments and jobs by designing attractive policies to firms (Håkan; & Scott, 2009).

6. Scale effect is the effect of increasing economic activities due to expansion of the economy by freer trade (Grossman; & Krueger, 1991).

7. Composition effect is the effect of changing in the composition of production which is induced by the country's comparative advantage (Grossman and Krueger, 1991).

8. Technique effect is the effect of behavior changing due to increasing income and then it induces clean-technology to get environmental quality (Grossman and Krueger, 1991).

9. Global Trade Analysis Project (GTAP) is the project that aims to lower the cost of entry for conducting qualitative research in international economic issues. The project consists of many parts such as a global database, a standard modeling framework and application software (Hertel, 1997).

10. Trade liberalization is movement toward a regime of trade that has no barriers either tariff or non-tariff barriers.

11. Free Trade Area (FTA) is a trade agreement in which all parties agree to use trade liberalization regimes among a group of trade partners e.g. North American Free Trade Area (NAFTA) and ASEAN Free Trade Area (AFTA)

12. ASEAN (Association of Southeast Asian nations) is a group of Southeast Asian nations comprised of ten countries; Indonesia, Malaysia, Philippines, Singapore, Thailand Brunei Darussalam, Viet Nam, Lao PDR, Myanmar and Cambodia.

13. ASEAN Economic Community (AEC) is one of the three pillars of the ASEAN Community. It aims to transform ASEAN into a region with free movement of goods, services, investment, skilled labor, and freer flow of capital in order to make ASEAN as a single market and production base (AEC Blueprint, 2008).

14. ASEAN Political-Security Community (APSC) is one of the three pillars of ASEAN Community. It aims to enhance ASEAN's political and security cooperation under the needs of living in peace with same ASEAN member nations and with the world in a democratic and harmonious environment (APSC Blueprint, 2009).

15. ASEAN Socio-Cultural Community (ASCC) is one of the three pillars of the ASEAN Community. It aims to enhance the well-being, livelihood, and welfare of the people in

ASEAN by focusing on human needs such as society, culture and environment (ASCC Blueprint, 2009).

16. Lax emission policy is a type of emission policy that causes a reduction in technological augmented outputs by 5 percent in the production sectors imposed the policy in modern technological countries, 10 percent in the production sectors imposed the policy in normal technological countries, and 15 percent in the production sectors imposed the policy in legacy technological countries[2].

17. Stringent emission policy is a type of emission policy that causes a reduction in technological augmented outputs by 10 percent in the production sectors imposed the policy in modern technological countries, 20 percent in the production sectors imposed the policy in normal technological countries, and 30 percent in the production sectors imposed the policy in legacy technological countries[3].

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[2] The percents of reduction cuased by a lax emission policy were calculated from the paper's results of Garbaccio, Ho, and Jorgenson (1999).

[3] The percents of reduction cuased by a stringent emission policy were calculated from the paper's results of Garbaccio, Ho, and Jorgenson (1999).

Research hypotheses

It is evident that economic activities among ASEAN states may increase dramatically due to the elimination of trade barriers and the ASEAN Community by 2015. In addition, China is now attempting to control the emissions which are a severe problem in China. However, this may create the environmental policy reform that induces impacts not only on such regions but also out of region. Hence, the hypotheses of this dissertation will be seen as follows;

1. A stringent emission policy imposed in ASEAN region under the ASEAN Community and FTA contexts could lead ASEAN to becoming better than a lax policy in long-run.
2. A stringent emission policy imposed in China under the ASEAN Community and FTA contexts could lead China to becoming better than a lax policy in long-run.
3. A stringent emission policy imposed in both ASEAN and China together under the ASEAN Community and FTA contexts could lead the two regions to becoming better than a lax policy in long-run.

CHAPTER 2

REVIEW OF LITERATURE

The debate in Trade and Environment

It is undeniable that trade and environment have been debated for many decades. This controversial issue has been introduced in wide areas at both local and international conferences. Some specialists believe that trade may be the channel of emission leakage which can be used by developed countries in order to avoid high abatement costs in their countries. However, on the other hand, there are some studies indicating that countries would gain from trade rather than losing from environment deterioration.

A variety of technical terms has been used to represent the relation between trade and environment for instance, the race to the bottom hypothesis and pollution haven hypothesis (PHH). Actually the former stemmed from that the US government decentralized the role of environmental policy design to the local governments in order to fit their area conditions. Because of large areas and radical differences in terms of geography and culture in the US, the local governments had issued environmental policies based on their benefit gaining from the policies. In other words, the local governments try to shape their environmental policies in order to attract industries investing in their state so that the employment rate will increase in their state. Thus, this competition would lead to the race to the bottom (Håkan and Scott, 2009).

However, it can be seen that such problem is scoped in domestic areas, but nowadays, trade is not just within a country but also across countries, namely international trade. Obviously, there are many differences among countries such as factor endowment, national income, a number of laborers, and environment regulation. These could induce the country’s comparative advantage. Moreover, another important factor is a disparity in environmental regulation between trading countries. If their comparative advantage is induced from their relatively lax environmental regulations, the countries will specialize in pollution intensive production. By contrast, countries having relatively stringent environmental regulation will specialize in clean industrial production trade (Copeland and Taylor, 2004). This illustrates the concept of the Pollution Haven Hypothesis (PHH) which is used by many environmentalists to dispute trade liberalization, in particular, the North American Free Trade Area (NAFTA) during the building period.

NAFTA was initiated in the 1990s. At that time, the US attempted to extend their trade by making a unilateral agreement with Canada and followed by Mexico to form a trilateral North American Free Trade Agreement. This situation caused a huge debate as the US had relatively more stringent environmental policies than other countries, particularly, Mexico. It seems to be that Mexico is a pollution haven for the US (Brown, Deardorff and Stern, 1992). In addition, to argue this issue, Grossman and Krueger (1991) conducted the study to examine the impact of North American Free Trade on the environment. They classified the effects into 3 types; scale effect, composition effect and technique effect. The scale effect was used to measure the increase of economic activity due to the expansion of the economy by freer trade. This causes a negative effect on the environment because the growing of production will raise emissions as well. The composition effect is the result of changing the composition of production which is induced from the country’s comparative advantage. If the determinant of the comparative advantage is environmental regulation, then the effect of composition should be negative owing to the PHH. However, if it is not, the composition effect signs would be ambiguous depending on what the determined factor is. Lastly, the technique effect is used to capture the results of behavior change due to increasing income. When economic activities increase, it raises the income per capita as well. Hence, people want to take care of themselves by enhancing environmental quality by strengthening environmental policy. This would create new clean technologies which in turn, reduce emissions in the country. Thus, such effects should be positive for the environment. By capturing these three effects, Grossman and Krueger found that there is an increase in emissions (SO_2 and Dark matter in the air) with per capita income at low levels followed by a decrease with high per capita income levels and the turning point is about $5000. From the results, it can be shown that the technique effect is stronger than other as it can offset the other two effects as well.

Like Grossman and Krueger (1991), there are several studies regarding trade liberalization, and the environment by examining the three effects. Grossman and Krueger (1994) used more environmental indicators such as concentrations of urban air pollution, measures of the state of the oxygen regime in river basins, concentrations of fecal contaminants in river basins, and concentration of heavy metals in river basins. The findings still confirm that growth leads to the deterioration of the environment at first followed by a subsequent improvement phase. Moreover, Reinert and Roland-Holst (2001) used an applied general equilibrium model (AGE) to simulate the impact of NAFTA and found that the base metals sector would be seriously impacted in the US and Canada rather than Mexico. This is the opposite from PHH due to the weaker environmental policy in Mexico. Another work on NAFTA analysis was conducted by Gamper-Rabindran (2006). She utilized the concept of location effect including the three effects to investigate NAFTA impacts, and the results show that even though the US has relatively stricter Environment policies than Mexico, trade in NAFTA did not cause Mexico to specialize in dirty-goods production over the period of 1989 – 1999.

Apart from NAFTA analysis, Tobey (1990), and Dean (2002) have tested the interaction between trade liberalization and environment as well. The former used the Heckscher-Ohlin-Vanek (HOV) model to capture the environmental policy effects on the world trade pattern while the latter used the Heckscher-Ohlin model with endogenous factor supply to analyze the impacts of trade liberalization in China water pollution. Tobey's findings illustrated that stringent environmental policies do not have a significant effect on trade patterns and Dean found that China gains the net benefit from trade liberalization. Regarding the issue of Pollution Haven, Ederington, Levinson, and Minier (2004) used the US trade pattern to investigate the relation between trade liberalization and pollution havens with a regression approach. He concluded that there is no significant connection between the two.

On the whole, it can be assumed that although the belief of either the race to the bottom hypothesis or the pollution haven hypothesis show negative sides of trade on the environment, many studies represent the positive ones. This kind of contradiction is still debatable on trade-environment nexus. However, before going further, it would be better to understand the relation and interaction of trade, environment policy, and pollution in a theoretical context first. Then we will move on to the empirical and applied studies.

The theoretical view of Trade and the Environment

Since Grossman and Krueger (1991) illustrated how scale, composition and technique effects interact with trade liberalization followed by the theory of trade and environment introduced by Copeland and Taylor (1994). They developed a simple static two-country general equilibrium model (North-South trade model) to illustrate how the North country trade with the South country. By assumption, there is a huge disparity in income per se between the two countries. Copeland and Taylor assume that the North has a large amount of human-capital per person relative to the South. This leads to higher income per capita in the North and lower income in the South. As a result, people in the North would prefer to have higher environmental quality than people in the South do. It would also raise the pollution tax in the North much higher than in the South. The firms in the North would find their abatement costs increased significantly. For this reason, they tend to import pollution-intensive goods from the South which has a relatively lax environmental policy, and export clean-goods instead. Consequently, the South is going to specialize in dirty-goods production. This result supports the Pollution Haven hypothesis with stringent environmental policy countries exporting clean-industrial products and importing dirty-industrial products from lax environmental policy countries.

Instead of the study of the North-South trade, Copeland and Taylor (1995) extended their scope of interest into the study of world pollution. They examined how national income and trade determine world pollution levels. The assumptions were that global environmental quality is a pure public good which is supplied by endogenously responding to trade-induced change in relative price and income. In addition, the emissions which are caused by industries are limited to their country. They then explored the effects of trade in goods and pollution permits on welfare and pollution levels. The key findings are defined as follows: 1) Free-trade raises the world pollution levels if there is a marked difference in income across countries because Free-Trade cannot equalize the factor prices among countries. Thus, there is a sharp decrease of pollution permit prices in human-capital-scarce countries. This can lead to the pollution havens effect due to a weak environment policy (low pollution permit price). Therefore, the world pollution level tends to increase. 2) In the long-run equilibrium (equalization in income across countries), the human-capital-scarce countries will gain from trade while the human-capital-abundant countries will lose because low-income countries take strategic advantage from trade by setting pollution levels in a free-trade regimes in order to increase their income.

The North-South model of Copeland and Taylor (1994) has been widely used and there are some extended papers of this model. Michid and Nishikim (2007) modified the concept of common pollutants in the model. Because the environmental regulations in each country and each sector are different, common pollutant model should represent that as well. In addition, the equilibrium in the North-South model leads the two countries to specialize in production of whether clean or dirty goods completely. This does not indicate the real world situation. For this reason, Michid and Nishikim used trade equilibrium with diversified production to answer the question: how does trade liberalization affect production and pollution emissions in individual industries? The result shows that the pollution-intensive industries relocate to the South and this brings disutility in the South. This paper was challenged by Bogmans and Withageni (2010). They investigated the Pollution Haven Hypothesis with the dynamic perspective method and found that if trading countries have a difference in terms of time preference, there will be at least one country specializing completely. Hence, the findings differ from other works which state that there is an imperfect specialization.

Another point of looking at the Trade and Environment Theory is raised by Chichilnisky (1994). She introduced the concept of property rights in the theory. By claiming that although the two countries have the same endowment, technology and preference, the problems in the environment may occur as there is a difference in defining property rights. Assuming that the North has well-defined property rights and the South has ill-defined property rights. This difference can lead to the so-called Tragedy of The Common problem talking about overconsumption of common resources. In this case, the North found that their resources have well defined property rights which make trade difficult. Thus, the North is going to import resources from the South at a level of overconsumption because the cost of depletion of the South's resources is lower due to the lack of defining property rights. This could encourage the South to specialize in its natural resources with a price that does not internalize the extracting costs. As a result, it can be seen that the South is going to be a Pollution Haven for the North.

Even though the theories mentioned above indicate the negative relation between trade and environment, some empirical studies show the opposite result from the theory. Antweiler, Copeland and Taylor (2001), Dean (2002), and Ederington, Levinson and Minier (2004) are all the good cases in point. They stated that from their studies in general, trade does not harm the environment; moreover, in some studies, countries may gain from trade as well. From these studies, there seems to be a contradiction between theoretical and empirical work. However, Copeland and Taylor (2003; & 2004) tried to explain why the results are so varied. There should be some conditions on the determinant of the relationship.

They proposed the ideas in their paper that the interaction between trade and environment stemmed from two hypotheses: The Pollution Haven Hypothesis and Factor

Endowment Hypothesis. They then introduced the determinants of comparative advantage by deriving hypotheses and proposed their three approaches as follows;

1. The induced comparative advantage from The Pollution Haven Hypothesis (Copeland; & Taylor, 2004): this predicts that lax environmental policy countries will specialize in pollution-intensive industry while stringent countries will specialize in clean-intensive industry. In fact, most of the lax countries are also low-income and lacking in capital products. Thus, the optimal pollution tax in lax countries is obviously lower than stringent countries. This leads to a comparative advantage from the kind of difference which plays the main role in the concept of the pollution haven hypothesis.

2. The induced comparative advantage from the Factor Endowment Hypothesis (Copeland; & Taylor, 2004): this idea was derived from differences in factor endowment. Normally, high-income countries have capital-labor ratios (K/L) much higher than low-income countries; therefore, the capital-abundance appears to be the comparative advantage of North countries. It then leads the North to supply capital intensive production increasingly which in turn raise pollutions in the North rather than the South.

3. The last determinants of comparative advantage that Copeland and Taylor (2004) introduced in their work are the combination of The Pollution Haven Hypothesis and the Factor Endowment Hypothesis: the concept is quite suitable for the real situation since on the one hand, there are differences in both factor endowment and technology across trading countries; on the other hand, environmental policy is not equal as well. The problem is how the trade pattern interacts with those differences. To solve this, we need to find what the key determinant of comparative advantage of each country is. If the North (capital-abundant country) has low income elasticity of marginal damage, or it is not high enough, the North tends to specialize in capital-intensive production (dirty-goods). Therefore, the pollution will rise in the North because the difference in factor

endowment dominates the difference in environment policy. However if the impact of factor endowment difference cannot be offset by the impact of difference in environmental policy, then the South would specialize in dirty-goods rather than the North.

The study of Mulatu, Gerlagh, Rigby and Wossink (2009) is the example that shows the determinant of the industry location induced from environmental regulation. The findings expressed that the magnitude of impact of environmental policies, which are introduced in 13 European countries with 16 manufactured industries, is not a significant difference from other traditional determinants such as agricultural, education, labor, R&D and market potential. It can be seen that the magnitude of the environmental regulation impact cannot offset other determinant impacts. Hence, the pollution haven hypothesis is ambiguous. This idea was supported by Elliott and Shimamoto (2008). Their study presented the fact that Japanese investments in terms of FDI in Malaysia, Indonesia and Philippines do not relate to the lax environmental policy in their countries. In fact, lax countries have low capital accumulation which is not attractive for investments. By contrast, the stringent environment policy in Japan induces Japanese private firms to improve industries in lax countries through technology transfer.

In summary, those theories try to explain the effect among trade, environment policy and environmental degradation, to some extent, e.g. the North-South Trade induced by income difference (Copeland and Taylor, 1994), property rights ill-defined (Chichilnisky, 1994), and the three determinants of Comparative advantage (Copeland and Taylor, 2004). Thus, we could see that in some cases, the outcome of the interaction would vary upon the circumstances. Because of globalization, countries have radically changed their infrastructure in terms of either economics or sociology. This change might become the determinant of countries' comparative advantages which determine trade patterns in a different way.

The overview of empirical works and the applied of CGE on Trade and Environment analysis

Empirical work in trade and environmental analysis has undergone development since Grossman and Krueger (1991) tried to assess the impacts of NAFTA, especially in methodology and technique. A number of circumstances were captured by many economists and this widened knowledge in the area. For example, Celik and Orbay (2011) studied the location choice of industry under environment policies, by using game theory. They assumed that the South determines its import tariff rate and emission tax rate under an uncertainty of the North's marginal damage cost and the North then chooses between staying at home and sending FDI to the South. This kind of three-stages game shows that the South may be better off, if the marginal damage cost in the North is quite low. Interestingly, the optimal tax, in the case of the North sending FDI to the South, is higher than the marginal damage cost of the North itself. They explained this situation that the North has invested in the South already, so the government doesn't need to protect their industries anymore. Thus, the government would raise emission tax in order to gain the benefit. In addition, Bao, Chen, and Song (2011) also studied the relationship between FDI and environmental pollution in China. Like Grossman and Krueger (1991) and Grossman and Krueger (1994), they would like to capture the effect of scale, composition and technique in order to determine the net effect which can indicate what happens in China related to FDI. By using simultaneous equations to estimate those effects, the result appears to be that the technique effect of FDI can offset the scale and composition effect so FDI, in general, would reduce pollution in China.

Another positive aspect of trade effects on environment would show that free trade can promote environmental technology transfer due to avoiding the cost of pollution taxes in their country via technology transfer (Iida and Takeuchi, 2011). Benarroch and Weder (2006) were looking at intra-industry trade in intermediate products. Their findings illustrate that this kind of trade can lower pollution because of the increasing return technology in final goods production. Moreover, Cadarso, López, Gómez, and Tobarra (2012) proposed the new concept of responsibility on environment deterioration. They pointed out that, in international trade, it is not fair for firms, if we use the concept of producer responsibility basis and it is also not fair for consumers, if we use only consumer responsibility basis. The reason for this is that trading countries can reallocate their productions around their partners. Thus, it can be seen that some of them can take advantage from that. For this reason, Cadarso, López, Gómez, and Tobarra introduced the concept of shared environmental responsibility and how to calculate it. The idea is quite useful and combines either producer or consumer together to share their responsibility on their emissions.

Even though many instruments were used to conduct researches in the trade-environment nexus as we can be seen above, the general equilibrium analysis is widely used due to the ability to take all interactions of all agents into consideration. One of the techniques using general equilibrium basis is Computable General Equilibrium (CGE). The traditional CGE is used to analyze all impacts as a static model. Thus, the need of forecasting and knowing the long term effects would improve CGE into Dynamic CGE currently. The majority of Dynamic CGE studies assume agents are myopic. These agents do not take the future into their consideration in the current period. As a result, the recursive solutions of each period are generated and linked together with the evolution of capital stock (O'Ryan, Miguel, Miller, and Pereira, 2010). However, Rutherford and Tarr (2003) have compared the impact of regional trading arrangements for Chile between Static CGE analysis and Dynamic CGE analysis. The outcomes are not significant in disparity. Although this confirms that we can use either static or dynamic CGE, most studies in the area of the trade-environment nexus tend to use the dynamic one due to the ability to forecast long-run effect. The empirical work of Dessus and Bussolo (1998) is one of the studies using dynamic CGE to estimate the effect of trade liberalization and pollution abatement on the economy and welfare of Costa Rica. The negative effect of trade liberalization will cause a fall in welfare due to the strong scale effect shown in this study. This will occur, if it does not come with environmental reform and emission abatement policy.

Garbaccio, Ho, and Jorgenson (1999) attempted to forecast what would happen if China implements a controlling carbon emission policy by setting 3 targets of reduction; 5%, 10% and 15%. A dynamic economy-energy-environment model for China has been built and used to estimate the effects on both economic welfare and environment. They came up with the results that in the long-run CO_2 will decrease, while GDP and consumption increase. In fact, it would drop GDP in the first few years of implementation but after that, it will rise over the base-line due to their assumption about the inelastic supply of labor in China. This assumption describes the situation that when the real wage falls due to the high price induced from decreasing in GDP in the first policy implementation, the Chinese labor supply is still at the same level as usual (no distortion in the labor market). Consequently, growth can be back soon after and then rise over the base-line in the long-run.

Qin, Bressers, Su, Jia, and Wang (2011) also assessed the economic impact of China's environmental policy by focusing on water pollution mitigation policy. They used a dynamic CGE as a tool of analysis in four cases of reduction targets: 20%, 30%, 40% and 50%. The result from the CGE estimation indicated that China can achieve the target of 20%-30% emission reduction with low economic cost, and the water pollution mitigation policy would shift dirty-industries in China to clean-industries. Another point to note is that GDP and welfare might decrease sharply in the first few years of implementing the policy but they will gain back later, like Garbaccio, Ho, and Jorgenson (1999). However if China set their target at a 40-50 percent emission reduction, the results appear to be a larger economic cost. They further explained that if the target was high, the benefit of the reduction in emissions cannot offset the loss of dropping GDP and welfare. This outcome is agreed by the study of Wu, Deng, Zhan, Wu, and Li (2009). Using a multi-sectoral dynamic applied general equilibrium (MADGEM), they simulated the reduction of emission, such as nitrogen and phosphorus in a catchment in Mongolia. The simulation illustrated that in the short-run, there is a negative impact on economy as the prices of the economic go up due to an increasing cost of production but in the long-run, this impact could slightly increase the prices of the economic products. Thus, the impacts in the long-term will be lower.

In conclusion, the trade-environment nexus has been examined with a variety of econometric tools and methodologies in order to take the impacts between them into account. However, one of the instruments in economics, namely Computable General Equilibrium (CGE) has been become a popular tool among economists as it can capture not only interactions of all agents involved in the circumstances of Trade liberalization, Environmental regulation and Pollution but also long-run equilibrium with dynamic CGE.

The General Structure of GTAP Model

The Computable General Equilibrium (CGE) was developed from Applied General Equilibrium which converts the Walrasian General Equilibrium structure from an abstract version into realistic models of actual economies. In fact, the Walrasian general equilibrium model provides the effects analysis of changing resource allocation in an economic system owing to policy changes (Shoven; & Whalley, 1992). This equilibrium is revealed when supply and demand are equalized across all interconnected markets in the economy. However, the idea seemed complex and abstract so it had been enhanced and transformed to the applied general equilibrium. Finally, it is constructed as the Computable General Equilibrium in order to compute all effects in explicit form.

The CGE model is used to solve supply, demand, and price which support the equilibrium across a set of markets. It can handle either a single or multiple regions. The key standard agents in the CGE framework are households, firms, government and global sectors. Households provide factors to firm production and get their income from firm payments. Firms produce outputs for households and government and thus the revenues of firms come from those outputs. The government supports public goods and services to the economy which is financed by taxes from households and firms. Moreover, an additional agent has been included, namely environment, in order to capture the impacts on the environment in the system. Due to the externalities of production and consumption, the environment in an economy is affected and this in turn creates negative feedbacks to both firms and consumers, as illustrated in Figure 3.1.1 (Batabyal; & Nijkamp, 2011).

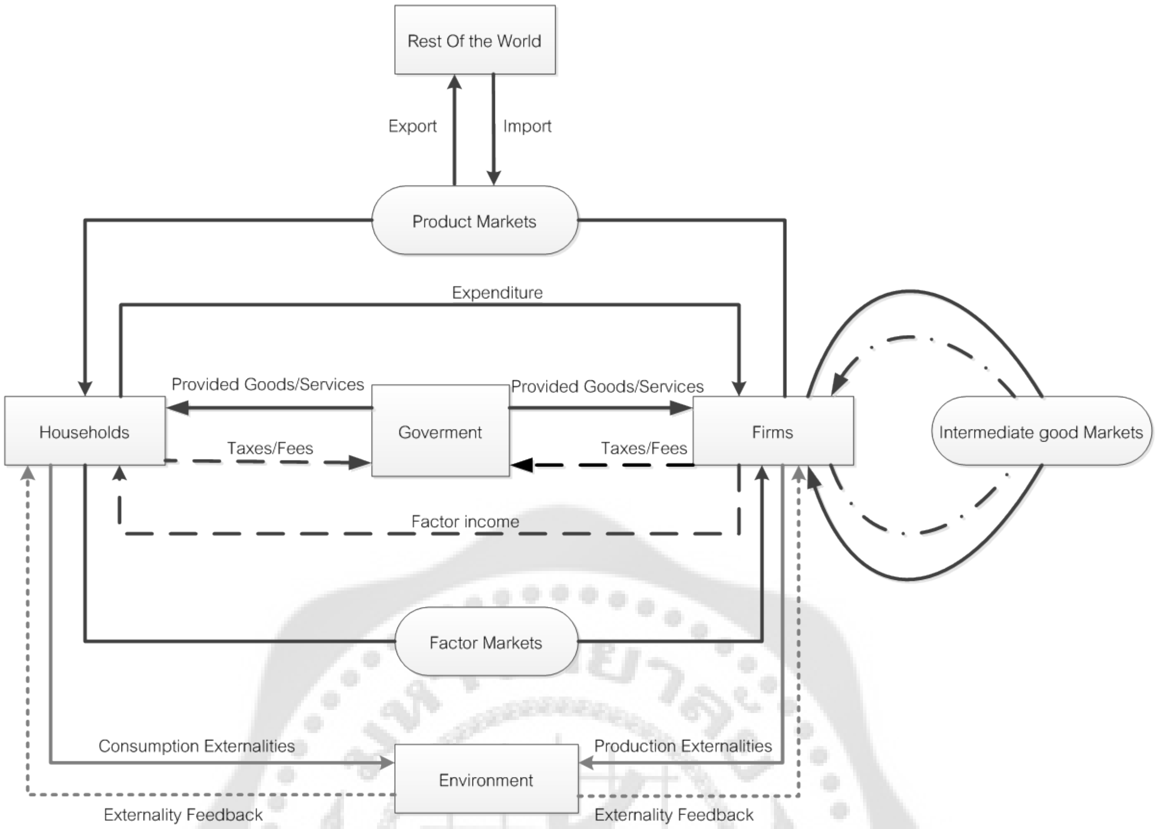

Figure 2 The circular flow of CGE model concept

Source: Amitrajeet A. Batabyal; & Peter Nijkamp. (2011)

Because the standard modeling framework is based on the theory of multi-regions, the applied general equilibrium model has to incorporate treatments of private household behavior, international trade, transport activity and global saving/investment relationship. Thus, a great variety of issues need to be addressed in the GTAP modeling framework, for example, trade policy reform, regional integration, energy policy, global climate change, technological progress and historical analysis of economic growth and trade.

In order to examine all effects in an economy, the number of GTAP model assumptions based on Walrasian equilibrium, and Walras's law were established. For instance, there are four sectors in the framework; 1) Industrial sector, 2) Household sector, 3) Government sector and 4) Global sector. Five important factors in the model are skilled labor, unskilled labor, capital, land and natural resources. The industrial sector does not require land factors except agricultural sector requires land in their production. Labor and land cannot be traded in markets while capital and intermediate inputs can. In addition capital is allowed to move over sectors within a region but cannot move across regions, similar to labor mobility in the GTAP model.

The behavior of firms is determined by minimizing costs of input given their level of output and fixed technology. The production functions are Leontief structure which means that the relationship between primary input and intermediate input is fixed. The relationship between intermediate input and output is also fixed. To derive factor input demand, the explicit form of constant return to scale technology (CRS) and nested constant elasticity of substation (CES) are used to solve this type of problem in the GTAP model. The input can be classified into two types; primary and intermediate input which are assumed separable technology. With these assumptions, the firm’s production level can be split into three levels. The top of the nested tree describes the fixed proportion between intermediate input and primary input. The middle level determines the combination of factors with CES and the firm’s decision about using intermediate input between domestic and foreign. The bottom level explains the supply of intermediate input. All three levels are shown in Figure 3.1.2 (Hertel, 1997).

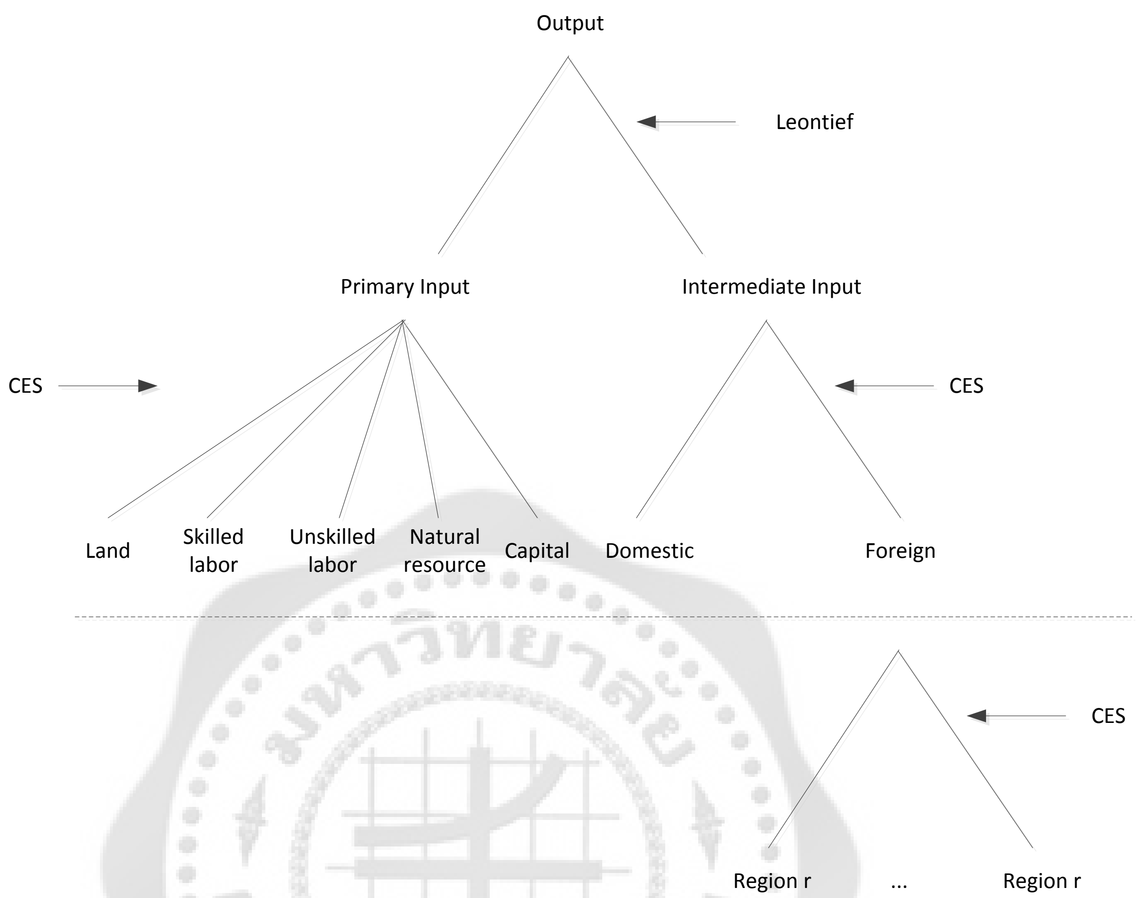

Figure 3 the three nested levels of production

Source: Thomas W. Hertel. (1997)

The regional household income is allocated by three sources of expenditure; 1) private household consumption 2) government expenditure and 3) national saving. The contribution proportion to each type of expenditures is assumed to be a constant budget share. Household behavior is determined with an aggregate utility function. The private households would like to maximize utility subject to their budget constraint. The optimization of behavior through the expenditure function is illustrated by the Constant Difference Elasticity (CDE) demand system which is easier to calibrate than the constant elasticity of substitution (CES) or the Linear Expenditure System (LES). However, the consumption bundles are CES combinations of domestic goods and import bundles as well as the import bundles are determined by the CES aggregation of imports from different regions as shown in figure 4.

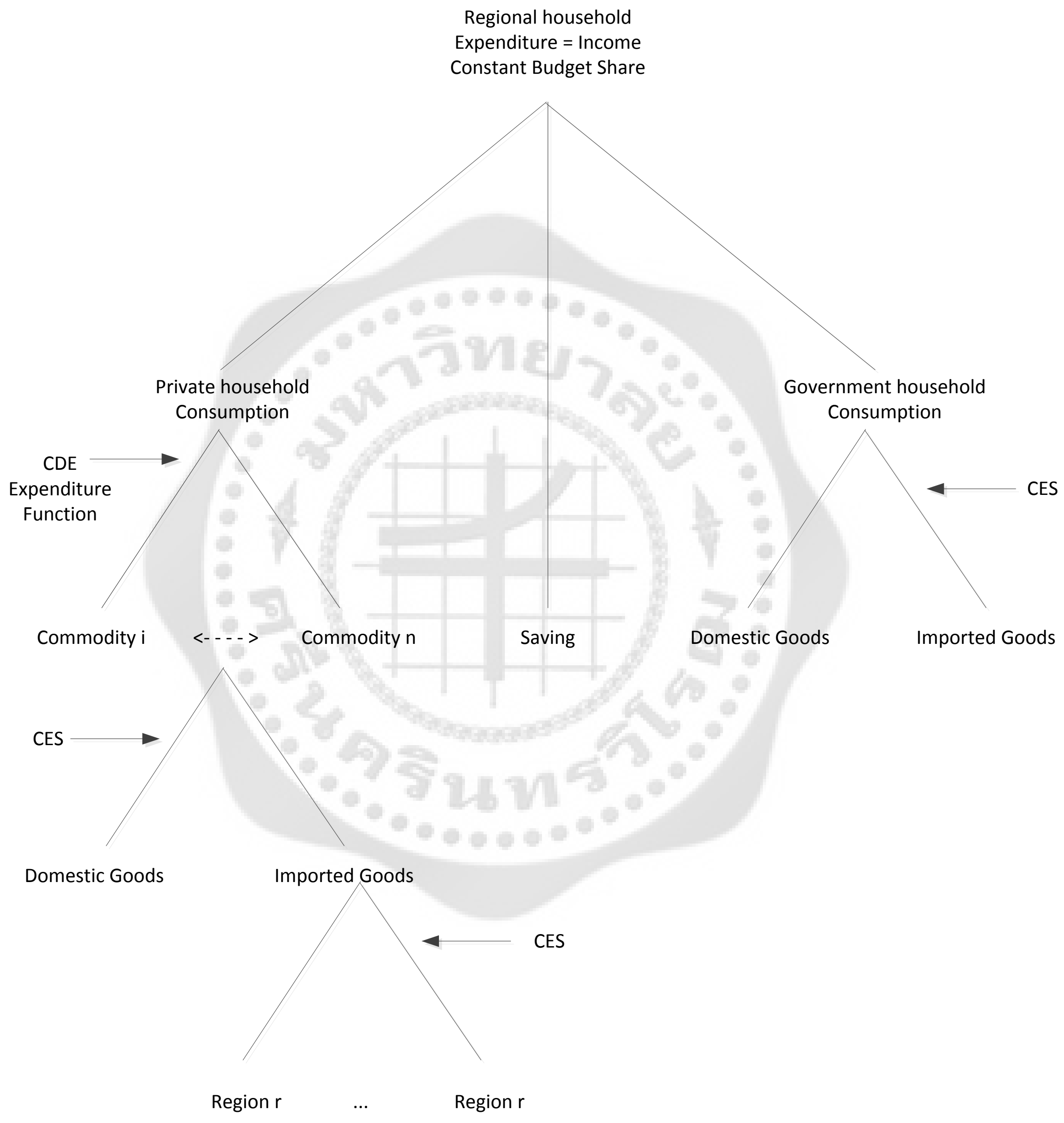

Figure 4 the structure of regional expenditure and income

Source: Thomas W. Hertel (1997)

Demand and supply are equal in all markets. This represents perfect competitive character. According to the equilibrium and Walras' law, if an excess supply exists, the price of that commodity would decrease so that the demand would increase and lead to a clear market. The intervention of government is imposed to an economy through tax and subsidy policies which are modeled as ad valorem equivalent.

There are two global sectors in the standard model, namely transportation and banking. The transportation sector takes the difference in the price of commodities between countries into their decisions and the banking sector would focus on the equilibrium of saving and investment. For more information, see Hertel (1997)

In equilibrium, there are three conditions which must exist; 1) all firms have zero profit, 2) all households reach their maximum utility on their budget constraint, and 3) global investment is equal to global saving. These conditions will occur, if closures are defined properly. The closures are crucial in the GTAP model. They are used to define the variables, whether endogenous or exogenous variables. The modeler could then shock the exogenous variable in the model. One thing to note is that the modeler has to define the number of endogenous variables equalizing to the number of equations, otherwise the model cannot be solved (Thomassin;& Mukhopadhyay, 2007; & 2010).

The integration of ASEAN and the analysis of impacts

The developing of trade has been rapidly changing for several decades. In the past, it was limited just in a country's border and then became trade between countries with a large number of barriers such as import/export tariff and nontariff barriers. However, these trade barriers are decreasing continually in order to encourage more trade activities. Currently, trade jumps to become a new regime: trade liberalization among a group of nations. The integrated regions will eliminate all trade barriers to zero either tariff or nontariff. European Union is a good example of region integration. They started with the European community and have now adapted their relation into the European Union (EU). This was followed by North American Free Trade (NAFTA) which stemmed from an attempt by the US, Canada and Mexico to strengthen their competitive advantage in the world market.

The radical change of trade in the world would be observed by Southeast Asian nations and put pressure on them to think about the integration of their region as well. Consequently, the ASEAN Declaration (Bangkok Declaration) was signed in order to form the Association of Southeast Asian Nations (ASEAN) in 1967. At that time, ASEAN consisted of Indonesia, Malaysia, Philippines, Singapore and Thailand. They were then joined by Brunei Darussalam, Viet Nam, Lao PDR, Myanmar and Cambodia. Currently there are ten member nations now in ASEAN (ASEAN, 2013).

Since ASEAN was officially established, there has been much progress in terms of achieving the ASEAN 2020 vision[4]. The ASEAN Community stems from the enhancing coalition among ASEAN, and has to be established by 2015. The community

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[4] The vision is of ASEAN as a concert of Southeast Asian nations, outward looking, living in peace, stability and prosperity, bonded together in partnership in dynamic development and in a community of caring societies.

comprises of three sub communities; the ASEAN Political-Security Community, the ASEAN Economic Community and the ASEAN Socio-Cultural Community. In particular, the ASEAN Economic Community (AEC) focuses on regional economic integration so that it supports for the missions: a single market and production base, a highly competitive economic region, a region of equitable economic development, and a region fully integrated into the global economy. As a result, AEC will lead ASEAN to a region with free movement of goods, services, investment, skilled labor, and freer flow of capital.

As ASEAN is becoming the ASEAN Community by 2015, there were many studies on the impact. Many papers were written in terms of the impacts on either an individual country or a whole region. For example, Philippines was interested in the effects of trade policy on their environment by using a simulation model. The result showed that the abatement cost may reduce due to trade reforms so Philippines could gain from it (Medalla, 2001). By contrast, the study on economic and environmental impacts of trade liberalization in Indonesia indicated the negative side of freer trade rather than positive ones (Gumilang, Mukhopadhyay, and Thomassin, 2011). The authors claimed that although the trade agreement might raise Indonesian output by 263 percent by 2022, it might be followed by a great deterioration of the environment with CO_2 emission growing by 731 percent. Moreover, Shuia and Harriss (2006) indicated how much CO_2 embeds in US-China trade. They revealed that the US can avoid releasing CO_2 emissions by importing goods from China by 3-6 percent while China has increased the CO_2 emission in its country by 7-14 percent in order to export goods to the US. The findings also showed that US-China trade raised global CO_2 emissions to approximately 720 million metric tons over the period of 1997-2003.

From these individual country impact studies, there are both negative and positive sides of trade liberalization as we have discussed earlier. However, the impacts of trade liberalization in terms of a whole region analysis were conducted as well. For example, Kitwiwattanachai, Nelson, and Reed (2010) studied the impact of the Free Trade Area by comparing ASEAN-China, ASEAN-Japan, ASEAN-Korea and the Multilateral Agreement of those countries. By using a Computable General Equilibrium (CGE), the result revealed that the multilateral agreement yields better gain in welfare and economic terms than bilateral agreements. However, their methodology does not internalize the impact of environmental degradation, so it might be an overestimation of the benefit. In addition, Thomassin and Mukhopadhyay (2007) used GTAP modeling to estimate the impact of East-Asian Free Trade (China, Indonesia, Japan, the Republic of Korea, Thailand and Vietnam) on the GDP of the individual countries, and industrial output. The paper also examines effects of East-Asian Free Trade on the environment through selective environmental indicators such as air pollution (CO_2, N_2O, and CH_4), water pollution (BOD, COD, and Suspended Solids), and industrial waste for these countries based on scenarios: 1) the trading countries decrease their tariff rate by 20% in agriculture products and 50% for others. 2) the trading countries cut their tariff rate by 80% in agricultural products and 100% for others. The findings illustrated a positive impact on their integration as East-Asian nations can gain higher economic growth when they combine together, like the findings of Kitwiwattanachai, Nelson, and Reed (2010). By contrast, the nonintegrated countries have lower industrial output compared to the business as usual case. In the meantime, the emission effect results showed that the scale effects play a significant role on increasing pollutants across East-Asian states but the role of technology and composition effects are fluctuation. Thus, they cannot support the pollution haven hypothesis.

Another two interesting studies regarding trade liberalization through nation integration regimes belong to Kojima and Bhattacharya (2007), and Petri, Plummer, and Zhai (2012). The first examined the Environment Impact Assessment (EIA) of future regional economic integration in East Asia. At that time, there was uncertainty of the possibility of integration across East Asia countries so the authors aim to show the different impacts between the shallow integration (few trade barriers case) and the deep integration of East Asia (no trade barrier case) on an economic and environmental context. In terms of economy, Thailand and Singapore are the two highest countries in GDP growth, whereas China, Japan, South Korea, the Rest of ASEAN, the Rest of OECD, and the Rest of the world will reduce their nominal GDP slightly in 2015. Moreover, the ferrous metals and the electricity sectors will be the two highest in CO_2 emissions. The second study focused on only ASEAN member nations which will become the ASEAN Economic Community (AEC) by 2015. Like the study of Kojima and Bhattacharya (2007), the authors used the CGE technique and Global Trade Analysis Project (GTAP) database. This study attempted to estimate the benefit of liberalizing trade and FDI in the AEC and the results revealed that the AEC could raise real income by 5.3 percent, like the European Community (EC). In fact, it may show larger gains than this if it leads to new trade agreements with key partners. However, this study did not take the reflections of environmental deterioration into consideration otherwise the AEC may need to rethink about these factors in order to see a net gain from all aspects including an environmental context.

In general, an integration of countries in order to gain from trade liberalization has spread widely in many parts of the world even though both negative and positive sides are shown in several studies. Nevertheless, most of the integrating countries could increase their income which is the first priority of social planners. This is why they tend to integrate and become part of an Economic Community in particular, ASEAN Economic Community (AEC). It has to be established by 2015 with a concept of single market and single production system. Thus, it is obvious that ASEAN member states may gain from increasing economic activities. However the community would be more effective if it comes with an appropriate environmental policy as mentioned before. For this reason, there is still a need to assess the effects of imposing an emission policy in the regions in order to maximize benefit both in terms of economic and emission views.

CHAPTER 3

METHODOLOGY

As the world economy has undergone change and becomes more comprehensive, there have been a huge number of activities and reactions from agents who try to benefit from trade. Obviously, some of them could gain from that, but others may lose especially from environmental impacts coming with trade. This creates the need for a study of the impact induced from not only new trade regimes, but also environmental policy. Regarding the ASEAN Community, plenty of efforts were made to encourage trade in the region and out by integrating into the ASEAN Community. These attempts would bring many changes which need to be analyzed.

In order to investigate this, the crucial methods are constructed in this dissertation. They have to take all agents including their interactions into consideration. Therefore, the partial equilibrium is not included in this study due to the inability to cover those actions simultaneously as well as the Input-Output technique which could not take into account price change. As a result, it is not used in the study (Hertel, 1997).

For this reason, the Computable General Equilibrium (CGE) is utilized to capture those effects. It is widely used in many areas of trade and environmental issues. Its concept is based on a Walrasian general equilibrium in which all markets are clear in all commodities in a set of relative prices. There are several advantages of CGE. Firstly, the model of industrial sectors is explicit, and linkages of sectors and feedback actions are defined. Secondly, both tariff and non-tariff barriers are taken into account. Thirdly, price plays a main role in the system in which either industrial sectors or consumers could adjust their actions responding to the price change. Fourthly, the behavior of trade in the model can be changed to acknowledge an imperfect substitution between domestic and international products (Thomassin and Mukhopadhyay, 2007).

The CGE model used in this study is built by the Global Trade Analysis Project (GTAP) at Purdue University, in the US. This project was established in 1992 and its aim was to lower the cost of carrying quantitative research in international economic issues (Hertel, 1997). GTAP has been used in many parts of the world because it provides not only comprehensive economic models with flexible construction, but also a wide range of data from each country. The massive database of GTAP consists of many kinds of information for example, input-output tables, bilateral trades, transport, and protection matrices. These are contributed from many sources under reconciliation processes which will be addressed in detail in section 3.3.

Most CGE applications use comparative static models to analyze in order to interpret impacts at only one period of time. However, the long-run forecasting, and the trend of impacts are still needed and lead to an analysis of the Dynamic CGE model which has become popular over the last decade. Dessus and Bussolo (1998), Garbaccio, Ho, and Jorgenson (1999), Qin, Bressers, Su, Jia, and Wang (2011), and O'ryan, Miguel, Miller, and Pereira (2011) are all good cases of using dynamic CGE to be an analysis tool due to an ability to capture long-run effects of an emission policy.

The aim of this chapter was to propose research methodology and data preparation which were used in this dissertation. The first section showed the transition from a GTAP standard model to a GTAP dynamic model which is called GDyn Model. This was followed by describing the GTAP database and the aggregation for being used in this study. The method of emission estimation then was showed through air pollution indicators. The scenarios were also constructed in order to analyze impacts both on

ASEAN and non-ASEAN regions. The last part of this chapter provided an explanation of the simulations and projections of data.

GTAP Dynamic Model (GDyn Model)

As GTAP standard model was a static analysis model, the results from a simulation could present impacts in only one period of time. In addition, one of the assumptions in the standard model which reflects an unrealistic circumstance in regional integration was that the capital is not allowed across regions. This would impose difficult work on that model. First, it was difficult to analyze policy shocks and seems to be hard work examination in the case of investment from foreign countries. Moreover, the implication of long-run analysis was not possible and cannot forecast effects in the steady state. As a result, the policy planners would have a lack of information to support their decision. For this reason, there was a need for dynamic analysis of the GTAP model and the so-called GDyn or Dynamic GTAP model was then established by Ianchovichina and McDougall (2000). They introduced the disequilibrium approach into the GTAP standard model by extending international capital mobility, capital accumulation, and an adaptive expectations theory of investment.

The GDyn is a recursive dynamic model which solves the problem in each period of time. The outcome in the previous period will have an effect on capital accumulation in the next period. Thus, the capital accumulation plays a main role in long-run equilibrium. In fact, this concept is based on the disequilibrium of capital investment. In other words, in a perfect competitive market, the capital would mobilize in the countries that have high return of investment, and finally, the rate of return must be equal among countries. This circumstance might not be realistic as we could see a disparity in the rate of return generally. Ianchovichina and McDougall had concerned in this point and introduced the concept of disequilibrium by imposing an expectation error in the rate of return. The expectation error is gradually reduced in the long-term so the dynamic analysis can be taken into account. With this idea, the GDyn could show the result in disequilibrium at the first few periods of the analysis time, and could forecast the effects in an equilibrium which could happen in the long-run.

Hence, the treatment of time is as a continuous time so the wealth accumulation equation is defined as shown in eq. 3.2.1

$$K = K_0 + \int_{T_0}^{T} I(\tau)d\tau \qquad \text{eq. 3.2.1}$$

where K is the capital stock, K_0 is the capital stock at some base time T_0, and I denotes the net investment.

GTAP-Dyn model then uses this concept of this time treatment applying with the capital accumulation as shown in eq. 3.2.2

$$QK = QK_0 + \int_{Time_0}^{Time} QCGDSNET d\tau \qquad \text{eq. 3.2.2}$$

where $QK(r)$ represents the capital stock in region r, $QK_0(r)$ is the capital stock at some base time $Time_0$, $Time$ is current time, and $QCGDSNET(r)$ denotes the net investment. After taking total differentiation, we obtain eq.3.2.3

$$QK(r)\frac{qk(r)}{100} = QCGDSNET(r).time \qquad \text{eq. 3.2.3}$$

where $qk(r)$ represents percentage change in the capital stock in region r, and $time$ is change in time. By multiplying both side by one hundred times the price of capital goods, we obtain eq.3.2.4

$$VK(r).qk(r) = 100\, NETINV(r).time \qquad \text{eq. 3.2.3}$$

where $VK(r)$ represents the money value of the capital stock in region r, and $NETINV$ is the money value of net investment.

In a static simulation, the $time$ variable is equal to zero. Thus, from eq. 3.2.3, the percentage change in the capital stock qk is also implied to be zero as VK is supposed to be positive value. For this reason, the dynamic model used in GTAP introduces some non-zero change in capital stocks so that the equilibrium could occur in the long-run as mentioned above.

The Data

This dissertation mainly employed GTAP data base version 8.1 and uses information in 2007 as a base year. This version is the latest update and complemented with the emission data of carbon dioxide (CO_2) as well. The GTAP database contains an enormous amount of data including input-output tables, trade data, bilateral agreements, and transportation information. Apart from the wide range of data provided in GTAP database, it is reliable and consistent with the process of updating data and data reconciliation. As it combines all world economies, the data comes from many sources such as the United Nation (UN) Statistical Office which provides information for COMTRADE (Commodity Trade), and partner countries which provide input-output tables of their country. For more detail see Hertel (1997).

GTAP database version 8.1 is currently up to date with two base years; 2004 and 2007. Actually, there are four basic data files namely set file, parameter file, main data file and energy volume file. The extra data file is CO_2 emission data which was first included with the GTAP version 8. As a result, the GTAP version 8.1 will be appropriated for this study in order to simulate impacts on total changes in emissions. However, we still need more data about other air pollution indicators to measure environmental degradation, such as methane (CH_4), nitrous oxide (N_2O), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}). These indicators can be divided into three groups 1) CO_2 GHGs (CO_2) 2) non-CO2 GHGs (CH_4, and N_2O) 3) non-GHG air emission pollutants (SO_2, NO_2, and PM_{10}). The first two groups could represent the global warming issue and the non-GHG air pollutants can illustrate the air quality issue. Thus, these 3 kinds of air indicators have effects on not only the environment but also human health.

This section provides general information of the five data files (set, parameter, main data, and energy volume) in GTAP version 8.1 and air pollution indicator data for estimating emissions in each region after imposing an emission policy.

Firstly, the set file in GTAP consists of arrays of basic information. For example, an array of regions which have been included in GTAP for 134 regions around the world, an array of trade commodities which accounted for 57 sectors, and an array of endowment commodities or primary factors which include skilled labor, unskilled labor, capital, land and natural resource. In this study, the regions are aggregated into 18 new regions, as presented in table 4, and also the sectors are aggregated into 14 new sectors as shown in table 5.

Table4 GTAP regions and the aggregation of the study's regions

No.	Old Code	Region Description	No.	New Code	Region Description
1	aus	Australia	1	AUS	Australia
2	nzl	New Zealand	2	NZL	New Zealand
3	xoc	Rest of Oceania	9	ROW	Rest Of the World
4	chn	China	3	CHN	China
5	hkg	Hong Kong	9	ROW	Rest Of the World
6	jpn	Japan	6	JPN	Japan
7	kor	Korea	7	KOR	Korea Republic
8	mng	Mongolia	9	ROW	Rest Of the World
9	twn	Taiwan	9	ROW	Rest Of the World
10	xea	Rest of East Asia	9	ROW	Rest Of the World
11	khm	Cambodia	11	KHM	Cambodia
12	idn	Indonesia	10	IDN	Indonesia
13	lao	Lao People's Democratic Republ	12	LAO	Lao Peoples's Democratic Rep
14	mys	Malaysia	13	MYS	Malaysia
15	phl	Philippines	14	PHL	Philippines
16	sgp	Singapore	15	SGP	Singapore
17	tha	Thailand	16	THA	Thailand
18	vnm	Viet Nam	17	VNM	Viet Nam
19	xse	Rest of Southeast Asia	18	XSE	Rest of Southeast Asia
20	bgd	Bangladesh	9	ROW	Rest Of the World
21	ind	India	5	IND	India
22	npl	Nepal	9	ROW	Rest Of the World
23	pak	Pakistan	9	ROW	Rest Of the World
24	lka	Sri Lanka	9	ROW	Rest Of the World
25	xsa	Rest of South Asia	9	ROW	Rest Of the World
26	can	Canada	9	ROW	Rest Of the World
27	usa	United States of America	8	USA	United States of America
28	mex	Mexico	9	ROW	Rest Of the World
29	xna	Rest of North America	9	ROW	Rest Of the World
30	arg	Argentina	9	ROW	Rest Of the World
31	bol	Bolivia	9	ROW	Rest Of the World
32	bra	Brazil	9	ROW	Rest Of the World
33	chl	Chile	9	ROW	Rest Of the World
34	col	Colombia	9	ROW	Rest Of the World
35	ecu	Ecuador	9	ROW	Rest Of the World
36	pry	Paraguay	9	ROW	Rest Of the World
37	per	Peru	9	ROW	Rest Of the World
38	ury	Uruguay	9	ROW	Rest Of the World
39	ven	Venezuela	9	ROW	Rest Of the World
40	xsm	Rest of South America	9	ROW	Rest Of the World
41	cri	Costa Rica	9	ROW	Rest Of the World
42	gtm	Guatemala	9	ROW	Rest Of the World
43	hnd	Honduras	9	ROW	Rest Of the World
44	nic	Nicaragua	9	ROW	Rest Of the World

Table 4 GTAP regions and the aggregation of the study's regions (Continued)

No.	Old Code	Region Description	No.	New Code	Region Description
45	pan	Panama	9	ROW	Rest Of the World
46	slv	El Salvador	9	ROW	Rest Of the World
47	xca	Rest of Central America	9	ROW	Rest Of the World
48	xcb	Caribbean	9	ROW	Rest Of the World
49	aut	Austria	4	EUR	Europe
50	bel	Belgium	4	EUR	Europe
51	cyp	Cyprus	4	EUR	Europe
52	cze	Czech Republic	4	EUR	Europe
53	dnk	Denmark	4	EUR	Europe
54	est	Estonia	4	EUR	Europe
55	fin	Finland	4	EUR	Europe
56	fra	France	4	EUR	Europe
57	deu	Germany	4	EUR	Europe
58	grc	Greece	4	EUR	Europe
59	hun	Hungary	4	EUR	Europe
60	irl	Ireland	4	EUR	Europe
61	ita	Italy	4	EUR	Europe
62	lva	Latvia	4	EUR	Europe
63	ltu	Lithuania	4	EUR	Europe
64	lux	Luxembourg	4	EUR	Europe
65	mlt	Malta	4	EUR	Europe
66	nld	Netherlands	4	EUR	Europe
67	pol	Poland	4	EUR	Europe
68	prt	Portugal	4	EUR	Europe
69	svk	Slovakia	4	EUR	Europe
70	svn	Slovenia	4	EUR	Europe
71	esp	Spain	4	EUR	Europe
72	swe	Sweden	4	EUR	Europe
73	gbr	United Kingdom	4	EUR	Europe
74	che	Switzerland	9	ROW	Rest Of the World
75	nor	Norway	9	ROW	Rest Of the World
76	xef	Rest of EFTA	9	ROW	Rest Of the World
77	alb	Albania	9	ROW	Rest Of the World
78	bgr	Bulgaria	4	EUR	Europe
79	blr	Belarus	9	ROW	Rest Of the World
80	hrv	Croatia	9	ROW	Rest Of the World
81	rou	Romania	4	EUR	Europe
82	rus	Russian Federation	9	ROW	Rest Of the World
83	ukr	Ukraine	9	ROW	Rest Of the World
84	xee	Rest of Eastern Europe	9	ROW	Rest Of the World
85	xer	Rest of Europe	9	ROW	Rest Of the World
86	kaz	Kazakhstan	9	ROW	Rest Of the World
87	kgz	Kyrgyztan	9	ROW	Rest Of the World
88	xsu	Rest of Former Soviet Union	9	ROW	Rest Of the World
89	arm	Armenia	9	ROW	Rest Of the World

Table 4 GTAP regions and the aggregation of the study's regions (Continued)

No.	Old Code	Region Description	No.	New Code	Region Description
90	aze	Azerbaijan	9	ROW	Rest Of the World
91	geo	Georgia	9	ROW	Rest Of the World
92	bhr	Bahrain	9	ROW	Rest Of the World
93	irn	Iran Islamic Republic of	9	ROW	Rest Of the World
94	isr	Israel	9	ROW	Rest Of the World
95	kwt	Kuwait	9	ROW	Rest Of the World
96	omn	Oman	9	ROW	Rest Of the World
97	qat	Qatar	9	ROW	Rest Of the World
98	sau	Saudi Arabia	9	ROW	Rest Of the World
99	tur	Turkey	9	ROW	Rest Of the World
100	are	United Arab Emirates	9	ROW	Rest Of the World
101	xws	Rest of Western Asia	9	ROW	Rest Of the World
102	egy	Egypt	9	ROW	Rest Of the World
103	mar	Morocco	9	ROW	Rest Of the World
104	tun	Tunisia	9	ROW	Rest Of the World
105	xnf	Rest of North Africa	9	ROW	Rest Of the World
106	ben	Benin	9	ROW	Rest Of the World
107	bfa	Burkina Faso	9	ROW	Rest Of the World
108	cmr	Cameroon	9	ROW	Rest Of the World
109	civ	Cote d'Ivoire	9	ROW	Rest Of the World
110	gha	Ghana	9	ROW	Rest Of the World
111	gin	Guinea	9	ROW	Rest Of the World
112	nga	Nigeria	9	ROW	Rest Of the World
113	sen	Senegal	9	ROW	Rest Of the World
114	tgo	Togo	9	ROW	Rest Of the World
115	xwf	Rest of Western Africa	9	ROW	Rest Of the World
116	xcf	Central Africa	9	ROW	Rest Of the World
117	xac	South Central Africa	9	ROW	Rest Of the World
118	eth	Ethiopia	9	ROW	Rest Of the World
119	ken	Kenya	9	ROW	Rest Of the World
120	mdg	Madagascar	9	ROW	Rest Of the World
121	mwi	Malawi	9	ROW	Rest Of the World
122	mus	Mauritius	9	ROW	Rest Of the World
123	moz	Mozambique	9	ROW	Rest Of the World
124	rwa	Rwanda	9	ROW	Rest Of the World
125	tza	Tanzania	9	ROW	Rest Of the World
126	uga	Uganda	9	ROW	Rest Of the World
127	zmb	Zambia	9	ROW	Rest Of the World
128	zwe	Zimbabwe	9	ROW	Rest Of the World
129	xec	Rest of Eastern Africa	9	ROW	Rest Of the World
130	bwa	Botswana	9	ROW	Rest Of the World
131	nam	Namibia	9	ROW	Rest Of the World
132	zaf	South Africa	9	ROW	Rest Of the World
133	xsc	Rest of South African Customs	9	ROW	Rest Of the World
134	xtw	Rest of the World	9	ROW	Rest Of the World

Table 5 GTAP sectors and the aggregation of new sectors in the study

No.	Old Code	Sector Description	No.	New Code	Sector Description
1	pdr	Paddy rice	1	Agr	Primary Agric., Forestry...
2	wht	Wheat	1	Agr	Primary Agric., Forestry...
3	gro	Cereal grains nec	1	Agr	Primary Agric., Forestry...
4	v_f	Vegetables, fruit, nuts	1	Agr	Primary Agric., Forestry...
5	osd	Oil seeds	1	Agr	Primary Agric., Forestry...
6	c_b	Sugar cane, sugar beet	1	Agr	Primary Agric., Forestry...
7	pfb	Plant-based fibers	1	Agr	Primary Agric., Forestry...
8	ocr	Crops nec	1	Agr	Primary Agric., Forestry...
9	ctl	Cattle,sheep,goats,horses	1	Agr	Primary Agric., Forestry...
10	oap	Animal products nec	1	Agr	Primary Agric., Forestry...
11	rmk	Raw milk	1	Agr	Primary Agric., Forestry...
12	wol	Wool, silk-worm cocoons	1	Agr	Primary Agric., Forestry...
13	frs	Forestry	1	Agr	Primary Agric., Forestry...
14	fsh	Fishing	1	Agr	Primary Agric., Forestry...
15	coa	Coal	2	Coal	Coal mining
16	oil	Oil	3	Oil	Crude Oil
17	gas	Gas	4	Gas	Natural gas extraction
18	omn	Minerals nec	7	CMnf	Capital-Intensive Manufactures
19	cmt	Meat: cattle,sheep, goats,horse	11	Pcf	Processd Food
20	omt	Meat products nec	11	Pcf	Processd Food
21	vol	Vegetable oils and fats	11	Pcf	Processd Food
22	mil	Dairy products	11	Pcf	Processd Food
23	pcr	Processed rice	11	Pcf	Processd Food
24	sgr	Sugar	11	Pcf	Processd Food
25	ofd	Food products nec	11	Pcf	Processd Food
26	b_t	Beverages and tobacco products	11	Pcf	Processd Food
27	tex	Textiles	9	LMnf	Labor-Intensive Manufactures
28	wap	Wearing apparel	9	LMnf	Labor-Intensive Manufactures
29	lea	Leather products	9	LMnf	Labor-Intensive Manufactures
30	lum	Wood products	9	LMnf	Labor-Intensive Manufactures
31	ppp	Paper products, publishing	7	CMnf	Capital-Intensive Manufactures
32	p_c	Petroleum, coal products	5	Oil_pcts	Refined oil products
33	crp	Chemical,rubber, plastic prods	7	CMnf	Capital-Intensive Manufactures
34	nmm	Mineral products nec	7	CMnf	Capital-Intensive Manufactures
35	i_s	Ferrous metals	7	CMnf	Capital-Intensive Manufactures
36	nfm	Metals nec	7	CMnf	Capital-Intensive Manufactures
37	fmp	Metal products	9	LMnf	Labor-Intensive Manufactures
38	mvh	Motor vehicles and parts	9	LMnf	Labor-Intensive Manufactures
39	otn	Transport equipment nec	9	LMnf	Labor-Intensive Manufactures
40	ele	Electronic equipment	9	LMnf	Labor-Intensive Manufactures

Table 5 GTAP sectors and the aggregation of new sectors in the study (Continued)

No.	Old Code	Sector Description	No.	New Code	Sector Description
41	ome	Machinery and equipment nec	9	LMnf	Labor-Intensive Manufactures
42	omf	Manufactures nec	9	LMnf	Labor-Intensive Manufactures
43	ely	Electricity	6	Electricity	Electricity
44	gdt	Gas manufacture, distribution	4	Gas	Natural gas extraction
45	wtr	Water	14	Util_Cns	Utilities and Construction
46	cns	Construction	14	Util_Cns	Utilities and Construction
47	trd	Trade	13	Trans_Comm	Transportation & Communication
48	otp	Transport nec	13	Trans_Comm	Transportation & Communication
49	wtp	Sea transport	13	Trans_Comm	Transportation & Communication
50	atp	Air transport	13	Trans_Comm	Transportation & Communication
51	cmn	Communication	13	Trans_Comm	Transportation & Communication
52	ofi	Financial services nec	12	Svces	Private Financial & Other Serv
53	isr	Insurance	12	Svces	Private Financial & Other Serv
54	obs	Business services nec	12	Svces	Private Financial & Other Serv
55	ros	Recreation and other services	12	Svces	Private Financial & Other Serv
56	osg	PubAdmin/Defence/ Health/Educat	10	Osg	Public Services
57	dwe	Dwellings	8	Dwe	Dwelling

Secondly, the parameter file contains two types: behavior parameters and one switch parameter. The examples of the formers are the elasticity of substitution between domestic and import product, and the elasticity of substitution between imports from different regions. The latter parameter is a binary switch mechanism of allocating investment funds.

Thirdly, the main data file provides important data, in particular trade data. It comprises of dollar values of flows of goods and services, for instance domestic purchases by firms, and consumption expenditure by household.

Finally, the energy data file illustrates the energy volume purchased by firms and households as well as the volume of bilateral trade in energy products. For example, the data of energy commodities, the volume of domestic input purchased by firms, the volume of import by government and the volume of bilateral trade.

Turning to the data of air pollution indicators, they are obtained from many sources either the GTAP data base itself or other empirical papers. For example the CO_2 emissions data file is embedded in GTAP data base version 8.1 already. In fact, GTAP provides data of CO_2 emission not only in terms of emission from production but also the emission trade among countries. This would enhance the ability to simulate the effect on CO_2 emission from the GTAP model directly. In addition, the data of other indicators are employed from other studies. For example, Rose and Lee (2008) provided the data of non-CO2 GHGs such as methane (CH_4) and nitrous (N_2O) complied with the GTAP version 6 structure. Moreover, the non-GHG air pollutant emission data such as SO_2, NO_2, and PM_{10} could be extracted from The Industrial Pollution Projection System (IPPS) which is a modeling system with a pollution emission data base. The IPPS database was very useful due to providing pollution intensities in sectors in the US based on International Standard Industrial Classification (ISIC).

Although the IPPS database represented SO_2, NO_2, and PM_{10} emissions in each sector with a unit of pounds/1987 US$ million output value, it cannot be used in this study directly owing to differences in advanced technology between the US and ASEAN states. For this reason, this dissertation will customize the data to take this kind of difference into account by weighting the data with technology different parameters between the US and other countries provided in the paper of Trefler (1993). However, the detail of estimating total emissions and emission intensities will be discussed in the next section.

Another important point to note is that as the impacts of imposing an emission policy in ASEAN and China may need a long time to be revealed through both economic and emission change, this paper needs to take long-run impacts into consideration. That is why the database has to support the simulations with dynamic analysis as well. The GDyn database is a utility database compatible with GTAP data base version 8.1. It extends the standard data base by adding three important parts to serve the inter-temporal decision of capital accumulation in disequilibrium approach as mentioned before (McDougall, Walmsley, Golub, Ianchovichina and Itakura, 2012).

Firstly, the six new arrays are combined with the standard one. They are used to keep data of normal capital growth rate (KHAT), target gross rate of return (RRGT), income from equity paid to regional household by the trust (YQHT), income from equity paid to the trust by domestic firms in the region (YQTF), and income from equity paid to households by domestic firms (YQHF). Secondly, the seven new behavioral parameters are used in this data base utility. They describe the initial income in million US dollars (INC), the lagged adjustment parameters including the coefficient of adjustment and actual rate of return (LAMBORG), the coefficient of adjustment in expected rate of return (LAMRORGE) and the coefficient of adjustment in perceived normal growth rate of capital stock (LAMBKHAT). The fifth parameter is the elasticity of rate of return to capital with respect to capital stock (RORGFLEX). The last two parameters are the rigidity of allocation of wealth by regional household (ROGWQH) and the rigidity of source of funding of enterprises. These rigidity parameters have been estimated within the GTAP model already. For more detail see McDougall, Walmsley, Golub, Ianchovichina and Itakura (2012).

The environmental quality indicators and the estimations

The present study focuses on air pollution for assessing the impact of the ASEAN community on environmental aspects as it appears to be a more serious issue now due to impacts on either global warming or human health. Hence, six air pollution indicators are obtained to represent the quality of the environment after ASEAN and China implement emission policy in their regions under the establishment of the ASEAN community and Free trade Agreements. Three of them are Green House Gases (GHGs): Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O) while the others are non-GHG air pollutants, namely Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), and Fine Particulate matter (PM_{10}). All of these have specific characteristic and effects as follows:

1. Carbon Dioxide (CO_2) is one of the Greenhouse Gases which could impact on global warming and this in turn contributes to the climate change issue. CO_2 has been growing sharply particularly in the ASIA region which accounted for at least 30 percent of the world CO_2 emission in 2010 (Clean Air Asia, 2012). In fact, 23 percent of such emissions came from the transportation sector (Schipper, Fabian, and Leather, 2009) as well as electricity and heat productions were the most contributing sector of emissions and accounted for 41 percent.

2. Methane (CH_4) is Greenhouse Gas which shares a vast majority of GHG emission in the world. It can be emitted by natural sources such as wetland and human activities, for example, leakage from natural gas systems and the raising of livestock (EPA, 2013). However, economic activities are also the main source of methane emission such as productions from industry and agriculture as well as waste management activities. In fact, methane emission can be reduced by natural processes, for instance soil and chemical reactions in the atmosphere could remove methane from the atmosphere.

Although a lifetime of CH_4 is shorter than CO_2, it has a greater ability to trap radiation than CO_2. Consequently, heating is trapped in the Earth's atmosphere and has become a global warming issue.

3. Nitrous oxide (N_2O) is also GHG and has increased significantly over the last two decades. Although N_2O is in a part of the Earth's nitrogen cycle, human activity in particular industry activities play a main role in contributing N_2O for example, agricultural production, fossil fuel combustion, wastewater management, and industrial production process. The important thing to note is that the lifetime of N_2O is very long. It could be active more than 120 years and its effect on heat trapping is over 300 times more than carbon dioxide. As a result, the global atmosphere could get warmer and become a global warming issue as well.

4. Sulfur Dioxide (SO_2) is a non-GHG air pollutant. It is colorless, gaseous, heavy, and pungent. It comes from the combustion and refinement of sulfur-containing raw materials such as coal, oil and metal-containing ores. This reflects the importance of industry sectors in the contribution of pollutants. It could influence a higher rate of morbidity and mortality from respiratory disease as well. Furthermore, SO_2 is a main source of acid rain which has a huge impact on urban areas like those in China. From an environmental point of view, acid rain and runoff have increased the acidity in lakes which are habitats of various fish species. As a result it may impact on the ability of fish to survive.

5. Nitrogen Oxide (NO_2) is one of the general sets of pollutants of Nitrogen oxides (NO_x) and most NO_x emissions come in the form of Nitric Oxide (NO). However, NO_2 is important in terms of determining Ozone (O_3) concentration because it is the prime source of tropospheric ozone in the presence of hydrocarbons and ultraviolet light. Moreover, the main source of NO is thermal combustion of fossil fuels. NO_x can integrate

to acid rain and tropospheric ozone which has an impact on ecological systems. In addition, breathing of concentrated NO_2 can harm the respiratory system resulting in pulmonary function degradation.

6. Particulate matter (PM_{10}) is also in the group of pollutants. It is a complex mixture of very small solids, liquid or gaseous particles in the air such as dust, smoke, mist, fumes and smog. Some of these particles can be seen but others cannot, especially PM_{10}. It is less than 10 micrometers in size that is much smaller than a human hair cross section. The high level of PM_{10} concentration may lead to higher morbidity and mortality from respiratory diseases such as lung cancer. In an environmental view, it could stop plant growth by covering leaves.

The data sources of these six air pollution indicators can be divided into three sources. Firstly, the GTAP data base v.8.1 is a source of CO_2 emission. The estimations of CO_2 emission by sectors in each region are calculated by Lee (2002; & 2008) based on GTAP commodity energy sources (coal, crude oil, natural gas, petroleum products, electricity, and gas). In fact, CO_2 emission data was provided separately with the GTAP data base v.7 but now it is embedded with GTAP database version 8 up already. In this study, the CO_2 data is aggregated into 14 sectors and 18 regions as declared in the previous section.

Secondly, the data of methane and nitrous oxide come from the paper of Rose and Lee (2008). They calculate non-CO_2 emission such as CH_4, and N_2O based on the structure of the GTAP data base version 6. To obtain emission intensity from the paper, the total output values by sector in each region have been extracted from the GTAP Input-Output table and used as a denominator in order to calculate CH_4 and N_2O emission intensities by sectors as shown in equation 3.4.1.

$$e_{ij} = \frac{E_{ij}}{O_{ij}} \qquad \text{eq. 3.4.1}$$

where e_{ij} is CH_4 and N_2O emission intensity of sector i in region j, E_{ij} is CH_4 and N_2O gas emission of sector i in region j with million ton unit and O_{ij} is the total output value of sector i in region j with a million US dollar unit.

Thirdly, the industrial pollution projection system (IPPS) data source provided the emission intensity of non-GHG air pollutants (SO_2, NO_2, and PM_{10}) by sectors in the US. In order to employ emission intensities to the present study we need to take into account the difference in technology progress between each region and the US. First of all, we use the labor productivity in the paper of Trefler (1993) as a proxy technology different parameter from the US. However, as Trefler (1993) had studied price difference between countries due to productivity differences, he estimated the different parameters of productivity between the US and other countries. The information is useful for this dissertation but the countries that are examined in Trefler (1993) don't cover all of the dissertation's regions. Thus, the author needs to employ per capita income data of the extended regions from the World Bank (WDI, 2013). Then compare it with the countries in Trefler (1993) in order that the estimated technology different parameters for extended regions are obtained. With these steps, we can transfer emission intensities of each sector, and each pollutant gas from IPPS to this dissertation as shown in equation 3.4.2

$$e_{ij} = \alpha_j T_{i,US} \qquad \text{eq. 3.4.2}$$

where e_{ij} is SO_2, NO_2 and PM_{10} emission intensity of sector i in region j, $T_{i,US}$ is SO_2, NO_2 and PM_{10} emission intensity of sector i in the US from IPPS, and α is technology different parameter of region j compared to the US.

The Development of Scenarios

As there are 3 objectives of this dissertation, the paper needs to develop 3 scenarios which have to represent all conditions of each circumstance. Apart from those 3 scenarios, the base case scenario is needed in the paper as well because each objective has to be examined under trade liberalization in either the ASEAN community or Free Trade with key partners. For this reason, including base case scenario, there are 4 scenarios that need to be created in order to be used in the simulation process.

Firstly, the base case scenario which will be included in simulation 1 must capture the circumstances of being the ASEAN community and trading with 6 FTA partners such as Australia, New Zealand, China, India, Japan, and South Korea. In fact, to capture trade liberalization in the ASEAN community, the base case scenario has to take tariff and non-tariff barrier eliminations into account. The data of two barriers is employed from the Market Access Map database (MAcMap-HS6 2007), which come with the Tariff Analytical and Simulation Tool for Economists (TASTE) program provided by the GTAP and Monash University team.

Moreover, the tariff between ASEAN and the 6 key FTA partners is calculated from the GTAP import tax rate data set. This tax is provided in the form of the percentage of ad valorem rate. It then needs to be transformed into the power of the ad valorem tariff rate because the RunDynam software, which is used to simulate effects in this dissertation, support tariff rate reduction in terms of the power of the ad valorem tariff rate as shown in equation 3.5.3

$$Power = 1 + \frac{\%Ad\ valorem\ tariff\ rate}{100} \qquad \text{eq. 3.4.3}$$

Secondly, the scenario of imposing an emission policy in ASEAN countries only in particular 3 main polluting sectors namely agriculture, capital intensive manufacture, and transportation and communication. This scenario is created under the assumption that ASEAN nations are going to harmonize their environmental policies according to the ASEAN Socio-Cultural Community (ASCC) Blueprint. Thus, they might set the same air pollution standard in their region and this would put the pressure on their firms to enhance the technology in order to meet that standard. However, it is possible that ASEAN may agree to pick a lax emission policy or a stringent emission policy. Thus, the paper has to split the second scenario into two cases: 1) the case that ASEANs impose a lax emission policy 2) the case that ASEAN imposes a stringent emission policy. In fact, it is obvious that the ASEAN members differ in terms of their technology and their previous emission standard. As a result, the pressure on firms in each member would be different even if they impose either a lax or stringent policy.

For this reason, the paper must take this issue into consideration by categorizing the focused nations into three groups regarding their technology difference (Trefler, 1993) as mentioned above.

1. The modern technological group: the countries where will be in this group should have the technologically different level compared to the US less than 20%. Thus, there is only Singapore in this group

2. The normal technological group: the countries where will be in this group should have the technologically different level compared to the US less than 90%. Thus, there are five focused countries in this group, namely Indonesia, Malaysia, Philippines, Thailand, and China.

3. The legacy technological group: this group is defined for the countries where have the technological levels lower than the US, significantly. Thus, there are four focused regions in this group, namely Cambodia, Lao, Vietnam, and the rest of Southeast Asia (Brunei Darussalam, and Myanmar).

As the focused regions will be simulated in order to measure effects of imposing an emission policy, are divided into three groups by their technological level, the pressure on their firms due to improving their previous technology in order to reach the new emission policy whether a lax emission policy or a stringent emission policy needs to be classified upon the group of technological group. For this reason, this dissertation obtains the number of effects on sectoral output from Garbaccio, Ho, and Jorgenson (1999). They studied the effect of imposing carbon tax on China's economy and production. They found that if carbon emissions are reduced 5 percent, Chinese outputs of agriculture, primary metal, and transport and communication will decrease by 10 percent averagely. Moreover, if carbon emissions are reduce to 10 percent due to the carbon tax, the three sectoral outputs will decrease by about 20 percent.

From the study of Garbaccio, Ho, and Jorgenson (1999), it can be seen that a lax emission policy and a stringent emission policy could reduce Chinas' main polluting sectoral outputs (agriculture, primary metal, and transport and communication) by about 10 and 20 percent, respectively. These effects are used in this dissertation as a baseline of shocking magnitude caused by an emission policy in ASEAN. In addition, as this baseline is conducted in China where can be the representative of the normal technological group, the other two group of technology are need to be defined the shocking magnitude as well.

Regarding the three main polluting productions in ASEAN, namely agriculture, capital-intensive manufacture, and transportation and communication, are impacted by an emission policy imposing in ASEAN, especially in the output that are augmented with technology. By comparing the baseline shocking magnitude of the normal technological group to the other two groups, the effects on technologically augmented outputs in those three main polluting sectors are defined in this dissertation as follows;

1. The technologically augmented outputs, in those three main polluting sectors productions in the regions where are in the modern technological group, would be decreased for 5 percent in a lax case, and 10 percent in a stringent case.
2. The technologically augmented outputs, in those three main polluting sectors productions in the regions where are in the normal technological group, would be decreased for 10 percent in a lax case, and 20 percent in the stringent case.
3. The technologically augmented outputs, in those three main polluting sectors productions in the regions where are in the legacy technological group, would be decreased for 15 percent in a lax case, and 30 percent in the stringent case.

Thirdly, the scenario of imposing an emission policy in China only in particular 3 main polluting sectors namely agriculture, capital-intensive manufacture, and transportation and communication, this scenario is created under the assumption that China has been confronted with the severe pollution problems currently. Thus, China may attempt to control its air emission by imposing an air emission policy in the region, and this would lead to a pressure on their firms to enhance their technology in order to meet that policy. However, it is possible that China may impose an emission policy whether a lax or stringent one, or relocate production in particular dirty-production to other regions. Thus the paper needs to split the third scenario into two sub-cases; 1) the case that China imposes a lax policy 2) the case that China imposes a stringent policy. In fact, China is in the normal technological level group so their technologically augmented outputs, in the three main polluting sectors productions, would be decreased for 10 percent in a lax case, and 20 percent in the stringent case.

Finally, the scenario of imposing an emission policy in both ASEAN and China together in particular 3 main polluting sectors namely agriculture, capital-intensive manufacture, and transportation and communication, this scenario is created under the assumption that ASEAN and China will implement an emission policy in their regions in the same year. However, this scenario is also divided into 2 sub-cases of a policy implementation. 1) Both regions decide to impose a lax emission policy together and 2) They choose a stringent emission policy to be imposed instead. These two kinds of policy may impact their technologically augmented outputs differently depending on the type of technological level group that they are in.

The simulation and the analysis of results

The previous section described the scenarios that illustrate each circumstance and condition related to this dissertation's objectives. The scenarios will be employed in the simulation stages. Before simulating those scenarios, the projection of future information must be obtained first. This projection data is important in order to illustrate the key information in the simulation system, for example the factor endowment estimation such as the growth rate of skilled labor and the growth rate of unskilled labor, GDP growth rate, and population growth rate.

The data of these projection variables are employed from the paper of Chappuis and Walmsley (2011). They use the data sources from many key providers, for example, the World Economic Outlook, The Centre d'Etudes Prospectives et d'Informations Internationales (CEPII)[5], and the United Nations and transfer the data into the GTAP projection utility program in order to aggregate these kinds of data into GTAP format. This additional program is useful and compatible with the GTAP and GEMPACK suite. For this reason, the program is chosen and used in this dissertation so that the 4 key

[5] CEPII is the main French research center in international economics which is founded in 1978

exogenous variables have been estimated and injected to the simulation stage for the periods of analysis (2015-2030).

After the projection of key exogenous variables has been conducted, then it is time for simulating by taking the scenarios from the previous section into account. To examine the 3 main objectives in this study, the 4 simulations including the base case simulation, is obtained by using RunDynam software version 3.64. In fact, the RunDynam software is a specific tool for dynamic recursive analysis. It was built by the Center of Policy Study, Monash University in Australia. It can solve a model on a year by year basis. In other words, the tool will solve the problems declared in the model and come up with the initial year results and then uses such initial results to estimate subsequent years later. In addition, RunDynam can provide results of simulation in various ways either by table or chart which can be observed in the next chapter. For more detail, see Walmsley and Itakura (2007).

All simulations have been defined upon the scenarios in the previous sections. Firstly, simulation 1 (base case simulation) uses the first scenario, which represents the situation of being the ASEAN Community and having FTA with 6 key partners without an implementation of a new emission policy, as a condition. Thus, the effects of the trade liberalization under the ASEAN community and the trades with 6 key FTA partners are captured in this simulation.

Secondly, simulation 2 (case of imposing an emission policy in ASEAN) uses the second scenario, which represents the situation of imposing an emission policy in ASEAN nations under the context of the ASEAN Community and its FTA, as a condition. In addition, as the paper needs to measure the differences of effects between an emission lax and stringent policy, simulation 2 is broken into 2 sub-simulations. Simulation 2.1 would represent the effects when ASEAN imposes a lax emission policy while simulation 2.2 illustrates stringent policy effects on the economy and emission in each region.

Thirdly, simulation 3 (case of imposing an emission policy in China), includes the situation conditions in scenario 3, which represents the situation of imposing an emission policy in China under the context of the ASEAN Community and its FTA, in the process of estimation. Thus, the effects could be revealed through the results. Moreover, like simulation 2, if China imposes a lax policy, the effects are captured in simulation 3.1’s results whereas simulation 3.2 uses the case of imposing a stringent policy in China.

Fourthly, simulation 4 (case of imposing an emission policy in both ASEAN and China), employs the conditions in the scenario 4, which represents the situation of imposing an emission policy in ASEAN and China together under the context of the ASEAN Community and its FTA, so that the effects on both the economy and the environment of ASEAN and China are measured. In fact, if the both regions decide to impose a lax emission policy instead of a stringent one, the results will be shown in simulation 4.1. In contrast, if they choose a stringent policy rather than a lax one, then simulation 4.2 could capture the effects.

Last but not least, as the agreement of ASEAN nations to form the ASEAN Community by 2015, this dissertation uses the committed year as a year of imposing emission policy as well. Therefore, all simulations above are simulated in 2015 and the results are captured from 2015 to 2030. The paper also treats all effects in 2015 as a short-run effect while the long-run effects are captured by combing the results from 2015 to 2030 (the end period of analysis time).

The analysis of results from the simulation is divided into two types of analysis tools. Firstly, comparative statics is a tool for comparing the results of the simulations in terms of either before and after implementing an emission policy or comparing effects between in short-term and long-term. However, in order to illustrate the real effect of imposing an emission policy. The results of simulation 2 to 4 need to be compared with the base case results otherwise the effects would combine between trade liberalization in the community and an emission policy. As a result, it appears to be an ambiguous interpretation and could mislead readers. For this reason, the paper has to illustrate the results in terms of the comparison with the base case for simulation 2-4 so that the real effects of imposing an emission policy in the two regions could be revealed. The comparative statics is then used as a tool for comparing the real effects of an emission policy on the economy and the environment of each region.

Secondly, the cost-effectiveness analysis (CEA) is obtained in order to reveal the economically most efficient emission policy between a lax emission policy and a stringent emission policy. CEA is commonly used in healthcare where it is difficult to put a value on outcomes, but the outcomes themselves can be counted and compared, for example the number of lives saved (Kaplan, Jul 26th 2012) . This tool could compare the effectiveness of the emission policies in terms of the effectiveness per unit of cost between the two types of an emission policy as shown in equation 3.6.1

$$EC\ Ratio_i = \frac{The\ amount\ of\ Emission\ Reductions_i}{GDP\ Losses_i} \qquad \text{eq. 3.6.1}$$

where EC_i is a effectiveness ratio of region i, i is region such as ASEAN, and China, the amount of emission reductions is the amount of emissions which are reduced by a lax emission policy or a stringent emission policy compared to the baseline (no emission policy), and GDP Losses are the number of nominal GDP which are lost by imposing a lax emission policy or a stringent emission policy compared to the baseline.

The ratios of both lax and stringent emission policies are then compared in order to illustrate the type of an emission policy that induces the economically most efficiency.

As a result, this dissertation comes up with both effects of imposing an emission policy in ASEAN and China and an appropriate emission policy for ASEAN and China so that the policy planner can use to implement in their country. This would benefit for them in terms of either their economy or air quality.

CHAPTER 4

EMPIRICAL RESULTS

As the dissertation's scenarios had been prepared in the previous chapter, they were taken into the simulating process in order to illustrate the results. They represented the effects of imposing an emission policy whether a lax or a stringent emission policy in ASEAN nations and China depending on the scenarios. In fact, results from each simulation were captured in both short and long run periods as the economic and emission effects require a long period of time to be revealed. Thus, this chapter was written in order to show all findings accompanied with the explanations and analysis.

The comparisons between base case simulation and the other 3 simulations were obtained and presented in the explanations of simulations. This could reveal the real effects of imposing an emission policy in the regions by taking the effect of being an ASEAN Community and trading with FTA partners as a base line. Thus, the effects of the lax and stringent policies were apparently revealed. Then the policy analysis could take place and express a better emission policy in terms of achieving cost-effectiveness.

This chapter was produced in order to demonstrate the results of the simulations and was organized by beginning with the results in simulation 1: base case simulation. This was followed by the results of simulation 2 (case of imposing an emission policy in ASEAN alone) and 3 (case of imposing an emission policy in China alone). The simulation 4's results were described at the end of this chapter by showing the effects of imposing emission policy in both ASEAN and China together. In addition, the explanations in each simulation began with the economic effects of a lax emission policy and a stringent emission policy, followed by, the emission effects both in terms of the emission change and sector analysis. Specifically, the simulation 2-4 took cost-effectiveness as a tool to express a suitable emission policy for each region.

4.1 Simulation 1 (Base case): tariff and non-tariff barriers among ASEAN nations are eliminated under the context of the ASEAN Community and its Free Trade Agreements, in 2015.

As considering the consequence of imposing an emission policy in ASEAN and China, the scenarios created in chapter 3 are used to simulate the results. In fact, the results of the emission policy in simulation 2 to 4 are based on the structure of those trade conditions as the effects of the emission policy could vary upon trade liberalized conditions under the ASEAN community and Free Trade Agreements.

Thus, simulation 1 in this paper is designed to be a base case simulation in order to use the results as a base line and compare with the other simulation results. Then the real effects of an emission policy imposed in whether China or ASEAN could be revealed by those comparisons. As a result, the effects under base case simulation could indicate the situation in ASEAN nations and other regions including the FTA partners in both economic and emission aspects.

Hence, this section presents those effects beginning with the economic effects in terms of nominal GDP first. Then the movement of outputs through the export and import of both China and ASEAN are discussed. This is followed by the total emission results in specific year: 2015 and 2030. In addition, these emissions are presented through the 6 air pollution indicators which can be divided into 3 groups namely, Carbon dioxide Green House Gas group (CO_2 GHG), Non-carbon dioxide Green House Gas group such as Methane (CH_4) and Nitrous Oxide (N_2O), and Non-GHG air Pollutant group for example, Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). The end of this chapter also shows the top 3 sectors that release air emissions in both 2015 and 2030.

Economic effect results in base case simulation

To capture what happens to each economy after forming to the ASEAN community, the estimated nominal GDP of non-ASEAN regions and ASEAN nations are obtained and presented in table 6. The figures show the GDP on the expenditure side consisting of consumption, investment, government expenditure and export-import in 2015. In general, it reveals that the European Union and United States of America have the highest GDP compared to non-ASEAN regions. Both of them are driven by the significant amount of consumption expenditure. However, China is ranked fourth of rank following Japan but the Chinese economy is run mainly by investment and consumption.

Regarding the ASEAN economies, Indonesia has the highest GDP accounting for 486,721 million US dollars while Thailand's GDP is 269,868 million US$ leading Thailand to rank second in the ASEAN group. In addition, consumption expenditure would play a main role in Indonesia whereas Thailand is driven by both consumption and investment, like China. In contrast, the lowest GDP is expressed in Lao and Cambodia which account for 5,526 and 7,932 million US$, respectively. From the view of GDP per capita, the rank would change; for example, Singapore would be the top of gaining GDP per capita instead of Indonesia. Never the less, for this section, the results are shown in terms of norminal GDP by region as basic information in order to compare with other simulations in the next three sections.

Table 6 the decomposition of nominal GDP in 2015 under the ASEAN Community and its FTAs (million US dollars)

Reg	Con (Million US$)	Inv (Million US$)	Gov (Million US$)	Exp (Million US$)	Imp (Million US$)	Total GDP (Million US$)	POP (Million)	GDP/Cap (US$)
Non-ASEAN regions								
AUS	478,172	207,374	152,171	189,175	-169,065	857,827	24	36,053
NZL	82,580	34,710	26,492	35,135	-35,826	143,090	5	31,099
CHN	1,435,345	1,666,406	540,139	1,276,385	-1,091,905	3,826,369	1,370	2,793
EUR	10,117,027	3,676,531	3,572,332	6,122,594	-6,135,644	17,352,840	N/A	N/A
IND	788,286	492,427	144,362	239,763	-327,715	1,337,122	1,308	1,022
JPN	2,483,898	878,349	783,055	906,572	-701,980	4,349,894	126	34,503
KOR	586,265	313,328	158,655	474,218	-439,338	1,093,128	49	22,254
USA	9,891,256	2,421,599	2,244,752	1,620,330	-2,142,459	14,035,478	324	43,335
ASEAN regions								
IDN	303,942	152,225	39,996	133,957	-143,398	486,721	252	1,932
KHM	5,963	3,348	441	7,013	-8,833	7,932	15	528
LAO	3,381	2,329	427	1,922	-2,532	5,526	7	834
MYS	87,945	58,022	23,696	220,234	-183,167	206,731	31	6,731
PHL	111,444	35,813	15,915	74,669	-79,743	158,099	101	1,559
SGP	78,232	61,014	19,762	256,781	-215,685	200,104	5	37,227
THA	139,268	98,013	31,915	203,173	-202,502	269,868	71	3,808
VNM	47,462	36,535	4,438	64,943	-80,707	72,671	92	786
XSE	18,184	7,008	4,317	14,152	-11,563	32,098	N/A	N/A

Remark: N/A stands for “not applicable”

However, the figures above were captured in 2015 only so they could only represent the short-run effects. Thus, the long-run effects are investigated in table 7. The table combines the entire GDPs from 2015 to 2030 by region in order to illustrate the effects in the long-run. They indicate that China could gain in GDP and become the third highest GDP country in the group of non-ASEAN countries while the European Union and USA are still the first two highest GDP regions. In addition, the number of investments in China shows the significant role in the economy while the European Union and the US are still driven mainly by consumption.

In the meantime, Indonesia and Thailand could keep their position in ASEAN but Singapore could see the highest GDP percapita in long term. In fact, the investment in Thailand has increased dramatically over the period and this drives Thai economy markedly while Indonesia's economy is still run by consumption. Lao, however, could see large improvements and becomes higher than Cambodia in long term.

Table 7 the decomposition of nominal GDP combined from 2015 to 2030 under the ASEAN Community and its FTAs (million US dollars)

Reg	Con (Million US$)	Inv (Million US$)	Gov (Million US$)	Exp (Million US$)	Imp (Million US$)	Total GDP (Million US$)	POP (Million)	GDP/Cap (US$)
				Non-ASEAN regions				
AUS	9,955,520	2,939,945	3,165,229	4,580,267	-3,408,884	17,232,076	414	41,632
NZL	1,564,744	794,979	500,465	764,908	-785,573	2,839,523	79	36,062
CHN	39,660,520	49,553,928	14,995,254	35,956,624	-32,705,740	107,460,586	22,216	4,837
EUR	185,790,640	67,016,224	65,555,772	121,727,480	-119,894,264	320,195,852	N/A	N/A
IND	18,650,870	12,823,524	3,387,367	8,447,165	-9,497,487	33,811,439	22,733	1,487
JPN	46,694,696	14,094,730	14,736,022	17,675,092	-14,914,461	78,286,079	1,977	39,588
KOR	10,557,752	4,291,532	2,846,406	11,312,190	-9,710,065	19,297,815	799	24,155
USA	183,695,184	39,217,772	41,640,220	40,489,556	-42,293,420	262,749,312	5,492	47,845
				ASEAN regions				
IDN	7,125,305	4,633,257	904,439	3,822,948	-4,299,144	12,186,805	4,268	2,855
KHM	91,442	87,120	6,476	205,294	-231,410	158,922	260	611
LAO	94,725	57,246	11,708	69,205	-71,839	161,046	116	1,394
MYS	2,191,015	1,857,128	587,481	5,261,989	-4,909,847	4,987,765	545	9,153
PHL	2,434,625	1,622,137	333,863	2,020,783	-2,524,065	3,887,343	1,822	2,133
SGP	1,701,983	2,031,958	430,047	5,508,222	-5,327,500	4,344,709	91	47,706
THA	2,868,089	3,345,850	644,626	5,212,407	-5,763,032	6,307,939	1,158	5,448
VNM	1,185,676	589,959	110,407	1,785,077	-1,809,644	1,861,474	1,561	1,192
XSE	528,578	235,572	123,844	390,947	-358,065	920,877	N/A	N/A

Remark: N/A stands for "not applicable"

To examine the movement of output in China and ASEAN regions, export and import in both regions is examined. Table 8 represents Chinese export in 2015 after ASEAN integration as the ASEAN community whereas table 9 shows imports. Both figures could reveal the vast majority of trade value in China depending on capital-intensive goods and labor manufactured products.

In addition, both the export and import figures indicate that the non-ASEAN regions are the key partners of China rather than the ASEAN nations. However, the main Chinese export markets in ASEAN are Malaysia, Singapore, Indonesia, Thailand, and Vietnam respectively while the key import partners of China in ASEAN are Malaysia, Thailand, Philippines, Singapore, and Indonesia respectively. This could reflect that Malaysia seems to be a key trading partner of China in ASEAN and Thailand could benefit from the positive net Thailand-China trade balance.

Table 8 China's export in 2015 under the ASEAN Community and its FTAs (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	8532.20	874.00	3.48	0.72	434.00	302.00	214.00	162.00	409.00	12.40
Coal	2758.31	0.96	0.00	0.00	3.66	23.80	0.00	1.10	1.94	0.05
Oil	749.02	124.00	0.00	0.00	0.01	0.02	216.00	85.80	0.00	0.06
Gas	417.22	0.01	0.00	0.00	0.83	0.15	13.50	1.78	0.96	0.03
Oil_pcts	17445.60	1784.00	-22.20	0.11	214.00	308.00	991.00	96.00	860.00	215.00
Electric	838.84	0.02	-0.31	0.75	0.03	0.01	0.03	13.60	180.00	0.49
CMnf	168123.00	3784.00	8.55	20.40	3562.00	1818.00	2451.00	4347.00	4100.00	474.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	844723.00	9459.00	403.00	78.80	17311.00	5184.00	12844.00	4379.00	8026.00	1248.00
Osg	6633.80	46.00	1.19	0.14	50.60	14.90	41.20	48.80	12.00	4.83
Pcf	20655.10	131.00	1.63	1.09	601.00	144.00	245.00	284.00	231.00	65.80
Svces	26241.90	192.00	2.46	0.20	232.00	44.80	658.00	245.00	53.30	20.70
Trans	42122.00	446.00	17.60	0.59	184.00	54.80	1052.00	690.00	98.30	24.80
Util_Cns	5435.54	70.90	7.90	3.03	129.00	3.94	8.10	73.10	30.20	8.88
Total	1144675.00	16912.00	423.00	106.00	22722.00	7898.00	18733.00	10428.00	14003.00	2075.00

Table 9 China's import in 2015 under the ASEAN Community and its FTAs (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	33148.00	206.00	25.30	7.49	279.00	138.00	2.32	760.00	409.00	155.00
Coal	771.99	1072.00	0.00	0.02	0.82	0.10	0.00	0.00	1196.00	0.92
Oil	85940.04	676.00	0.00	5.46	161.00	0.10	0.00	113.00	170.00	149.00
Gas	1099.28	0.66	0.00	-0.03	1.35	-0.58	0.00	-0.36	-1.59	1.13
Oil_pcts	23177.08	357.00	0.00	1.74	783.00	88.90	2130.00	1292.00	0.44	6.59
Electric	375.73	0.01	0.00	0.01	2.60	0.01	0.01	1.33	0.00	0.27
CMnf	292116.00	6137.00	37.70	49.80	6681.00	2296.00	4549.00	9058.00	925.00	116.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	450014.00	3987.00	38.70	2.83	19100.00	19915.00	10428.00	17941.00	1455.00	105.00
Osg	5599.10	14.10	1.60	0.18	18.00	13.30	24.50	21.00	8.43	0.80
Pcf	16177.00	1833.00	2.76	0.18	3046.00	39.60	255.00	725.00	189.00	22.10
Svces	33548.60	30.30	12.00	2.49	204.00	79.20	1807.00	133.00	41.00	6.64
Trans	59955.00	134.00	33.10	2.74	363.00	133.00	2176.00	596.00	79.70	13.80
Util_Cns	3959.00	16.30	0.38	0.03	91.00	4.45	14.70	21.50	11.70	1.80
Total	1005878.00	14463.00	152.00	72.90	30731.00	22706.00	21387.00	30662.00	4484.00	580.00

Although China would prefer to trade with non-ASEAN markets rather than ASEAN, China is still one of key markets of ASEAN nations. This can be seen in table 10 and 11 which illustrate the export and import of ASEAN members in 2015 under the ASEAN Community conditions. The figures show that non-ASEAN regions is the main export markets of all ASEAN nations apart from Lao, however; Malaysia, Philippines, Singapore, and Thailand have a huge portion of export to China as well. In general, the key products of ASEAN export are labor-intensive manufacture and capital-intensive manufacture. In addition, oil and petroleum products could also play the main role in the export of Malaysia, Singapore, Thailand, and Vietnam.

On an import side, Indonesia, Malaysia, Philippines, and Vietnam import goods mainly from non-ASEAN regions followed by the ASEAN and China markets while Cambodia, Lao, Thailand, and the rest of Southeast Asia would prefer to import from the ASEAN market first, and the non-ASEAN and China markets later. The main import products in ASEAN nations are labor-intensive products and capital-intensive goods as well as oil, since there are high numbers of imports in Indonesia, Malaysia, Philippines, Singapore and Thailand. In addition, Lao is the only one country where has a portion of trade within ASEAN higher than the other two channels in both export and import. Another important point to note is that Malaysia has the highest portion of trade value through either export or import with China. In fact, the value of both export and import could account for over 40,000 million US dollars. In other words, it seems that a positive correlation between the Malaysian and Chinese economies exists.

Table 10 the ASEAN nations' exports in 2015 under the ASEAN Community and its FTAs (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	179.00	1789.60	2317.00	22.80	49.48	212.99	9.47	-7.04	132.59
Coal	951.00	8687.43	1494.91	0.00	0.00	0.00	0.02	0.00	0.50
Oil	651.00	4654.45	812.61	0.00	0.00	0.00	5.46	90.49	6.75
Gas	0.66	7701.27	148.12	0.00	0.00	0.00	-0.03	-2.07	-0.22
OilPcts	334.00	1571.60	562.00	0.00	0.00	0.00	1.74	53.17	5.35
CMnf	5312.00	21360.90	9041.73	32.70	45.94	294.23	43.90	51.79	783.08
LMnf	3775.00	24564.00	13461.83	35.00	4704.60	361.88	2.67	12.72	524.34
Osg	14.10	639.75	15.08	1.60	64.78	1.97	0.18	15.43	0.30
Pcf	1687.00	10945.20	5311.25	2.72	58.18	37.17	0.22	-4.31	8.95
Trans	134.00	4129.70	169.07	33.10	696.03	35.59	2.74	69.37	3.70
UtilCns	16.30	362.86	19.71	0.38	8.49	0.50	0.03	0.82	0.04
Total	13084.00	87439.00	33387.03	140.00	5892.91	956.43	68.90	333.63	1515.17

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	253.00	976.99	992.88	114.00	1086.24	95.64	2.21	57.42	218.13
Coal	0.74	0.98	0.03	0.09	0.05	0.00	0.00	0.00	0.00
Oil	155.00	7070.06	2543.59	0.10	0.05	0.30	0.00	0.10	0.00
Gas	1.35	3053.06	8.00	-0.58	-52.50	-5.47	0.00	0.02	0.00
OilPcts	739.00	1984.10	2000.31	83.80	592.92	346.25	1999.00	12148.40	18199.00
CMnf	6133.00	14342.00	13214.23	2055.00	2971.76	1922.27	4271.00	16967.50	17017.46
LMnf	18869.00	62676.00	44871.00	19732.00	22328.90	11830.64	10254.00	36588.00	55116.00
Osg	18.00	476.19	16.94	13.30	304.35	13.99	24.50	1266.74	36.95
Pcf	2811.00	8039.40	5961.15	37.30	1721.74	1802.84	234.00	1556.70	2760.37
Trans	363.00	9082.20	362.01	133.00	3600.20	168.46	2176.00	15483.00	575.47
UtilCns	91.00	1937.71	91.28	4.45	100.95	6.65	14.70	567.93	40.32
Total	29640.00	116200.00	70453.80	22251.00	35349.00	16314.85	20781.00	110349.00	94950.80

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	610.00	1299.80	998.90	350.00	2236.38	608.31	143.00	1309.29	1041.96
Coal	0.00	0.00	0.00	1081.00	368.69	114.96	0.73	6.14	51.92
Oil	109.00	148.42	15.25	164.00	4200.98	3158.33	144.00	3254.41	1477.51
Gas	-0.36	-24.99	-2.49	-1.59	-130.69	-12.63	0.97	1203.55	2861.38
OilPcts	1208.00	2181.60	4802.00	0.41	0.80	29.92	5.32	46.07	6.66
CMnf	8027.00	16494.00	10420.00	790.00	2532.20	1678.70	107.00	51.88	182.60
LMnf	17450.00	69628.00	24721.00	1346.00	26489.50	5949.60	94.10	672.12	272.29
Osg	21.00	640.37	20.55	8.43	390.37	10.04	0.80	67.79	1.19
Pcf	633.00	14247.30	8588.00	159.00	4285.34	4744.37	20.70	107.56	130.53
Trans	596.00	12064.80	493.71	79.70	1686.14	92.84	13.80	318.98	19.43
UtilCns	21.50	467.33	25.37	11.70	254.56	15.98	1.80	39.00	2.58
Total	28809.00	121565.00	50319.00	4030.00	43743.00	16466.10	538.00	7330.00	6060.34

Table 11 the ASEAN nations' imports in 2015 under the ASEAN Community and its FTAs (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	999.00	4737.13	317.82	3.65	16.81	34.88	0.89	1.23	59.15
Coal	1.07	0.27	2.97	0.00	0.00	0.01	0.00	0.00	1.33
Oil	129.00	3999.68	2451.48	0.00	0.00	0.00	0.00	2.56	0.70
Gas	0.01	5.75	0.09	0.00	0.00	0.00	0.00	0.00	0.00
OilPcts	1872.00	4197.04	7282.00	-25.50	-39.54	597.56	0.11	0.04	116.23
CMnf	4159.00	16590.00	10432.08	1.56	-63.37	1431.41	23.10	50.81	452.28
LMnf	10059.00	24293.70	19503.62	396.00	154.77	3287.74	75.00	113.50	971.31
Osg	46.00	1033.65	21.55	1.19	52.18	0.84	0.14	9.02	0.13
Pcf	139.00	1951.00	7715.04	-1.39	-38.47	942.44	1.40	24.26	369.74
Trans	446.00	7580.00	391.38	17.60	329.58	15.07	0.59	25.23	1.04
UtilCns	70.90	1131.62	44.22	7.90	123.04	4.99	3.03	47.46	1.78
Total	18114.00	74559.00	48535.52	403.00	631.31	6317.72	105.00	287.38	1982.11
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	524.00	1663.57	2203.35	352.00	1008.08	219.75	263.00	778.80	1022.81
Coal	4.07	356.22	577.86	24.80	29.08	411.04	0.00	0.01	0.00
Oil	0.01	2456.22	1383.17	0.02	5463.63	605.74	224.00	30468.11	2791.69
Gas	0.83	658.90	150.90	0.15	5.71	0.66	13.50	1856.70	-10.47
OilPcts	226.00	1156.75	5217.06	324.00	1732.87	1213.27	1039.00	5542.08	1568.20
CMnf	3890.00	23649.00	10164.30	2010.00	9827.70	4233.06	2638.00	18919.10	4421.09
LMnf	18020.00	57220.90	24703.14	5427.00	24552.10	10008.43	13228.00	55484.40	17755.63
Osg	50.60	1024.69	21.85	14.90	368.94	7.52	41.20	2603.59	31.70
Pcf	659.00	2303.10	4640.17	151.00	1036.50	5619.61	265.00	3394.00	1429.63
Trans	184.00	6819.40	287.65	54.80	2239.11	93.90	1052.00	22330.90	555.65
UtilCns	129.00	2021.59	44.78	3.94	69.67	5.28	8.10	522.26	31.03
Total	23919.00	110240.00	49739.80	8407.00	48529.00	22497.57	19429.00	166312.00	29961.86
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	190.00	1484.04	2032.90	480.00	1621.10	786.34	14.20	41.00	109.68
Coal	1.20	158.50	764.22	2.14	0.10	14.01	0.05	0.10	0.01
Oil	89.10	19896.33	971.81	0.00	1.00	0.00	0.06	1.10	0.62
Gas	1.78	161.43	3024.38	1.04	0.07	0.18	0.03	0.31	0.01
OilPcts	100.00	1132.36	2317.25	814.00	825.81	5758.05	228.00	62.30	547.54
CMnf	4674.00	25672.40	15953.30	4509.00	10865.70	6739.50	526.00	436.98	1198.14
LMnf	4316.00	16348.10	61584.20	8740.00	14143.70	12358.50	1321.00	1322.31	2090.69
Osg	48.80	1058.60	22.09	12.00	468.69	7.43	4.83	244.91	3.92
Pcf	307.00	1379.20	5657.11	263.00	2238.90	2714.55	72.80	36.88	1273.06
Trans	690.00	10293.90	443.14	98.30	2057.41	103.55	24.80	534.99	28.91
UtilCns	73.10	1155.55	46.73	30.20	477.49	17.65	8.88	140.43	5.98
Total	10750.00	90464.00	93446.00	15184.00	35903.00	28603.00	2221.00	3669.00	5290.61

Emission effect results in base case simulation

The previous part has discussed economic effects under the ASEAN Community and the FTA with key partner conditions. This section will further discuss the emission effects in each region, especially ASEAN nations and China. To display the total emissions, 6 air emission indicators are obtained and divided into 3 groups of gases. The first group is Carbon dioxide greenhouse gas (CO_2 GHG). The second group is Non-carbon dioxide greenhouse gases such as Methane (CH_4) and Nitrous oxide (N_2O) and the last one is Non-GHG air pollutant gases for instance, Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). These types of pollution indicators could hurt both the environment and humans/animals. In facts, the gases in non-GHG pollutant group could impact on human health through the respiratory system, directly. That is why this study focuses on both GHGs and non-GHG air pollutants.

This section will reveal the total emissions of each indicator in each region after ASEAN forms their countries into the ASEAN community in 2015. Sector analysis, then, follows in order to show the top 3 sectors that release emissions in the air, both in 2015 and 2030. Table 12 reveals total emissions in the regions of non-ASEAN and ASEAN in 2015 and 2030. It is clear that China is the main polluter compared to the non-ASEAN regions for CO_2 and non-CO_2 GHG emission in 2015 and 2030 followed by the US while the European Union accounts for a large number of total emissions of non-GHG air pollutants in 2015. But in 2030 China could take the position of top polluter in the non-GHG air pollutants.

In addition, Indonesia, for both years, has been the number one emitting country in ASEAN followed by Thailand. However, Vietnam could emit more CH_4 pollutions than Thailand in 2030. This might be caused by the significant growth in the agriculture sector in Vietnam in the long-run as CH_4 has a high correlation with agriculture growth.

Table 12 total emissions in each region under the ASEAN Community and its FTAs (million tons)

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	358.39	30.60	5375.89	3400.19	1271.45	946.96	387.05	4628.99
	2030	671.44	49.41	19277.58	5166.18	3813.41	1419.78	656.70	7866.46
CH_4	2015	60.81	15.77	641.17	224.48	289.61	6.13	22.74	293.55
	2030	160.24	32.38	3076.39	424.73	727.34	10.50	37.13	709.28
N_2O	2015	14.39	7.48	376.38	194.25	37.57	9.78	9.38	167.88
	2030	31.48	15.48	1360.01	358.72	98.13	15.05	14.63	364.42
SO_2	2015	31.45	4.80	564.84	697.84	75.68	123.91	60.60	303.07
	2030	44.80	8.63	1850.21	1008.01	228.23	160.69	87.10	480.41
NO_2	2015	18.89	2.91	342.06	424.22	45.88	75.24	36.82	184.30
	2030	26.87	5.22	1118.96	611.30	138.17	97.44	53.09	291.46
PM_{10}	2015	12.94	1.87	220.03	265.39	29.35	47.42	23.10	114.95
	2030	18.60	3.43	727.04	389.69	89.20	62.10	32.44	185.08
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	331.97	2.93	1.10	186.47	66.19	68.68	222.39	86.78
	2030	1180.50	7.75	3.05	492.01	148.01	156.87	574.52	157.93
CH_4	2015	137.37	5.82	6.31	28.56	14.94	1.00	44.01	43.48
	2030	440.65	12.51	20.22	90.80	37.89	2.35	106.09	113.41
N_2O	2015	20.94	1.08	1.18	4.03	4.94	0.72	10.73	7.59
	2030	67.83	2.36	3.82	10.95	15.40	1.63	24.52	18.70
SO_2	2015	34.15	0.40	0.31	17.40	7.79	9.09	20.99	5.82
	2030	103.57	0.93	1.11	43.31	23.05	16.08	55.80	9.05
NO_2	2015	20.65	0.25	0.19	10.67	4.82	5.55	12.85	3.57
	2030	62.48	0.59	0.67	26.38	14.28	9.78	34.07	5.52
PM_{10}	2015	13.48	0.11	0.12	6.24	2.61	3.33	7.62	2.09
	2030	41.48	0.24	0.46	16.24	7.61	6.08	20.54	3.37

Source: Author’s calculation

As the findings of total emissions could not represent the main sectors contributing to those emissions, table 13, 14 and 15 are obtained in order to present the 3 highest polluting sectors in 2015 and 2030 under the ASEAN community.

Firstly, table 13 expresses the first 3 sectors contributing to CO_2 emission which is the representative of the CO_2 GHG group. In general, electricity, capital-intensive manufacture, and transportation and communication are the largest polluting sectors in China and ASEAN, similar to Thomassin and Mukhopadhyay (2007). Moreover, agriculture could take place in Cambodia, as well as oil and petroleum product play the main role in Singapore and Malaysia in 2030. Regarding CH_4 emission in table 14 (the representative of non-CO_2 GHG group) is mainly emitted by agriculture, public administration like trash incineration, and transportation and communication. In addition, the coal sector could be in the ranks of China and Vietnam while Singapore and Malaysia still have oil and petroleum product sector in their ranks.

Turning to the air pollutant emission such as SO_2 (the representative of non-GHG pollutant group), owing to the limitation in this paper, the data of air pollutant emission intensities emitted from productions covers just capital-intensive manufacturing, labor-intensive manufacturing, processing food sector. Therefore the figures in table 15 could rank among those 3 sectors only. However, it is evident that capital-intensive manufacture accounts for the vast majority of emissions followed by labor-intensive manufacture and processing food in both years. These ranks are changed in Cambodia where labor-intensive manufacture has a bigger portion of emissions than capital-intensive manufacture in 2030 while processing food sector emits more SO_2 pollutions than labor-intensive manufacture in Lao for both two years.

Table 13 the rank of sectors which emit carbon dioxide (CO_2) in 2015 under the ASEAN Community and its FTAs

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Electricity (3221.11)	Electricity (113.33)	Trans &Com (1.73)	Electricity (0.43)	Electricity (66.87)	Electricity (28.83)	Trans &Com (30.99)	Electricity (89.37)	Electricity (31.26)
2	CMnf (1022.67)	CMnf (74.72)	Electricity (0.74)	Trans &Com (0.31)	Trans &Com (49.82)	Trans &Com (22.71)	Electricity (23.08)	Trans &Com (61.86)	Trans &Com (22.47)
3	Trans &Com (367.87)	Trans &Com (60.45)	Agr (0.30)	CMnf (0.19)	CMnf (28.10)	CMnf (7.60)	Oil_pcts (14.03)	CMnf (30.62)	CMnf (20.58)
Year 2030									
1	Electricity (11602.95)	Electricity (494.62)	Trans &Com (4.02)	Electricity (1.10)	Electricity (156.24)	Electricity (56.04)	Oil_pcts (58.24)	Electricity (218.29)	Electricity (56.47)
2	CMnf (3394.83)	CMnf (233.42)	Electricity (2.72)	Trans &Com (0.86)	Oil_pcts (114.13)	Trans &Com (47.66)	Trans &Com (53.04)	Trans &Com (131.47)	Trans &Com (47.46)
3	Trans &Com (968.17)	Oil_pcts (147.95)	Agr (0.69)	CMnf (0.74)	Trans &Com (109.61)	CMnf (22.6)	Electricity (44.48)	CMnf (84.02)	CMnf (33.28)

Table 14 the rank of sectors which emit methane (CH_4, the representative of non-CO_2 GHG pollution indicators) in 2015 under the ASEAN Community and its FTAs

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (256.52)	Agr (58.76)	Agr (5.31)	Agr (5.95)	Agr (6.98)	Agr (7.73)	Osg (0.54)	Agr (31.28)	Agr (35.44)
2	Coal (219.07)	Osg (36.43)	Osg (0.50)	Osg (0.34)	Osg (6.43)	Osg (6.66)	Oil_pcts (0.29)	Osg (5.56)	Osg (5.84)
3	Osg (160.05)	Trans &Com (16.32)	Trans &Com (0.01)	Trans &Com (0.005)	Oil_pcts (4.69)	Coal (0.35)	Trans &Com (0.15)	Trans &Com (3.27)	Coal (1.95)
Year 2030									
1	Coal (1705.51)	Agr (203.69)	Agr (12.00)	Agr (19.15)	Oil_pcts (23.25)	Agr (26.10)	Oil_pcts (1.20)	Agr (72.28)	Agr (87.54)
2	Agr (943.43)	Osg (68.86)	Osg (0.48)	Osg (0.94)	Oil (21.61)	Osg (9.82)	Osg (0.87)	Oil_pcts (11.20)	Osg (14.01)
3	Osg (397.84)	Oil_pcts (64.23)	Trans &Com (0.03)	Oil_pcts (0.05)	Agr (19.06)	Coal (1.51)	Trans &Com (0.26)	Osg (8.28)	Coal (10.12)

Table 15 the rank of sectors which emit sulfur dioxide (SO_2, the representative of pollutants indicators) in 2015 under the ASEAN Community and its FTAs

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (485.61)	CMnf (29.23)	CMnf (0.21)	CMnf (0.24)	CMnf (13.20)	CMnf (5.18)	CMnf (7.24)	CMnf (16.13)	CMnf (4.32)
2	LMnf (68.70)	LMnf (3.00)	LMnf (0.16)	Pcf (0.05)	LMnf (3.55)	LMnf (1.94)	LMnf (1.77)	LMnf (3.91)	LMnf (1.08)
3	Pcf (10.52)	Pcf (1.92)	Pcf (0.03)	LMnf (0.01)	Pcf (0.65)	Pcf (0.66)	Pcf (0.08)	Pcf (0.95)	Pcf (0.42)
Year 2030									
1	CMnf (1612.04)	CMnf (91.32)	LMnf (0.45)	CMnf (0.96)	CMnf (35.24)	CMnf (15.41)	CMnf (13.35)	CMnf (44.26)	CMnf (6.99)
2	LMnf (209.08)	LMnf (8.24)	CMnf (0.44)	Pcf (0.14)	LMnf (7.02)	LMnf (6.48)	LMnf (2.57)	LMnf (10.13)	LMnf (1.24)
3	Pcf (29.08)	Pcf (4.01)	Pcf (0.05)	LMnf (0.01)	Pcf (1.05)	Pcf (1.15)	Pcf (0.15)	Pcf (1.41)	Pcf (0.82)

In conclusion, the economy and emission under the ASEAN community and the Free Trade Agreements with key 6 partners such as Australia, New Zealand, China, India, Japan, and South Korea are different by comparison among both ASEAN and non-ASEAN regions. In fact, the benefit from integrating to the Community has been mentioned in the study of Petri, Plummer, and Zhai (2012). They claimed that the ASEAN Economic Community could raise real income in ASEAN dramatically. At least the real income could grow to 5.3 percent equaling to the European Community when they first combined together.

This dissertation shows the extended results that by comparing the results between the short and long run, Thailand illustrates a dramatic improvement in its investment especially in 2030, even though the GDP is approximately a half of Indonesia's GDP. In addition, Lao could enjoy the higher GDP than Cambodia in the long-run, although it is the lowest in the first year of joining to the ASEAN community. The GDP in China also grow up significantly from the short-run to the long-run. In addition, Chinese economy is driven mainly by investment and consumption, like Thailand,

Regarding the total emissions in each region, it is obvious that China has the largest portion of emissions compared with other non-ASEAN regions while Indonesia is the top polluter in ASEAN in both 2015 and 2030. Moreover, sector analysis illustrates that electricity, capital-intensive manufacture, and transportation and communication are the highest polluting sectors for CO_2 pollution while agriculture, public administration such as trash incineration, and transportation and communication play a main role in emitting non-CO_2 GHGs such as CH_4 and N_2O. As, for the non-GHG air pollutant group, the data sources of the dissertation are limited so the paper could examine only the 3 main sectors. However, the results still indicate that most air pollution contributing sectors are capital-intensive manufacture, labor-intensive manufacture and processing food, respectively.

4.2 Simulation 2: ASEAN nations impose an emission policy on the 3 main sectors such as agriculture, capital-intensive manufacture, and transportation and communication in 2015.

As the ASEAN members have agreed to integrate and incorporate their countries into the ASEAN community under the three pillars of cooperation, namely the ASEAN Political-Security Community (APSC), the ASEAN Economic Community (AEC) and the ASEAN Socio-Cultural Community (ASCC), obviously, the AEC could encourage significant trade within the region and without. This would be followed by high emissions due to an increase in their production. In addition, the movement of output and input could carry these effects into both the ASEAN nations and trading partners. Nevertheless, the ASCC pillar would take this problem into consideration and encourage the ASEAN nations to impose an emission policy on ASEAN in order to control and reduce emissions caused by the trade liberalization in the ASEAN community and the FTAs with the 6 key partners.

On the one hand, an emission policy could limit their emissions, particularly the six key emission indicators: carbon dioxide greenhouse gas (CO_2), non-carbon dioxide greenhouse gases (CH_4 and N_2O) and non-GHG air pollutants (SO_2, NO_2, and PM_{10}). These kinds of emissions could hurt either the environment or humans as were mentioned in chapter 3. Thus, it appears to benefit to the community by reducing the risk of exposure in dirty air. On the other hand, it may lead to a drop in their economic growth as dirty-intensive production has to be controlled especially the three main polluting sectors: agriculture, capital-intensive manufacture, and transportation and communication. Consequently, the ASEAN firms have to spend a huge investment in technology improvement in order to meet the conditions of the emission policy.

Moreover, if the ASEAN nations lose more in their economy than they benefit from reducing emissions, they may implement a lax emission policy rather than a stringent one. But if they pay more attention to decreased emissions than saving their economy, a stringent policy would be imposed in the region. These two kinds of thinking need to be analyzed in order to reveal what kind of an emission policy, ASEAN should deal with, so the cost-effectiveness analysis is used in this case. The analysis compares the reduction in emissions and the cost of policy implementation in terms of GDP loss. In fact, both emission and GDP changes used in the analysis are captured over a long period of time because the economic and emission effects take time to express themselves. This is why the long-run results would reveal the real effects on the region better than the short-run.

This simulation results are organized by beginning with the economic effects on Gross Domestic Product (GDP) which is calculated from an expenditure side such as consumption, investment, government expenditure, export, and import. The economic effects are also divided into the effects under a lax policy and a stringent policy. This is followed by emission effect results with comparison among regions and across sectors. Last but not least, the end of this chapter shows the results of the cost-effectiveness analysis in order to become information for policy makers so that they can design suitable emission policies for the ASEAN region.

Economic effect results of the lax emission policy in the ASEAN region

To examine the impacts on each economy due to a lax emission policy imposed on ASEAN, the decomposition GDP compared to the base case is opted as shown in table 16. It is evident that GDP in ASEAN will decline for all members of ASEAN in 2015. In fact, it appears that low income countries like Cambodia and Lao are affected by that policy much more than other members even though their exports could increase due to higher trade with non-ASEAN countries. However, the increase in the exports cannot offset the marked fall in their consumption and investment so they could lose potential GDP that they could gain in the base case by almost -14 percent. This is followed by Vietnam accounting for about -13 percent owing to the reduction in consumption and investment like Lao and Cambodia. In fact, a significant decrease in consumption and investment in Cambodia, Lao and Vietnam is caused by a reducing reginal income earned from selling factors and products. This leads to a fall in demand of both domestic and imported goods. In addition, such three nations also face a mark drop in the rate of investment return so their investments from either domestic or foreign investors plummet dramatically. In contrast, Singapore could reduced its negative effects by keeping a positive trade balance, and Philippines also increases its exports in labor-intensive significantly instead of suffering from the policy. Thus, the two members could see a smaller decrease in its GDP than other members.

Regarding the effects on the GDP of non-ASEAN regions, most of them could gain benefits and enjoy higher GDP, except for China and South Korea. In fact, the small drop in the Chinese and South Korean GDP are caused by diminishing of exports especially in labor-intensive goods and energy products because all ASEAN nations attempt to improve their exports in both two types of goods in order to reduce the losses from an emission policy. Thus, the ASEAN’s exports in labor-intensive goods and energy products could take place in China and South Korea’s markets. However, this type of situation could change in the long-term which is presented in table 17.

The table illustrates the effects on each source of GDP in terms of the combined results from 2015 to 2030 and compares to the combined base case results. As the previous table indicates a reduction in the ASEAN nations’ GDP, the long-term results still replicate the implications from the short-run ones. In general, each source of GDP for all members will be deteriorated by the policy. In fact, the main factor contributing to the drop in the Indonesian and Thai GDP is a mark fall in investment as their rate of investement return drops the most in the long run, while export causes a fall in the Malaysian GDP in particular intra-ASEAN market.

Moreover, regarding long-term effects, all non-ASEAN regions including China and South Korea could benefit from an ASEAN emission policy as their GDP could increase especially in India which will gain the most accounting for a 0.55 percent increase higher than the base case. This would be a result of larger investment and a huge amount of consumption due to an enormous Indian population. However, the exports of all regions still fall either in ASEAN or non-ASEAN regions. This circumstance needs to be assessed in terms of the mobility of output in order to know why export and import in particular China falls after ASEAN imposes a lax emission policy.

Table 16 the change in nominal GDP sources in 2015 after imposing a lax policy in ASEAN compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	1128	1297	355	67	674	2173	0.25
NZL	115	161	36	-36	60	217	0.15
CHN	-597	1194	-289	-3015	-1095	-1612	-0.04
EUR	2450	14782	779	-3421	4640	9949	0.06
IND	1375	1208	225	-316	284	2210	0.17
JPN	1968	6036	601	-4222	640	3742	0.09
KOR	-45	754	-31	-963	-206	-78	-0.01
USA	6513	10564	1447	-3240	4016	11268	0.08
ASEAN regions							
IDN	-28453	-21145	-4209	3224	-4893	-45689	-9.39
KHM	-905	-727	-73	418	-181	-1105	-13.93
LAO	-480	-511	-67	58	-227	-773	-13.99
MYS	-7547	-13271	-2145	-2317	-7155	-18125	-8.77
PHL	-7845	-5473	-1268	4253	373	-10707	-6.77
SGP	-2920	-4411	-764	-1530	-1706	-7919	-3.96
THA	-12591	-16406	-3155	2691	-6108	-23354	-8.65
VNM	-5800	-6784	-589	2654	-1127	-9392	-12.92
XSE	-1408	-1336	-371	145	-427	-2543	-7.92

Table 17 the change in the combined nominal GDP sources between 2015 and 2030 after imposing a lax policy in ASEAN compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	-4581	25853	-1303	-9806	-296	10459	0.06
NZL	202	7047	91	-2700	534	4106	0.14
CHN	11672	417092	4614	-274108	-31826	191096	0.18
EUR	117456	750088	42244	-33840	193056	682892	0.21
IND	81864	179286	16058	-68388	21234	187586	0.55
JPN	-19772	142538	-5980	-97250	-55069	74605	0.10
KOR	8691	57542	2474	-52270	-25146	41583	0.22
USA	67696	285676	15896	-89496	2056	277716	0.11
ASEAN regions							
IDN	-934708	-1225831	-128099	-131025	-527809	-1891854	-15.52
KHM	-16998	-32232	-1271	-22202	-36511	-36193	-22.77
LAO	-20955	-19704	-2671	-9672	-14107	-38897	-24.15
MYS	-238718	-541954	-66288	-575498	-688427	-734030	-14.72
PHL	-276595	-330332	-40802	-53346	-202127	-498948	-12.84
SGP	-103012	-259977	-26651	-272359	-316315	-345683	-7.96
THA	-357971	-1011786	-86038	-447777	-835272	-1068298	-16.94
VNM	-162964	-191942	-16114	-150691	-200280	-321429	-17.27
XSE	-48018	-39951	-11800	-19447	-22567	-96650	-10.50

China exports and imports in 2015 are shown in table 18 and 19. The findings indicate that China experiences the fall of exports to most partners in total, except for Philippines. In fact, the main sector that shows a significant drop is labor-intensive manufacture. This might be caused by the increase in labor-intensive exports of ASEAN to the world which will be discussed in the next section. However, China could raise exports in the 3 impacted sectors that ASEAN imposes policy on, such as agriculture, capital-intensive manufacture, and transportation and communication.

Moreover, imports in China also decrease in total as in export cases but imports from Philippines still increase dramatically due to the huge improvement in labor-intensive product imports. In fact, China lowers imports from ASEAN in particular the 3 main sectors imposed policy, while it imports more from non-ASEAN regions in those sectors. Interestingly, China faces a significant decrease in labor-intensive product imports from non-ASEAN whereas the imports from ASEAN in this product go up sharply. This is a good point in case that reflects high exports in labor-intensive products from ASEAN to the world. However, in order to analyze this phenomenon precisely, the ASEAN output movement is examined and discussed in the next section.

Table 18 the change of Chinese exports to other regions after imposing a lax policy in ASEAN compared to the base case in 2015 (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	135.90	146.00	0.74	0.11	49.00	38.00	29.00	35.00	53.00	2.10
Coal	-120.32	-0.16	0.00	0.00	-0.69	-10.00	0.00	-0.34	-0.34	-0.02
Oil	-11.32	-16.00	0.00	0.00	0.00	0.00	-11.00	-5.20	0.00	-0.01
Gas	-18.98	0.00	0.00	0.00	-0.33	-0.07	-1.80	-1.19	-0.70	-0.01
Oil_pcts	-48.70	-113.00	-2.10	-0.02	-13.00	-11.00	-56.00	-7.70	-90.00	-14.00
Electric	1.09	0.00	-0.11	-0.29	-0.01	0.00	0.00	-3.30	-60.00	-0.09
CMnf	2522.00	596.00	37.85	3.90	445.00	237.00	189.00	524.00	537.00	130.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-3440.00	-1245.00	-67.00	-34.70	-1568.00	-134.00	-383.00	-771.00	-451.00	-213.00
Osg	-8.00	-8.10	-0.28	-0.03	-7.30	-2.40	-0.90	-8.80	-2.77	-0.71
Pcf	94.40	-9.00	0.57	-0.11	-18.00	-4.00	-2.00	-8.00	-11.00	3.20
Svces	-27.90	-27.00	-0.38	-0.04	-26.00	-4.90	-12.00	-36.00	-6.60	-2.30
Trans	318.00	1.00	0.50	-0.08	13.00	1.60	40.00	-28.00	3.70	1.70
Util_Cns	10.31	-11.00	-1.72	-0.71	-10.00	-0.64	-0.19	-11.60	-4.30	-1.71
Total	-594.00	-687.00	-31.00	-32.10	-1136.00	110.00	-207.00	-323.00	-34.00	-95.00

Table 19 the change of Chinese imports to other regions after imposing a lax policy in ASEAN compared to the base case in 2015 (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	318.10	-56.00	-6.80	-4.99	-66.00	-31.00	-0.41	-202.00	-122.00	-60.90
Coal	-25.32	56.00	0.00	0.00	0.10	0.01	0.00	0.00	53.00	0.09
Oil	-256.51	134.00	0.00	-0.71	25.00	0.00	0.00	39.00	31.00	20.00
Gas	22.09	0.72	0.00	0.02	2.76	2.43	0.00	0.68	5.78	0.22
Oilpcts	-73.06	26.00	0.00	0.51	28.00	0.90	0.00	44.00	0.08	0.17
Electrc	-0.50	0.00	0.00	0.00	0.83	0.00	0.00	0.55	0.00	0.07
CMnf	6271.00	-1724.00	-14.10	-13.60	-2416.00	-825.00	-825.00	-2368.00	-343.00	-75.50
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-7106.00	680.00	3.60	4.51	1395.00	2710.00	895.00	2320.00	144.00	-3.00
Osg	-21.10	3.70	0.37	0.12	3.80	2.50	1.90	5.80	2.77	0.16
Pcf	82.00	60.00	-0.50	0.15	-183.00	-1.50	7.00	-12.00	-3.00	-4.50
Svces	-204.70	8.60	2.50	0.56	37.00	13.00	129.00	26.00	14.50	1.11
Trans	216.00	-12.00	-5.10	0.33	-68.00	-22.00	-206.00	-71.00	-14.40	-4.32
UtilCns	-4.20	2.10	0.02	0.01	4.70	0.37	0.50	0.30	0.70	0.05
Total	-779.00	-822.00	-21.00	-13.10	-1236.00	1851.00	1.00	-219.00	-231.00	-127.00

Table 20 and 21 illustrate the mobility of the ASEAN outputs through the 3 main channels: China, non-ASEAN, and ASEAN compared to the base case one. It is obvious that ASEAN is suffering from the policy in the production of 3 main sectors: agriculture, capital-intensive manufacture, and transportation and communication. This is revealed by a dramatic decrease in the exports of those sectors. In total exports, the trade within the ASEAN region decline for all members apart from Vietnam which could have a small increase in exports to the ASEAN markets. However, ASEAN move exports to the non-ASEAN channel as we can see the portion of the exports to non-ASEAN markets going up significantly.

In addition, Philippines, Thailand, and Singapore could improve their exports to the Chinese market due to high labor-intensive product exports, while Indonesia, Cambodia, Lao, Malaysia, and Vietnam face decreasing total exports to Chinese market as a result of lacking in the 3 main products. Nonetheless, the trend of the ASEAN exports indicates that instead of suffering from the decline in agriculture, capital-intensive manufacture, and transportation and communication goods, ASEAN nations could gain by pushing up their labor-intensive outputs to the world. This is relevant to the situation of labor-intensive product exports and imports in China which show a decrease and an increase with most ASEAN partners, respectively.

Turning to ASEAN imports, the figures in table 21 show a significant increase in agriculture and capital goods imports from China and non-ASEAN markets to all ASEAN nations while labor-intensive goods imports fall in the two main markets as well. These two main movements could lead to a reduction in the total of ASEAN imports excluding Philippines which still imports more from China and non-ASEAN markets. The imports in Singapore also increase in the ASEAN channel due to high labor-intensive and oil product imports.

Table 20 The change of ASEAN state exports after imposing a lax policy in ASEAN compared to the base case in 2015 (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-43.00	-700.76	-173.11	-6.00	-14.63	-7.96	-4.11	-5.20	2.25
Coal	45.00	618.36	-135.20	0.00	0.00	0.00	0.00	0.00	-0.06
Oil	129.00	766.36	76.10	0.00	0.00	0.00	-0.71	-12.06	-0.96
Gas	0.72	2828.63	44.27	0.00	0.00	0.00	0.02	1.42	0.15
Oil_pcts	22.00	134.50	12.21	0.00	0.00	0.00	0.51	16.96	0.54
CMnf	-1379.00	-7071.20	-1158.63	-11.40	-27.96	-99.87	-10.90	-29.88	-79.43
LMnf	605.00	7050.00	1078.29	3.00	628.92	7.95	3.80	91.39	43.28
Osg	3.70	179.67	1.62	0.37	16.45	0.16	0.12	11.38	0.11
Pcf	50.00	244.10	12.98	-0.48	-12.55	-3.88	0.14	3.18	0.32
Trans	-12.00	-388.80	-9.35	-5.10	-111.65	-4.71	0.33	9.89	0.59
Util_Cns	2.10	51.36	-0.37	0.02	0.43	-0.03	0.01	0.16	0.00
Total	-567.00	4038.00	-245.24	-17.00	543.22	-106.45	-10.20	99.62	-31.23

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-57.00	-211.11	-28.37	-24.00	-218.64	-3.36	-0.34	-10.34	2.91
Coal	0.09	0.12	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Oil	24.00	495.39	134.01	0.00	0.00	-0.01	0.00	-0.01	0.00
Gas	2.76	2611.43	17.83	2.43	165.42	15.82	0.00	0.01	0.00
Oil_pcts	25.00	83.80	-17.46	0.70	5.81	-8.99	-1.00	-4.80	-648.00
CMnf	-2068.00	-7265.60	-2572.05	-708.00	-1142.84	-287.51	-731.00	-4311.50	-532.49
LMnf	1358.00	5983.00	292.50	2662.00	3689.80	311.98	860.00	4281.00	-909.33
Osg	3.80	106.93	1.31	2.50	60.41	0.84	1.90	107.50	-4.92
Pcf	-165.00	-509.10	-163.77	-1.30	-85.25	-33.82	5.00	32.10	-3.12
Trans	-68.00	-1818.90	-62.97	-22.00	-632.90	-23.15	-206.00	-1544.20	-54.51
Util_Cns	4.70	116.81	-8.42	0.37	9.42	-0.41	0.50	27.61	-4.78
Total	-900.00	966.00	-2385.10	1926.00	2345.00	-18.81	58.00	639.00	-2239.20

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-148.00	-392.60	-51.90	-96.00	-847.17	-28.53	-53.70	-260.18	-32.75
Coal	0.00	0.00	0.00	43.00	22.58	-11.18	0.06	1.34	-2.10
Oil	37.00	48.94	3.22	30.00	417.36	217.03	19.00	264.85	9.33
Gas	0.68	43.83	4.41	5.78	429.62	40.78	0.18	1153.86	-644.59
Oil_pcts	38.00	96.50	-122.00	0.07	0.18	2.13	0.13	2.51	-0.02
CMnf	-1923.00	-6876.60	-1374.00	-271.00	-1344.76	-289.40	-65.20	-43.99	-73.58
LMnf	2212.00	11161.00	817.00	128.00	3831.10	137.60	-2.40	-16.65	-10.64
Osg	5.80	192.30	2.76	2.77	137.09	1.67	0.16	14.18	0.01
Pcf	-10.00	-303.30	-161.00	-2.00	-101.23	-64.10	-3.90	-32.72	-11.84
Trans	-71.00	-1526.20	-37.47	-14.40	-322.49	-14.97	-4.32	-106.86	-5.60
Util_Cns	0.30	6.41	-2.82	0.70	18.42	-1.08	0.05	1.33	-0.28
Total	168.00	3421.00	-898.00	-160.00	2802.00	10.40	-107.00	1024.00	-771.12

Table 21 The change of ASEAN state imports after imposing a lax policy in ASEAN compared to the base case in 2015(million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	169.00	743.36	-19.71	0.90	5.50	-1.41	0.16	0.41	-2.79
Coal	-0.18	-0.05	-0.15	0.00	0.00	0.00	0.00	0.00	-0.06
Oil	-16.00	-475.86	7.91	0.00	0.00	0.00	0.00	1.22	0.51
Gas	0.00	-1.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	-119.00	-265.07	-230.65	-2.30	-3.12	-115.23	-0.02	-0.01	-5.98
CMnf	682.00	3067.00	-812.36	45.74	76.73	-23.28	4.80	12.42	-42.45
LMnf	-1368.00	-3432.00	-880.40	-79.00	-122.36	54.00	-39.80	-48.64	-57.40
Osg	-8.10	-176.07	-1.12	-0.28	-11.93	-0.05	-0.03	-2.03	-0.02
Pcf	-11.00	-166.20	-171.60	0.75	2.41	8.16	-0.17	-4.21	-42.20
Trans	1.00	12.00	-47.53	0.50	7.16	-1.55	-0.08	-3.29	-0.27
Util_Cns	-11.00	-176.95	-5.99	-1.72	-26.67	-1.01	-0.71	-11.11	-0.38
Total	-708.00	-2134.00	-2183.74	-35.00	-90.48	-78.43	-36.00	-57.56	-152.10

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	62.00	181.77	-179.48	47.00	146.44	-23.06	35.00	98.10	-92.92
Coal	-0.77	-57.41	-51.20	-11.90	-8.89	-22.80	0.00	0.00	0.00
Oil	0.00	-242.02	41.62	0.00	-99.02	44.45	-11.00	-1226.53	269.22
Gas	-0.33	-225.05	39.78	-0.07	-2.15	0.12	-1.80	-151.52	87.95
Oil_pcts	-14.00	-71.07	-277.53	-12.00	-62.96	-18.05	-58.00	-302.74	-11.27
CMnf	509.00	3052.00	-1521.70	272.00	1438.40	-547.83	204.00	1399.30	-1579.79
LMnf	-1662.00	-5476.20	136.41	-144.00	-781.90	570.06	-393.00	-1747.30	1583.76
Osg	-7.30	-143.32	-0.10	-2.40	-59.04	-0.15	-0.90	-65.11	7.04
Pcf	-21.00	-120.30	-85.96	-5.00	-46.30	-68.04	-2.00	-29.10	-68.55
Trans	13.00	476.60	-8.36	1.60	62.75	-8.29	40.00	815.00	-60.77
Util_Cns	-10.00	-154.67	-1.57	-0.64	-11.35	-0.74	-0.19	-11.97	0.79
Total	-1158.00	-4024.00	-1919.20	140.00	334.00	-76.76	-199.00	-1710.00	203.19

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	45.00	379.93	-35.30	66.00	239.60	-46.75	2.50	7.68	-3.85
Coal	-0.38	-44.62	-87.97	-0.39	-0.02	-1.20	-0.02	-0.03	0.00
Oil	-5.40	-1021.59	102.74	0.00	-0.03	0.00	-0.01	-0.12	0.00
Gas	-1.19	-96.46	-682.20	-0.78	-0.12	0.02	-0.01	-0.10	0.01
Oil_pcts	-8.10	-88.86	-30.89	-107.00	-184.11	-144.02	-16.00	-4.14	-18.45
CMnf	593.00	3656.20	-1769.50	617.00	1721.20	-997.35	147.00	126.59	-56.52
LMnf	-846.00	-3626.95	289.00	-543.00	-1387.20	301.60	-234.00	-245.36	-61.43
Osg	-8.80	-186.30	-1.41	-2.77	-104.57	-0.72	-0.71	-34.97	0.08
Pcf	-11.00	-98.90	-45.04	-14.00	-153.10	-91.41	4.10	3.59	25.62
Trans	-28.00	-441.80	-74.60	3.70	67.36	-9.75	1.70	37.90	-1.02
Util_Cns	-11.60	-182.58	-6.22	-4.30	-69.03	-2.02	-1.71	-27.02	-1.05
Total	-322.00	-3533.00	-2385.00	-54.00	-291.00	-996.00	-99.00	-231.40	-115.88

Economic effect results of the stringent policy in the ASEAN region

The lax policy impacts discussed in the previous section could hurt all ASEAN members, in particular the three low income countries: Cambodia, Lao, and Vietnam. Even though ASEAN increases exports in labor-intensive good instead of the 3 main capital products, this could not help ASEAN much in terms of GDP loss. However, this section will further examine the case of imposing a stringent policy in ASEAN rather than a lax one by starting with the decomposition of GDP under a stringent policy compared to the base case in 2015 as shown in table 22.

The stringent policy effect results still replicate the direction of lax policy effects but the impacts are stronger about double. As a result, Cambodia and Lao remain the first two countries in ASEAN to face a significant drop in GDP. In addition, China and South Korea are also affected from the policy similar to the lax case, but this time, South Korea GDP maintains a –0.01 percent decrease, same as the lax one while China faces a double impact of the lax policy of -0.04 to -0.08 percent in the stringent case.

Moreover, the combined effects from 2015 to 2030 in table 23 show a differing result in the GDP of Australia. In fact, Australia could gain benefits in either the short-run or long-run in lax policy case but in stringent case, the long-run effects could reduce the GDP to -0.03 percent. In addition, India still gains from the policy and keeps the highest gaining position in the long-run, like the lax case. For ASEAN nations, the results retain the same implication as in lax policy case. For example, Indonesia and Thailand could suffer mainly from a drop in their investment, and the low income countries like Cambodia and Lao still suffer from the policy more than other members.

However, exports and imports still need to be investigated precisely as they could convey the effects of an emission policy in ASEAN to the outside of regions. Thus, the movement of China and ASEAN outputs will be revealed in the next section.

Table 22 the change in nominal GDP sources in 2015 after imposing a stringent policy in ASEAN compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
			Non-ASEAN regions				
AUS	2255	2595	710	133	1347	4345	0.51
NZL	229	322	72	-71	119	435	0.30
CHN	-1195	2387	-578	-6030	-2190	-3225	-0.08
EUR	4900	29563	1558	-6841	9279	19902	0.11
IND	2751	2417	451	-632	567	4421	0.33
JPN	3936	12071	1203	-8445	1281	7484	0.17
KOR	-90	1508	-61	-1925	-411	-157	-0.01
USA	13026	21128	2895	-6480	8032	22536	0.16
			ASEAN regions				
IDN	-56906	-42291	-8418	6449	-9787	-91379	-18.77
KHM	-1810	-1453	-146	836	-363	-2210	-27.86
LAO	-961	-1021	-134	116	-454	-1546	-27.98
MYS	-15093	-26542	-4290	-4634	-14311	-36249	-17.53
PHL	-15689	-10947	-2537	8506	746	-21414	-13.54
SGP	-5841	-8822	-1528	-3059	-3413	-15838	-7.91
THA	-25181	-32813	-6310	5381	-12215	-46709	-17.31
VNM	-11599	-13569	-1179	5309	-2254	-18784	-25.85
XSE	-2816	-2673	-742	291	-855	-5086	-15.85

Table 23 the change in the combined nominal GDP sources between 2015 and 2030 after imposing a stringent policy in ASEAN compared to the base case (million US$)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
			Non-ASEAN region				
AUS	-21878	34620	-6460	-20292	-9062	-4947	-0.03
NZL	15790	19037	5162	-15137	4185	20666	0.73
CHN	46272	836700	20402	-543584	-88786	448576	0.42
EUR	240368	1204752	88368	-13248	267960	1252280	0.39
IND	130272	380471	29763	-119936	73455	347115	1.03
JPN	17728	249447	6488	-175954	-120327	218036	0.28
KOR	40120	124012	11424	-97604	-46787	124739	0.65
USA	-41968	307056	-8508	-169012	-126804	214372	0.08
			ASEAN regions				
IDN	-1775020	-2108330	-239796	-379337	-984925	-3517559	-28.86
KHM	-34222	-55967	-2550	-43437	-67284	-68893	-43.35
LAO	-42323	-30585	-5343	-20595	-23765	-75082	-46.62
MYS	-449501	-942369	-124420	-1075716	-1239570	-1352435	-27.12
PHL	-518918	-613587	-76429	-119270	-389408	-938796	-24.15
SGP	-196617	-487158	-50807	-514645	-599119	-650109	-14.96
THA	-548497	-1568805	-131033	-963962	-1519903	-1692393	-26.83
VNM	-297186	-328802	-29361	-286900	-363519	-578729	-31.09
XSE	-171363	-48706	-37981	-106229	-77691	-286589	-31.12

As the output flow of China could express the ASEAN reaction to a stringent policy, the change of Chinese exports and imports from the base case, in order to reveal the real impacts of the policy, are presented in table 24 and 25. In general, it can be seen that both a lax and a stringent policy could impact on Chinese exports and imports in the same way. For example, China could export more in the 3 imposed sectors which suffer in ASEAN and labor-intensive product exports fall to all Chinese partners. This leads China to a marked decrease in its total export to all markets except for Philippines. On the other hand, China imports more from non-ASEAN regions particularly in the 3 impacted sectors but imports labor-intensive goods from ASEAN nations instead.

Table 24 the change of Chinese exports to other regions after imposing a stringent policy in ASEAN compared to the base case in 2015 (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	273.90	291.00	1.48	0.22	99.00	77.00	58.00	70.00	107.00	4.10
Coal	-243.74	-0.31	0.00	0.00	-1.38	-20.10	0.00	-0.68	-0.68	-0.03
Oil	-21.55	-31.70	0.00	0.00	0.00	0.00	-21.00	-10.50	0.00	-0.01
Gas	-37.87	-0.01	0.00	0.00	-0.65	-0.14	-3.70	-2.37	-1.40	-0.01
Oilpcts	-97.30	-226.00	-4.10	-0.04	-27.00	-22.00	-112.00	-15.30	-180.00	-29.00
Electrc	2.09	-0.01	-0.21	-0.59	-0.01	0.00	0.00	-6.58	-120.90	-0.18
CMnf	5044.00	1192.00	75.65	7.90	889.00	475.00	378.00	1047.00	1073.00	261.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-6878.00	-2490.00	-133.00	-69.41	-3135.00	-269.00	-766.00	-1543.00	-902.00	-426.00
Osg	-19.00	-16.10	-0.56	-0.06	-14.50	-4.80	-1.90	-17.60	-5.55	-1.42
Pcf	190.00	-19.00	1.14	-0.23	-36.00	-8.00	-4.00	-17.00	-22.00	6.30
Svces	-56.90	-53.00	-0.76	-0.07	-52.00	-9.70	-23.00	-72.00	-13.30	-4.60
Trans	636.00	3.00	0.90	-0.15	26.00	3.20	80.00	-56.00	6.70	3.50
UtilCns	18.42	-22.10	-3.44	-1.42	-20.00	-1.27	-0.37	-23.20	-8.70	-3.42
Total	-1188.00	-1373.00	-63.00	-64.00	-2272.00	220.00	-415.00	-647.00	-69.00	-189.00

Table 25 the change of Chinese imports to other regions after imposing a stringent policy in ASEAN compared to the base case in 2015 (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	636.00	-112.90	-13.70	-9.98	-132.00	-62.00	-0.82	-404.00	-245.00	-122.30
Coal	-49.63	112.00	0.00	0.00	0.20	0.01	0.00	0.00	105.00	0.17
Oil	-512.12	269.00	0.00	-1.41	49.00	0.00	0.00	78.00	62.00	41.00
Gas	43.29	1.44	0.00	0.04	5.51	4.85	0.00	1.36	11.56	0.45
Oilpcts	-145.02	51.00	0.00	1.02	56.00	1.80	0.00	87.00	0.17	0.35
Electrc	-0.90	0.00	0.00	0.01	1.67	0.00	0.00	1.10	0.00	0.13
CMnf	12546.00	-3448.00	-28.25	-27.20	-4832.00	-1649.00	-1651.00	-4737.00	-686.00	-151.40
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-14213.00	1360.00	7.10	8.97	2790.00	5420.00	1791.00	4639.00	288.00	-6.00
Osg	-43.40	7.40	0.75	0.24	7.60	4.90	3.80	11.60	5.47	0.31
Pcf	164.00	120.00	-1.01	0.30	-366.00	-3.00	13.00	-25.00	-5.00	-9.00
Svces	-410.40	17.30	5.10	1.11	75.00	25.80	257.00	51.00	29.00	2.22
Trans	433.00	-24.00	-10.10	0.65	-136.00	-43.80	-413.00	-142.00	-28.90	-8.63
UtilCns	-8.31	4.10	0.03	0.01	10.00	0.74	1.10	0.60	1.50	0.10
Total	-1558.00	-1644.00	-41.00	-26.10	-2472.00	3701.00	1.00	-438.00	-462.00	-254.00

The mobility of ASEAN outputs was also investigated and shown in table 26 and 27. In general, the figures repeat the characteristics in the lax case; for instance the fall in ASEAN trade, the increase in exports to non-ASEAN regions and the movement of the 3 main impacted outputs across each market. However, the results still confirm that ASEAN productions and trade move to the labor-intensive sector as well as energy sectors like coal, oil, and petroleum products. This could help ASEAN from suffering in agriculture, capital-intensive manufacture, and transportation and communication.

On the whole of economic effects, it can be seen that all ASEAN nations will face a serious situation due to lacking in the 3 main impacted products. The policy does not impact only their exports/imports but also their consumption and investment. These effects take place over a long period of time. In addition, the results show a severe decrease in GDP, in particular low income countries such as Cambodia and Lao in both short-run and long-run while China and South Korea could experience a small decrease in the short-run and gain back in the long-run.

Moreover, the movement of outputs in China reveals that Chinese exports decrease in total for all partners except for Philippines market and ASEAN increases the export in labor-intensive products and energy sectors in the world instead of the 3 main sectors. This might substitute for Chinese exports in the labor-intensive and energy sectors as Eichengreen, Rhee, and Tong. (July, 2007) stated that China and low income countries especially in Asia may compete to each other in consumer good export. However, it can be seen that a lax policy and a stringent policy could impact on ASEAN and non-ASEAN regions in the same way but it appears a stronger degree of impact in the stringent case.

Table 26 the change of the ASEAN state exports after imposing a stringent policy in ASEAN compared to the base case in 2015 (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-86.30	-1399.86	-347.14	-12.00	-29.41	-17.02	-8.22	-10.38	4.51
Coal	90.00	1234.67	-268.30	0.00	0.00	0.00	0.00	0.00	-0.11
Oil	258.00	1528.71	152.31	0.00	0.00	0.00	-1.41	-24.34	-1.93
Gas	1.44	5658.18	88.47	0.00	0.00	0.00	0.04	2.83	0.29
Oil_pcts	44.00	269.19	22.52	0.00	0.00	0.00	1.02	34.06	1.08
CMnf	-2758.00	-14142.30	-2318.47	-22.84	-55.97	-199.26	-21.70	-59.81	-158.55
LMnf	1211.00	14100.00	2156.68	6.10	1258.98	15.87	7.63	183.10	85.57
Osg	7.40	361.28	3.23	0.75	32.82	0.32	0.24	22.78	0.21
Pcf	101.00	486.10	24.96	-0.97	-25.19	-7.80	0.27	6.35	0.63
Trans	-24.00	-778.00	-19.02	-10.10	-225.12	-9.30	0.65	19.61	1.16
Util_Cns	4.10	102.59	-0.74	0.03	0.85	-0.07	0.01	0.31	0.00
Total	-1134.00	8073.00	-489.47	-34.00	1083.45	-212.90	-20.40	199.90	-64.46
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-115.00	-421.24	-56.63	-47.80	-437.91	-6.84	-0.69	-20.72	6.92
Coal	0.17	0.24	-0.01	0.01	0.01	0.00	0.00	0.00	0.00
Oil	47.00	988.87	269.01	0.00	0.00	-0.03	0.00	-0.01	0.00
Gas	5.51	5222.50	35.59	4.85	330.42	31.62	0.00	0.01	0.00
Oil_pcts	50.00	168.71	-32.81	1.50	10.51	-17.90	-2.00	-5.60	-1297.00
CMnf	-4135.00	-14530.67	-5142.21	-1416.00	-2284.67	-571.63	-1463.00	-8620.10	-1064.89
LMnf	2717.00	11961.00	583.10	5324.00	7375.50	625.07	1720.00	8565.00	-1816.66
Osg	7.60	215.64	2.61	4.90	121.39	1.65	3.80	214.88	-9.85
Pcf	-330.00	-1015.30	-328.53	-2.60	-171.39	-68.75	11.00	64.20	-5.24
Trans	-136.00	-3637.40	-126.84	-43.80	-1264.28	-46.48	-413.00	-3091.30	-108.11
Util_Cns	10.00	234.72	-17.04	0.74	19.01	-0.82	1.10	54.31	-9.55
Total	-1801.00	1933.00	-4770.10	3853.00	4691.00	-36.72	117.00	1280.00	-4480.40
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-295.00	-783.90	-104.00	-193.00	-1696.34	-57.86	-107.40	-520.25	-66.08
Coal	0.00	0.00	0.00	87.00	45.06	-22.18	0.12	2.67	-4.19
Oil	74.00	98.18	6.49	60.00	834.61	434.07	39.00	531.69	17.65
Gas	1.36	87.65	8.82	11.56	859.65	81.65	0.37	2306.82	-1289.17
Oil_pcts	75.00	192.90	-243.00	0.15	0.37	4.36	0.25	5.06	-0.04
CMnf	-3847.00	-13751.30	-2748.00	-542.00	-2691.72	-576.00	-129.80	-88.01	-147.33
LMnf	4424.00	22319.00	1632.00	255.00	7662.50	275.30	-4.80	-33.90	-21.29
Osg	11.60	384.49	5.51	5.47	275.03	3.33	0.31	28.36	0.03
Pcf	-20.00	-605.60	-324.00	-4.00	-202.46	-126.20	-7.70	-65.63	-23.82
Trans	-142.00	-3054.50	-76.25	-28.90	-646.89	-29.94	-8.63	-214.08	-11.19
Util_Cns	0.60	13.62	-5.50	1.50	36.76	-2.17	0.10	2.57	-0.55
Total	337.00	6840.00	-1798.00	-319.00	5608.00	20.20	-215.00	2049.00	-1544.23

Table 27 the change of the ASEAN state imports after imposing a stringent policy in ASEAN compared to the base case in 2015 (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	338.00	1489.83	-39.62	1.79	11.00	-2.94	0.32	0.81	-5.57
Coal	-0.37	-0.11	-0.29	0.00	0.00	0.00	0.00	0.00	-0.12
Oil	-33.20	-951.82	14.82	0.00	0.00	0.00	0.00	2.45	1.04
Gas	-0.01	-2.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	-238.00	-530.44	-462.39	-4.50	-6.33	-229.36	-0.04	-0.03	-12.96
CMnf	1364.00	6130.00	-1623.72	91.54	153.36	-46.56	9.70	25.04	-83.91
LMnf	-2735.00	-6864.10	-1759.80	-157.00	-244.81	109.10	-79.72	-97.29	-115.72
Osg	-16.10	-352.20	-2.25	-0.56	-23.84	-0.10	-0.06	-4.06	-0.03
Pcf	-22.00	-333.40	-343.21	1.51	4.94	17.32	-0.33	-8.42	-84.43
Trans	3.00	24.00	-95.37	0.90	14.33	-3.10	-0.15	-6.61	-0.54
Util_Cns	-22.10	-353.10	-12.08	-3.44	-53.32	-2.03	-1.42	-22.10	-0.76
Total	-1416.00	-4270.00	-4368.59	-71.00	-180.83	-156.95	-72.20	-114.87	-304.69
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	124.00	365.54	-357.86	94.00	290.79	-46.12	71.00	197.00	-185.85
Coal	-1.53	-114.92	-103.30	-23.75	-17.68	-45.70	0.00	0.00	0.00
Oil	0.00	-485.05	82.23	0.00	-199.03	88.91	-22.00	-2452.96	536.51
Gas	-0.65	-451.09	79.56	-0.14	-4.31	0.24	-3.70	-302.54	175.83
Oil_pcts	-29.00	-142.24	-557.05	-24.00	-125.82	-36.01	-117.00	-607.37	-22.54
CMnf	1017.00	6104.00	-3047.24	543.00	2876.70	-1093.76	407.00	2795.70	-3158.92
LMnf	-3323.00	-10949.30	271.91	-289.00	-1565.70	1140.13	-787.00	-3494.60	3165.41
Osg	-14.50	-285.71	-0.22	-4.80	-116.95	-0.30	-1.90	-128.21	14.08
Pcf	-43.00	-242.50	-172.94	-9.00	-90.60	-135.07	-4.00	-58.10	-135.95
Trans	26.00	951.20	-16.90	3.20	125.49	-16.79	80.00	1630.00	-123.53
Util_Cns	-20.00	-308.43	-3.00	-1.27	-22.58	-1.49	-0.37	-24.93	1.48
Total	-2315.00	-8047.00	-3839.40	280.00	667.00	-151.54	-399.00	-3423.00	407.48
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	89.00	758.96	-74.60	132.00	479.20	-94.70	5.00	15.45	-7.83
Coal	-0.75	-89.34	-174.94	-0.77	-0.03	-2.50	-0.03	-0.06	-0.01
Oil	-10.90	-2042.18	204.47	0.00	-0.06	0.00	-0.01	-0.24	0.00
Gas	-2.37	-192.70	-1364.40	-1.56	-0.25	0.03	-0.02	-0.21	0.02
Oil_pcts	-16.50	-178.51	-63.78	-214.00	-368.61	-288.01	-31.00	-8.48	-34.80
CMnf	1187.00	7315.30	-3540.80	1234.00	3442.40	-1995.40	295.00	251.66	-112.04
LMnf	-1692.00	-7254.24	578.10	-1086.00	-2773.40	603.30	-468.00	-491.80	-121.76
Osg	-17.60	-370.60	-2.85	-5.55	-209.65	-1.44	-1.42	-69.96	0.15
Pcf	-22.00	-198.80	-90.08	-28.00	-308.20	-181.80	8.20	7.16	51.25
Trans	-56.00	-881.70	-148.39	6.70	135.91	-19.30	3.50	74.81	-2.05
Util_Cns	-23.20	-366.06	-12.43	-8.70	-137.06	-4.03	-3.42	-53.98	-2.08
Total	-644.00	-7064.00	-4769.00	-108.00	-581.00	-1989.00	-197.00	-464.80	-231.56

Emission effect results of simulation 2: ASEAN imposes an emission policy in 2015

The previous section discussed the economic effects of an emission policy on ASEAN either a lax policy or a stringent one. This section would pay attention to emission effects caused by the two kinds of emission policy imposed in the ASEAN region. To illustrate the changed emissions in each region, 6 air emission indicators were studied and divided into three groups of gases. The first group is Carbon dioxide greenhouse gas (CO_2 GHG). The second group is Non-carbon dioxide greenhouse gases such as Methane (CH_4) and Nitrous oxide (N_2O) and the last one is non-GHG air pollutant gases for instance, Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). These types of pollution indicators could hurt both the environment and humans/animals especially the non-GHG pollutants could impact human health through the respiratory system, directly. That is why this study focuses on how much changes in total emissions are, due to an emission policy.

First of all, this section revealed the total emissions of each indicator in each region after ASEAN implements an emission policy either lax or stringent in 2015. The changes in emissions from the base case are compared between the lax and stringent cases in order to express the differences between the two policies among regions. After this, sector analysis was presented by ranking the main contributing emission sectors. Finally, the paper discussed the cost-effectiveness analysis results. This section illustrated which type of the policy the ASEAN nations should opt for, in terms of the total change in emissions and the change in GDP complied with the long-run effects.

The emission effects of lax and stringent policies are presented in table 28 and 29, respectively. The figures in both tables reveal the same implications that Indonesia is the top polluter in ASEAN followed by Thailand both in 2015 and 2030 while China is the top one for CO_2 and non-CO_2 GHG emission compared to the non-ASEAN state group. In the meantime, European Union is the highest polluting region in non-GHG air pollutants in 2015 whereas China could retake that place in 2030.

Table 28 the total emissions in each region under a lax emission policy imposed in ASEAN in 2015 (million tons)

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	359.84	30.69	5382.83	3404.50	1274.17	948.60	387.53	4632.80
	2030	671.54	49.47	19313.62	5168.58	3834.67	1418.38	655.69	7851.51
CH_4	2015	60.72	15.81	640.92	224.38	290.45	6.13	22.74	293.31
	2030	157.33	32.10	3065.75	425.47	728.77	10.42	37.01	707.49
N_2O	2015	14.50	7.50	377.19	194.87	37.74	9.81	9.46	168.60
	2030	31.07	15.34	1362.23	358.33	98.51	15.02	14.76	362.55
SO_2	2015	31.87	4.85	567.38	701.03	76.17	124.84	61.19	304.08
	2030	45.84	8.77	1866.11	1015.47	232.57	162.49	88.51	482.47
NO_2	2015	19.14	2.94	343.55	426.10	46.17	75.79	37.16	184.89
	2030	27.49	5.30	1128.44	615.76	140.76	98.50	53.93	292.69
PM_{10}	2015	13.13	1.89	221.25	266.88	29.57	47.87	23.38	115.42
	2030	19.06	3.49	733.88	392.82	91.03	62.91	33.07	185.96
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	316.55	2.59	1.01	169.87	62.12	66.54	205.46	75.93
	2030	982.48	5.67	2.12	390.59	125.76	143.00	432.84	126.14
CH_4	2015	135.82	5.67	5.94	28.54	14.41	0.97	43.59	41.19
	2030	390.87	10.45	15.86	81.02	32.43	2.13	91.29	100.14
N_2O	2015	21.10	1.06	1.11	3.98	4.91	0.65	10.77	7.19
	2030	59.81	1.97	3.00	9.28	13.25	1.37	21.69	16.40
SO_2	2015	31.71	0.34	0.27	14.24	7.21	8.23	18.15	5.01
	2030	80.66	0.66	0.65	28.13	18.55	13.24	39.94	6.58
NO_2	2015	19.20	0.22	0.16	8.79	4.49	5.04	11.18	3.09
	2030	48.73	0.42	0.39	17.25	11.55	8.08	24.52	4.04
PM_{10}	2015	12.40	0.08	0.10	4.82	2.31	2.93	6.30	1.70
	2030	32.01	0.16	0.26	10.07	5.86	4.89	14.16	2.35

Table 29 the total emissions in each region under a stringent emission policy imposed in ASEAN in 2015 (million tons)

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	361.29	30.77	5389.76	3408.81	1276.89	950.24	388.01	4636.62
	2030	670.21	50.13	19336.92	5156.98	3855.43	1416.71	655.65	7799.60
CH_4	2015	60.62	15.85	640.67	224.28	291.29	6.13	22.75	293.06
	2030	153.42	31.67	3052.02	416.31	724.82	10.34	36.96	686.42
N_2O	2015	14.61	7.52	377.99	195.49	37.90	9.85	9.54	169.32
	2030	30.39	15.10	1362.95	357.17	98.00	14.98	14.85	360.71
SO_2	2015	32.30	4.89	569.92	704.23	76.67	125.78	61.79	305.09
	2030	46.75	8.67	1879.84	1020.37	237.56	163.39	89.56	484.91
NO_2	2015	19.39	2.97	345.03	427.98	46.47	76.33	37.51	185.48
	2030	28.03	5.24	1136.68	618.73	143.76	99.03	54.54	294.17
PM_{10}	2015	13.32	1.91	222.47	268.36	29.80	48.33	23.66	115.90
	2030	19.44	3.45	739.54	394.74	93.07	63.30	33.53	186.89
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	301.12	2.25	0.93	153.27	58.05	64.40	188.54	65.08
	2030	820.71	4.25	1.69	314.14	106.14	131.26	398.90	101.76
CH_4	2015	134.28	5.51	5.57	28.51	13.88	0.94	43.17	38.91
	2030	336.55	8.01	9.00	72.82	27.86	1.96	83.27	86.42
N_2O	2015	21.27	1.03	1.05	3.94	4.89	0.57	10.81	6.78
	2030	49.08	1.51	1.72	7.66	11.43	1.12	18.09	13.97
SO_2	2015	29.26	0.29	0.23	11.08	6.64	7.36	15.31	4.19
	2030	61.87	0.45	0.37	16.72	14.53	10.41	22.84	4.66
NO_2	2015	17.75	0.19	0.14	6.92	4.16	4.54	9.50	2.62
	2030	37.46	0.29	0.23	10.38	9.11	6.39	14.11	2.88
PM_{10}	2015	11.31	0.06	0.09	3.41	2.01	2.53	4.99	1.31
	2030	24.25	0.09	0.14	5.45	4.31	3.69	7.73	1.56

In order to assess the real impacts of the policy on emissions, the total emissions above have to be eliminated the effects of the base case first, as shown in table 30, 31, and 32. They illustrate the deviation emissions from the base case and the results of this are compared between the lax and stringent cases across China and ASEAN nations. The figures in table 30 indicate that apart from CH_4, Chinese emissions increase in both kinds of policy for most indicators. In fact, the stringent policy imposed in ASEAN could have more impact on China as the number of emissions is as twice the lax case.

Turning to ASEAN emissions as a whole, it is obvious that all emissions decrease significantly. In fact, the reduction in non-GHG air pollutants is much larger than those in CO_2 and non-CO_2 GHG in both 2015 and 2030. This relates to the production structure in ASEAN as a whole which is not an industrial region. In other words, it seems to be a low impact on nonindustrial countries as CO_2 and non-CO_2 GHG have a positive correlation to industrial production process. However, these kinds of impacts are revealed as a whole of the ASEAN region which might have differences across ASEAN nations. In addition, this paper further looks at the individual ASEAN nation analysis as presented in table 31 and 32.

The results in these tables still indicate that each ASEAN member could see decreases in all emissions both in 2015 and 2030 similar to the entire ASEAN trend, however; only Indonesia and Thailand pollute more N_2O in 2015. This could be caused by the high exports in oil and petroleum products of both countries. In fact, as N_2O has a high positive correlation on agriculture, and oil and petroleum products (See detail in appendix), if those countries export more oil and petroleum products, they must produce more. Thus, this will lead to an increase in N_2O as well. In addition, oil and petroleum production has not been affected by the policy also. That is why Indonesia and Thailand could experience a small rise in N_2O.

Table 30 the comparison between China and ASEAN of the deviation of emissions from the base case caused by both lax and stringent emission policies imposed in ASEAN in 2015 (million tons)

		CHINA				ASEAN			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch
CO_2	2015	6.94	0.13	13.88	0.26	-68.10	-6.90	-136.20	-13.80
	2030	36.03	0.19	59.34	0.31	-518.92	-18.67	-845.57	-30.42
CH_4	2015	-0.25	-0.04	-0.50	-0.08	-6.12	-2.03	-12.24	-4.05
	2030	-10.64	-0.35	-24.36	-0.79	-107.01	-12.01	-257.39	-28.88
N_2O	2015	0.81	0.21	1.62	0.43	-0.59	-1.07	-1.18	-2.14
	2030	2.22	0.16	2.94	0.22	-19.89	-12.59	-53.13	-33.62
SO_2	2015	2.54	0.45	5.08	0.90	-10.93	-11.29	-21.87	-22.58
	2030	15.90	0.86	29.63	1.60	-65.01	-25.48	-121.51	-47.63
NO_2	2015	1.49	0.43	2.97	0.87	-6.45	-10.91	-12.90	-21.83
	2030	9.48	0.85	17.72	1.58	-39.11	-25.21	-73.21	-47.19
PM_{10}	2015	1.22	0.56	2.44	1.11	-5.00	-13.93	-10.01	-27.85
	2030	6.84	0.94	12.50	1.72	-26.46	-27.33	-48.96	-50.56

Table 31 the comparison across ASEAN members of the deviation of emissions from the base case cused by both lax and stringent emission policies imposed in ASEAN in 2015 (million tons)

		IDN				MYS			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch
CO_2	2015	-15.42	-4.65	-30.85	-9.29	-16.60	-8.90	-33.21	-17.81
	2030	-198.02	-16.77	-359.79	-30.48	-101.42	-20.61	-177.86	-36.15
CH_4	2015	-1.54	-1.12	-3.08	-2.24	-0.03	-0.09	-0.05	-0.18
	2030	-49.79	-11.30	-104.11	-23.63	-9.78	-10.77	-17.98	-19.80
N_2O	2015	0.17	0.81	0.34	1.62	-0.04	-1.11	-0.09	-2.23
	2030	-8.03	-11.83	-18.76	-27.65	-1.67	-15.22	-3.28	-30.00
SO_2	2015	-2.44	-7.16	-4.89	-14.31	-3.16	-18.16	-6.32	-36.33
	2030	-22.91	-22.12	-41.69	-40.26	-15.18	-35.05	-26.60	-61.40
NO_2	2015	-1.45	-7.02	-2.90	-14.04	-1.87	-17.55	-3.74	-35.10
	2030	-13.75	-22.00	-25.02	-40.05	-9.13	-34.62	-16.00	-60.67
PM_{10}	2015	-1.09	-8.05	-2.17	-16.10	-1.41	-22.67	-2.83	-45.34
	2030	-9.47	-22.83	-17.23	-41.53	-6.17	-38.01	-10.79	-66.46
		KHM				LAO			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch
CO_2	2015	-0.34	-11.59	-0.67	-23.04	-0.09	-8.00	-0.17	-15.66
	2030	-2.08	-26.80	-3.50	-45.21	-0.94	-30.71	-1.37	-44.70
CH_4	2015	-0.15	-2.66	-0.31	-5.32	-0.37	-5.86	-0.74	-11.75
	2030	-2.06	-16.45	-4.50	-35.96	-4.36	-21.57	-11.23	-55.50
N_2O	2015	-0.03	-2.45	-0.05	-4.90	-0.07	-5.71	-0.14	-11.46
	2030	-0.39	-16.67	-0.86	-36.29	-0.82	-21.40	-2.10	-55.02
SO_2	2015	-0.06	-14.14	-0.11	-28.21	-0.04	-11.90	-0.07	-23.78
	2030	-0.27	-28.93	-0.48	-52.06	-0.46	-41.52	-0.74	-66.49
NO_2	2015	-0.03	-12.97	-0.07	-25.88	-0.02	-11.70	-0.04	-23.38
	2030	-0.17	-28.37	-0.30	-51.10	-0.28	-41.29	-0.44	-66.11
PM_{10}	2015	-0.03	-25.28	-0.06	-50.46	-0.02	-13.27	-0.03	-26.53
	2030	-0.08	-34.64	-0.15	-61.93	-0.19	-42.69	-0.31	-68.61

Table 32 the comparison across ASEAN members of the deviation of emissions from the base case cused by both lax and stringent emission policies imposed in ASEAN in 2015 (million tons)

		PHL				SGP			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch
CO_2	2015	-4.07	-6.15	-8.15	-12.31	-2.14	-3.11	-4.28	-6.23
	2030	-22.25	-15.03	-41.88	-28.29	-13.87	-8.84	-25.61	-16.33
CH_4	2015	-0.53	-3.54	-1.06	-7.08	-0.03	-2.97	-0.06	-5.94
	2030	-5.46	-14.41	-10.03	-26.47	-0.21	-9.12	-0.39	-16.41
N_2O	2015	-0.02	-0.45	-0.04	-0.89	-0.07	-10.13	-0.15	-20.25
	2030	-2.15	-13.97	-3.96	-25.74	-0.26	-16.01	-0.51	-31.30
SO_2	2015	-0.57	-7.38	-1.15	-14.76	-0.86	-9.49	-1.72	-18.98
	2030	-4.50	-19.52	-8.52	-36.96	-2.83	-17.62	-5.66	-35.22
NO_2	2015	-0.33	-6.87	-0.66	-13.74	-0.51	-9.14	-1.02	-18.29
	2030	-2.73	-19.09	-5.16	-36.17	-1.70	-17.34	-3.39	-34.65
PM_{10}	2015	-0.30	-11.42	-0.60	-22.83	-0.40	-11.97	-0.80	-23.94
	2030	-1.75	-22.99	-3.29	-43.30	-1.19	-19.53	-2.38	-39.19
		THA				VNM			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch	Val_Ch	%Ch
CO_2	2015	-16.93	-7.61	-33.86	-15.22	-10.85	-12.50	-21.70	-25.01
	2030	-141.68	-24.66	-175.63	-30.57	-31.79	-20.13	-56.17	-35.57
CH_4	2015	-0.42	-0.95	-0.83	-1.89	-2.28	-5.25	-4.57	-10.51
	2030	-14.80	-13.95	-22.82	-21.51	-13.27	-11.70	-26.99	-23.80
N_2O	2015	0.04	0.38	0.08	0.77	-0.40	-5.27	-0.80	-10.55
	2030	-2.83	-11.54	-6.43	-26.22	-2.31	-12.33	-4.74	-25.33
SO_2	2015	-2.84	-13.53	-5.68	-27.06	-0.81	-13.99	-1.63	-27.98
	2030	-15.86	-28.42	-32.95	-59.06	-2.47	-27.32	-4.39	-48.55
NO_2	2015	-1.67	-13.01	-3.34	-26.01	-0.48	-13.36	-0.95	-26.72
	2030	-9.55	-28.04	-19.96	-58.58	-1.48	-26.87	-2.64	-47.78
PM_{10}	2015	-1.32	-17.30	-2.64	-34.59	-0.39	-18.57	-0.78	-37.15
	2030	-6.38	-31.07	-12.80	-62.35	-1.02	-30.35	-1.81	-53.70

As we have discussed the emission change caused by an emission policy, it does not address what the main sectors contributing to emissions are. Hence, this section is produced in order to reveal the first three sectors releasing air pollutions in 2015 and 2030 under a lax policy and a stringent one as shown in table 33 to 38, respectively.

Firstly, table 33 indicates the first 3 sectors polluting of CO_2 GHG emissions under a lax emission policy. In general, electricity, capital-intensive manufacture, and transportation and communication are the largest polluting sectors in China and ASEAN. Moreover, agriculture could take place in Cambodia, as well as oil and petroleum sector plays the main role in Singapore and Malaysia in 2030. CH_4 emission (the representative of the non-CO_2 GHG group) in table 34 is commonly emitted by agriculture, public administration (e.g. trash incineration), and transportation and communication. However, coal sector is in the rank of main polluting sectors in China and Vietnam while Singapore, Malaysia and Lao have oil and petroleum sectors in their rank of main polluting sectors.

Turning to the emission of non-GHG air pollutants such as SO_2 (the representative of the non-GHG air pollutant group), as the data of the non-GHG air pollutant emission intensities covers just capital-intensive manufacturing, labor-intensive manufacturing, processing food sector due to the limitation of the dissertation's data source, the figures in table 35 rank among those 3 sectors only. However, it is evident that capital-intensive manufacture causes the vast majority of emissions followed by labor-intensive manufacture and processing food in both years. This rank changes in Cambodia where labor-intensive manufacture has larger portions of emissions than capital-intensive manufacture, while processing food sector emits more SO_2 than labor-intensive manufacture in Lao.

Table 36 and 38 illustrate the rank of main emitting sectors under a stringent policy imposed in ASEAN compared between China and ASEAN nations. In general, the order of the main polluting sectors is similar to the lax policy case but the number of emissions is greater. For example, the capital-intensive manufacturing sector in Indonesia could emit CO_2 in 2015 to just over 68 million tons whereas it could reduce the emissions to 62 million tons under the stringent policy. But both of cases could lead capital-intensive manufacture to the second rank of main polluting sectors in Indonesia.

Table 33 the rank of main sectors emitting carbon dioxide (CO_2) under a lax emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Electricity (3223.33)	Electricity (104.74)	Trans &Com (1.62)	Electricity (0.41)	Electricity (58.95)	Electricity (26.16)	Trans &Com (30.27)	Electricity (81.38)	Electricity (25.98)
2	CMnf (1028.74)	CMnf (68.36)	Electricity (0.53)	Trans &Com (0.28)	Trans &Com (49.15)	Trans &Com (22.32)	Electricity (22.09)	Trans &Com (59.08)	Trans &Com (21.10)
3	Trans &Com (367.99)	Trans &Com (59.12)	Agr (0.30)	CMnf (0.16)	Oil_pcts (22.18)	CMnf (6.57)	Oil_pcts (13.63)	CMnf (24.78)	CMnf (16.26)
Year 2030									
1	Electricity (11617.50)	Electricity (405.93)	Trans &Com (2.99)	Electricity (0.73)	Electricity (120.93)	Electricity (46.81)	Oil_pcts (52.12)	Electricity (160.45)	Electricity (43.77)
2	CMnf (3427.94)	CMnf (178.89)	Electricity (1.87)	Trans &Com (0.70)	Oil_pcts (97.87)	Trans &Com (43.06)	Trans &Com (49.99)	Trans &Com (105.95)	Trans &Com (41.65)
3	Trans &Com (970.70)	Oil_pcts (125.78)	Agr (0.57)	CMnf (0.41)	Trans &Com (94.91)	CMnf (16.98)	Electricity (39.93)	CMnf (56.83)	CMnf (22.43)

Table 34 the rank of main sectors emitting methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a lax emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (257.04)	Agr (60.44)	Agr (5.21)	Agr (5.63)	Agr (6.92)	Agr (7.80)	Osg (0.53)	Agr (31.62)	Agr (33.81)
2	Coal (218.41)	Osg (32.62)	Osg (0.44)	Osg (0.30)	Osg (6.26)	Osg (6.09)	Oil_pcts (0.28)	Osg (5.05)	Osg (5.21)
3	Osg (159.96)	Trans&Com (15.96)	Trans&Com (0.01)	Trans&Com (0.004)	Oil_pcts (4.52)	Coal (0.32)	Trans&Com (0.15)	Trans&Com (3.13)	Coal (1.90)
Year 2030									
1	Coal (1693.26)	Agr (180.16)	Agr (9.97)	Agr (15.00)	Oil (20.91)	Agr (22.46)	Oil_pcts (1.07)	Agr (64.32)	Agr (77.05)
2	Agr (944.55)	Osg (59.33)	Osg (0.45)	Osg (0.74)	Oil_pcts (19.94)	Osg (8.21)	Osg (0.80)	Oil_pcts (9.31)	Osg (11.97)
3	Osg (398.63)	Oil_pcts (54.60)	Trans&Com (0.02)	Oil_pcts (0.05)	Agr (16.17)	Coal (1.34)	Trans&Com (0.25)	Osg (6.85)	Coal (9.65)

Table 35 the rank of main sectors emitting sulfur dioxide (SO_2, the representative of non-GHG air pollutants indicators) under a lax emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (488.50)	CMnf (26.74)	LMnf (0.17)	CMnf (0.21)	CMnf (9.94)	CMnf (4.48)	CMnf (6.31)	CMnf (13.05)	CMnf (3.41)
2	LMnf (68.34)	LMnf (3.10)	CMnf (0.14)	Pcf (0.04)	LMnf (3.69)	LMnf (2.10)	LMnf (1.84)	LMnf (4.18)	LMnf (1.19)
3	Pcf (10.53)	Pcf (1.86)	Pcf (0.03)	LMnf (0.02)	Pcf (0.61)	Pcf (0.64)	Pcf (0.08)	Pcf (0.92)	Pcf (0.40)
Year 2030									
1	CMnf (1627.76)	CMnf (69.98)	LMnf (0.35)	CMnf (0.53)	CMnf (21.33)	CMnf (11.58)	CMnf (10.65)	CMnf (29.93)	CMnf (4.71)
2	LMnf (209.23)	LMnf (7.02)	CMnf (0.27)	Pcf (0.11)	LMnf (5.83)	LMnf (5.94)	LMnf (2.45)	LMnf (8.72)	LMnf (1.14)
3	Pcf (29.11)	Pcf (3.65)	Pcf (0.04)	LMnf (0.01)	Pcf (0.97)	Pcf (1.03)	Pcf (0.14)	Pcf (1.29)	Pcf (0.73)

Table 36 the rank of main sectors emitting carbon dioxide (CO_2) under a stringent emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
					Year 2015				
1	Electricity (3225.54)	Electricity (96.15)	Trans &Com (1.51)	Electricity (0.39)	Electricity (51.03)	Electricity (23.48)	Trans &Com (29.56)	Electricity (73.39)	Electricity (20.7)
2	CMnf (1034.82)	CMnf (62.00)	Electricity (0.33)	Trans &Com (0.25)	Trans &Com (48.48)	Trans &Com (21.94)	Electricity (21.10)	Trans &Com (56.29)	Trans &Com (19.73)
3	Trans &Com (368.11)	Trans &Com (57.80)	Agr (0.29)	CMnf (0.13)	Oil_pcts (21.36)	CMnf (5.53)	Oil_pcts (13.23)	CMnf (18.93)	CMnf (11.95)
					Year 2030				
1	Electricity (11626.07)	Electricity (333.82)	Trans &Com (2.20)	Trans &Com (0.63)	Electricity (94.63)	Trans &Com (38.86)	Trans &Com (47.70)	Electricity (128.41)	Trans &Com (37.60)
2	CMnf (3454.96)	CMnf (134.25)	Electricity (1.44)	Electricity (0.60)	Oil_pcts (85.27)	Electricity (38.79)	Oil_pcts (47.25)	Trans &Com (93.53)	Electricity (33.95)
3	Trans &Com (975.12)	Trans &Com (108.55)	Agr (0.43)	CMnf (0.21)	Trans &Com (83.99)	CMnf (12.03)	Electricity (35.49)	Gas (78.75)	CMnf (14.12)

Table 37 the rank of main sectors emitting methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a stringent emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (257.57)	Agr (62.13)	Agr (5.12)	Agr (5.30)	Agr (6.87)	Agr (7.88)	Osg (0.51)	Agr (31.96)	Agr (32.19)
2	Coal (217.74)	Osg (28.80)	Osg (0.39)	Osg (0.26)	Osg (6.08)	Osg (5.52)	Oil_pcts (0.27)	Osg (4.54)	Osg (4.59)
3	Osg (159.86)	Trans &Com (15.60)	Trans &Com (0.01)	Trans &Com (0.004)	Oil (4.38)	Coal (0.29)	Trans &Com (0.15)	Trans &Com (2.98)	Coal (1.85)
Year 2030									
1	Coal (1678.43)	Agr (146.94)	Agr (7.59)	Agr (8.37)	Oil (20.30)	Agr (19.4)	Oil_pcts (0.97)	Agr (53.40)	Agr (65.53)
2	Agr (944.56)	Osg (51.25)	Osg (0.40)	Osg (0.5)	Oil_pcts (17.37)	Osg (6.92)	Osg (0.74)	Gas (8.45)	Osg (10.40)
3	Osg (400.04)	Oil_pcts (46.70)	Trans &Com (0.02)	Oil_pcts (0.06)	Agr (13.31)	Coal (1.17)	Trans &Com (0.24)	Oil_pcts (7.79)	Coal (9.18)

Table 38 the rank of main sectors emitting sulfur dioxide (SO_2, the representative of non-GHG air pollutants indicators) under a stringent emission policy imposed in ASEAN in 2015 compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (491.38)	CMnf (24.25)	LMnf (0.19)	CMnf (0.18)	CMnf (6.67)	CMnf (3.77)	CMnf (5.37)	CMnf (9.97)	CMnf (2.51)
2	LMnf (67.99)	LMnf (3.20)	CMnf (0.07)	Pcf (0.04)	LMnf (3.84)	LMnf (2.25)	LMnf (1.91)	LMnf (4.44)	LMnf (1.30)
3	Pcf (10.54)	Pcf (1.80)	Pcf (0.03)	LMnf (0.02)	Pcf (0.58)	Pcf (0.61)	Pcf (0.08)	Pcf (0.90)	Pcf (0.38)
Year 2030									
1	CMnf (1640.59)	CMnf (52.52)	LMnf (0.28)	CMnf (0.28)	CMnf (10.94)	CMnf (8.20)	CMnf (7.92)	CMnf (15.83)	CMnf (2.97)
2	LMnf (210.11)	LMnf (6.03)	CMnf (0.13)	Pcf (0.08)	LMnf (4.90)	LMnf (5.41)	LMnf (2.37)	LMnf (5.85)	LMnf (1.04)
3	Pcf (29.13)	Pcf (3.33)	Pcf (0.03)	LMnf (0.02)	Pcf (0.88)	Pcf (0.91)	Pcf (0.12)	Pcf (1.16)	Pcf (0.65)

The cost-effectiveness analysis based on long-term effects

Both economic and emission effects that were been discussed in the previous section reveal either similarities or differences among regions. This depends on the structure of production and trade in those countries as well as the nations' characteristics. For this reason, if ASEAN choose a lax emission policy to be implemented, the effects will obviously be different from the choice of a stringent one. It seems doubtful what a suitable emission policy for ASEAN is. To answer the question, the cost-effectiveness analysis is obtained in order to analyze the long-term effects and is then transformed into a ratio of change in emissions and GDP due to the lax and stringent emission policies as presented in table 39.

The table reveals that if ASEAN imposes a lax emission policy, ASEAN could reduce the total emissions to -5,890 million tons and losing its GDP to -5,031,982 million US dollars over the period of time. Thus the ratio of the emission reduction and the decrease in GDP is 0.117 percent. In contrast, ASEAN could decrease emissions to -11,277 million tons and lose its GDP by -9,160,585 million US dollars from 2015 to 2030. In other words, the ratio of the ASEAN cost-effectiveness is 0.123 percent, if ASEAN implements a stringent emission policy. Although, it seems not much difference between the two ratios, ASEAN could choose a stringent emission policy to be implemented instead of a lax one, if it behaves on a rational basis. However, if ASEAN cares about the short-term impacts more than the long-term, it may select a lax emission policy rather than a stringent one.

Regarding the Chinese aspect under the case of imposing a lax policy in ASEAN, the emissions in China increase slightly to 438 million tons and the GDP in China grow to 191,096 million US dollars, while emission in China could soar to 620 million tons with a marked rise in GDP to 448,576 million US dollars in the case of imposing a stringent emission policy in ASEAN. As a result, it is obvious that China will enjoy the benefit of a stringent emission policy imposed in ASEAN rather than a lax one because the ratio in the stringent case is lower than the lax case. In other words, China could gain more benefits from the rising GDP than losing from the increasing emissions.

Furthermore, in terms of individual ASEAN members, the impacts are different. Most ASEAN nations enjoy a stringent emission policy imposed in their region apart from Malaysia which will be better off, if it implements a lax policy. In fact, Malaysia could export more in oil and petroleum products while it is suffering from the emission policies, particularly a stringent one (Table 40). In addition, oil and petroleum production is not affected by an emission policy so Malaysia would emit more emissions in the case of stringent policy than the lax one.

In conclusion, it can be seen that ASEAN should implement a stringent emission policy to gain more benefits in the long-run. On the one hand, this will lead ASEAN as a whole to face a significant drop in its GDP particularly in the first period of implementation. On the other hand, it could earn benefits back by the marked reduction in emissions as well. However, China could take this opportunity and increase its GDP dramatically in the long-run especially when ASEAN imposes a stringent emission policy. Thus, a stringent policy is the best choice for ASEAN to implement and this is also good for China in terms of achieving their better cost-effectiveness.

Table 39 the percentage of an emission change to GDP change ratio from 2015 to 2030 under an emission policy imposed in ASEAN in 2015 compared between ASEAN and China

	CHN		ASEAN	
	Lax policy	Stringent policy	Lax policy	Stringent policy
Emission Change	438	620	-5890	-11277
GDP Change	191096	448576	-5031982	-9160585
% Ratio	0.229	0.138	0.117	0.123

Table 40 the percentage of an emission change to GDP change ratio from 2015 to 2030 under an emission policy imposed in ASEAN compared across ASEAN members

	IDN		KHM		LAO		MYS	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-2012	-3966	-43	-85	-62	-126	-1170	-2138
GDP Change	-1891854	-3517559	-36193	-68893	-38897	-75082	-734030	-1352435
% Ratio	0.1063	0.1127	0.1199	0.1238	0.1585	0.1679	0.1593	0.1581

	PHL		SGP		THA		VNM	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-302	-576	-171	-331	-1394	-2285	-575	-1082
GDP Change	-498948	-938796	-345683	-650109	-1068298	-1692393	-321429	-578729
% Ratio	0.0605	0.0613	0.0494	0.0509	0.1305	0.1350	0.1789	0.1869

4.3. Simulation 3: China imposes an emission policy on the 3 main sectors such as agriculture, capital-intensive manufacture, and transportation and communication in 2015.

As China has been facing severe pollution, especially in the main cities, the emissions cause an enormous of impact on human and animal health, and ecological deterioration. This may cause China to impose an emission policy in order to slow down the growth in emissions particularly in the 6 main air pollutants: CO_2, CH_4, N_2O, SO_2, NO_2, and PM_{10}. On the one hand, the policy could help China to reduce these kinds of emissions and improve China's ambient air quality. On the other hand, they could harm China's economy as well. The GDP in China may decrease because the emission policy may lead to a reduction in their outputs augmented to technology change due to changing traditional technologies to clean technologies. In fact, China would implement the policy on the 3 main sectors contributing to emissions namely agriculture, capital-intensive manufacture, and transportation and communication.

However, the effects on Chinese economy and environment would differ between a lax policy and a stringent policy. To analyze which an emission policy is better for China and China's partners such as ASEAN, The third scenario is used to simulate the effects on economies and emissions of each region. Therefore, this section will describe such effects. The first part explored the effects on each economy which was divided into lax and stringent policy effects. The results of emission effects were also shown in the second part. At the end of these simulation results, an analysis of cost-effectiveness for China and ASEAN nations was presented in order to inform decision makers in designing an effective emission policy in terms of cost-effectiveness achievement.

Economic effect results of simulation 3.1: China imposes a lax emission policy in 2015

The effects of imposing a lax emission policy in China in terms of the deviation of Gross Domestic Product (GDP) from the base case were shown in table 41 It can be seen that the short-term effects of the lax policy in 2015 causes a significant decrease in China's GDP by -12.05 percent from the attainable GDP in the base case. This would cost China about 461,184 million US dollars in order to gain benefits from reduction in emissions. However, the GDP of non-ASEAN countries could increase slightly as in Australia, New Zealand, European Union, India, Japan, and the US with the exception of South Korea.

Furthermore, ASEAN experiences a slight rise in GDP excluding Cambodia, Philippines and Vietnam. It is interesting that while China is suffering from the lax policy, the ASEAN economy was expected to grow dramatically but it has not. However, Eichengreen, Rhee and Tong (2007) claimed that China's growth has negative effects on the export of low income countries for instance, Cambodia, Bangladesh and Sri Lanka, in particular consumer goods whereas it has a positive effect on both capital and intermediate goods export of high income countries like Singapore, and Japan. From this point of view, when China's growth suffers from the policy, Singapore should have a decrease in export which in turn reduces its GDP, as well as Cambodia could increase its export markedly but the simulation results in general didn't reflect those implications as in Eichengreen, Rhee and Tong's paper.

To investigate this phenomenon, long-term effects are taken into consideration. Thus, each source of nominal GDP is combined from 2015 to 2030 and shown in table 42. The results illustrate the deviation of nominal GDP's expenditure sources such as consumption, investment, government expenditure, export, and import compared to the base case. In general, China will see a dramatic drop in all GDP sources, especially in investment. As a result, GDP in China decreases to -19.76 percent compared to the base case. In fact, the lax emission policy doesn't only affect Chinese production but also its demand in consumption and investment. In addition, South Korea still suffers from the policy in the long-term analysis, and The US could see a drop in its GDP slightly over the period of time as both region' consumption decrese slightly.

Regarding ASEAN nations, Philippines and Cambodia still suffer from the policy, like in the short-term effects. In fact, the number of decreasing in the Philippines' imports is larger than the number of dropping in the exports so a positive trade balance appears in Philippines. However, the key factors reducing GDP in Philippines are the dramatic drop in consumption followed by investment, and government expenditure. As a result, Philippines could lose GDP for -52,576 million US$ compared to the base case. In addition, Malaysia and the rest of Southeast Asia (Brunei Darussalam and Myanmar) are affected by the policy as well. This is caused by the decrease in exports and consumption in those countries respectively. In contrast, Vietnam, in the long-run analysis, could gain and become the top gainer from imposing a lax emission policy in China. Its GDP improves from a -0.35 percent differing from the base case in 2015 to 4.41 percent over time. In fact, the key contributing factor to Vietnamese GDP is a marked increase in its investment as the investment agreements between Vietnam and Europion Union, as well as Japan[6] could draw a huge of money in terms of investment in Vietnam. Both EU and Japan could benefit from the emission policy imposed in China as their GDP grows up.

[6] Mukim, Megha. (2005). *ASEAN Foreign Direct Investment Trends: Implications for EU-ASEAN Relations*. EPC Issue Paper No.31. p.11.

Hence, the FDI in Vietnam from the two regions increases and lead to a rise in its consumption which contributes to its GDP as well.

In addition, Cambodia and Lao are a good case in point. Both countries are low income countries and suppose to gain from the suffering in China due to the lax emission policy as claimed by Eichengreen, Rhee and Tong (2007). But this seems not to appear in this dissertation's findings. Thus, the output movement of these countries needs to be examined for the effects on their export and import as presented in the next part.

Table 41 the change in nominal GDP decomposition in 2015 after imposing an emission lax policy in China compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	4981	4197	1588	1888	2981	9674	1.13
NZL	277	247	88	108	175	546	0.38
CHN	-170079	-227652	-71269	27696	19881	-461184	-12.05
EUR	-3589	18179	-1476	16155	10701	18569	0.11
IND	2715	2155	482	1228	1928	4653	0.35
JPN	2079	6734	612	389	4172	5642	0.13
KOR	-786	-89	-270	1113	1325	-1358	-0.12
USA	7889	14359	1733	3852	7121	20710	0.15
ASEAN regions							
IDN	1356	820	173	141	325	2166	0.45
KHM	-10	-11	-1	5	-4	-12	-0.15
LAO	29	25	4	5	16	48	0.87
MYS	11	127	-4	-683	-616	66	0.03
PHL	-505	-287	-82	-208	-390	-693	-0.44
SGP	34	433	5	-333	-104	243	0.12
THA	35	45	-5	-229	-253	98	0.04
VNM	-183	-207	-20	-147	-301	-255	-0.35
XSE	65	28	15	40	35	113	0.35

Table 42 the change in the combined nominal GDP decomposition between 2015 and 2030 after imposing a lax emission policy in China compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	-14528	61675	-4084	-13122	5786	24156	0.14
NZL	-3147	13628	-912	-6177	-25	3418	0.12
CHN	-6926992	-13716616	-2763128	-855988	-3025838	-21236886	-19.76
EUR	-78016	1706192	-21052	-358496	141520	1107108	0.35
IND	225536	459096	43210	-176214	54366	497261	1.47
JPN	-37652	364508	-10210	-225240	-102734	194140	0.25
KOR	-34658	99570	-9032	-201506	-133729	-11897	-0.06
USA	-343968	474580	-74652	-276136	-163864	-56312	-0.02
ASEAN regions							
IDN	13015	146513	2173	-73105	16160	72436	0.59
KHM	-511	-499	-37	-1094	-1294	-847	-0.53
LAO	-127	1122	-17	-75	551	351	0.22
MYS	-22041	26303	-5799	-43439	-16635	-28340	-0.57
PHL	-32765	-18271	-4585	-44620	-47666	-52576	-1.35
SGP	507	46775	241	-54429	-38136	31230	0.72
THA	-6050	68209	-946	-64922	-19724	16015	0.25
VNM	30060	116379	3020	-92785	-25362	82037	4.41
XSE	-11501	-2869	-2796	-7569	-6492	-18245	-1.98

As the simulation shows a variety of results in particular the change in GDP, this indicates that all sources of expenditure in each region play a role in determining GDP, not just export. However, the causes of fluctuation in the GDPs do not only come from the implementation of an emission policy in China but also the integration of the ASEAN nations. Because this simulation is run under the condition of the elimination of tariff and non-tariff barriers due to the ASEAN Community, ASEAN countries could benefit from their trade liberalization in the community. Consequently, the effects of imposing an emission policy in China on ASEAN economies could be reduced, as ASEAN countries avoid problems by increasing their exports and imports in the community instead of suffering from lower demand in China.

To examine the output mobility affected by a lax policy in China, table 43 – 46 are examined. The figures in the tables present the value change of export and import in China and ASEAN compared with the base case. Table 43 and 44 present deviated exports and imports in China, respectively. From the tables, China's economy could suffer from a lax policy as the exports plummet in the 3 imposed products. However, China counters its losses by increasing labor-intensive manufacturing exports significantly. This is why China could keep a positive trade balance even though the economy suffers from the policy. In addition, the vast majority of China's exports go to non-ASEAN regions rather than ASEAN countries accounting for 28,759 million US dollars whereas it falls to -1,573 million US dollars in export to the ASEAN nations compared with the base case.

To fill a lack in agricultural and capital-intensive goods, China increases its imports from each region especially non-ASEAN regions accounting for 71,018 million US dollars. In contrast, China's imports in consumer goods such as labor-intensive manufacturing and processing food products drop in all partners as well. This could reflect the low demand in China in consumption. Surprisingly, transportation and communication import in China should increase owing to the lax policy applied in this sector but decreases in all regions instead.

Table 43 the change of China export to other regions after imposing a lax emission policy compared to a base case (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	-1874.92	-125.00	-0.79	-0.11	-76.00	-43.00	-25.00	-34.00	-53.00	-2.20
Coal	430.55	0.13	0.00	0.00	0.62	9.00	0.00	0.29	0.23	0.01
Oil	167.66	28.00	0.00	0.00	0.00	0.01	39.00	18.20	0.00	0.01
Gas	502.12	0.01	0.00	0.00	0.69	0.11	17.10	0.96	0.17	0.01
Oil_pcts	1302.50	132.00	1.10	0.01	16.00	21.00	75.00	10.00	86.00	12.00
Electric	288.56	0.01	0.21	0.24	0.01	0.00	0.01	3.80	24.00	0.12
CMnf	-70773.00	-1214.00	-38.85	-6.60	-1212.00	-616.00	-866.00	-1662.00	-1230.00	-148.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	93256.00	769.00	63.00	15.40	1265.00	439.00	1053.00	826.00	525.00	100.00
Osg	1536.50	9.40	0.29	0.03	10.20	3.00	9.20	9.70	2.50	1.02
Pcf	-111.40	1.00	-0.10	0.01	-1.00	-1.00	0.00	-1.00	-1.00	0.20
Svces	6098.10	38.00	0.47	0.04	47.00	8.90	146.00	51.00	11.00	4.10
Trans	-2120.00	-18.00	-0.90	-0.02	-8.00	-3.00	-50.00	-32.00	-5.90	-1.10
Util_Cns	58.10	0.90	0.01	0.04	0.00	-0.02	0.01	0.30	0.00	0.10
Total	28759.00	-380.00	25.00	9.00	43.00	-183.00	398.00	-810.00	-641.00	-34.00

Table 44 the change of China import from other regions after imposing a lax emission policy compared to the base case (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	4152.20	25.00	3.20	4.71	40.00	18.00	0.54	109.00	70.00	29.00
Coal	-88.98	-106.00	0.00	0.00	-0.09	-0.01	0.00	0.00	-100.00	-0.07
Oil	-4296.05	-40.00	0.00	-0.28	-11.00	-0.01	0.00	-10.00	-10.00	-10.00
Gas	-300.21	-0.33	0.00	0.00	-1.05	-0.19	0.00	-0.07	-0.12	-0.08
Oil_pcts	-1050.01	-15.00	0.00	-0.16	-33.00	-3.40	-84.00	-53.00	-0.02	-0.19
Electric	-83.60	0.00	0.00	0.00	-0.73	0.00	0.00	-0.41	0.00	-0.07
CMnf	66866.00	1404.00	4.00	11.40	1297.00	585.00	1044.00	1710.00	176.00	23.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-35025.00	-349.00	-1.80	-1.44	-1617.00	-1266.00	-926.00	-1271.00	-79.00	-9.50
Osg	-1136.10	-3.90	-0.39	-0.07	-4.40	-2.90	-6.30	-5.50	-2.06	-0.21
Pcf	-343.00	-57.00	-0.04	-0.05	-76.00	-0.40	-5.00	-16.00	-3.00	-0.70
Svces	-5984.90	-7.00	-2.73	-0.51	-43.00	-15.60	-392.00	-31.00	-8.80	-1.52
Trans	-967.00	-4.00	-0.30	-0.18	-5.00	0.00	-37.00	-9.00	-0.20	-0.30
Util_Cns	-488.63	-2.50	-0.05	-0.01	-12.70	-0.59	-2.20	-3.10	-1.60	-0.28
Total	21260.00	846.00	1.00	13.40	-467.00	-685.00	-408.00	420.00	41.00	29.00

Furthermore, the ASEAN output mobility is also affected by the policy therefore; the export and import in each ASEAN nation are captured and presented in table 45 and 46. The tables illustrate the deviation of the export and import in each ASEAN country compared to their base case by separating their trading partners into 3 regions, namely China, non-ASEAN, and ASEAN itself.

In general, all ASEAN nations increase their export within the ASEAN markets due to deceasing demand in China and the ASEAN Community. This is how ASEAN countries avoid negative impacts from China's emission policy. However, Thailand, Indonesia and Vietnam could gain benefits by expanding their exports to China in particular the capital-intensive sector. Singapore is a good case in point, its export drops in all 3 main markets including the ASEAN markets. This is caused by dramatically low export in labor-intensive manufacturing goods. Like Singapore, Malaysia experiences a marked fall in its export to both China and non-ASEAN regions as well, but increases slightly in ASEAN markets. In addition, the ASEAN export could face the positive effects from the significant increase in agricultural and capital-intensive goods export to most of the 3 main markets especially China. However, there is a dramatic decrease in labor-intensive goods in all ASEAN nations as well as a drop in processing food products in some ASEAN members. This is confirmed by Eichengreen, Rhee and Tong (2007) who claimed that China could compete with low income countries in consumer goods. Hence, it can be seen that when China moves its exports from capital-intensive and agricultural goods to labor-intensive and processing food products, such product exports in ASEAN fall remarkably.

From ASEAN import view, it is obvious that imports from China go down in most ASEAN countries such as Thailand, Vietnam, Indonesia, and Philippines whereas Singapore, Cambodia and Lao could import more from China particularly in labor-intensive manufacture goods. Labor-intensive manufacturing products from China hold the main role in the ASEAN import. This leads to the reduction in the labor-intensive goods import from the other two main markets. Moreover, as the ASEAN nations form the ASEAN Community, the imports from ASEAN together go up for each member, in particular Vietnam which accounts for 206 million US dollars. This excludes Malaysia and Singapore which are affected by the significant increase in labor-intensive goods import from China. As a result, Malaysia and Singapore have to reduce such imports from the ASEAN regions.

As the base case scenario is conducted under tariff and non-tariff barrier elimination in ASEAN, trade in the community shows the upward trend of trading within ASEAN rather than non-ASEAN and China. This is reinforced by the lax emission policy implemented in China which in turn pushes up trade in the ASEAN region. For this reason, if ASEAN has not formed into the ASEAN Community before China implements an emission policy, it will be hard for the ASEAN nations to avoid the effects.

Table 45 the change of ASEAN exports after imposing a lax emission policy in China compared to the base case (million US dollars)

		IDN			KHM			LAO	
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	20.00	2.92	28.33	2.80	0.52	1.41	4.03	-0.53	0.63
Coal	-90.00	2.08	26.80	0.00	0.00	0.00	0.00	0.00	0.01
Oil	-38.00	20.41	0.00	0.00	0.00	0.00	-0.28	-0.77	-0.05
Gas	-0.33	-28.59	-0.32	0.00	0.00	0.00	0.00	-0.07	-0.01
Oil_pcts	-14.00	16.35	0.89	0.00	0.00	0.00	-0.16	-0.96	-0.08
CMnf	1162.00	922.10	342.81	3.30	1.66	11.61	9.40	4.68	19.11
LMnf	-311.00	-1372.00	-384.32	-1.60	-21.22	-2.59	-1.24	-11.29	-9.06
Osg	-3.90	-12.96	-0.30	-0.39	0.09	0.00	-0.07	-0.70	-0.01
Pcf	-50.00	-47.90	-7.00	-0.03	0.27	0.22	-0.05	-0.59	-0.07
Trans	-4.00	-18.20	-0.94	-0.30	9.44	0.41	-0.18	-2.49	-0.11
Util_Cns	-2.50	-1.43	-0.19	-0.05	0.02	0.00	-0.01	-0.01	0.00
Total	661.00	-530.00	8.89	1.00	-7.33	11.60	10.80	-13.31	7.89
		MYS			PHL			SGP	
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	36.00	9.54	16.50	15.00	18.81	1.22	0.47	0.01	1.18
Coal	-0.08	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
Oil	-11.00	37.15	5.00	-0.01	0.00	0.00	0.00	0.00	0.00
Gas	-1.05	104.97	-0.04	-0.19	22.94	2.32	0.00	0.00	0.00
Oil_pcts	-30.00	15.62	0.00	-3.10	4.60	1.39	-76.00	77.90	-28.00
CMnf	1124.00	597.00	531.21	514.00	200.54	88.35	937.00	618.40	613.01
LMnf	-1580.00	-1111.00	-473.10	-1247.00	53.30	-44.12	-893.00	-798.00	-776.03
Osg	-4.40	-0.12	-0.02	-2.90	4.32	0.19	-6.30	-3.95	-0.26
Pcf	-70.00	8.90	7.92	-0.30	24.89	6.38	-5.00	4.00	5.08
Trans	-5.00	73.40	3.06	0.00	78.10	3.32	-37.00	80.40	0.56
Util_Cns	-12.70	9.53	0.05	-0.59	1.80	0.06	-2.20	3.05	0.04
Total	-596.00	-232.00	91.90	-740.00	462.00	61.42	-473.00	-82.00	-184.90
		THA			VNM			XSE	
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	86.00	2.20	12.00	58.00	20.94	8.91	26.00	0.50	3.90
Coal	0.00	0.00	0.00	-88.00	11.83	4.53	-0.05	-0.06	1.00
Oil	-9.90	-3.32	-0.28	-10.00	68.34	27.00	-10.00	23.06	2.10
Gas	-0.07	1.21	0.11	-0.12	26.62	2.51	-0.07	28.68	-15.04
Oil_pcts	-47.00	18.50	-8.00	-0.01	0.02	0.30	-0.13	0.28	-0.03
CMnf	1417.00	755.00	486.00	143.00	85.90	50.60	20.00	1.65	5.15
LMnf	-1218.00	-1395.00	-433.00	-70.00	-507.30	-59.10	-7.90	-28.45	-5.11
Osg	-5.50	-0.39	-0.06	-2.06	4.08	0.08	-0.21	-0.65	-0.02
Pcf	-13.00	4.80	15.00	-3.00	21.15	9.79	-0.60	-0.97	-0.01
Trans	-9.00	108.70	3.20	-0.20	25.72	1.33	-0.30	0.41	0.01
Util_Cns	-3.10	1.05	-0.10	-1.60	0.07	0.01	-0.28	-0.17	-0.02
Total	167.00	-508.00	79.00	18.00	-219.00	47.80	25.00	19.00	-6.01

Table 46 the change of ASEAN imports after imposing a lax emission policy in China compared to the base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-152.00	96.96	8.17	-0.97	0.39	0.19	-0.16	0.07	0.32
Coal	0.16	-0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.01
Oil	28.00	13.00	6.00	0.00	0.00	0.00	0.00	-0.02	-0.03
Gas	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	143.00	-35.19	-33.16	1.30	0.02	3.41	0.01	0.00	1.00
CMnf	-1414.00	855.00	371.18	-48.26	10.05	41.64	-8.10	1.48	12.05
LMnf	854.00	-361.90	-207.08	76.00	-54.53	-33.30	17.90	-2.53	-10.95
Osg	9.40	0.67	0.13	0.29	-0.33	-0.01	0.03	0.09	0.00
Pcf	1.00	19.00	24.01	-0.14	0.17	-0.86	0.01	0.43	4.20
Trans	-18.00	48.10	3.89	-0.90	-0.11	0.01	-0.02	0.38	0.02
Util_Cns	0.90	8.71	0.36	0.01	-0.11	-0.01	0.04	0.39	0.01
Total	-511.00	649.00	177.08	28.00	-45.57	10.09	10.00	0.27	6.00

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-103.00	82.25	29.98	-55.00	34.81	4.31	-35.00	19.75	28.81
Coal	0.71	3.51	12.50	10.80	-1.01	-1.00	0.00	0.00	0.00
Oil	0.00	9.00	5.94	0.01	29.00	2.10	41.00	82.90	17.88
Gas	0.69	7.28	-0.92	0.11	-0.29	0.00	17.10	0.40	4.37
Oil_pcts	16.00	5.91	35.70	22.00	-6.32	-3.11	80.00	48.21	14.40
CMnf	-1409.00	1090.00	475.10	-719.00	635.10	210.11	-948.00	1030.90	282.88
LMnf	1351.00	-1503.80	-717.90	478.00	-800.20	-188.06	1091.00	-1405.30	-524.65
Osg	10.20	-11.09	-0.20	3.00	-6.63	-0.14	9.20	-18.27	0.07
Pcf	0.00	10.30	7.92	-2.00	-1.10	3.00	0.00	8.40	5.99
Trans	-8.00	-0.60	0.83	-3.00	-18.61	-0.66	-50.00	97.10	6.29
Util_Cns	0.00	-3.27	-0.21	-0.02	-0.65	-0.05	0.01	-2.11	-0.14
Total	-93.00	-350.00	-148.90	-256.00	-163.00	22.97	353.00	-292.00	-164.66

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-46.00	38.75	7.20	-69.00	40.00	10.74	-2.80	1.24	1.12
Coal	0.32	5.37	25.92	0.26	0.00	-0.20	0.01	0.00	0.00
Oil	18.90	96.90	6.99	0.00	0.01	0.00	0.01	0.00	0.00
Gas	0.96	0.38	-15.89	0.19	-0.05	-0.02	0.02	-0.01	0.00
Oil_pcts	12.00	3.68	4.99	106.00	-49.47	-53.53	12.00	-1.04	-8.13
CMnf	-1911.00	1732.80	440.30	-1443.00	1042.60	445.00	-171.00	53.34	107.60
LMnf	914.00	-1220.82	-381.30	641.00	-788.30	-195.20	111.00	-47.31	-35.54
Osg	9.70	-9.97	-0.16	2.50	-5.06	-0.12	1.02	-0.02	0.01
Pcf	-2.00	10.10	2.89	-2.00	0.80	-1.07	0.30	0.53	5.08
Trans	-32.00	8.80	1.03	-5.90	-15.80	-0.84	-1.10	2.41	0.27
Util_Cns	0.30	2.14	-0.01	0.00	-3.36	-0.14	0.10	0.90	0.04
Total	-979.00	607.00	86.00	-735.00	181.00	206.00	-46.00	10.50	71.20

Economic effect results of simulation 3.2: China imposes a stringent emission policy in 2015

This simulation is used to evaluate what the effects would be if China imposes a stringent emission policy rather than a lax one. Obviously, the more stringent in the policy, the higher losses in polluting sectors e.g. agriculture, capital-intensive manufacture, and transportation and communication. This leads to a slow growth of the Chinese economy. Thus, the change in China's GDP after imposing a stringent policy can be seen in table 47. By comparing with the base case, China would suffer from the stringent emission policy much more than it would face in the lax policy simulation due to a serious drop in China' technological augmented outputs. Its GDP falls from the base case dramatically to -24.11 percent. The cost to China would be 922,369 million US dollars, double the result in the lax case.

However, most non-ASEAN regions could experience a higher GDP except for South Korea which decreases slightly due to a fall in its national income which in turn reduce South Korea's consumption. In fact, Australia is the country that will benefit from the stringent policy imposed in China especially in 2015 more than others, accounting for a 2.26 percent increase because China imports a large amount of energy, capital-intensive, and agriculture products from Australia. Thus, its national income increases significantly and plays a main role in Australian increasing consumption which is a main contributing factor to its GDP. In ASEAN regions, like the lax case, Cambodia, Philippines, and Vietnam still experience negative effects from the policy more than other ASEAN nations which could gain roughly twice as much as in the lax policy. Especially Lao become the most gainer in ASEAN in 2015 when China imposes a stringent emission policy as it could increase the capital-intensive export to both China and ASEAN nations significantly, as well as Lao would see the increasing national income which lead to a higher consumption in Lao. To sum up, the effects of a stringent policy in the short-term analysis replicate the lax policy results but seem stronger in both gains and losses.

Nevertheless, the short-run analysis may be inadequate to determine all impacts from the policy. Thus the combined decomposition of GDP is examined by the comparison with the long-run results in the base case as shown in table 48. The table indicates that the US will increase its GDP in the long-term of a stringent case whereas it could suffer in the long-run of a lax policy case. For ASEAN nations, it is interesting to note that in the case of a lax policy, Cambodian GDP is reduced either in the short or long term, while for a stringent policy, Cambodia could improve the falling GDP in the short-run and become the top gainer in the long-run with a 6.63 percent increase in its GDP. This would be results of a dramatically increasing in labor-intensive goods export to EU and a rise in Cambodien household income which in turn increases its consumption as well as Cambodia's rate of return on investment goes up so this could attract many FDIs from other regions to Cambodia.

In contrast, Vietnam was a top gainer under a lax policy in particular the long-run period but becomes the highest loser in a stringent policy case with a huge decrease in its GDP of -37.21 percent. In fact, the worse change in Vietnam is caused by a dramatic drop in its investment and consumption, even though it can earn more from increasing exports. This phenomenon could be felt as Vietnam's exports in gas products drop significantly particulary to non-ASEAN countries such as EU, China, the US, and Malaysia where used to be the main Vietnam's market for energy product, imports such goods from China instead. Moreover, the rate of investment return in Vietnam has decreased along the period of implementing a stringent policy in China so Vietnam could see a marked drop in its investment. For these reasons, Vietnam's GDP become the worst when China imposes a stringent policy.

On the whole of changing in GDP, there are different implications between the short and long run effects in the case of stringent policy, unlike the lax policy. In fact, in the short-run, the results reflect the same implications in both lax and stringent policy, but in the long-run, ASEAN nations are impacted dramatically in both positive and negative ways by a stringent policy. As a result, the low income countries like Cambodia could recover GDP and become the top gainer in the long-term, while Vietnam will be confronted with significant losses in its GDP.

Table 47 the change in each source of nominal GDP in 2015 after imposing a stringent emission policy in China compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	Total	%Change
			Non-ASEAN regions				
AUS	9962	8394	3177	3777	5962	19348	2.26
NZL	554	494	176	217	349	1093	0.76
CHN	-340158	-455304	-142537	55391	39762	-922369	-24.11
EUR	-7178	36359	-2952	32313	21400	37142	0.21
IND	5430	4310	964	2456	3855	9305	0.70
JPN	4159	13469	1224	778	8345	11284	0.26
KOR	-1573	-177	-541	2226	2651	-2716	-0.25
USA	15778	28717	3466	7703	14242	41422	0.30
			ASEAN regions				
IDN	2712	1640	347	282	649	4332	0.89
KHM	-19	-21	-2	10	-9	-24	-0.30
LAO	58	51	7	10	32	95	1.72
MYS	21	254	-9	-1366	-1232	131	0.06
PHL	-1010	-574	-164	-415	-779	-1386	-0.88
SGP	68	865	11	-666	-208	487	0.24
THA	70	89	-10	-457	-506	196	0.07
VNM	-365	-415	-40	-293	-602	-510	-0.70
XSE	129	55	29	81	69	225	0.70

Table 48 the change in each source of combined nominal GDP between 2015 and 2030 after imposing a stringent emission policy compared to the base case (million US$)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	-19176	109241	-5066	-16046	11540	57413	0.33
NZL	-6393	21940	-1866	-11208	-1609	4082	0.14
CHN	-12874628	-24486622	-5137275	-2345004	-5637356	-39206173	-36.48
EUR	4752	3011296	13276	-445472	310568	2273284	0.71
IND	435970	850321	83582	-317091	102064	950718	2.81
JPN	-54504	634387	-14093	-358734	-170271	377327	0.48
KOR	-58911	172813	-15367	-354813	-239489	-16790	-0.09
USA	-306688	948888	-63088	-408660	-229184	399636	0.15
ASEAN regions							
IDN	21383	271926	4095	-123738	39450	134216	1.10
KHM	6093	10034	439	2673	8699	10540	6.63
LAO	-4322	3373	-511	-3899	-114	-5245	-3.26
MYS	-40800	44611	-10620	-83596	-37186	-53219	-1.07
PHL	-58138	-26055	-7686	-82552	-83483	-90947	-2.34
SGP	-485	79841	87	-77946	-52561	54058	1.24
THA	13497	187829	4394	-95545	14045	96130	1.52
VNM	-348018	-475612	-35154	197740	31520	-692563	-37.21
XSE	-19243	-3635	-4670	-12487	-10109	-29927	-3.25

Although the change in GDP could represent the effects in each economy, the movement of output was still needed to assess how the effects are conveyed. Hence, table 49 and 50 were formulated in order to determine export and import in China. The mobility of the ASEAN outputs was also shown in table 51 and 52.

As the figures in table 49 illustrate Chinese exports under a stringent policy in terms of value changes from the base case, China’s export could lose due to the stringent policy much more than in the lax policy case. For example the 3 main polluting productions fall double as the results of the lax policy and labor-intensive products still play the main role in the Chinese export after implementing the stringent policy. On the other hand, China needs to fill a lack of products in agriculture and capital-intensive manufacture by importing more from its partners as presented in table 50. China reduces import in transportation and communication as in the lax policy case even though it imposes the policy on this sector also. However, the proportion of trade either of export or import in China is still allocated to the non-ASEAN regions more than the ASEAN markets.

Table 49 the change of Chinese exports to other regions in 2015 after imposing a stringent emission policy in China compared to the base case (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	-3749.72	-250.00	-1.58	-0.21	-152.00	-85.00	-51.00	-69.00	-106.00	-4.38
Coal	860.11	0.27	0.00	0.00	1.24	18.00	0.00	0.57	0.46	0.02
Oil	337.21	55.00	0.00	0.00	0.00	0.01	77.00	36.20	0.00	0.02
Gas	1003.26	0.02	0.00	0.00	1.38	0.23	34.20	1.92	0.34	0.03
Oil_pcts	2608.10	264.00	2.20	0.02	31.00	41.00	150.00	21.00	171.00	23.00
Electric	578.12	0.01	0.42	0.47	0.01	0.00	0.02	7.50	49.00	0.24
CMnf	-141548.00	-2429.00	-77.75	-13.16	-2423.00	-1233.00	-1732.00	-3325.00	-2460.00	-295.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	186511.00	1538.00	127.00	31.20	2529.00	878.00	2105.00	1651.00	1050.00	200.00
Osg	3073.00	18.80	0.58	0.05	20.40	6.00	18.30	19.50	5.00	2.03
Pcf	-224.80	1.00	-0.20	0.02	-1.00	-3.00	0.00	-2.00	-2.00	0.50
Svces	12193.10	76.00	0.95	0.08	95.00	17.80	293.00	102.00	22.10	8.30
Trans	-4240.00	-36.00	-1.80	-0.03	-17.00	-6.00	-100.00	-64.00	-11.90	-2.10
Util_Cns	115.19	1.80	0.02	0.07	1.00	-0.04	0.03	0.70	0.00	0.20
Total	57518.00	-761.00	50.00	18.00	86.00	-365.00	796.00	-1620.00	-1282.00	-67.00

Table 50 the change of Chinese imports from other regions in 2015 after imposing a stringent emission policy in China compared to the base case (million US dollars)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	8308.40	51.00	6.30	9.41	80.00	36.00	1.09	218.00	141.00	57.00
Coal	-178.95	-211.00	0.00	0.00	-0.18	-0.02	0.00	0.00	-199.00	-0.13
Oil	-8592.10	-79.00	0.00	-0.55	-23.00	-0.01	0.00	-20.10	-20.00	-19.00
Gas	-600.33	-0.66	0.00	-0.01	-2.11	-0.38	0.00	-0.15	-0.24	-0.16
Oil_pcts	-2102.02	-30.00	0.00	-0.32	-66.00	-6.80	-169.00	-105.00	-0.03	-0.37
Electric	-167.20	0.00	0.00	0.00	-1.46	0.00	0.00	-0.82	0.00	-0.15
CMnf	133733.00	2809.00	8.00	22.90	2593.00	1171.00	2087.00	3419.00	351.00	47.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-70049.00	-697.00	-3.60	-2.89	-3234.00	-2532.00	-1851.00	-2542.00	-158.00	-18.70
Osg	-2271.30	-7.72	-0.78	-0.15	-8.70	-5.74	-12.70	-11.09	-4.13	-0.41
Pcf	-685.00	-115.00	-0.08	-0.10	-152.00	-0.70	-10.00	-32.00	-7.00	-1.40
Svces	-11967.80	-14.00	-5.43	-1.03	-86.00	-31.10	-783.00	-61.10	-17.70	-3.04
Trans	-1933.00	-7.00	-0.50	-0.36	-9.00	0.00	-74.00	-18.00	-0.50	-0.60
Util_Cns	-975.46	-5.10	-0.10	-0.01	-25.40	-1.17	-4.50	-6.20	-3.13	-0.56
Total	42519.00	1692.00	3.00	26.80	-934.00	-1370.00	-816.00	840.00	82.00	58.00

Regarding the mobility of outputs in the ASEAN nations, table 51 indicates that they could enjoy more exports in agricultural and capital-intensive products, especially Thailand which can hold a top position in export of capital-intensive goods. However, as China enhances exports in labor-intensive products, this could substitute for exports in such products from the ASEAN nations as it can be seen a drop in the labor-intensive sector in each ASEAN member. In addition, it appears that except for agricultural and capital-intensive goods, the exports from ASEAN to China are much less than they were in the lax policy case. This may be caused by the low demand in China due to the stronger emission policy. Thus, the export value within ASEAN nations could increase more than the lax case one, excluding Singapore and the rest of Southeast Asia.

As mentioned, China reduced its impacts of the emission policy by increasing labor-intensive manufacturing exports. The ASEAN import figures in table 52 support this argument by showing the decline from both non-ASEAN and ASEAN imports in labor-intensive goods while improving from China. In contrast, the agricultural and capital-intensive manufacturing import falls from China but rises from the other two markets. Additionally, the trend of importing from ASEAN themselves is increased in all members apart from Malaysia and Singapore, similar to the lax case.

To sum up, export and import under a stringent emission policy are varied across three main markets: China, non-ASEAN regions, and ASEAN members but it appears that the mobility of outputs within the ASEAN region is higher than in the lax case. However, some ASEAN countries like Thailand, Indonesia, and Malaysia could gain more from exporting capital-intensive goods while most ASEAN nations could lose from a significant decrease in labor-intensive manufacturing exports as well. The import of labor-intensive manufacturing goods from China to ASEAN increases significantly so the import from non-ASEAN and ASEAN markets drops markedly. However, in general, the impacts of the stringent policy duplicate the same implications as in the lax policy case, and they could encourage trade in ASEAN as well.

Table 51 the change of ASEAN exports in 2015 after imposing a stringent emission policy in China compared to the base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	40.00	4.63	59.36	5.60	1.13	3.81	7.93	-1.07	1.37
Coal	-181.00	6.16	54.60	0.00	0.00	0.00	0.00	0.00	0.02
Oil	-76.00	42.82	1.00	0.00	0.00	0.00	-0.55	-1.73	-0.13
Gas	-0.66	-55.10	-1.66	0.00	0.00	0.00	-0.01	-0.15	-0.02
Oil_pcts	-27.00	30.70	3.69	0.00	0.00	0.00	-0.32	-1.93	-0.14
CMnf	2324.00	1846.10	685.63	6.60	3.11	23.01	18.70	9.25	38.21
LMnf	-623.00	-2748.00	-766.44	-3.30	-41.35	-6.20	-2.48	-22.59	-20.11
Osg	-7.72	-22.83	-0.59	-0.78	0.36	0.00	-0.15	-1.38	-0.03
Pcf	-100.00	-94.80	-11.00	-0.07	0.54	0.35	-0.09	-1.18	-0.15
Trans	-7.00	-35.40	-1.69	-0.50	18.89	0.81	-0.36	-5.08	-0.23
Util_Cns	-5.10	-3.86	-0.38	-0.10	0.06	0.00	-0.01	-0.02	0.00
Total	1323.00	-1058.00	16.78	2.00	-14.55	21.98	21.70	-27.59	16.69
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	73.00	20.00	35.01	30.00	39.43	2.53	0.94	0.23	3.25
Coal	-0.16	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
Oil	-22.00	73.28	10.00	-0.01	0.00	0.00	0.00	0.00	0.00
Gas	-2.11	209.05	-0.05	-0.38	45.86	4.65	0.00	0.00	0.00
Oil_pcts	-59.00	32.24	-1.00	-6.20	9.81	1.88	-152.00	155.90	-51.00
CMnf	2249.00	1195.00	1062.42	1029.00	401.08	176.69	1873.00	1235.80	1229.01
LMnf	-3161.00	-2222.00	-946.20	-2494.00	110.50	-90.15	-1787.00	-1594.00	-1552.05
Osg	-8.70	-0.44	-0.02	-5.74	8.54	0.35	-12.70	-8.88	-0.52
Pcf	-140.00	20.80	15.94	-0.60	50.67	13.76	-9.00	9.40	9.17
Trans	-9.00	147.80	5.22	0.00	153.20	6.53	-74.00	160.80	1.23
Util_Cns	-25.40	19.95	0.27	-1.17	3.72	0.13	-4.50	5.18	-0.01
Total	-1192.00	-462.00	182.90	-1480.00	922.00	122.84	-946.00	-165.00	-370.80
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	172.00	5.30	23.90	117.00	41.87	16.81	51.00	2.11	8.81
Coal	0.00	0.00	0.00	-176.00	22.87	9.18	-0.09	-0.13	2.00
Oil	-19.30	-6.56	-0.54	-19.00	138.69	54.01	-19.00	45.12	6.20
Gas	-0.15	2.41	0.21	-0.24	53.11	5.05	-0.13	56.35	-29.07
Oil_pcts	-95.00	36.10	-17.00	-0.03	0.04	0.61	-0.25	0.36	-0.05
CMnf	2834.00	1512.00	975.00	287.00	170.80	101.30	39.00	3.31	10.60
LMnf	-2435.00	-2791.00	-863.00	-141.00	-1011.60	-119.20	-15.80	-58.18	-11.33
Osg	-11.09	-1.78	-0.12	-4.13	8.17	0.17	-0.41	-1.60	-0.03
Pcf	-27.00	11.60	32.00	-5.00	41.30	19.46	-1.30	-2.05	-0.23
Trans	-18.00	215.30	8.39	-0.50	51.53	2.76	-0.60	0.02	0.03
Util_Cns	-6.20	2.19	-0.09	-3.13	1.16	-0.01	-0.56	-0.53	-0.05
Total	333.00	-1012.00	156.00	36.00	-440.00	94.50	51.00	38.00	-13.02

Table 52 the change of ASEAN imports in 2015 after imposing a stringent emission policy in China compared to the base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-305.00	192.02	16.05	-1.94	0.77	0.49	-0.32	0.14	0.74
Coal	0.32	-0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.03
Oil	57.00	26.90	13.99	0.00	0.00	0.00	0.00	-0.03	-0.06
Gas	0.02	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	285.00	-71.28	-66.31	2.50	0.15	6.82	0.03	0.00	1.01
CMnf	-2828.00	1714.00	742.35	-96.46	20.20	84.38	-16.18	2.95	25.10
LMnf	1707.00	-723.80	-412.16	152.00	-109.24	-69.80	36.00	-5.26	-21.92
Osg	18.80	0.33	0.27	0.58	-0.77	-0.01	0.05	0.19	0.01
Pcf	2.00	36.80	49.02	-0.27	0.34	-1.82	0.02	0.84	7.51
Trans	-36.00	96.20	8.78	-1.80	-1.19	0.02	-0.03	0.75	0.04
Util_Cns	1.80	19.43	0.72	0.02	-0.34	-0.03	0.07	0.87	0.03
Total	-1022.00	1298.00	354.16	56.00	-91.21	21.29	20.00	0.64	13.01

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-205.00	165.59	61.05	-110.00	67.63	8.42	-69.00	39.81	58.75
Coal	1.41	7.02	26.00	21.70	-2.02	-2.10	0.00	0.00	0.00
Oil	0.00	17.00	11.87	0.01	57.00	3.09	81.00	166.90	35.74
Gas	1.38	14.54	-1.84	0.23	-0.59	-0.01	34.20	-0.30	8.77
Oil_pcts	33.00	12.41	71.40	45.00	-12.55	-5.21	160.00	93.51	28.70
CMnf	-2818.00	2179.00	949.00	-1438.00	1271.20	421.12	-1896.00	2061.90	563.79
LMnf	2703.00	-3008.50	-1436.70	956.00	-1599.40	-376.13	2181.00	-2809.60	-1049.40
Osg	20.40	-22.39	-0.38	6.00	-12.16	-0.28	18.30	-34.46	0.13
Pcf	-1.00	22.80	15.82	-4.00	-1.20	4.00	0.00	17.80	11.19
Trans	-17.00	-0.30	1.85	-6.00	-37.33	-1.31	-100.00	194.20	12.68
Util_Cns	1.00	-6.44	-0.45	-0.04	-1.28	-0.11	0.03	-3.33	-0.19
Total	-186.00	-700.00	-300.80	-512.00	-325.00	46.93	705.00	-585.00	-328.31

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-91.80	77.40	11.40	-138.00	79.90	20.37	-5.61	2.46	2.34
Coal	0.64	10.75	51.93	0.53	0.00	-0.40	0.02	0.00	0.00
Oil	37.90	194.91	10.97	0.00	0.01	0.00	0.02	-0.01	-0.01
Gas	1.92	-0.34	-30.78	0.38	-0.10	-0.03	0.03	-0.01	0.00
Oil_pcts	23.00	8.36	7.98	211.00	-98.32	-108.07	25.00	-2.08	-17.16
CMnf	-3821.00	3464.60	882.70	-2886.00	2085.10	892.00	-342.00	106.27	216.21
LMnf	1828.00	-2442.48	-762.60	1282.00	-1577.00	-390.50	222.00	-94.82	-72.18
Osg	19.50	-18.02	-0.32	5.00	-10.22	-0.23	2.03	0.07	0.03
Pcf	-4.00	21.20	6.88	-3.00	1.60	-2.15	0.60	0.98	12.17
Trans	-64.00	17.70	1.96	-11.90	-32.71	-1.48	-2.10	4.79	0.51
Util_Cns	0.70	4.27	0.08	0.00	-5.63	-0.28	0.20	2.10	0.08
Total	-1959.00	1209.00	170.00	-1469.00	362.00	409.00	-91.00	20.00	143.51

Emission effect results of the simulation 3: China imposes an emission policy in 2015

The previous section discussed the economic effects and the findings show the highly significant demand for capital-intensive goods in China. This leads to an increase in capital-intensive manufacturing exports of either non-ASEAN or ASEAN regions. However, it is evident that the environment could be affected from this trade as well. In fact, although China imposes an emission policy in the country, the effects are not felt in China only but could spread to other regions also. Thus, this section takes the environmental effects into account and presents them by comparing the lax and stringent emission policy results.

When China imposes an emission policy, obviously emissions in China plummet sharply as shown in table 53 for a lax policy case and table 54 for a stringent policy case. In general, Indonesia and Thailand are the two highest emission contributors in ASEAN for all air emission indicators: CO_2, CH_4, N_2O, SO_2, NO_2, and PM_{10}. Vietnam is the third highest of CH_4 and N_2O while Malaysia is the third one of CO_2, SO_2, NO_2, and PM_{10}.

Moreover, China, European Union, and the US are the 3 main regions for emitting all kinds of pollution. In fact, the results show that India plays a main role in CH_4 emission as well. This could be caused by a huge portion of the agricultural sector in India because the majority of emissions in CH_4 come from an agricultural sector as presented in table 59.

The results from table 53 and 54 also indicate that European Union is the top polluting region in the group of non-GHG air pollutants: SO_2, NO_2, and PM_{10}. This is supported by the CIA-ASIA Factsheet (2010) which states that most pollutant gases are generated from the combustion in industrial production. That is why industrial regions like European Union emit more of those air pollutants than China and the US.

Table 53 the total emissions in each region after imposing a lax emission policy in China in 2015

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	364.40	30.78	5071.03	3415.31	1282.04	954.05	390.93	4645.83
	2030	662.20	48.87	15326.73	5108.62	3832.24	1405.79	645.77	7711.91
CH_4	2015	61.13	15.87	619.91	225.28	290.86	6.16	22.79	294.87
	2030	150.92	31.23	2360.90	413.58	733.82	10.20	36.13	677.54
N_2O	2015	14.53	7.53	381.03	195.54	37.80	9.85	9.65	169.12
	2030	30.31	14.93	1135.12	352.10	99.70	14.81	14.86	353.27
SO_2	2015	32.48	4.89	562.86	707.79	77.13	126.41	62.60	306.76
	2030	47.08	8.81	1576.54	1020.82	238.04	163.44	90.40	484.38
NO_2	2015	19.50	2.96	340.91	430.08	46.74	76.71	37.99	186.47
	2030	28.23	5.32	953.50	618.92	144.04	99.05	55.02	293.82
PM_{10}	2015	13.40	1.91	219.03	269.97	30.00	48.59	24.02	116.64
	2030	19.59	3.51	619.31	395.25	93.30	63.41	34.01	186.84
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	335.18	2.94	1.11	188.39	66.58	69.19	224.66	87.36
	2030	1163.07	7.55	3.12	486.69	144.86	152.99	569.70	157.13
CH_4	2015	138.02	5.85	6.35	28.67	14.96	1.00	44.30	43.67
	2030	432.96	12.33	20.02	87.02	37.04	2.28	103.80	107.97
N_2O	2015	21.06	1.09	1.19	4.06	4.96	0.75	10.82	7.63
	2030	67.56	2.33	3.78	10.78	15.09	1.69	24.24	18.03
SO_2	2015	35.05	0.41	0.32	17.98	8.03	9.44	21.73	5.97
	2030	107.26	0.94	1.18	45.06	23.42	17.41	58.61	8.71
NO_2	2015	21.18	0.26	0.19	11.01	4.96	5.76	13.28	3.66
	2030	64.68	0.60	0.71	27.41	14.49	10.57	35.74	5.30
PM_{10}	2015	13.89	0.12	0.12	6.52	2.73	3.50	7.97	2.16
	2030	43.07	0.25	0.49	17.00	7.84	6.67	21.75	3.31

Table 54 the total emissions in each region after imposing a stringent emission policy in China in 2015

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	370.40	30.97	4766.18	3430.43	1292.63	961.13	394.81	4662.66
	2030	655.21	48.45	12198.88	5089.28	3857.84	1396.92	637.63	7638.95
CH_4	2015	61.45	15.97	598.65	226.07	292.10	6.19	22.85	296.18
	2030	143.05	30.18	1840.81	416.77	742.68	9.98	35.35	674.95
N_2O	2015	14.68	7.58	385.69	196.83	38.03	9.92	9.91	170.35
	2030	29.31	14.44	946.11	346.92	101.41	14.64	15.07	344.28
SO_2	2015	33.51	4.98	560.87	717.75	78.58	128.92	64.61	310.45
	2030	49.12	8.96	1328.90	1030.98	246.04	165.77	93.20	486.70
NO_2	2015	20.11	3.01	339.76	435.95	47.59	78.18	39.17	188.64
	2030	29.45	5.41	803.87	625.00	148.84	100.42	56.66	295.19
PM_{10}	2015	13.86	1.95	218.04	274.55	30.65	49.77	24.95	118.33
	2030	20.47	3.57	521.46	399.48	96.62	64.48	35.34	187.84
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	338.39	2.95	1.11	190.30	66.98	69.70	226.92	87.94
	2030	1148.88	7.62	3.31	481.57	142.81	150.03	570.92	168.98
CH_4	2015	138.67	5.87	6.40	28.77	14.98	1.00	44.59	43.86
	2030	425.71	13.02	15.27	83.83	36.24	2.22	101.49	107.25
N_2O	2015	21.19	1.09	1.20	4.09	4.98	0.78	10.90	7.68
	2030	66.93	2.46	2.89	10.54	14.72	1.74	23.76	18.64
SO_2	2015	35.95	0.41	0.32	18.57	8.27	9.79	22.47	6.12
	2030	110.14	0.96	1.52	46.23	23.71	18.50	60.90	15.90
NO_2	2015	21.72	0.26	0.20	11.35	5.10	5.96	13.72	3.74
	2030	66.39	0.61	0.91	28.11	14.64	11.21	37.12	9.68
PM_{10}	2015	14.31	0.12	0.13	6.80	2.84	3.66	8.33	2.23
	2030	44.31	0.25	0.66	17.52	8.03	7.16	22.71	6.00

To examine precisely between the effects in China and the ASEAN nations, table 55, 56, and 57 have been created. These tables present a comparison of change in total emissions from the base case between a lax and stringent emission policy imposed in China in 2015. Figures in table 55 indicate that the policy either a lax or stringent one could reduce all types of emissions in China except for N_2O which increases slightly. This circumstance would be caused by a small dependency on the capital-intensive production of N_2O. Normally, the contributing sector for N_2O is mainly the agricultural sector whereas CH_4 emissions depend on both agricultural and capital-intensive sectors.

Thus, reduction in dirty-productions contributing to N_2O emission is not high enough so the N_2O still rises slightly due to an increase in trade.

Turning to the emission results in ASEAN in 2015, they could be divided into 2 groups. The first is the emission results of CO_2 and non-CO_2 GHG. They increase in 2015 but they will decrease in 2030. In other words, the emission effects on ASEAN emissions, in particular CO_2 and non-CO_2 GHG, will be eliminated in the long run even though they could increase in the short run. The second group is the emissions of non-GHG air pollutants (SO_2, NO_2, and PM_{10}). They increase in 2015 due to a dramatic rise in the ASEAN's exports and this remains the same in 2030. By comparing between the lax and stringent policy, it seems that the effects of stringent policy double in the lax case. For instance, CO_2 increases about 9 million tons in ASEAN under a lax policy while it could be as high as 18 million tons under a stringent policy.

Changing emissions in each ASEAN member are shown in table 56 and 57. Both tables still replicate similar results to the case of ASEAN as a whole. However, there are some differences across regions. Firstly, CO_2 and non-CO_2 GHG emissions increase slightly for all ASEAN nations but will be reduced in the long run. Nonetheless, this does not include Lao and Singapore. In fact, instead of a decrease in CO_2 in 2030 like other ASEAN members, Lao will increase more CO_2 emissions and Singapore will face this circumstance as Lao but in N_2O. This situation may be caused by the gain in GDP in the short and long run in both countries due to the China emission policy. Moreover, non-GHG air pollutants increase either in the short or long term in the ASEAN states, except for non-GHG air pollutants in Vietnam which will decrease in the long term of the lax policy case. However, if China decides to implement a stringent policy, Vietnam could see a significant increase in non-GHG air pollutants in both the short and long run as in other ASEAN members.

Table 55 the emission deviation from the base case between lax and stringent emission policies imposed in China compared between China and ASEAN (million tons)

		CHINA				ASEAN			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-304.85	-5.67	-609.71	-11.34	9.07	0.92	18.14	1.84
	2030	-3950.85	-20.49	-7078.70	-36.72	-37.45	-1.35	-49.78	-1.79
CH_4	2015	-21.26	-3.32	-42.52	-6.63	1.47	0.49	2.93	0.97
	2030	-715.49	-23.26	-1235.58	-40.16	-22.64	-2.54	-42.77	-4.80
N_2O	2015	4.65	1.24	9.31	2.47	0.39	0.70	0.77	1.40
	2030	-224.89	-16.54	-413.89	-30.43	-2.10	-1.33	-4.22	-2.67
SO_2	2015	-1.98	-0.35	-3.96	-0.70	3.01	3.11	6.02	6.22
	2030	-273.67	-14.79	-521.30	-28.18	9.77	3.83	25.11	9.84
NO_2	2015	-1.15	-0.34	-2.30	-0.67	1.77	2.99	3.53	5.98
	2030	-165.46	-14.79	-315.10	-28.16	5.77	3.72	14.99	9.66
PM_{10}	2015	-0.99	-0.45	-1.98	-0.90	1.42	3.95	2.84	7.90
	2030	-107.73	-14.82	-205.58	-28.28	4.41	4.56	10.69	11.04

Table 56 the emission deviation from the base case between a lax and a stringent emission policy imposed in China compared among ASEAN members (million tons)

		IDN				MYS			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	3.21	0.97	6.42	1.93	1.91	1.02	3.83	2.05
	2030	-17.43	-1.48	-31.62	-2.68	-5.31	-1.08	-10.44	-2.12
CH_4	2015	0.65	0.48	1.31	0.95	0.10	0.37	0.21	0.74
	2030	-7.70	-1.75	-14.95	-3.39	-3.78	-4.16	-6.97	-7.67
N_2O	2015	0.13	0.61	0.26	1.22	0.03	0.72	0.06	1.43
	2030	-0.28	-0.41	-0.91	-1.34	-0.16	-1.49	-0.41	-3.73
SO_2	2015	0.90	2.64	1.80	5.28	0.59	3.36	1.17	6.72
	2030	3.69	3.57	6.57	6.34	1.74	4.03	2.91	6.73
NO_2	2015	0.53	2.58	1.06	5.15	0.34	3.21	0.68	6.41
	2030	2.20	3.52	3.91	6.26	1.04	3.93	1.73	6.56
PM_{10}	2015	0.41	3.06	0.82	6.11	0.28	4.51	0.56	9.01
	2030	1.59	3.84	2.83	6.83	0.77	4.73	1.28	7.89

		KHM				LAO			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	0.01	0.50	0.03	0.97	0.01	0.72	0.01	1.14
	2030	-0.20	-2.58	-0.13	-1.63	0.06	2.10	0.25	8.30
CH_4	2015	0.02	0.41	0.05	0.85	0.04	0.71	0.09	1.42
	2030	-0.18	-1.41	0.52	4.13	-0.20	-0.99	-4.96	-24.51
N_2O	2015	0.00	0.44	0.01	0.89	0.01	0.71	0.02	1.42
	2030	-0.03	-1.43	0.10	4.09	-0.04	-1.08	-0.93	-24.37
SO_2	2015	0.01	1.62	0.01	3.25	0.01	2.73	0.02	5.54
	2030	0.01	1.11	0.03	3.41	0.07	6.60	0.41	37.37
NO_2	2015	0.00	1.50	0.01	3.00	0.00	2.66	0.01	5.39
	2030	0.01	1.02	0.02	3.64	0.04	6.55	0.24	35.99
PM_{10}	2015	0.00	2.79	0.01	5.57	0.00	3.16	0.01	6.42
	2030	0.00	2.01	0.00	1.05	0.03	6.77	0.21	45.41

Table 57 the emission deviation from the base case between a lax and a stringent emission policy imposed in China compared among ASEAN members (million tons)

		PHL				SGP			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	0.39	0.59	0.79	1.19	0.51	0.75	1.02	1.49
	2030	-3.16	-2.13	-5.20	-3.52	-3.88	-2.47	-6.85	-4.36
CH_4	2015	0.02	0.10	0.03	0.23	0.00	0.24	0.00	0.47
	2030	-0.85	-2.23	-1.65	-4.36	-0.07	-2.89	-0.13	-5.43
N_2O	2015	0.02	0.47	0.05	0.94	0.03	4.09	0.06	8.17
	2030	-0.31	-2.02	-0.68	-4.42	0.06	3.98	0.12	7.16
SO_2	2015	0.24	3.12	0.49	6.25	0.35	3.88	0.70	7.75
	2030	0.37	1.62	0.66	2.87	1.33	8.29	2.42	15.07
NO_2	2015	0.14	2.95	0.28	5.90	0.21	3.72	0.41	7.44
	2030	0.21	1.44	0.36	2.54	0.79	8.07	1.44	14.68
PM_{10}	2015	0.12	4.49	0.23	8.98	0.17	5.01	0.33	10.03
	2030	0.23	3.06	0.42	5.52	0.59	9.78	1.08	17.78
		THA				VNM			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	2.26	1.02	4.53	2.04	0.58	0.67	1.17	1.35
	2030	-4.82	-0.84	-3.60	-0.63	-0.80	-0.51	11.04	6.99
CH_4	2015	0.29	0.67	0.59	1.33	0.19	0.44	0.38	0.87
	2030	-2.29	-2.16	-4.60	-4.34	-5.44	-4.79	-6.16	-5.44
N_2O	2015	0.09	0.83	0.18	1.65	0.05	0.60	0.09	1.21
	2030	-0.29	-1.17	-0.77	-3.13	-0.68	-3.61	-0.06	-0.34
SO_2	2015	0.74	3.53	1.48	7.06	0.15	2.54	0.29	5.07
	2030	2.81	5.04	5.11	9.15	-0.34	-3.79	6.84	75.62
NO_2	2015	0.43	3.38	0.87	6.76	0.09	2.41	0.17	4.82
	2030	1.67	4.91	3.05	8.95	-0.23	-4.08	4.15	75.16
PM_{10}	2015	0.35	4.61	0.70	9.22	0.07	3.43	0.14	6.85
	2030	1.22	5.92	2.17	10.57	-0.06	-1.75	2.63	78.15

As pollution indicators are polluted by different sectors, sector analysis is needed in order to compare each sector in China and the ASEAN nations. Thus, the top 3 sectors contributing to emissions of CO_2, non-CO_2 GHG, and non-GHG air pollutants in 2015 and 2030 are shown in table 58 to 63 by separating the lax and stringent cases. In general, CO_2 emissions depend mainly on electricity, capital-intensive manufacturing, and transportation and communication sectors for both kinds of the policy. However, agricultural, and petroleum and coal products (oil_pcts) sectors could take place in Cambodia and Singapore, respectively.

Moreover, the sectors that have combustion in the main process of production like agriculture, transportation and communication, and public administration, such as trash incineration, play a main role in non-CO_2 GHG emissions, however; the coal sector is important for the emission of CH_4 in China as well. This could reflect the problem of non-CO_2 emissions for agricultural countries like China, and ASEAN.

Furthermore, as the data source of air pollution intensities is limited, the emission of non-GHG air pollutants such as SO_2, NO_2, and PM_{10} could be examined in only 3 sectors, namely capital-intensive manufacture, labor-intensive manufacture and processing food. However, in general, the results indicate that capital-intensive manufacture is the top polluting sector followed by labor-intensive manufacturing and food processing sector, respectively. This changes in Cambodia and Lao slightly

On the whole of the emission results by sector, it can be seen that electricity, capital-intensive manufacture and transportation create the vast majority of emissions in CO_2 while agriculture, public administration, and transportation play a main role in non-CO_2 GHG emission. In addition capital-intensive manufacture is the top sector in non-GHG air pollutant emission in both China and ASEAN under both emission policies implemented in China.

Table 58 the rank of main sectors emitting CO_2 under a lax emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
					Year 2015				
1	Electricity (2951.04)	Electricity (114.00)	Trans &Com (1.73)	Electricity (0.43)	Electricity (67.52)	Electricity (28.85)	Trans &Com (31.19)	Electricity (89.86)	Electricity (31.20)
2	CMnf (1017.96)	CMnf (77.17)	Electricity (0.74)	Trans &Com (0.31)	Trans &Com (49.78)	Trans &Com (22.61)	Electricity (23.33)	Trans &Com (61.87)	Trans &Com (22.41)
3	Trans &Com (356.54)	Trans &Com (60.60)	Agr (0.31)	CMnf (0.19)	CMnf (29.51)	CMnf (8.01)	Oil_pcts (14.09)	CMnf (32.19)	CMnf (21.39)
					Year 2030				
1	Electricity (8909.99)	Electricity (475.87)	Trans &Com (3.94)	Electricity (1.11)	Electricity (155.56)	Electricity (54.44)	Oil_pcts (54.67)	Electricity (216.63)	Electricity (55.47)
2	CMnf (2891.24)	CMnf (242.85)	Electricity (2.61)	Trans &Com (0.85)	Trans &Com (108.93)	Trans &Com (46.51)	Trans &Com (52.55)	Trans &Com (131.98)	Trans &Com (49.03)
3	Trans &Com (849.70)	Oil_pcts (140.62)	Agr (0.68)	CMnf (0.79)	Oil_pcts (106.63)	CMnf (23.46)	Electricity (44.61)	CMnf (89.36)	CMnf (32.96)

Table 59 the rank of main sectors emitting methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a lax emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
					Year 2015				
1	Agr (263.11)	Agr (59.14)	Agr (5.34)	Agr (6.00)	Agr (7.03)	Agr (7.78)	Osg (0.54)	Agr (31.55)	Agr (35.69)
2	Coal (212.52)	Osg (36.57)	Osg (0.50)	Osg (0.34)	Osg (6.41)	Osg (6.63)	Oil_pcts (0.29)	Osg (5.56)	Osg (5.81)
3	Osg (138.82)	Trans &Com (16.36)	Trans &Com (0.01)	Trans &Com (0.005)	Oil_pcts (4.70)	Coal (0.35)	Trans &Com (0.16)	Trans &Com (3.27)	Coal (1.91)
					Year 2030				
1	Coal (1225.14)	Agr (202.85)	Agr (11.82)	Agr (18.98)	Oil_pcts (21.73)	Agr (25.59)	Oil_pcts (1.12)	Agr (71.39)	Agr (83.75)
2	Agr (788.30)	Osg (68.84)	Osg (0.48)	Osg (0.93)	Oil (19.90)	Osg (9.70)	Osg (0.88)	Oil_pcts (10.61)	Osg (14.48)
3	Osg (322.39)	Oil_pcts (61.04)	Trans &Com (0.03)	Oil_pcts (0.04)	Agr (18.78)	Coal (1.30)	Trans &Com (0.26)	Osg (8.26)	Coal (7.83)

Table 60 the rank of main sectors emitting sulfur dioxide (SO_2, the representative of non-GHG air pollutants indicators) under a lax emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (483.38)	CMnf (30.19)	CMnf (0.21)	CMnf (0.25)	CMnf (13.87)	CMnf (5.46)	CMnf (7.63)	CMnf (16.96)	CMnf (4.49)
2	LMnf (69.22)	LMnf (2.94)	LMnf (0.16)	LMnf (0.01)	LMnf (3.47)	LMnf (1.91)	LMnf (1.72)	LMnf (3.83)	LMnf (1.05)
3	Pcf (10.25)	Pcf (1.92)	Pcf (0.03)	Pcf (0.05)	Pcf (0.65)	Pcf (0.66)	Pcf (0.08)	Pcf (0.95)	Pcf (0.42)
Year 2030									
1	CMnf (1372.91)	CMnf (95.00)	CMnf (0.45)	CMnf (1.04)	CMnf (37.03)	CMnf (16.00)	CMnf (14.73)	CMnf (47.06)	CMnf (6.92)
2	LMnf (178.57)	LMnf (8.29)	LMnf (0.44)	Pcf (0.14)	LMnf (7.00)	LMnf (6.27)	LMnf (2.53)	LMnf (10.15)	LMnf (0.99)
3	Pcf (25.06)	Pcf (3.97)	Pcf (0.05)	LMnf (0.01)	Pcf (1.02)	Pcf (1.14)	Pcf (0.15)	Pcf (1.39)	Pcf (0.80)

Table 61 the rank of main sectors emitting CO_2 under a stringent emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Electricity (2680.96)	Electricity (114.66)	Trans &Com (1.74)	Electricity (0.42)	Electricity (68.18)	Electricity (28.86)	Trans &Com (31.38)	Electricity (90.36)	Electricity (31.14)
2	CMnf (1013.26)	CMnf (79.63)	Electricity (0.75)	Trans &Com (0.31)	Trans &Com (49.73)	Trans &Com (22.52)	Electricity (23.58)	Trans &Com (61.88)	Trans &Com (22.36)
3	Trans &Com (345.21)	Trans &Com (60.76)	Agr (0.31)	CMnf (0.20)	CMnf (30.93)	CMnf (8.41)	Oil_pcts (14.14)	CMnf (33.76)	CMnf (22.20)
Year 2030									
1	Electricity (6861.86)	Electricity (460.14)	Trans &Com (4.14)	Electricity (1.18)	Electricity (155.04)	Electricity (53.49)	Trans &Com (52.35)	Electricity (217.48)	CMnf (60.94)
2	CMnf (2432.94)	CMnf (250.25)	Electricity (2.43)	CMnf (1.12)	Trans &Com (108.47)	Trans&Com (45.95)	Oil_pcts (51.55)	Trans &Com (134.28)	Electricity (52.67)
3	Trans &Com (748.06)	Trans &Com (137.00)	Agr (0.71)	Trans &Com (0.89)	Oil_pcts (100.28)	CMnf (24.18)	Electricity (44.93)	CMnf (93.52)	Trans &Com (32.45)

Table 62 the rank of main sectors emitting methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a stringent emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (269.69)	Agr (59.52)	Agr (5.36)	Agr (6.04)	Agr (7.08)	Agr (7.83)	Osg (0.54)	Agr (31.82)	Agr (35.95)
2	Coal (205.57)	Osg (36.71)	Osg (0.50)	Osg (0.34)	Osg (6.40)	Osg (6.59)	Oil_pcts (0.29)	Osg (5.56)	Osg 5.78)
3	Osg (117.60)	Trans &Com (16.40)	Trans &Com (0.01)	Trans &Com (0.01	Oil_pcts (4.71)	Coal (0.35)	Trans &Com (0.16)	Trans &Com (3.27)	Coal (1.86)
Year 2030									
1	Coal (902.01)	Agr (200.79)	Agr (12.48)	Agr (14.38)	Oil_pcts (20.43)	Agr (24.92)	Oil_pcts (1.06)	Agr (69.86)	Agr (90.67)
2	Agr (658.51)	Osg (68.90)	Osg (0.51)	Osg (0.77)	Oil (18.49)	Osg (9.73)	Osg (0.88)	Oil_pcts (10.12)	Osg (8.86)
3	Osg (259.03)	Oil_pcts (58.26)	Trans &Com (0.03)	Oil_pcts (0.04)	Agr (18.33)	Coal (1.14)	Trans &Com (0.26)	Osg (8.35)	Coal (7.25)

Table 63 the rank of main sectors emitting sulfur dioxide (SO_2, the representative of non-GHG air pollutants indicators) under a stringent emission policy imposed in China compared between ASEAN members and China (million tons)

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (481.15)	CMnf (31.15)	CMnf (0.22)	CMnf (0.26)	CMnf (14.53)	CMnf (5.74)	CMnf (8.03)	CMnf (17.78)	CMnf (4.66)
2	LMnf (69.74)	LMnf (2.88)	LMnf (0.16)	Pcf (0.05)	LMnf (3.38)	LMnf (1.87)	LMnf (1.68)	LMnf (3.74)	LMnf (1.03)
3	Pcf (9.98)	Pcf (1.93)	Pcf (0.03)	LMnf (0.01)	Pcf (0.65)	Pcf (0.66)	Pcf (0.08)	Pcf (0.95)	Pcf (0.42)
Year 2030									
1	CMnf (1155.28)	CMnf (97.90)	LMnf (0.48)	CMnf (1.47)	CMnf (38.24)	CMnf (16.50)	CMnf (15.87)	CMnf (49.26)	CMnf (12.79)
2	LMnf (151.94)	LMnf (8.35)	CMnf (0.44)	Pcf (0.12)	LMnf (7.01)	LMnf (6.11)	LMnf (2.50)	LMnf (10.30)	LMnf (2.19)
3	Pcf (21.68)	Pcf (3.89)	Pcf (0.05)	LMnf (0.07)	Pcf (0.97)	Pcf (1.10)	Pcf (0.13)	Pcf (1.35)	Pcf (0.91)

The end of this section revealed an effective emission policy for China and ASEAN by taking the effects of imposing an emission policy on both the economy and emission into consideration. It is obvious that the emissions of 6 pollution indicators in China and ASEAN are varied due to the structure of production and trade in each country. However, an emission policy which should be implemented in order to achieve their cost-effectiveness is analyzed in terms of the changes in emissions and GDP in the long-run compared to the base case as presented in table 64 and 65.

On the one hand, if China imposes a lax emission policy, China could reduce total emissions to -37,182 million tons while decreasing its GDP to -21,236,886 million US dollars over 16 years. Thus, the ratio of the cost-effectiveness is 0.175 percent. On the other hand, China could decrease its emissions to -69,515 million tons and lose its GDP to -39,206,173 million US dollars from 2015 to 2030. In other word, China could see a ratio at 0.177 percent, if it implements a stringent policy. Although, there is a slight disparity between the two ratios, China should choose the stringent policy instead of the lax one, if it behaves as self-interested basis. However, if China cares more about short-run impacts than the long-run, it might take a lax emission policy rather than a stringent one.

Regarding the ASEAN aspect, when China imposes a lax emission policy, the emissions in ASEAN decrease slightly to -36 million tons and ASEAN could gain GDP to 102,061 million US dollars while the emissions in ASEAN could increase to 990 million tons with a marked drop in GDP to -576,957 million US dollars, if China imposes a stringent emission policy. As a result, it is obvious that ASEAN would enjoy the benefit from a lax policy imposed in China rather than a stringent one because ASEAN could reduce emissions and raise its GDP in the case of lax policy.

However, China may make a decision based on its benefit. Consequently, China should impose a stringent emission policy instead of a lax one. Thus, ASEAN region as a whole would face a serious problem with an increase in emissions and a decrease in its GDP but in terms of individual ASEAN member, the impacts are different. Some countries could benefit from the stringent policy like Indonesia, and Thailand as they could gain significantly in GDP to 134,216 and 96,130 million US dollars, respectively with a very small increase in their emissions. In contrast, if China imposes a stringent emission policy, Vietnam, and Malaysia could see a severe drop in their GDP (-692,563, and -53,219 million US dollars, respectively) with a huge increase in emissions, especially Vietnam which could increase emissions to 791 million tons. Like Vietnam, Philippines also experience a significant fall in GDP (-90,947 million US dollars) with small reductions in its emissions.

In conclusion, it can be seen that China will implement a stringent emission policy in order to achieve its cost-effectiveness in the long-run. This will cause the ASEAN region to experience a dramatic drop in its GDP as a whole, with a marked rise in its emissions, however; Indonesia, Thailand and Singapore could enlarge their GDP significantly while Vietnam will confront with a severe decrease in GDP with rising emissions from the stringent policy in China.

Table 64 the percentage of changing emissions and GDP ratio between 2015 and 2030 in China and ASEAN region

	CHN		ASEAN	
	Lax policy	Stringent policy	Lax policy	Stringent policy
Emission Change	-37182	-69515	-36	990
GDP Change	-21236886	-39206173	102061	-576957
% Ratio	0.175	0.177	-0.036	-0.172

Table 65 the percentage of changing emission and GDP ratio between 2015 and 2030 across ASEAN members

	IDN		KHM		LAO		MYS	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-1	8	-2	7	2	-8	18	39
GDP Change	72436	134216	-847	10540	351	-5245	-28340	-53219
% Ratio	-0.001	0.006	0.247	0.062	0.492	0.160	-0.063	-0.072
	PHL		SGP		THA		VNM	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-11	-18	11	34	58	157	-99	791
GDP Change	-52576	-90947	31230	54058	16015	96130	82037	-692563
% Ratio	0.021	0.020	0.036	0.064	0.361	0.163	-0.120	-0.114

4.4. Simulation 4: both ASEAN and China impose an emission policy on the 3 main sectors such as agriculture, capital-intensive manufacture, and transportation and communication in 2015

The previous two simulations analyzed the effects of an emission policy in ASEAN and in China, respectively. They revealed a variety of results among regions and sectors either in the country imposing policy or trading partners. It is obvious that both China and ASEAN could get a significant drop in their GDP when imposing an emission policy alone. However, the results also indicated that China and ASEAN attempts to reduce their losses in decreasing GDP by increasing exports in labor-intensive manufacturing goods instead of suffering from the 3 main impacted sectors.

In addition, some ASEAN nations could see gains in their GDP if China imposes an emission policy such as Indonesia, Lao, Singapore, and Thailand in both short-run and long-run analysis. By contrast, when the ASEAN states impose an emission policy, China and South Korea could face a drop in their GDP in the short-run, but it will increase in the long-run. In terms of emissions, both China and ASEAN could achieve reducing their emissions, however; it can be seen that emissions move to other regions instead. For example, when ASEAN imposes an emission policy alone, there is an increase in emissions in China and non-ASEAN regions. By contrast, when China imposes an emission policy alone, ASEAN and non-ASEAN regions also face a rise in their emissions. This situation leads to the question: what will the effects be, if China and ASEAN implement the same type of an emission policy together, in the same year?

To answer this question, simulation 4 was obtained and discussed in this section. The first part describes effects on the economy of China, ASEAN, and non-ASEAN regions in terms of changing in their GDP compared to the base case. The second part then illustrated emission effects in each region and compared these with lax and stringent policy cases. Finally, cost-effectiveness was examined in order to analyze both kinds of policy and presented the results in terms of changing emission and GDP ratios.

Economic effect results of a lax emission policy in both ASEAN and China in 2015

The results of the simulation in terms of GDP deviation from the base case after imposing a lax emission policy in both ASEAN and China in 2015 are shown in table 66. It is undeniable that both China and ASEAN members could seriously suffer as their GDP falls dramatically due to a remarkable decrease in their technological augmented ouputs. Nonetheless, non-ASEAN regions could gain improved GDP, especially Australia which accounts for a 1.38 percent increase over its base case because of a significantly higher capital-intensive and agricultural product import from China. By contrast, South Korea faces negative impact and this lowers its GDP by -0.13 percent compared to the base case due to the substitution of South Korea’s labor-intensive market from China’s labor-intensive goods.

Regarding the ASEAN nations, low income countries such as Cambodia, Lao, and Vietnam experience a large decline in their GDP and become the top 3 nations losing GDP. However, comparing with simulation 2 (imposing an emission policy in ASEAN alone), Cambodia and Vietnam could lose more while Lao could see a small increasing GDP in this case as China’s labor-intensive exports could take place in the market of Cambodia and Vietnam and lead to less consumption and investment of them. In addition, other ASEAN members excluding Philippines could increase their GDP slightly compared to the case of imposing a lax emission policy in ASEAN alone, even though their GDP decreases in total compared to the base case. The reason for a decrease in Philippines’ GDP is that its consumption and investment fall significantly.

On the whole of short-run effects, it could be interpreted that when China and ASEAN impose an emission policy together, some ASEAN nations’ GDP could be better but some are worse compared to the case of imposing an emission policy in their region alone. However, the long-run effect results in table 67 indicated additional implications. Firstly, China can gain a small amount in the GDP compared to the case of imposing an emission policy in China only, even though the GDP will still be lower than the base case by -19.68 percent. Secondly, South Korea and the US which suffer in the long-run in the case of imposing the policy in China only could see a marked rise in their GDP compared to the base case in the case of imposing an emission policy in ASEAN and China together. Thirdly, India remains the top gainer in three cases of imposing an emission in ASEAN alone, in China alone, and in ASEAN and China together. Fourthly, Lao loses the most in the long-run even though its GDP increases in the short-run. Finally, Malaysia, Philippines, and Vietnam face larger negative impacts than in the case of imposing an emission policy in ASEAN alone whereas Singapore sees a small improvement in its GDP.

Table 66 the change in nominal GDP decomposition in 2015 after imposing a lax emission policy in both ASEAN and China compared to the base case (million US$)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	6109	5494	1943	1955	3655	11846	1.38
NZL	392	408	124	73	234	764	0.53
CHN	-170677	-226458	-71558	24681	18786	-462798	-12.09
EUR	-1138	32961	-697	12736	15340	28522	0.16
IND	4091	3363	707	912	2211	6863	0.51
JPN	4047	12770	1213	-3834	4813	9384	0.22
KOR	-831	665	-301	150	1120	-1436	-0.13
USA	14402	24922	3180	612	11137	31979	0.23
ASEAN regions							
IDN	-27097	-20326	-4035	3366	-4569	-43523	-8.94
KHM	-915	-737	-74	423	-186	-1117	-14.08
LAO	-451	-485	-63	63	-211	-726	-13.14
MYS	-7536	-13144	-2149	-3000	-7771	-18059	-8.74
PHL	-8350	-5761	-1350	4046	-17	-11400	-7.21
SGP	-2887	-3978	-759	-1863	-1811	-7675	-3.84
THA	-12556	-16362	-3160	2462	-6360	-23257	-8.62
VNM	-5982	-6992	-609	2508	-1428	-9647	-13.27
XSE	-1343	-1309	-357	186	-393	-2430	-7.57

Table 67 the change in the combined nominal GDP decomposition between 2015 and 2030 after imposing a lax emission policy in both ASEAN and China compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regions							
AUS	-15218	91903	-4120	-21629	8938	41999	0.24
NZL	-3743	20930	-1077	-8770	566	6772	0.24
CHN	-6945468	-13416040	-2770179	-1078760	-3061980	-21148467	-19.68
EUR	45104	2523224	23012	-402648	370464	1818228	0.57
IND	303866	638211	58626	-242683	79299	678721	2.01
JPN	-80360	507793	-23517	-317892	-150089	236113	0.30
KOR	-31729	153469	-8137	-251364	-156395	18634	0.10
USA	-241408	817872	-50780	-365748	-127236	287172	0.11
ASEAN regions							
IDN	-936699	-1103636	-127868	-190425	-512736	-1845892	-15.15
KHM	-16750	-31067	-1253	-22529	-35988	-35610	-22.41
LAO	-21147	-18665	-2695	-9873	-13708	-38673	-24.01
MYS	-261590	-521928	-72313	-618249	-708213	-765866	-15.35
PHL	-308169	-345614	-45138	-97210	-247359	-548772	-14.12
SGP	-104387	-219482	-26895	-322516	-351399	-321880	-7.41
THA	-365913	-953432	-87447	-503467	-850585	-1059672	-16.80
VNM	-190336	-193406	-18735	-167240	-212780	-356936	-19.17
XSE	-58732	-42881	-14392	-26518	-28853	-113672	-12.34

The previous section indicated the economic effects in terms of GDP change. It is undeniable that the change of GDP could be caused by trade through export and import of outputs. Thus, this section will describe a movement of output in particular China and ASEAN countries. Table 68 shows China’s export to non-ASEAN regions and ASEAN members under a lax emission policy. As China faces a lack in agriculture, capital-intensive manufacture, and transportation and communication due to the policy, Chinese exports drop in those 3 sectors apparently. However, the results indicate differences seen in simulation 3 (imposing an emission policy in China alone), for example, the amount of decreases in Chinese exports is less than the case where China imposes an emission policy alone. In fact, China could increase its agricultural exports to Indonesia, Singapore and Thailand although China imposes an emission policy on agriculture like ASEAN. This reflects the net positive impact on China's export caused by an emission policy in both regions. In addition, labor-intensive products, which were strategic export goods of China in the case of imposing an emission policy in China alone, could fall in Indonesia, Cambodia, Lao, and Malaysia as well as non-ASEAN regions. This could indicate the competition between China and ASEAN in labor-intensive goods as we shall see in the ASEAN export figures.

China's imports were presented in table 69. The table illustrates that the vast majority of China's trade goes to non-ASEAN markets, in particular agricultural and capital-intensive products while China reduces the two sector imports from ASEAN nations apart from Singapore which could maintain capital-intensive goods exports to China even though confronted with the policy pressure as well. Moreover, China imports more labor manufacturing goods from Philippines, Thailand, Indonesia, Vietnam, Lao, and Cambodia. As a result, the import of labor-intensive goods from non-ASEAN markets decrease significantly.

Table 68 the change of China export to other regions in 2015 after imposing a lax emission policy in both ASEAN and China compared to the base case (million US$)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	-1738.87	20.00	-0.05	0.01	-26.00	-4.00	4.00	1.00	0.00	-0.10
Coal	308.24	-0.02	0.00	0.00	-0.07	-1.00	0.00	-0.05	-0.11	-0.01
Oil	158.44	11.00	0.00	0.00	0.00	0.01	28.00	13.10	0.00	0.00
Gas	483.23	0.01	0.00	0.00	0.36	0.04	15.30	-0.22	-0.53	0.01
Oil_pcts	1254.90	19.00	-1.00	-0.01	2.00	9.00	19.00	2.60	-4.00	-3.00
Electric	289.56	0.00	0.11	-0.06	0.00	0.00	0.01	0.50	-36.00	0.03
CMnf	-68253.00	-619.00	-1.05	-2.60	-767.00	-379.00	-677.00	-1139.00	-693.00	-17.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	89816.00	-476.00	-3.00	-19.30	-303.00	305.00	670.00	54.00	74.00	-113.00
Osg	1527.50	1.30	0.01	-0.01	3.00	0.60	8.20	1.00	-0.30	0.31
Pcf	-17.00	-9.00	0.47	-0.10	-19.00	-5.00	-2.00	-10.00	-12.00	3.40
Svces	6067.10	11.00	0.09	0.01	21.00	4.00	135.00	15.00	4.40	1.90
Trans	-1801.00	-17.00	-0.50	-0.09	5.00	-1.40	-10.00	-60.00	-2.60	0.70
Util_Cns	66.30	-10.10	-1.71	-0.67	-9.00	-0.66	-0.17	-11.20	-4.30	-1.61
Total	28165.00	-1067.00	-7.00	-23.00	-1093.00	-73.00	190.00	-1133.00	-675.00	-128.00

Table 69 the change of China import to other regions in 2015 after imposing a lax emission policy in both ASEAN and China compared to the base case (million US$)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	4470.20	-31.00	-3.70	-0.30	-26.00	-13.00	0.14	-93.00	-52.00	-33.00
Coal	-113.29	-50.00	0.00	0.00	0.01	0.00	0.00	0.00	-47.00	0.02
Oil	-4551.66	95.00	0.00	-0.98	13.00	-0.01	0.00	29.00	21.00	11.00
Gas	-279.02	0.39	0.00	0.02	1.70	2.23	0.00	0.61	5.66	0.14
Oil_pcts	-1123.97	11.00	0.00	0.35	-5.00	-2.50	-84.00	-9.00	0.07	-0.01
Electric	-84.00	0.00	0.00	0.00	0.10	0.00	0.00	0.14	0.00	-0.01
CMnf	73139.00	-320.00	-10.10	-2.20	-1119.00	-239.00	218.00	-659.00	-167.00	-52.40
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-42132.00	331.00	1.70	3.06	-222.00	1444.00	-30.00	1049.00	65.00	-12.30
Osg	-1157.40	-0.20	-0.01	0.05	-0.60	-0.40	-4.40	0.30	0.68	-0.05
Pcf	-262.00	2.00	-0.54	0.10	-259.00	-1.90	2.00	-28.00	-6.00	-5.20
Svces	-6189.60	1.70	-0.20	0.04	-5.00	-2.60	-263.00	-5.00	5.70	-0.41
Trans	-750.00	-16.00	-5.30	0.15	-73.00	-22.00	-243.00	-80.00	-14.70	-4.60
Util_Cns	-491.93	-0.50	-0.03	0.00	-7.90	-0.22	-1.70	-2.80	-0.80	-0.23
Total	20480.00	24.00	-19.00	0.40	-1703.00	1166.00	-407.00	201.00	-190.00	-98.00

Table 70 and 71 presented the mobility of the ASEAN’s outputs through the 3 main markets namely China, non-ASEAN, and ASEAN itself after imposing a lax emission policy in both China and ASEAN in 2015. The figures reveal that non-ASEAN markets are the main export markets for ASEAN nations, as the amount of export increases in all members particularly Indonesia, Thailand, Philippines and Vietnam. By contrast, trading within ASEAN could drop among all members as well, except for Philippines and Vietnam which export more labor-intensive and oil goods to ASEAN, respectively. In fact, labor-intensive products become the main export goods for most members e.g. Indonesia, Philippines, Thailand, Vietnam, Cambodia, and Lao. On the other hand, most ASEAN imports, in table 71, indicate a significant decrease in all 3 main markets apart from Philippines which imports more from non-ASEAN markets, as well as Singapore which has high imports in labor-intensive products from China and ASEAN. Furthermore, all ASEAN states fill the lack of output particularly in the 3 impacted sectors by importing mainly from non-ASEAN regions. This would be the results of an emission policy impacts imposed in both ASEAN and China. Thus, non-ASEAN region could significantly benefit from increasing their products.

Table 70 the change of ASEAN state exports in 2015 after imposing a lax emission policy in both ASEAN and China compared to the base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-23.00	-696.85	-144.48	-3.20	-14.10	-6.55	-0.12	-5.72	2.89
Coal	-45.00	621.44	-106.40	0.00	0.00	0.00	0.00	0.00	-0.04
Oil	91.00	786.66	76.20	0.00	0.00	0.00	-0.98	-13.04	-1.02
Gas	0.39	2801.55	42.96	0.00	0.00	0.00	0.02	1.34	0.14
Oil_pcts	9.00	150.74	13.10	0.00	0.00	0.00	0.35	16.00	0.47
CMnf	-217.00	-6147.60	-816.02	-8.10	-26.43	-88.37	-1.50	-25.27	-60.32
LMnf	294.00	5676.00	694.97	1.40	608.84	5.33	2.55	80.15	33.23
Osg	-0.20	169.71	1.32	-0.01	16.64	0.16	0.05	10.68	0.09
Pcf	1.00	195.20	4.98	-0.52	-12.31	-3.73	0.09	2.58	0.24
Trans	-16.00	-405.00	-10.31	-5.30	-102.16	-4.31	0.15	7.21	0.47
Util_Cns	-0.50	49.85	-0.55	-0.03	0.45	-0.03	0.00	0.15	0.00
Total	94.00	3508.00	-236.35	-16.00	534.90	-94.97	0.70	86.18	-24.44
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-21.00	-200.65	-11.77	-9.00	-200.37	-2.15	0.13	-10.31	5.08
Coal	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	13.00	530.53	139.00	-0.01	0.00	-0.02	0.00	-0.01	0.00
Gas	1.70	2715.35	17.74	2.23	187.80	18.09	0.00	0.01	0.00
Oil_pcts	-5.00	101.42	-16.35	-2.30	10.21	-7.50	-77.00	74.10	-675.00
CMnf	-943.00	-6667.80	-2039.85	-194.00	-942.00	-196.78	205.00	-3692.10	81.51
LMnf	-222.00	4870.00	-181.60	1415.00	3743.00	267.96	-33.00	3484.00	-1686.36
Osg	-0.60	106.60	1.29	-0.40	64.40	1.00	-4.40	103.45	-5.16
Pcf	-235.00	-498.20	-155.75	-1.60	-60.36	-25.44	1.00	37.30	1.96
Trans	-73.00	-1744.50	-60.91	-22.00	-554.60	-19.93	-243.00	-1465.80	-52.94
Util_Cns	-7.90	127.34	-8.37	-0.22	11.32	-0.34	-1.70	29.75	-4.74
Total	-1497.00	736.00	-2294.10	1186.00	2806.00	43.61	-415.00	558.00	-2425.10
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-62.00	-390.50	-39.90	-38.00	-827.24	-20.53	-28.00	-258.57	-27.83
Coal	0.00	0.00	0.00	-45.00	33.51	-6.45	0.01	1.28	-1.10
Oil	28.00	45.62	3.03	20.00	485.61	244.04	10.00	287.91	11.43
Gas	0.61	45.03	4.52	5.66	456.29	43.38	0.12	1181.60	-659.62
Oil_pcts	-10.00	115.00	-129.00	0.06	0.20	2.43	0.00	2.77	-0.05
CMnf	-507.00	-6119.20	-885.00	-128.00	-1259.76	-237.30	-45.20	-42.33	-68.24
LMnf	994.00	9763.00	384.00	57.00	3323.80	77.60	-10.30	-46.49	-16.76
Osg	0.30	191.94	2.70	0.68	142.17	1.74	-0.05	13.42	0.00
Pcf	-23.00	-297.50	-146.00	-4.00	-81.08	-53.32	-4.50	-33.87	-12.14
Trans	-80.00	-1420.60	-34.38	-14.70	-296.68	-13.74	-4.60	-107.35	-5.57
Util_Cns	-2.80	7.45	-2.82	-0.80	18.40	-1.08	-0.23	1.07	-0.30
Total	335.00	2913.00	-820.00	-141.00	2585.00	58.20	-82.00	1042.00	-778.12

Table 71 the change of ASEAN state imports in 2015 after imposing a lax emission policy in ASEAN and China compared to the base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	17.00	841.42	-11.73	-0.07	5.89	-1.22	0.00	0.48	-2.47
Coal	-0.02	-0.06	-0.11	0.00	0.00	0.00	0.00	0.00	-0.04
Oil	12.00	-462.96	13.91	0.00	0.00	0.00	0.00	1.21	0.49
Gas	0.01	-1.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	24.00	-300.46	-263.80	-1.00	-3.09	-111.12	-0.01	-0.01	-5.97
CMnf	-732.00	3922.00	-441.18	-2.46	86.81	19.46	-3.30	13.97	-29.40
LMnf	-514.00	-3795.00	-1085.48	-3.00	-176.98	20.60	-22.00	-51.27	-68.32
Osg	1.30	-175.41	-0.98	0.01	-12.40	-0.06	-0.01	-1.94	-0.01
Pcf	-10.00	-148.20	-147.59	0.62	2.68	8.20	-0.16	-3.78	-38.99
Trans	-17.00	61.10	-43.75	-0.50	7.05	-1.54	-0.09	-2.95	-0.25
Util_Cns	-10.10	-166.94	-5.62	-1.71	-26.89	-1.03	-0.67	-10.62	-0.37
Total	-1219.00	-1486.00	-2007.67	-7.00	-136.02	-67.33	-26.10	-57.19	-146.19
	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-41.00	264.02	-148.40	-8.00	178.15	-18.75	1.00	117.90	-64.00
Coal	-0.06	-53.90	-38.60	-1.00	-9.90	-23.90	0.00	0.00	0.00
Oil	0.00	-234.02	47.55	0.01	-71.01	45.45	30.00	-1143.53	287.08
Gas	0.36	-217.78	38.86	0.04	-2.45	0.12	15.30	-151.52	92.31
Oil_pcts	2.00	-64.17	-241.83	11.00	-69.18	-20.16	22.00	-256.43	3.13
CMnf	-900.00	4142.00	-1048.60	-448.00	2073.50	-336.82	-744.00	2429.30	-1297.77
LMnf	-310.00	-6980.90	-581.39	334.00	-1583.00	382.00	697.00	-3152.60	1058.01
Osg	3.00	-153.51	-0.31	0.60	-64.56	-0.29	8.20	-80.28	7.10
Pcf	-22.00	-108.90	-77.06	-7.00	-46.40	-67.04	-2.00	-18.60	-61.46
Trans	5.00	476.00	-7.53	-1.40	44.03	-9.06	-10.00	912.10	-55.49
Util_Cns	-9.00	-156.93	-1.69	-0.66	-11.99	-0.79	-0.17	-14.18	0.65
Total	-1251.00	-4373.00	-2070.10	-116.00	171.00	-52.81	153.00	-2003.00	40.53
	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-2.00	418.78	-31.10	-3.00	278.60	-37.02	-0.30	8.91	-2.74
Coal	-0.06	-39.25	-60.95	-0.12	-0.02	-1.40	-0.01	-0.03	0.00
Oil	13.90	-922.59	108.72	0.00	-0.02	0.00	0.00	-0.12	0.00
Gas	-0.22	-96.30	-698.10	-0.59	-0.18	0.00	0.01	-0.11	0.01
Oil_pcts	3.00	-86.08	-27.90	-2.00	-233.96	-198.52	-3.00	-5.29	-26.48
CMnf	-1317.00	5389.90	-1329.00	-826.00	2763.80	-549.87	-24.00	178.42	50.78
LMnf	68.00	-4847.01	-92.30	98.00	-2175.70	106.40	-123.00	-293.67	-96.97
Osg	1.00	-195.37	-1.58	-0.30	-110.13	-0.84	0.31	-34.70	0.09
Pcf	-13.00	-87.90	-42.05	-16.00	-153.30	-92.46	4.40	4.05	30.71
Trans	-60.00	-433.00	-72.76	-2.60	50.55	-10.49	0.70	40.20	-0.77
Util_Cns	-11.20	-181.04	-6.22	-4.30	-71.39	-2.15	-1.61	-26.04	-1.00
Total	-1302.00	-2928.00	-2300.00	-789.00	-110.00	-791.00	-144.00	-221.90	-44.58

Economic effect results of a stringent emission policy in both ASEAN and China in 2015

The previous section examined economic effects under a lax emission policy imposed in ASEAN and China together in the same year. This can hurt both ASEAN and China during the period of implementation. In fact, some ASEAN nations could see an improved GDP compared to the case of implementing a lax emission policy in ASEAN alone, while the economy of China is slightly worse than the case of imposing a lax emission in China alone. However, this paper had further assessed the scenario of imposing a stringent emission policy instead of a lax one.

The short-run results of the GDP deviation from the base case under a stringent policy were shown in table 72. As in the lax case, China and South Korea are the only two regions, in the non-ASEAN group, that experience a decrease in their GDP about doubles the decreased percentage in the lax case. This is caused by a marked fall in China's consumption and investment owing to a severe drop in China's technological augmented outputs as well as high imports in capital-intensive goods and reduced consumption due to labor-intensive product export replacement by ASEAN and China in South Korea. In the meantime, low income countries such as Cambodia, Lao and Vietnam still suffer dramatically compared to other ASEAN members, similar to the lax case.

Moreover, the long-run effects, shown in table 73, still replicate lax case implications. For example, only China encounters severe problems as its GDP fall down to -36.32 percent compared to the base case. This percentage looks similar to the results in the case of imposing a stringent policy in China alone. In other words, ASEAN's emission policy could impact China's economy, insignificantly while China's emission policy has a stronger impact on ASEAN's economy compared with the case of imposing an emission policy in ASEAN alone. For instance, Cambodia, Lao, Singapore and the rest of Southeast Asia could see an increased GDP whereas Malaysia, Philippines, Thailand, and Vietnam face decreases.

Table 72 the change in nominal GDP decomposition in 2015 after imposing a stringent emission policy in both ASEAN and China compared to base case (million USD)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
			Non-ASEAN regions				
AUS	12217	10989	3887	3909	7309	23693	2.76
NZL	784	817	249	146	468	1528	1.07
CHN	-341353	-452917	-143115	49361	37572	-925595	-24.19
EUR	-2277	65922	-1393	25473	30680	57045	0.33
IND	8182	6727	1414	1824	4422	13726	1.03
JPN	8095	25539	2426	-7667	9625	18768	0.43
KOR	-1663	1331	-602	301	2240	-2873	-0.26
USA	28804	49844	6361	1223	22274	63958	0.46
			ASEAN regions				
IDN	-54195	-40652	-8070	6731	-9137	-87047	-17.88
KHM	-1830	-1474	-148	846	-371	-2233	-28.15
LAO	-903	-971	-127	126	-422	-1451	-26.26
MYS	-15072	-26289	-4299	-6000	-15542	-36119	-17.47
PHL	-16700	-11522	-2701	8091	-33	-22799	-14.42
SGP	-5774	-7957	-1517	-3725	-3621	-15351	-7.67
THA	-25112	-32724	-6320	4923	-12721	-46513	-17.24
VNM	-11964	-13983	-1219	5016	-2856	-19294	-26.55
XSE	-2687	-2618	-714	372	-785	-4861	-15.14

Table 73 the change in the combined nominal GDP decomposition between 2015 and 2030 after imposing a stringent emission policy in both ASEAN and China compared with the base case (million US dollars)

REG	Consumption	Investment	Gov Expenditure	Export	Import	TotalCh	%Change
Non-ASEAN regins							
AUS	-41598	147530	-11522	-38384	4541	51486	0.30
NZL	-9017	32169	-2630	-16303	-2758	6976	0.25
CHN	-1.3E+07	-2.4E+07	-5145681	-2611508	-5629750	-3.9E+07	-36.32
EUR	177712	4208032	77980	-538536	550032	3375156	1.05
IND	581362	1204121	115140	-447838	145155	1307630	3.87
JPN	-117228	855160	-33143	-527276	-315313	492826	0.63
KOR	-30321	289632	-6911	-462509	-295909	85800	0.44
USA	-517856	1192160	-108684	-620212	-392064	337472	0.13
ASEAN regions							
IDN	-1890682	-1735416	-247448	-590505	-957365	-3506687	-28.77
KHM	-33060	-54376	-2470	-43273	-66067	-67112	-42.23
LAO	-38398	-33484	-4908	-18418	-25058	-70150	-43.56
MYS	-489757	-918557	-135017	-1146270	-1277866	-1411735	-28.30
PHL	-575250	-639504	-84065	-196703	-469176	-1026346	-26.40
SGP	-196162	-421180	-50469	-599090	-659802	-607099	-13.97
THA	-608723	-1586337	-145227	-1029822	-1578850	-1791257	-28.40
VNM	-348592	-337223	-34276	-318001	-390216	-647875	-34.80
XSE	-112183	-78096	-27471	-49071	-51794	-215028	-23.35

As the last two tables illustrate stronger effects of China’s emission policy than effects of ASEAN’s emission policy, ASEAN nation economies are remarkably changed either in terms of better off or worse off. The effects may pass through trade between ASEAN and China. Thus, the change of China’s export and import from the base case are captured and presented in table 74 and 75. In general, it can be seen that both types of policy could impact on China’s trade in the same way. For example, China’s exports in the 3 impacted sectors could drop to about double the results in the lax case and exports in labor-intensive goods increase significantly in non-ASEAN markets, as well as Philippines, Singapore, Thailand and Vietnam.

Moreover, the imports in China show the signs of direction, like the lax case, but the amount of changes in imports approximately doubles. Nevertheless, both export and import in China indicate that the vast majority of China's trade goes to non-ASEAN markets rather than ASEAN markets. This leads to benefits for non-ASEAN from the emission policy in China, and as a result, it lead to a weak impact of the ASEAN emission policy on China's economy.

Table 74 the change of China's exports to other regions in 2015 after imposing a stringent emission policy in ASEAN and China compared to base case (million US$)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	-3477.82	40.00	-0.10	0.01	-52.00	-8.00	7.00	1.00	1.00	-0.20
Coal	615.57	-0.04	0.00	0.00	-0.14	-2.10	0.00	-0.11	-0.22	-0.01
Oil	316.17	23.00	0.00	0.00	0.00	0.01	57.00	26.20	0.00	0.01
Gas	965.17	0.02	0.00	0.00	0.72	0.08	30.50	-0.45	-1.06	0.01
Oilpcts	2511.80	38.00	-1.90	-0.01	4.00	19.00	38.00	5.00	-8.00	-6.00
Electrc	579.22	0.01	0.21	-0.12	0.01	0.00	0.01	1.00	-72.00	0.06
CMnf	-136502.00	-1237.00	-2.11	-5.20	-1535.00	-758.00	-1355.00	-2278.00	-1386.00	-34.00
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	179631.00	-952.00	-6.00	-38.60	-606.00	609.00	1339.00	108.00	147.00	-227.00
Osg	3055.10	2.70	0.01	-0.01	6.00	1.10	16.50	1.90	-0.60	0.61
Pcf	-36.00	-17.00	0.95	-0.21	-37.00	-11.00	-4.00	-19.00	-25.00	6.80
Svces	12136.20	23.00	0.19	0.01	43.00	8.10	270.00	30.00	8.70	3.70
Trans	-3601.00	-34.00	-0.90	-0.18	9.00	-2.80	-19.00	-120.00	-5.10	1.40
UtilCns	134.61	-20.30	-3.42	-1.34	-19.00	-1.32	-0.34	-22.40	-8.70	-3.23
Total	56328.00	-2134.00	-13.00	-45.90	-2186.00	-145.00	381.00	-2267.00	-1351.00	-257.00

Table 75 the change of China's imports from other regions in 2015 after imposing a stringent emission policy in ASEAN and China compared to base case (million US$)

SEC	NonASEAN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	8944.30	-62.00	-7.40	-0.61	-52.00	-25.00	0.27	-187.00	-104.00	-65.90
Coal	-228.58	-100.00	0.00	0.00	0.02	0.00	0.00	0.00	-95.00	0.04
Oil	-9102.33	190.00	0.00	-1.96	26.00	-0.01	0.00	58.00	42.00	22.00
Gas	-557.08	0.78	0.00	0.04	3.40	4.47	0.00	1.21	11.32	0.29
Oil_pcts	-2245.93	21.00	0.00	0.71	-9.00	-5.00	-169.00	-19.00	0.13	-0.02
Electric	-168.10	0.00	0.00	0.00	0.21	0.00	0.00	0.28	0.00	-0.02
CMnf	146281.00	-639.00	-20.20	-4.30	-2239.00	-478.00	436.00	-1318.00	-335.00	-105.20
Dwe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LMnf	-84264.00	663.00	3.40	6.13	-445.00	2888.00	-61.00	2097.00	131.00	-24.20
Osg	-2316.69	-0.30	-0.02	0.09	-1.10	-0.80	-8.80	0.50	1.36	-0.10
Pcf	-520.00	4.00	-1.09	0.20	-518.00	-3.70	3.00	-57.00	-12.00	-10.40
Svces	-12378.20	3.30	-0.30	0.08	-10.00	-5.10	-525.00	-10.00	11.30	-0.82
Trans	-1501.00	-31.00	-10.60	0.29	-145.00	-44.00	-486.00	-159.00	-29.40	-9.20
Util_Cns	-983.77	-1.00	-0.06	0.00	-15.80	-0.44	-3.40	-5.60	-1.60	-0.46
Total	40960.00	49.00	-37.00	0.70	-3405.00	2331.00	-814.00	402.00	-380.00	-195.00

The mobility of ASEAN's outputs is also investigated and shown in table 76 and 77. These tables present the amount of changes in exports and imports from the base case, respectively. They are divided into 3 markets: China, non-ASEAN, and ASEAN itself. The figures still repeat those circumstances in the lax case; e.g. the fall in trade across ASEAN market and the increase in exports to non-ASEAN region. Moreover, the results continue to confirm that the ASEAN's production and trade are shifting to labor-intensive sector as well as energy sectors such as gas, oil, and petroleum. This could prevent ASEAN from suffering in agriculture, capital-intensive manufacture, and transportation and communication. However, the growth in energy sectors in ASEAN could lead to an increase in its emissions as well.

On the whole of economic effects, it can be seen that all ASEAN nations face a serious situation due to lack of outputs in particular the 3 main impacted sectors. The policy does not only affect their export/import but also consumption and investment.

These effects could take a long period of time to be felt. In addition, the results indicate a severe decrease in GDP especially in low income countries such as Cambodia and Lao both in short-term and long-term while South Korea could experience small decreases in the short-run and gain in the long-run.

Moreover, the effects on China’s economy are quite similar to the case of imposing an emission policy in China without ASEAN. This can be interpreted that ASEAN emission policy could impact on China’s economy very slightly while China emission policy could significantly impact on ASEAN’s economy both in terms of negative and positive ones. In other words, the effects of an emission policy came from China to ASEAN is much stronger than those from ASEAN to China.

Table 76 the change of ASEAN state exports in 2015 after imposing a stringent emission policy in both ASEAN and China compared to base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-46.00	-1393.63	-289.97	-6.30	-28.32	-13.20	-0.24	-11.43	5.77
Coal	-91.00	1240.87	-213.70	0.00	0.00	0.00	0.00	0.00	-0.09
Oil	182.00	1569.23	153.31	0.00	0.00	0.00	-1.96	-26.16	-2.05
Gas	0.78	5601.94	85.84	0.00	0.00	0.00	0.04	2.68	0.27
Oil_pcts	18.00	297.50	26.30	0.00	0.01	0.00	0.71	32.09	0.94
CMnf	-434.00	-12295.10	-1632.94	-16.30	-52.90	-176.07	-2.90	-50.57	-121.64
LMnf	587.00	11351.00	1391.03	2.90	1218.71	9.66	5.10	160.21	66.46
Osg	-0.30	338.56	2.65	-0.02	33.29	0.32	0.09	21.34	0.19
Pcf	1.00	391.30	12.96	-1.04	-24.73	-7.48	0.18	5.16	0.47
Trans	-31.00	-813.00	-20.81	-10.60	-206.17	-8.49	0.29	14.43	0.94
Util_Cns	-1.00	99.86	-1.10	-0.06	0.89	-0.07	0.00	0.30	0.00
Total	188.00	7015.00	-471.69	-32.00	1069.80	-190.81	1.40	172.39	-47.78

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-43.00	-401.22	-21.53	-17.80	-400.39	-4.30	0.26	-20.50	9.16
Coal	0.02	0.24	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Oil	25.00	1063.14	279.01	-0.01	0.00	-0.03	0.00	-0.01	0.00
Gas	3.40	5431.36	35.59	4.47	376.60	36.29	0.00	0.01	0.00
Oil_pcts	-10.00	201.85	-32.71	-4.70	20.32	-16.02	-154.00	151.20	-1348.00
CMnf	-1887.00	-13335.70	-4076.79	-387.00	-1883.49	-394.35	410.00	-7386.20	164.13
LMnf	-443.00	9738.00	-363.12	2831.00	7486.00	535.92	-66.00	6966.00	-3368.71
Osg	-1.10	216.13	2.56	-0.80	130.26	2.00	-8.80	207.99	-10.37
Pcf	-469.00	-996.50	-311.49	-3.30	-119.73	-54.98	2.00	75.60	3.92
Trans	-145.00	-3489.70	-121.72	-44.00	-1111.10	-39.75	-486.00	-2930.50	-106.00
Util_Cns	-15.80	255.68	-16.66	-0.44	22.63	-0.68	-3.40	59.49	-9.55
Total	-2994.00	1472.00	-4587.20	2373.00	5611.00	86.33	-830.00	1115.00	-4850.20

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-123.00	-778.43	-79.10	-76.00	-1655.98	-42.06	-56.50	-518.04	-54.75
Coal	0.00	0.00	0.00	-90.00	68.03	-12.88	0.02	2.54	-2.20
Oil	56.00	91.23	6.02	40.00	973.30	488.07	20.00	576.80	23.75
Gas	1.21	90.05	9.03	11.32	912.10	86.76	0.24	2362.14	-1318.23
Oil_pcts	-19.00	228.20	-260.00	0.12	0.41	4.96	-0.01	5.35	-0.09
CMnf	-1013.00	-12237.50	-1770.00	-256.00	-2521.39	-476.60	-89.90	-84.71	-136.58
LMnf	1989.00	19526.00	767.00	115.00	6652.50	156.10	-20.60	-92.38	-32.63
Osg	0.50	382.67	5.40	1.36	283.29	3.48	-0.10	26.65	-0.01
Pcf	-47.00	-592.10	-292.00	-9.00	-160.16	-106.64	-9.00	-67.63	-24.13
Trans	-159.00	-2842.30	-68.17	-29.40	-594.16	-27.28	-9.20	-213.64	-11.16
Util_Cns	-5.60	15.82	-5.58	-1.60	37.81	-2.18	-0.46	2.05	-0.59
Total	669.00	5827.00	-1642.00	-283.00	5168.00	112.60	-165.00	2087.00	-1555.25

Table 77 the change of ASEAN state imports in 2015 after imposing a stringent emission policy in both ASEAN and China compared to base case (million US dollars)

	IDN			KHM			LAO		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	33.00	1682.75	-23.63	-0.15	11.81	-2.45	0.00	0.95	-4.83
Coal	-0.04	-0.12	-0.23	0.00	0.00	0.00	0.00	0.00	-0.08
Oil	23.00	-924.92	28.81	0.00	0.00	0.00	0.00	2.42	0.99
Gas	0.02	-2.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Oil_pcts	47.00	-601.82	-527.69	-2.00	-6.22	-221.03	-0.01	-0.03	-11.95
CMnf	-1465.00	7844.00	-882.38	-4.92	173.42	39.72	-6.60	27.94	-58.81
LMnf	-1027.00	-7587.00	-2170.95	-5.00	-354.05	38.30	-44.10	-102.45	-137.54
Osg	2.70	-350.83	-1.98	0.01	-24.75	-0.12	-0.01	-3.89	-0.03
Pcf	-20.00	-296.60	-294.18	1.24	5.38	17.39	-0.31	-7.55	-76.97
Trans	-34.00	119.20	-86.89	-0.90	13.14	-3.08	-0.18	-5.95	-0.50
Util_Cns	-20.30	-333.98	-11.23	-3.42	-53.76	-2.05	-1.34	-21.33	-0.74
Total	-2438.00	-2971.00	-4015.33	-14.00	-273.01	-135.57	-52.40	-114.35	-291.88

	MYS			PHL			SGP		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-81.00	528.13	-295.70	-16.00	358.41	-37.61	3.00	236.90	-127.09
Coal	-0.13	-108.90	-77.30	-2.00	-19.67	-47.80	0.00	0.00	0.00
Oil	0.00	-468.05	94.10	0.01	-141.03	90.90	59.00	-2286.16	572.24
Gas	0.72	-435.55	78.72	0.08	-4.90	0.23	30.50	-302.53	184.77
Oil_pcts	4.00	-129.73	-485.66	21.00	-138.47	-41.22	43.00	-513.76	5.16
CMnf	-1801.00	8282.00	-2095.26	-895.00	4146.90	-673.54	-1489.00	4856.50	-2595.09
LMnf	-619.00	-13958.80	-1165.78	667.00	-3169.10	764.00	1394.00	-6304.30	2116.02
Osg	6.00	-305.96	-0.61	1.10	-129.11	-0.58	16.50	-160.56	14.16
Pcf	-44.00	-219.70	-156.11	-13.00	-91.00	-133.07	-4.00	-38.40	-123.73
Trans	9.00	950.80	-15.06	-2.80	88.17	-18.10	-19.00	1824.20	-110.98
Util_Cns	-19.00	-313.77	-3.43	-1.32	-23.96	-1.59	-0.34	-28.35	1.30
Total	-2501.00	-8748.00	-4141.20	-232.00	340.00	-103.61	306.00	-4007.00	79.06

	THA			VNM			XSE		
SEC	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN	CHN	NonASEAN	ASEAN
Agr	-4.00	837.36	-63.20	-6.00	557.80	-73.33	-0.60	17.78	-5.69
Coal	-0.11	-79.19	-122.01	-0.24	-0.04	-2.90	-0.01	-0.06	-0.01
Oil	26.90	-1846.28	215.44	0.00	-0.05	0.00	0.01	-0.25	-0.01
Gas	-0.45	-192.38	-1395.19	-1.17	-0.35	0.00	0.01	-0.22	0.02
Oil_pcts	7.00	-170.05	-57.80	-3.00	-466.91	-396.06	-6.00	-10.48	-51.97
CMnf	-2635.00	10779.80	-2658.10	-1652.00	5525.50	-1101.74	-47.00	358.32	102.57
LMnf	136.00	-9696.17	-186.50	196.00	-4350.90	213.80	-246.00	-585.48	-192.84
Osg	1.90	-389.73	-3.17	-0.60	-221.57	-1.65	0.61	-69.38	0.18
Pcf	-25.00	-177.70	-86.20	-32.00	-308.50	-186.90	8.80	8.09	63.41
Trans	-120.00	-864.90	-145.50	-5.10	103.20	-20.76	1.40	80.68	-1.57
Util_Cns	-22.40	-360.88	-12.34	-8.70	-141.69	-4.31	-3.23	-51.83	-2.00
Total	-2604.00	-5859.00	-4600.00	-1577.00	-217.00	-1581.00	-288.00	-444.90	-89.06

Emission effect results of the emission policy in both ASEAN and China in 2015

The previous section discussed the economic effects of an emission policy imposed in ASEAN and China, either a lax emission policy or a stringent one. This section focused on emission effects caused by these two types of policy. To indicate emission changes in each region, 6 air emission indicators were captured, and divided into three different kinds of gases. The first one is Carbon dioxide greenhouse gas (CO_2 GHG). The second is Non-carbon dioxide greenhouse gases such as Methane (CH_4) and Nitrous (N_2O) and the last one is non-GHG air pollutants for instance, Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). These 6 pollution indicators could harm both the environment and human/animal. Specifically, the non-GHG air pollutants could impact human health directly through the respiratory system. For this reason, this study focuses on the change in total emissions due to an emission policy.

First of all, this section revealed total emissions for each indicator, in each region, after imposing an emission policy, in the two regions, in 2015. The comparisons of the emission deviation from the base case between lax and stringent policy were examined in order to identify the differences between the two policies in regions. Sector analysis was then analyzed by ranking the main contributing emission sectors. Finally, this section concluded with cost-effectiveness analysis. This would illustrate a type of an emission policy that should be imposed in ASEAN and China. The cost-effectiveness ratio was presented in a form of emission change and GDP change ratio, which was measured in term of the long-run effects.

Effects of lax and stringent emission policies, in terms of total emission changes in each region and each sector, were shown in table 78 and 79, respectively. Both tables revealed that Indonesia is the main polluter in ASEAN followed by Thailand in both 2015 and 2030 while China is the main one for CO_2 and non-CO_2 GHG emission in the non-ASEAN state group. In the meantime, European Union could place in non-GHG air pollutants emission in 2015 whereas China will take the position back in 2030.

Table 78 the total emissions in each region in 2015 under a lax emission policy imposed in both ASEAN and China (million tons)

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	365.85	30.87	5077.98	3419.62	1284.77	955.68	391.41	4649.64
	2030	662.99	48.94	15368.20	5114.72	3852.21	1404.55	645.10	7707.42
CH_4	2015	61.03	15.91	619.66	225.18	291.69	6.16	22.79	294.62
	2030	148.08	30.89	2351.06	415.47	735.06	10.12	36.01	680.65
N_2O	2015	14.64	7.55	381.84	196.16	37.97	9.88	9.73	169.84
	2030	29.84	14.77	1134.86	351.74	100.05	14.77	14.99	351.11
SO_2	2015	32.91	4.93	565.40	710.99	77.62	127.35	63.20	307.77
	2030	48.13	8.96	1591.41	1028.54	242.38	165.30	91.82	486.20
NO_2	2015	19.75	2.99	342.40	431.96	47.03	77.26	38.34	187.06
	2030	28.85	5.41	962.35	623.53	146.64	100.15	55.86	294.90
PM_{10}	2015	13.59	1.93	220.25	271.46	30.22	49.05	24.30	117.11
	2030	20.05	3.57	625.75	398.52	95.13	64.25	34.65	187.64
Emission	**Year**	**IDN**	**KHM**	**LAO**	**MYS**	**PHL**	**SGP**	**THA**	**VNM**
CO_2	2015	319.75	2.60	1.02	171.78	62.51	67.05	207.73	76.51
	2030	971.50	5.57	2.18	385.94	123.29	139.33	433.48	125.03
CH_4	2015	136.48	5.69	5.98	28.64	14.43	0.97	43.88	41.38
	2030	382.97	10.32	15.49	77.44	31.65	2.07	89.22	95.16
N_2O	2015	21.23	1.06	1.12	4.01	4.94	0.67	10.86	7.23
	2030	59.30	1.95	2.93	9.09	12.95	1.43	21.29	15.90
SO_2	2015	32.61	0.35	0.28	14.82	7.46	8.58	18.89	5.15
	2030	84.56	0.68	0.72	29.73	18.95	14.47	41.98	7.01
NO_2	2015	19.74	0.22	0.17	9.14	4.63	5.25	11.61	3.18
	2030	51.06	0.43	0.43	18.19	11.78	8.81	25.72	4.30
PM_{10}	2015	12.81	0.09	0.11	5.10	2.43	3.10	6.66	1.77
	2030	33.69	0.17	0.29	10.77	6.11	5.44	15.08	2.52

Table 79 the total emission in each region in 2015 under a stringent emission policy imposed in both ASEAN and China (million tons)

Emission	Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA
CO_2	2015	373.31	31.13	4780.06	3439.06	1298.09	964.41	395.77	4670.29
	2030	655.09	48.50	12333.95	5068.69	3883.11	1392.74	637.10	7553.46
CH_4	2015	61.25	16.05	598.15	225.87	293.77	6.20	22.86	295.70
	2030	135.71	29.39	1820.12	401.64	741.78	9.80	35.20	640.64
N_2O	2015	14.89	7.62	387.30	198.07	38.36	9.99	10.08	171.80
	2030	27.91	14.04	941.54	344.94	101.61	14.53	15.29	337.86
SO_2	2015	34.37	5.06	565.96	724.14	79.57	130.79	65.79	312.47
	2030	51.12	9.20	1356.67	1042.99	254.83	168.44	95.70	491.56
NO_2	2015	20.62	3.07	342.73	439.70	48.18	79.27	39.87	189.83
	2030	30.63	5.56	820.45	632.20	154.10	101.99	58.14	298.12
PM_{10}	2015	14.24	1.99	220.48	277.53	31.10	50.68	25.51	119.27
	2030	21.34	3.68	533.27	404.46	100.30	65.70	36.47	189.83
Emission	Year	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
CO_2	2015	307.53	2.28	0.94	157.10	58.84	65.42	193.06	66.24
	2030	834.11	4.03	1.54	305.84	102.54	125.31	373.63	98.77
CH_4	2015	135.59	5.56	5.65	28.72	13.92	0.94	43.76	39.28
	2030	297.52	8.15	11.83	66.74	26.53	1.86	79.34	78.36
N_2O	2015	21.53	1.04	1.06	4.00	4.94	0.63	10.99	6.88
	2030	40.03	1.53	2.24	7.45	10.90	1.22	18.09	13.19
SO_2	2015	31.07	0.30	0.25	12.25	7.12	8.07	16.79	4.49
	2030	72.72	0.47	0.40	19.32	15.28	12.47	26.60	5.26
NO_2	2015	18.82	0.19	0.15	7.61	4.44	4.95	10.37	2.79
	2030	43.96	0.30	0.24	11.92	9.53	7.60	16.37	3.25
PM_{10}	2015	12.13	0.06	0.10	3.97	2.25	2.87	5.69	1.46
	2030	28.76	0.10	0.16	6.59	4.77	4.61	9.25	1.80

However, to assess the real impact of an emission policy, we needed to eliminate the effects of trade liberalization in the ASEAN Community and its FTA by subtracting the total emissions in the base case from the total emissions mentioned above. For this reason, tables 80 – 82 were created. They illustrated the deviation of emissions from the base case and compare them across China and ASEAN nations. Figures in table 80 indicated that most air emission indicators could fall in general except for N_2O in 2015 which still increase slightly. However, by comparing the results with, the case of imposing an emission policy in China alone, it can be seen that China's emissions in particular non-GHG air pollutants could increase significantly in 2015. For example, SO_2 emission changes, in the case of imposing an emission policy in China alone, was -0.35 percent for a lax policy case, and -0.70 percent for a stringent case, but these numbers could increase to 0.10 and 0.20 percent, when China and ASEAN impose an emission policy together. This leads to a higher number of SO_2 emissions in long term than it was in the case of implementing an emission policy in China only.

Turning to emission effects on ASEAN, it is clear that emissions in ASEAN as a whole plummet in all indicators; however by comparing the results with the case of imposing an emission policy in ASEAN alone, the figures reveal an increase in emissions in the short-run for all indicators. In addition, long-run effects differ across indicators. For instance, emissions in CO_2 and non-CO_2 GHG gases could decrease while SO_2, NO_2, and PM_{10} increase more in the long-run.

Furthermore, individual ASEAN member emissions were investigated precisely and the results were shown in table 81 and 82. The results indicate a variety of effects in each indicator and member. For example, all emission indicators could grow slightly in Indonesia in the short-run compared with the case of imposing an emission policy in ASEAN alone. In the long-run the emissions in non-GHG air pollutants increase further but decrease in CO_2 and non-CO_2 GHG gases. By contrast, the non-CO_2 gases, in Cambodia in the long-run, could increase under the stringent policy case whereas they fall under the case of a lax one.

On the whole of emission effects in each ASEAN state, all emissions could decrease significantly compared with the base case. However, if the emissions are compared to the case of implementing an emission policy in ASEAN alone, the figures illustrate higher emissions both in short-run and long-run in non-GHG air pollutants (SO_2,

NO_2, and PM_{10}) while CO_2 and non-CO_2 GHG gases could increase slightly in the short-run and fall in the long-run.

Table 80 the emission deviation from the base case of both lax and stringent emission policies in both China and ASEAN in 2015 and 2030 (million tons)

		CHINA				ASEAN			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-297.91	-5.54	-595.83	-11.08	-59.05	-5.98	-118.07	-11.96
	2030	-3909.38	-20.28	-6943.63	-36.02	-543.08	-19.54	-890.21	-32.03
CH_4	2015	-21.51	-3.35	-43.02	-6.71	-4.65	-1.54	-9.31	-3.08
	2030	-725.33	-23.58	-1256.27	-40.84	-129.00	-14.48	-271.23	-30.44
N_2O	2015	5.46	1.45	10.93	2.90	-0.20	-0.37	-0.41	-0.74
	2030	-225.15	-16.56	-418.47	-30.77	-22.20	-14.05	-53.98	-34.16
SO_2	2015	0.56	0.10	1.12	0.20	-7.92	-8.18	-15.84	-16.36
	2030	-258.80	-13.99	-493.54	-26.67	-55.27	-21.67	-101.21	-39.67
NO_2	2015	0.33	0.10	0.67	0.20	-4.68	-7.92	-9.36	-15.85
	2030	-156.61	-14.00	-298.52	-26.68	-33.34	-21.49	-61.09	-39.38
PM_{10}	2015	0.23	0.10	0.46	0.21	-3.58	-9.98	-7.17	-19.95
	2030	-101.29	-13.93	-193.77	-26.65	-22.13	-22.85	-40.28	-41.60

Table 81 the comparison of the emission deviation from the base case of both lax and stringent emission policies among ASEAN members in 2015 and 2030 (million tons)

		IDN				MYS			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-12.22	-3.68	-24.44	-7.36	-14.69	-7.88	-29.38	-15.75
	2030	-209.00	-17.70	-346.39	-29.34	-106.06	-21.56	-186.17	-37.84
CH_4	2015	-0.89	-0.65	-1.78	-1.29	0.08	0.28	0.16	0.56
	2030	-57.68	-13.09	-143.13	-32.48	-13.36	-14.72	-24.06	-26.50
N_2O	2015	0.30	1.42	0.59	2.84	-0.02	-0.40	-0.03	-0.79
	2030	-8.53	-12.57	-27.80	-40.98	-1.85	-16.94	-3.49	-31.91
SO_2	2015	-1.54	-4.52	-3.08	-9.03	-2.58	-14.80	-5.15	-29.60
	2030	-19.00	-18.35	-30.85	-29.78	-13.59	-31.37	-24.00	-55.40
NO_2	2015	-0.92	-4.44	-1.83	-8.88	-1.53	-14.34	-3.06	-28.68
	2030	-11.42	-18.28	-18.52	-29.64	-8.19	-31.04	-14.46	-54.82
PM_{10}	2015	-0.67	-4.99	-1.35	-9.99	-1.13	-18.17	-2.27	-36.33
	2030	-7.79	-18.78	-12.72	-30.66	-5.47	-33.67	-9.65	-59.43
		KHM				LAO			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-0.32	-10.99	-0.64	-21.99	-0.08	-7.28	-0.16	-14.53
	2030	-2.18	-28.12	-3.72	-47.99	-0.87	-28.63	-1.52	-49.68
CH_4	2015	-0.13	-2.23	-0.26	-4.47	-0.33	-5.18	-0.65	-10.34
	2030	-2.19	-17.49	-4.35	-34.80	-4.73	-23.39	-8.40	-41.51
N_2O	2015	-0.02	-2.00	-0.04	-4.01	-0.06	-5.03	-0.12	-10.06
	2030	-0.42	-17.71	-0.83	-35.13	-0.89	-23.30	-1.58	-41.38
SO_2	2015	-0.05	-12.45	-0.10	-24.95	-0.03	-9.17	-0.06	-18.33
	2030	-0.25	-27.19	-0.46	-49.52	-0.39	-35.40	-0.71	-63.71
NO_2	2015	-0.03	-11.41	-0.06	-22.87	-0.02	-9.04	-0.03	-18.07
	2030	-0.16	-26.68	-0.29	-48.64	-0.24	-35.24	-0.42	-63.40
PM_{10}	2015	-0.03	-22.40	-0.05	-44.89	-0.01	-10.10	-0.02	-20.20
	2030	-0.08	-32.42	-0.14	-58.60	-0.17	-36.22	-0.30	-65.35

Table 82 the comparison of the emission deviation from the base case of both lax and stringent emission policy among ASEAN members in 2015 and 2030 (million tons)

		PHL				SGP			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	Val Ch	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-3.69	-5.57	-7.36	-11.12	-1.63	-2.37	-3.26	-4.74
	2030	-24.73	-16.71	-45.48	-30.73	-17.54	-11.18	-31.56	-20.12
CH_4	2015	-0.51	-3.44	-1.03	-6.86	-0.03	-2.73	-0.05	-5.46
	2030	-6.23	-16.45	-11.36	-29.98	-0.28	-11.84	-0.49	-20.86
N_2O	2015	0.00	0.02	0.00	0.04	-0.04	-6.04	-0.09	-12.08
	2030	-2.45	-15.92	-4.50	-29.21	-0.20	-12.30	-0.41	-25.07
SO_2	2015	-0.33	-4.26	-0.66	-8.52	-0.51	-5.61	-1.02	-11.22
	2030	-4.09	-17.76	-7.76	-33.68	-1.61	-10.01	-3.61	-22.46
NO_2	2015	-0.19	-3.92	-0.38	-7.85	-0.30	-5.43	-0.60	-10.85
	2030	-2.50	-17.52	-4.74	-33.23	-0.97	-9.94	-2.17	-22.23
PM_{10}	2015	-0.18	-6.93	-0.36	-13.85	-0.23	-6.96	-0.46	-13.91
	2030	-1.50	-19.71	-2.84	-37.32	-0.64	-10.52	-1.46	-24.07
		THA				VNM			
		Case:Lax Policy		Case:Stringent Policy		Case:Lax Policy		Case:Stringent Policy	
Emission	Year	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch	ValCh	%Ch
CO_2	2015	-14.66	-6.59	-29.33	-13.19	-10.27	-11.83	-20.53	-23.66
	2030	-141.04	-24.55	-200.89	-34.97	-32.90	-20.83	-59.16	-37.46
CH_4	2015	-0.12	-0.28	-0.25	-0.56	-2.10	-4.82	-4.20	-9.65
	2030	-16.87	-15.90	-26.75	-25.22	-18.25	-16.09	-35.05	-30.91
N_2O	2015	0.13	1.21	0.26	2.42	-0.35	-4.67	-0.71	-9.35
	2030	-3.23	-13.18	-6.43	-26.22	-2.81	-15.00	-5.52	-29.50
SO_2	2015	-2.10	-10.00	-4.20	-20.00	-0.67	-11.46	-1.33	-22.91
	2030	-13.82	-24.77	-29.20	-52.33	-2.04	-22.58	-3.79	-41.90
NO_2	2015	-1.24	-9.62	-2.47	-19.25	-0.39	-10.95	-0.78	-21.90
	2030	-8.35	-24.51	-17.70	-51.95	-1.23	-22.19	-2.28	-41.21
PM_{10}	2015	-0.97	-12.69	-1.93	-25.37	-0.32	-15.15	-0.63	-30.29
	2030	-5.46	-26.59	-11.29	-54.97	-0.85	-25.27	-1.57	-46.65

Although we had discussed emission change induced by an emission policy in the previous section, this did not determine the main sectors contributing to emissions. Hence, this section was examined in order to reveal the 3 highest sectors releasing air pollutions in 2015 and 2030 under lax and stringent policies as shown in table 83 to 88.

Firstly, table 83 indicated the top 3 sectors polluting CO_2 GHG emission under a lax emission policy. It can be seen that electricity, capital-intensive manufacture, and transportation and communication are the main sectors emitting CO_2 in China and ASEAN. However, agriculture could take place in Cambodia, as well as oil and petroleum production play a main role in Singapore as well. Regarding CH_4 emission (the representative of non-CO_2 GHG gases) in table 84, the emissions are mainly emitted by agriculture, public administration such as trash incineration, and transportation and communication. In addition, coal sector is among the rank of China and Vietnam while Singapore and Malaysia still rank in oil and petroleum sector.

Turning to the non-GHG air pollutant emissions such as SO_2 (the representative of non-GHG air pollutants), as data of non-GHG air pollutant emission intensities covers only capital-intensive manufacturing, labor manufacturing, and food processing sector, the figures in table 85 could rank in those 3 sectors only. However, it was evident that capital-intensive manufacture creates the vast majority of emissions followed by labor-intensive manufacture and food processing in both years. This rank changes in Cambodia where labor-intensive manufacture has a higher portion of emission than capital-intensive manufacture while food processing sector emits more SO_2 than labor-intensive manufacture in Lao.

Table 86 and 88 illustrated the rank of emitting sectors under a stringent policy in China and ASEAN nations. In general, the ranks of emitting sectors caused by a stringent policy are similar to the ones caused by a lax policy but the degree of impact is stronger. For example, the capital-intensive manufacturing sector in Indonesia emits CO_2 in 2015 to just over 70 million tons whereas it could reduce emissions to 66 million tons under a stringent policy. But both cases could lead capital-intensive manufacture to the second rank of polluting sectors in Indonesia.

Table 83 the rank of sectors which emit carbon dioxide (CO_2) under a lax emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Electricity (2953.25)	Electricity (105.4)	Trans& Com (1.62)	Electricity (0.41)	Electricity (59.60)	Electricity (26.17)	Trans& Com (30.47)	Electricity (81.87)	Electricity (25.92)
2	CMnf (1024.04)	CMnf (70.81)	Electricity (0.54)	Trans& Com (0.28)	Trans& Com (49.11)	Trans& Com (22.23)	Electricity (22.34)	Trans& Com (59.09)	Trans& Com (21.04)
3	Trans& Com (356.66)	Trans& Com (59.28)	Agr (0.30)	CMnf (0.17)	CMnf (22.56)	CMnf (6.97)	Oil_pcts (13.69)	CMnf (26.35)	CMnf (17.07)
Year 2030									
1	Electricity (8928.81)	Electricity (391.77)	Trans& Com (2.97)	Electricity (0.75)	Electricity (120.5)	Electricity (45.58)	Trans& Com (49.54)	Electricity (160.91)	Electricity (42.57)
2	CMnf (2922.47)	CMnf (188.83)	Electricity (1.79)	Trans& Com (0.69)	Trans& Com (94.20)	Trans& Com (42.03)	Oil_pcts (48.90)	Trans& Com (106.57)	Trans& Com (40.00)
3	Trans& Com (851.62)	Trans& Com (120.52)	Agr (0.56)	CMnf (0.46)	Oil_pcts (91.20)	CMnf (17.90)	Electricity (39.89)	CMnf (60.92)	CMnf (24.28)

Table 84 the rank of sectors which emit methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a lax emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (263.63)	Agr (60.82)	Agr (5.24)	Agr (5.67)	Agr (6.97)	Agr (7.85)	Osg (0.53)	Agr (31.89)	Agr (34.07)
2	Coal (211.85)	Osg (32.76)	Osg (0.44)	Osg (0.30)	Osg (6.24)	Osg (6.05)	Oil_pcts (0.28)	Osg (5.05)	Osg (5.19)
3	Osg (138.73)	Trans&Com (16.00)	Trans&Com (0.01)	Trans&Com (0.004)	Oil_pcts (4.53)	Coal (0.32)	Trans&Com (0.15)	Trans&Com (3.13)	Coal (1.85)
Year 2030									
1	Coal (1216.22)	Agr (178.63)	Agr (9.84)	Agr (14.66)	Oil (19.27)	Agr (21.96)	Oil_pcts (1.01)	Agr (63.07)	Agr (74.86)
2	Agr (787.42)	Osg (58.97)	Osg (0.45)	Osg (0.72)	Oil_pcts (18.58)	Osg (8.12)	Osg (0.80)	Oil_pcts (8.78)	Osg (11.41)
3	Osg (322.59)	Oil_pcts (52.01)	Trans&Com (0.02)	Oil_pcts (0.04)	Agr (15.84)	Coal (1.17)	Trans&Com (0.25)	Osg (6.85)	Coal (7.49)

Table 85 the rank of sectors which emit sulfur dioxide (SO_2, the representative of non-GHG air pollutants indicators) under a lax emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (486.27)	CMnf (27.70)	LMnf (0.17)	CMnf (0.22)	CMnf (10.60)	CMnf (4.76)	CMnf (6.70)	CMnf (13.88)	CMnf (3.58)
2	LMnf (68.87)	LMnf (3.04)	CMnf (0.15)	Pcf (0.04)	LMnf (3.61)	LMnf (2.06)	LMnf (1.80)	LMnf (4.09)	LMnf (1.17)
3	Pcf (10.26)	Pcf (1.86)	Pcf (0.03)	LMnf (0.02)	Pcf (0.61)	Pcf (0.64)	Pcf (0.08)	Pcf (0.92)	Pcf (0.40)
Year 2030									
1	CMnf (1387.74)	CMnf (73.87)	LMnf (0.36)	CMnf (0.60)	CMnf (22.98)	CMnf (12.21)	CMnf (11.92)	CMnf (32.09)	CMnf (5.10)
2	LMnf (178.63)	LMnf (7.10)	CMnf (0.28)	Pcf (0.11)	LMnf (5.81)	LMnf (5.73)	LMnf (2.41)	LMnf (8.63)	LMnf (1.19)
3	Pcf (25.04)	Pcf (3.60)	Pcf (0.04)	LMnf (0.01)	Pcf (0.94)	Pcf (1.01)	Pcf (0.14)	Pcf (1.27)	Pcf (0.72)

Table 86 the rank of sectors which emit carbon dioxide (CO_2) under a stringent emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Electricity (2685.38)	Electricity (97.47)	Trans& Com (1.52)	Electricity (0.39)	Electricity (52.34)	Electricity (23.52)	Trans& Com (29.95)	Electricity (74.38)	Electricity (20.58)
2	CMnf (1025.41)	CMnf (66.91)	Electricity (0.35)	Trans& Com (0.25)	Trans& Com (48.40)	Trans& Com (21.75)	Electricity (21.59)	Trans& Com (56.32)	Trans& Com (19.62)
3	Trans& Com (345.46)	Trans& Com (58.11)	Agr (0.30)	CMnf (0.15)	Oil_pcts (21.50)	CMnf (6.34)	Oil_pcts (13.34)	CMnf (22.07)	CMnf (13.56)
Year 2030									
1	Electricity (6918.12)	Electricity (324.9)	Trans& Com (2.19)	Electricity (0.542)	Electricity (93.83)	Trans& Com (37.17)	Trans& Com (47.19)	Electricity (125.96)	Trans& Com (34.49)
2	CMnf (2490.04)	CMnf (160.50)	Electricity (1.22)	Trans& Com (0.537)	Trans& Com (82.72)	Electricity (37.03)	Oil_pcts (41.79)	Trans& Com (91.13)	Electricity (31.67)
3	Trans& Com (752.83)	Trans& Com (113.61)	Agr (0.44)	CMnf (0.24)	Oil_pcts (73.93)	CMnf (13.70)	Electricity (35.45)	Gas (55.70)	CMnf (16.74)

Table 87 the rank of sectors which emit methane (CH_4, the representative of non-CO_2 GHG pollution indicators) under a stringent emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	Agr (270.73)	Agr (62.88)	Agr (5.17)	Agr (5.38)	Agr (6.97)	Agr (7.98)	Osg (0.51)	Agr (32.50)	Agr (32.70)
2	Coal (204.64)	Osg (29.08)	Osg (0.38)	Osg (0.26)	Osg (6.05)	Osg (5.45)	Oil_pcts (0.27)	Osg (4.54)	Osg (4.54)
3	Osg (117.40)	Trans&Com (15.69)	Trans&Com (0.01)	Trans&Com (0.004)	Oil (4.41)	Coal (0.30)	Trans&Com (0.15)	Trans&Com (2.98)	Coal (1.76)
Year 2030									
1	Coal (886.65)	Agr (116.87)	Agr (7.74)	Agr (11.19)	Oil (17.39)	Agr (18.49)	Oil_pcts (0.86)	Agr (53.56)	Agr (62.19)
2	Agr (653.36)	Osg (49.65)	Osg (0.40)	Osg (0.55)	Oil_pcts (15.06)	Osg (6.79)	Osg (0.75)	Oil_pcts (6.85)	Osg (9.42)
3	Osg (259.19)	Oil_pcts (43.88)	Trans&Com (0.02)	Oil_pcts (0.04)	Agr (12.96)	Coal (0.90)	Trans&Com (0.23)	Osg (6.50)	Coal (5.56)

Table 88 the rank of sectors which emit sulfur dioxide (SO_2, the representative of non-GHG air pollutant indicators) under a stringent emission policy in both ASEAN and China in 2015 and 2030

Rank	CHN	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM
Year 2015									
1	CMnf (486.92)	CMnf (26.18)	LMnf (0.18)	CMnf (0.19)	CMnf (8.00)	CMnf (4.33)	CMnf (6.16)	CMnf (11.63)	CMnf (2.85)
2	LMnf (69.04)	LMnf (3.08)	CMnf (0.09)	Pcf (0.04)	LMnf (3.67)	LMnf (2.18)	LMnf (1.83)	LMnf (4.27)	LMnf (1.25)
3	Pcf (10.00)	Pcf (1.81)	Pcf (0.03)	LMnf (0.02)	Pcf (0.58)	Pcf (0.62)	Pcf (0.08)	Pcf (0.90)	Pcf (0.38)
Year 2030									
1	CMnf (1182.40)	CMnf (62.79)	LMnf (0.29)	CMnf (0.31)	CMnf (13.62)	CMnf (9.35)	CMnf (10.06)	CMnf (19.28)	CMnf (3.51)
2	LMnf (152.69)	LMnf (6.60)	CMnf (0.15)	Pcf (0.08)	LMnf (4.88)	LMnf (5.05)	LMnf (2.29)	LMnf (6.22)	LMnf (1.12)
3	Pcf (21.58)	Pcf (3.33)	Pcf (0.03)	LMnf (0.01)	Pcf (0.82)	Pcf (0.88)	Pcf (0.11)	Pcf (1.09)	Pcf (0.62)

The cost-effectiveness analysis based on long-run effects

Both economic and emission effects discussed in the previous section revealed similarities and differences compared to the case of imposing an emission policy in ASEAN alone and in China alone. These would depend on the structure of production and trade in the countries, as well as the nation's characteristics. However, the effects of China's emission policy could change ASEAN's economy and emissions significantly whereas ASEAN emission policy appears to have a low impact on China's economy and emissions in particular CO_2 and non-CO_2 gases. Consequently, it seems doubtful, which the most suitable type of an emission policy imposed in both regions is. To answer the question, cost-effectiveness tool is obtained to analyze long-run effects and to transform them into a ratio of changes in emission and GDP caused by an emission policy as presented in table 89.

The table revealed that if ASEAN and China impose a lax emission policy together, ASEAN could reduce total emissions to -5,809 million tons with losses in GDP to -5,086,973 million US dollars over the period of time. Thus, the ratio of emission reductions to decreases in GDP is 0.114 percent. By contrast, ASEAN could decrease its emissions to -10,935 million tons and lose its GDP to -9,343,289 million US dollars from 2015 to 2030. In other words, ASEAN could get the ratio to 0.117 percent, if ASEAN and China implement a stringent policy together. Although, there seems to be a slight disparity between the two ratios, ASEAN could benefit by a stringent policy instead of a lax one, if it behaves on rational basis.

Regarding China, when the two regions impose a lax emission policy together, total emissions in China decrease to -36,684 million tons with a GDP falls to -21,148,467 million US dollars. By Contrast, total emissions in China could decrease to -68,333 million tons with a marked fall in GDP to -39,025,357 million US dollars in a stringent case. Thus, the ratios of lax and stringent cases are 0.173 and 0.175, respectively. As a result, it is obvious that China could benefit more from a stringent policy instead of a lax one because the ratio in the stringent case is higher than the lax case. In other words, China could achieve an effective result by imposing a stringent policy rather than a lax policy

Furthermore, in terms of the individual ASEAN member's impacts (Table 90), the results of both policies are obviously different. However, most ASEAN nations could benefit from a stringent policy apart from Malaysia and Lao which have a higher cost-effectiveness ratio with a lax policy than a stringent one.

In conclusion, it can be seen that ASEAN as a whole and China should implement a stringent emission policy rather than a lax one in order to achieve their cost-effectiveness, if both regions behave on rational basis. On the one hand, this could lead the two regions to a significant drop in their GDP during the first period of implementation. On the other hand, they could regain benefits from marked reductions in emissions during the period of time as well. However, some ASEAN nations such as Malaysia and Lao do not achieve cost-effectiveness with a stringent emission policy but benefits from a huge reduction in their emissions can compensate their loss in GDP in the future. For this reason, a stringent policy should be imposed in ASEAN and China in order to gain benefits in long term from a dramatic decrease in emissions.

Table 89 the percentage of emission change to GDP change ratio caused by an emission policy imposed in both ASEAN and China between 2015 and 2030, compared between ASEAN and China

	CHN		ASEAN	
	Lax policy	Stringent policy	Lax policy	Stringent policy
Emission Change	-36684	-68333	-5809	-10935
GDP Change	-21148467	-39025357	-5086973	-9343289
% Ratio	0.173	0.175	0.114	0.117

Table 90 the percentage of emission change to GDP change ratio caused by an emission policy imposed in both ASEAN and China between 2015 and 2030, compared across ASEAN members

	IDN		KHM		LAO		MYS	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-1984	-3998	-44	-84	-60	-108	-1152	-2110
GDP Change	-1845892	-3506687	-35610	-67112	-38673	-70150	-765866	-1411735
% Ratio	0.1075	0.1140	0.1237	0.1244	0.1559	0.1533	0.1504	0.1495
	PHL		SGP		THA		VNM	
	Lax	Stringent	Lax	Stringent	Lax	Stringent	Lax	Stringent
Emission Change	-310	-588	-159	-307	-1339	-2306	-589	-1112
GDP Change	-548772	-1026346	-321880	-607099	-1059672	-1791257	-356936	-647875
% Ratio	0.0564	0.0573	0.0493	0.0506	0.1264	0.1288	0.1649	0.1716

CHAPTER 5

CONCLUSION

The ASEAN nations will form their countries into the ASEAN Community in order to enhance trade within the region and strengthen their competitive advantage in the world markets. It is evident that this trade liberalized regime could improve ASEAN trade both in and out the region but it will also lead to increasing environmental degradation, in particular the 6 air pollutants: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). As a result, ASEAN could suffer from deterioration to the environment and human/animal health induced from such air pollutants.

Several studies, for example Sébastien and Maurizio (1998), and Middleton (2012) stated that trade liberalization should come with environmental policy reform otherwise it could harm society by creating severe environmental problem. This idea is supported by many empirical works e.g. Gumilang, Mukhopadhyay, and Thomassin (2011) which showed the negative aspect of freer trade in Indonesia through a huge increase of emissions, and Shuia and Harriss (2006) illustrated the CO_2 embedded with the US-China trade which lead to higher CO_2 emissions in China but lower in the US.

In addition, the Socio-Cultural Community (ASCC) Blueprint, in particular section D, indicates a coalition in ASEAN in terms of harmonizing environmental policies and databases among ASEAN nations, even though the progress of action appears to be much slower than the progress of the ASEAN Economic Community (AEC). For these reasons, ASEAN may impose an emission policy in the region in order to avoid a pollution haven hypothesis problem and gain larger benefits from the trade liberalization. In addition, China may need to implement an emission policy in its country as well due to current severe wide spread emissions. This leads to bad air quality, especially in main cities, and the deterioration in Chinese health due to respiratory diseases.

This dissertation has examined effects of an emission policy in three cases: 1) an emission policy is imposed in ASEAN only 2) an emission policy is imposed in China only, and 3) an emission policy is imposed in ASEAN and China together. These 3 cases were investigated under trade liberalized conditions in the ASEAN community and the FTAs with the 6 key partners: Australia, New Zealand, China, India, Japan, and South Korea. In fact, tariff and non-tariff barriers among ASEAN nations are eliminated due to the agreement in the ASEAN community as well as the tariff barriers between ASEAN and the 6 key partners are removed owing to the Free Trade Agreements.

To assess these circumstances, 3 main simulations and the base case simulation were obtained. The base case simulation is a representative of the fact that ASEAN nations already combined their countries with the ASEAN Community and trade with other partners including the 6 FTA partners. The 3 main simulations represent the circumstances that an emission policy imposed in ASEAN and China, separately and together. After the simulations were formulated, the results of each 3 main simulations were compared with the base case simulation results in order to reveal the real effects of an emission policy in each case.

As the previous chapters already presented the results of the study, this chapter summarized main ideas and key findings in order to illustrate the main policy implications in this dissertation. The chapter was organized beginning with the conclusions of each simulation. The policy implementations then were created by the cost-effective emission policy for both ASEAN and China. Last but not least, future study was recommended at the end of this chapter so that this dissertation could be extended in order to enhance the results in the future.

Conclusion of the simulation results

The aims of this dissertation are to investigate effects of an emission policy implemented in ASEAN and/or China under the conditions of trade liberalization in the ASEAN community and the FTAs between ASEAN and the 6 key partners. There are 3 main simulations that reveal the results of each objective. The first illustrates the economic and emission effects of imposing an emission policy in ASEAN alone. The second presents these kinds of impacts in the case of implementing an emission policy in China alone, and the third main simulation takes into account the effects of launching an emission policy in ASEAN and China together. In addition, an emission policy used in each simulation is divided into a lax emission policy and a stringent one as these types of policy play a different role in each economy and resulting emissions. The lax emission policy is defined as an emission policy which could reduce technological augmented output by 5 percent for the legacy technological country group, 10 percent for the normal technological country group, and 15 percent for the modern technological country group. The stringent emission policy is defined as an emission policy which could reduce technological augmented output by 10 percent for the legacy technological country group, 20 percent for the normal technological country group, and 30 percent for the modern technological country group. The study also measures the effects of the policy in both short and long terms, as they need a long period of time to express themselves.

As a result, the dissertation includes comparisons in several aspects e.g. the comparison between the main simulation results and the base simulation results, the comparison between the effects of a lax emission policy and a stringent one, and the comparison between short and long run effects. Thus, it appears to be complex in terms of the interpretation. However, this section highlights the key findings and implications from the 3 main simulations as follows;

In the case of imposing an emission policy in ASEAN nations (simulation 2), the results reveal that both lax and stringent policies have a negative impact on each ASEAN nation's economy as their GDP could plummet significantly, especially the three low income countries: Cambodia, Lao, and Vietnam. Even though the ASEAN nations attempt to increase exports in labor-intensive goods instead of the 3 main imposed policy products (agriculture, capital-intensive manufacture, and transportation and communication), this does not offset deterioration from the policy in terms of loss in GDP. In the meantime, China and South Korea are also affected by the policy in ASEAN as their GDP deceases slightly but other non-ASEAN regions could gain benefits by increasing their GDP. Long-term effects indicate the same implications as short-term effects for ASEAN members whereas non-ASEAN regions including China and South Korea experience higher GDP, especially India which would see the highest gains in both short and long run periods.

The mobility of outputs in China and ASEAN shows that China could increase exports in the 3 main impacted sectors to non-ASEAN and ASEAN markets whereas China's imports in labor-intensive manufacture rise significantly. This is relevant to the output movement in the ASEAN nations. They could see a dramatic decrease in their exports of such 3 sectors while labor-intensive goods play a main role in ASEAN exports. The exports in energy sectors also increase in ASEAN.

From the view point of emission effects, it appears effective results of emission reductions caused by an emission policy imposed in ASEAN as each member could reduce emissions significantly, especially a stringent policy which could decrease all air pollution indicators by half compared to a lax policy. However, emissions in China show a slight increase in all types of emissions except for CH_4 which could fall insignificantly.

Turning to the case of imposing an emission policy in China alone (simulation 3), the results illustrate that not only China but also South Korea, Cambodia, Philippines, and Vietnam could suffer losses from both lax and stringent policies imposed in China as their GDP could decrease during the first period of policy implementation. It appears that losses are more severe under a stringent policy. However, long run effects illustrate differences between the two types of policy. For example, Cambodia could lose GDP significantly while Vietnam gains the most in the case of a lax policy. In contrast, Cambodia could increase its GDP and becomes the top gainer while Vietnam could see a significant drop in GDP in the stringent case.

Exports and imports in China and ASEAN indicate that labor-intensive manufacture becomes a strategic sector under pressure from the policy. As a result, China's exports in labor-intensive goods increase significantly while the 3 main impacted sectors drop dramatically. The increasing labor-intensive product exports in China also substitute for the exports in ASEAN as they fall in all export markets of ASEAN. However, some ASEAN members could benefit from a marked increase in capital-intensive manufacturing exports to China, such as Thailand, Indonesia, Malaysia, and Singapore. This can be seen that emissions may move to some ASEAN nations due to a stronger emission policy in China compared to ASEAN. Thus, it would lead to a pollution haven hypothesis problem as the two regions have a disparity in an emission policy.

Emission effects in China caused by an emission policy imposed in China lead to a larger number of reductions in CO_2 and non-CO_2 GHG gases than non-GHG air pollutant reductions. Moreover, emissions in ASEAN as a whole change as well. In fact,

CO_2 and non-CO_2 GHG emissions increase slightly in the short run due to an increase in exports of ASEAN capital-intensive goods but will decrease in the long run. The emissions of non-GHG air pollutants show a strong impact of Chinese emission policy on ASEAN region as they increase markedly in both the short and long run. The emissions in individual ASEAN members are different depending on their trade patterns but in general, each member's emissions illustrate the same resulting implications as in ASEAN as a whole

In summary, the results of imposing an emission policy in China could be supported by the study of Garbaccio, Ho, and Jorgenson (1999) who claimed that China's economy could drop the first few years of an implementation of CO_2 reduction policy in China, however; in the long run, CO_2 will decrease markedly. Wu et.al (2009) also agreed with this point of view by showing that the reduction emission policy, particularly nitrogen and phosphorus in the catchment extent in Mongolia could harm the economy in the short run but in the long-run, it will be better off from the benefits of reducing in such emissions.

Both simulation 2 and 3 present the results of imposing an emission policy in only ASEAN and only China, respectively. Hence, simulation 4 is conducted in order to reveal results when ASEAN and China impose the same kind of an emission policy in their country together. The results, in general, appear to be the combination of effects between the previous two cases. For example, low income countries in ASEAN such as Cambodia, Lao, and Vietnam could suffer from both lax and stringent policies while the economies of China and South Korea are deteriorated by such policy as well. The other non-ASEAN counties benefit from the policy, especially India which could be the highest GDP gainer in all 3 cases. However, the number of gaining and losing in GDP in each region is different compared to the case of implementing an emission policy in the two regions separately.

Moreover, in the case of imposing an emission policy in both ASEAN and China together, it can be seen that there is competition in the export of labor-intensive manufacturing products between ASEAN and China as they face a lack in the 3 main impacted sectors (agriculture, capital-intensive manufacture, and transportation and communication). Thus, both regions need to improve their exports in labor-intensive products instead. As a result, the markets of labor-intensive products have to be shared between the two regions instead of taking all labor-intensive goods markets as in the case of implementing an emission policy in ASEAN and China separately.

Trade patterns in both ASEAN and China, for this case, cause different impacts between the two. To investigate this phenomenal, the mobility of outputs in ASEAN and China is observed. The findings shows that as the main trading partners of China are non-ASEAN markets rather than ASEAN, the effects of ASEAN emission policy could not be carried to China, properly. Meanwhile, Chinese emission policy could impact on ASEAN significantly as China plays an important role in the ASEAN trade. Therefore, an emission policy in China has significant impacts on the ASEAN nations in terms of either economic or emission change while an emission policy in ASEAN appears to have weak impacts on both economy and emission in China.

Moreover, the sector analysis results from such 3 main simulations indicate the 3 main polluting sectors, similarly. For instance, the 3 main polluting sectors of CO_2 emissions are electricity, capital-intensive manufacture, and transportation and communication while CH_4 emissions (the representative of non-CO_2 GHG gases) are mainly caused from agriculture, public administration such as trash incineration, and transportation and communication. Regarding, non-GHG air pollutant emissions such as

SO_2 (the representative of non-GHG air pollutants), as the data of non-GHG air emission intensities covers only capital-intensive manufacturing, labor manufacturing, and food processing sectors, the dissertation could compare non-GHG air pollutant emissions across these 3 sectors. However, it is evident that capital-intensive manufacture causes the vast majority of emissions followed by labor-intensive manufacture and processing food. This rank changes in Cambodia where labor-intensive manufacture contributes a larger portion of emissions than capital-intensive manufacture, while food processing sector emits more SO_2 than labor-intensive manufacture in Lao.

In conclusion, an emission policy imposed whether in the ASEAN nations or China could hurt their economies during the first period of implementation. However, in the case of imposing an emission policy in ASEAN only, China could regain GDP in the long run. As a result, China could see a higher GDP than the base case in the end. By contrast, in the case of implementing an emission policy in China only, some ASEAN countries could gain benefits such as Indonesia, Singapore, and Thailand while the others could lose GDP. This is different between the cases of lax and stringent policies, as well as different between the case of short and long run, as mentioned in Chapter 4.

An emission policy could reduce emissions in the imposing regions with double degree of impacts in the case of a stringent policy. However, the results of imposing an emission in China alone (simulation 3) also show a significant increase in the intra-ASEAN trade as a result of trade liberalization in the ASEAN community. This could abate the deterioration in ASEAN due to the emission policy imposed in China otherwise ASEAN would confront more serious effects from such policy.

Policy implications

Apart from measuring the effects of an emission policy imposed in ASEAN and/or China, this dissertation further examines the different effects caused by both types of an emission policy, namely a lax emission policy, and a stringent emission policy. It is obvious that the more stringent in an emission policy, the greater reduction in emissions, however; the economies that impose a stringent emission policy could be worse off in terms of a drop in GDP than those that impose a lax policy.

This paradox is assessed in this dissertation and the cost-effectiveness ratio is introduced in order to compare results between the two types of emission policies. Hence, policy planners could choose a suitable emission policy that achieves their cost-effectiveness. For this reason, this section will summarize the cost-effective emission policy for both China and ASEAN under the conditions in each simulation.

In the case of imposing an emission policy in ASEAN only, the cost-effectiveness ratios indicate that ASEAN could achieve its effective cost with a stringent emission policy. Fortunately, China will benefit from imposing a stringent emission policy imposed in ASEAN as well since China could increase its GDP significantly while its emissions grow slightly. This seems to be a win-win policy for both China and ASEAN as whole. However, Malaysia, in this case, is the only one of ASEAN member that could not achieve cost-effective results as its cost-effectiveness ratio in the lax case is better than the stringent one due to high exports in energy products such as oil and petroleum productions in the stringent case. In addition, both oil and petroleum products are not included in the coverage of imposing an emission policy so emissions from the both two sectors would increase significantly when the exports of these sectors grow up. Thus, Malaysia should reduce or control emissions from oil and petroleum productions itself in order to achieve cost-effectiveness in the long run rather than extend the coverage sectors in all ASEAN members, otherwise other members would see a bigger drop in GDP as well.

Moreover, in the case of implementing an emission policy in China only, the results show a different strategy between China and ASEAN. In fact, China will choose a stringent emission policy to be imposed in this case as it leads to an achievement in Chinese cost-effectiveness. By contrast, ASEAN as a whole will be worse off from the stringent policy imposed in China since emissions increase and GDP decreases dramatically. This situation will be opposite if China imposes a lax emission policy instead. This is a good case in point that when China has stronger emission policy than ASEAN, there appears to be a pollution haven hypothesis problem in ASEAN. This could cause both a severe emission problem and a decline economic problem in ASEAN. For this reason, ASEAN should take this into consideration in order to prevent the situation.

Likewise in both cases above, the simulation results of imposing an emission policy in ASEAN and China together reveal that ASEAN and China will be better off in the long-run, if they implement a stringent policy rather than a lax one. However, Lao and Malaysia could not meet their achievement in their cost-effectiveness while the other members could gain from a stringent policy.

However, the most important point is that China and ASEAN may not want to impose an emission policy although the 3 cases come up with the benefit from achieving their cost-effectiveness in the case of a stringent emission policy. As they are not certain of the benefits from imposing an emission policy, this section of the dissertation will illustrates the lower bound benefits from an emission reduction in the two regions owing to an emission policy.

To illustrate the value of an emission policy imposed in China and ASEAN, this dissertation employs the benefits of an emission reduction from the paper of Austin et al. (1998). They estimated benefits from emission reduction policies in Maryland, United States of America. The model covers several types of effects on both human and nonhuman e.g. human morbidity effects, human mortality effects, and visibility effects. The results showed that human mortality effects play a main role in the emission reduction valuation. In fact, the paper investigated benefits by each pollutant such as SO_2, and NO_x, as well as the results were calculated in terms of benefits per capita, and per ton of emission reductions.

Austin et al. (1998) claimed that the avoiding mortality benefits for Maryland from SO_2 reduction are approximately 50,000 US dollars per ton. Obviously, the elasticity of income between the US and developing countries is different. To transfer these benefits, we need to take the disparity in the elasticity of income into account. Moreover, Alberini et.al. (1997) found that the Willingness to Pay (WTP) to avoid illness caused by air emission in the US is about $40 while Taiwan is $28, in the case of using same income elasticity for both countries. However, if the income elasticity in Taiwan is 0.4 (given that the US income elasticity is 1) which was estimated by the Taiwan study, the WTP of Taiwan is $34. From these findings, it can be seen that the lower bound of WTP compared between the US and Taiwan is about 70 percent. However, to show benefits of emission reduction in ASEAN, we assume that such benefits of emission reduction per ton in ASEAN would be half of Maryland ($25,000) because this assumption is less than the lower bound of benefits in Alberini et.al. (1997). Thus, the benefits from emission reductions in Maryland could transfer to be the benefits of emission reductions in ASEAN and this could be represent the case of lower bound benefits as well.

After recalculating benefits per capita per ton by comparing the number of population in Maryland to those in ASEAN, and China, the results are multiplied by the number of the SO_2 reductions in each region estimated from this dissertation. The transferred benefits from reduction in SO_2 emissions are then compared with GDP losses caused by an emission policy as shown in table 91 to 93. The results illustrate a significant higher number of benefits than GDP losses even though the benefits are captured from the avoiding mortality effects of the reductions in SO_2 only. In other words, if the other benefits such as the benefits from the reduction in CO_2, CH_4, N_2O, NO_2, and PM_{10} are taken into account, it appears that it is worth more to impose an emission policy in the region in order to gain benefits in the long term.

Consequently, as the benefits from reducing emissions is larger than the losses in GDP, it can be seen that, ASEAN and China would be willing to opt for a stringent emission policy to be implemented in their region rather than a lax emission policy as it is a dominant strategy for both regions in the two-stages game. In fact, in the first stage, ASEAN and China have to decide whether imposing an emission policy or not. This stage concludes that both regions need to implement an emission policy because their benefits are greater than their costs as described above. After that, ASEAN and China must decide what type of an emission policy that they should impose in the second stage. From the ratios of cost-effectiveness in those 3 simulations, ASEAN and China will choose a stringent emission policy to be implemented as the payoff of achieving cost-effectiveness is higher than the lax one. For these reasons, the implementation of an emission stringent policy is the best strategy for both ASEAN and China.

Table 91 the benefits and costs of imposing an emission policy in ASEAN under the conditions in simulation 2

	ASEAN	
	Lax Case	Stringent Case
Benefits from the SO_2 reduction	279628953	542819431
Costs of imposing the emission policy	5031982	9160585
Difference between Benefits and Costs	274596971	533658846

Table 92 the benefits and costs of imposing an emission policy in China under the conditions in simulation 3

	CHINA	
	Lax Case	Stringent Case
Benefits from the SO_2 reduction	11642888934	23027077321
Costs of imposing the emission policy	21236886	39206173
Difference between Benefits and Costs	11621652048	22987871148

Table 93 the benefits and costs of imposing an emission policy in ASEAN and China under the conditions in simulation 4

	CHINA		ASEAN	
	Lax	Stringent	Lax	Stringent
Benefits	10954871647	21689907310	230816959	428602218
Costs	21148467	39025357	5086973	9343289
Difference	10933723180	21650881953	225729986	419258929

Future study recommendations

Even though this dissertation has taken most conditions of trade liberalization and environmental issues into account, there are several points that could be enhanced and extended in order to strengthen the simulation results in the future. First of all, this dissertation covers non-GHG air pollutants for only the 3 main types of pollutants namely, Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate matter (PM_{10}). Although these pollutants play a main role in human effects through the respiratory system, the other types of non-GHG air pollutants still need to be investigated as well, for example Fine particulate matter ($PM_{2.5}$), and Volatile organic compounds (VOCs). These emission indicators could represent the quality of ambience in particular main city and industrial area.

The limitation in the emission intensities of non-GHG air pollutants is another point to extend this dissertation, as the IPPS which is the data source of non-GHG air pollutant intensities provides pollutant intensities in only 3 sectors, namely capital-intensive manufacture, labor-intensive manufacture, and processing food. Thus, sector analysis could not take the other sectors into account. If this gap could be filled by additional data sources, supporting data of the non-GHG air pollutant intensities for the rest sectors, it would be useful and could complete sector analysis results. As a result, social planners could design an emission policy for the sectors contributing to non-GHG air pollutant emissions effectively.

Furthermore, as the simulations in this dissertation were computed under the condition of the trade liberalization in the ASEAN community and its FTAs, the configurations of tariff and non-tariff barriers were conducted in a uniform of timeline which may not reflect the real time of the elimination plan for each country. To improve this point, future reseach should create the tariff and non-tariff barriers elimination in each sector in each region depending on its actual plan according to the agreements.

The study would pays attention to the cost estimation of imposing an emission policy rather than the benefits of an emission reduction. Although the benefits of SO_2 emission reductions have been calculated by transferring data from another study conducted in Maryland and the results illustrate the significantly larger benefits than the losses in GDP, this is just to show a case of the valuation of imposing an emission policy.

Thus, the benefits would not represent the exact value of all emission reductions in each studied country as they need to be conducted specifically. For this reason, further study could be carried out a benefit aspect in order to compare with the costs of implementing an emission policy estimated from this dissertation e.g. the willingness to pay for avoiding mortality caused by emissions in China and ASEAN nations.

Another point to note is that the dynamic model used in this dissertation was not designed for taking the emission trade under the Kyoto Protocol into account. However, this does not matter at this moment because the main countries focused on the dissertation have not got into the process of emission trade under the Kyoto Protocol yet. Nevertheless, if China and/or ASEAN join the emission trade program in the future, the model would need to be modified in order to support such emission trade. As the emission trade under the Kyoto Protocol is provided for carbon trade only, the GDyn-E model, which is developed by the GTAP team, could handle it. This model has been expanded from the GDyn model used in this study to cover in particular the carbon trade. In addition, if such trade expands to sulfur dioxide or other pollutant trades, the model needs to take those into consideration as well.

Last but not least, another constraint of the model is the utility functions. As the externalities from emissions effects are not taken into the utility functions, the results of the simulations could not illustrate a disutility from increasing emissions due to trade liberalization. Also they could not reflect the improved utility when the regions impose an emission policy leading to the dramatic drop in emissions. For this reason, further modifications for this dissertation should internalize emission externalities into the utility functions in order to express the acknowledgements of all agents impacted by emission changes.

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APPENDIX

Table 94 CO_2 emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	358	31	5,376	3,400	1,271	947	387	4,629	332	3	1	186	66	69	222	87	20
2016	371	32	5,862	3,485	1,364	965	400	4,718	355	3	1	198	70	72	237	92	22
2018	400	34	6,947	3,659	1,560	1,010	427	4,968	410	3	1	223	78	79	267	100	26
2020	433	36	8,248	3,856	1,789	1,067	458	5,304	479	4	2	252	85	87	302	107	30
2022	469	38	9,825	4,076	2,066	1,131	492	5,704	569	4	2	286	94	97	342	114	34
2024	511	40	11,696	4,322	2,396	1,202	529	6,169	682	5	2	327	104	109	385	122	39
2026	559	43	13,902	4,586	2,800	1,275	568	6,690	820	6	2	375	117	123	428	132	44
2028	612	46	16,425	4,866	3,270	1,348	611	7,252	986	7	3	429	131	139	507	144	51
2030	671	49	19,278	5,166	3,813	1,420	657	7,866	1,181	8	3	492	148	157	575	158	59

Table 95 CH_4 emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	61	16	641	224	290	6	23	294	137	6	6	29	15	1	44	43	21
2016	65	17	714	234	317	6	23	308	149	6	7	31	16	1	47	46	22
2018	74	18	888	254	375	7	25	343	176	7	9	35	18	1	53	51	27
2020	85	21	1,109	277	434	7	27	386	208	8	10	41	21	1	61	59	31
2022	98	23	1,384	303	494	8	29	436	244	9	11	48	25	1	69	68	37
2024	113	26	1,719	333	553	8	31	496	284	10	13	56	28	2	77	78	44
2026	128	28	2,115	364	611	9	33	564	331	11	15	66	32	2	85	90	51
2028	144	30	2,570	394	669	10	35	633	383	12	17	77	35	2	96	101	59
2030	160	32	3,076	425	727	10	37	709	441	13	20	91	38	2	106	113	67

Table 96 N_2O emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	14	7	376	194	38	10	9	168	21	1	1	4	5	1	11	8	4
2016	15	8	418	201	41	10	10	176	23	1	1	4	5	1	11	8	4
2018	17	9	515	217	50	10	10	195	28	1	2	5	6	1	13	9	5
2020	19	10	633	235	59	11	11	218	34	1	2	6	8	1	15	10	6
2022	22	11	766	255	68	12	12	244	40	2	2	7	9	1	17	12	7
2024	24	12	913	279	76	13	13	273	47	2	2	8	11	1	19	13	8
2026	27	13	1,065	304	84	14	13	304	54	2	3	9	12	1	21	15	10
2028	29	15	1,216	331	91	14	14	334	61	2	3	10	14	1	23	17	11
2030	31	15	1,360	359	98	15	15	364	68	2	4	11	15	2	25	19	13

Table 97 SO_2 emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	31	5	565	698	76	124	61	303	34	0	0	17	8	9	21	6	1
2016	33	5	616	716	82	128	63	315	36	0	0	18	8	9	22	6	1
2018	36	5	729	750	96	134	67	337	40	0	0	20	9	10	25	7	1
2020	39	6	863	786	114	138	72	357	47	1	1	23	10	11	29	8	1
2022	40	6	1,021	825	134	141	76	378	56	1	1	26	12	12	33	8	2
2024	41	7	1,199	866	156	145	79	400	67	1	1	29	14	13	39	8	2
2026	42	7	1,399	909	180	149	82	424	78	1	1	33	17	14	46	8	2
2028	43	8	1,616	957	204	154	85	451	91	1	1	38	20	15	50	9	2
2030	45	9	1,850	1,008	228	161	87	480	104	1	1	43	23	16	56	9	2

Table 98 NO_2 emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	19	3	342	424	46	75	37	184	21	0	0	11	5	6	13	4	1
2016	20	3	373	435	50	78	38	192	22	0	0	11	5	6	14	4	1
2018	22	3	441	456	58	81	41	205	24	0	0	12	6	6	15	4	1
2020	23	3	523	478	69	84	44	217	29	0	0	14	6	7	18	5	1
2022	24	4	618	501	81	86	46	230	34	0	0	16	7	7	20	5	1
2024	25	4	726	526	94	88	48	243	40	0	1	18	9	8	24	5	1
2026	25	4	847	552	109	90	50	257	47	0	1	20	10	9	28	5	1
2028	26	5	978	581	123	94	52	274	55	1	1	23	12	9	30	5	1
2030	27	5	1,119	611	138	97	53	291	62	1	1	26	14	10	34	6	1

Table 99 PM_{10} emissions under the base case in each year (million tons)

Year	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
2015	13	2	220	265	29	47	23	115	13	0	0	6	3	3	8	2	0
2016	14	2	240	272	32	49	24	120	14	0	0	6	3	3	8	2	0
2018	15	2	285	286	37	51	26	128	16	0	0	7	3	4	9	3	0
2020	16	2	338	300	44	53	27	136	19	0	0	8	3	4	11	3	0
2022	17	2	400	315	52	54	29	144	22	0	0	9	4	5	12	3	1
2024	17	3	470	331	61	56	30	153	26	0	0	11	5	5	14	3	1
2026	18	3	548	349	70	57	31	162	31	0	0	12	5	5	17	3	1
2028	18	3	634	369	80	60	32	173	36	0	0	14	6	6	18	3	1
2030	19	3	727	390	89	62	32	185	41	0	0	16	8	6	21	3	1

Table 100 CO_2 emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	6	1	117	63	23	11	6	51	8	0	0	1	0	0	12	2	0
Coal	3	0	118	1	1	0	0	2	0	0	0	0	1	0	0	0	0
Oil	2	0	37	8	6	0	0	25	5	0	0	0	0	0	2	0	0
Gas	4	0	29	22	13	0	1	73	11	0	0	0	2	0	8	0	0
Oil_pcts	13	1	87	136	39	31	16	189	28	0	0	23	1	14	8	0	2
Electricity	219	7	3,221	1,375	819	452	202	2,442	113	1	0	67	29	23	89	31	5
CMnf	39	3	1,023	332	165	152	47	330	75	0	0	28	8	0	31	21	3
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	1	1	143	61	16	13	9	73	17	0	0	9	0	0	4	5	1
Osg	1	0	60	48	0	53	4	90	4	0	0	0	0	0	0	1	1
Pcf	3	1	60	54	31	10	3	65	6	0	0	4	1	0	5	1	0
Svces	1	0	41	97	4	25	4	45	1	0	0	1	0	0	0	1	1
Trans_Comm	65	16	368	1,180	151	190	91	1,219	60	2	0	50	23	31	62	22	6
Util_Cns	2	0	71	22	3	11	4	27	4	0	0	3	0	0	1	1	0
Total	358	31	5,376	3,400	1,271	947	387	4,629	332	3	1	186	66	69	222	87	20

Table 101 CH_4 emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	37	14	257	98	171	4	4	69	59	5	6	7	8	0	31	35	18
Coal	12	0	219	20	11	0	1	24	1	0	0	0	0	0	0	2	0
Oil	0	0	1	1	1	0	0	25	8	0	0	4	0	0	0	0	0
Gas	4	0	0	20	1	0	0	71	5	0	0	2	0	0	1	0	1
Oil_pcts	0	0	2	2	7	0	2	1	12	0	0	5	0	0	3	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CMnf	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Osg	7	1	160	73	88	2	14	88	36	0	0	6	7	1	6	6	1
Pcf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Svces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trans_Comm	1	0	2	8	10	0	2	14	16	0	0	4	0	0	3	0	0
Util_Cns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	61	16	641	224	290	6	23	294	137	6	6	29	15	1	44	43	21

Table 102 N_2O emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	11	7	312	116	30	6	2	128	17	1	1	4	4	0	10	7	4
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil_pcts	0	0	4	17	2	1	1	5	0	0	0	0	0	0	0	0	0
Electricity	0	0	4	4	1	0	0	2	0	0	0	0	0	0	0	0	0
CMnf	0	0	33	36	3	1	6	8	0	0	0	0	0	1	0	0	0
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Osg	0	0	21	7	2	0	1	8	3	0	0	0	1	0	0	1	0
Pcf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Svces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trans_Comm	3	0	1	13	0	2	0	16	0	0	0	0	0	0	0	0	0
Util_Cns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	14	7	376	194	38	10	9	168	21	1	1	4	5	1	11	8	4

Table 103 SO_2 emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil_pcts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CMnf	29	4	486	575	64	104	51	249	29	0	0	13	5	7	16	4	1
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	2	0	69	98	9	17	9	44	3	0	0	4	2	2	4	1	0
Osg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pcf	1	0	11	25	3	3	1	10	2	0	0	1	1	0	1	0	0
Svces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trans_Comm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Util_Cns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	31	5	565	698	76	124	61	303	34	0	0	17	8	9	21	6	1

Table 104 NO_2 emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil_pcts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CMnf	17	2	289	342	38	62	30	148	17	0	0	8	3	4	10	3	0
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	1	0	46	66	6	12	6	30	2	0	0	2	1	1	3	1	0
Osg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pcf	1	0	7	16	2	2	1	6	1	0	0	0	0	0	1	0	0
Svces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trans_Comm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Util_Cns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	19	3	342	424	46	75	37	184	21	0	0	11	5	6	13	4	1

Table 105 PM_{10} emissions polluted by each sector under the base case in 2015 (million tons)

SEC	AUS	NZL	CHN	EUR	IND	JPN	KOR	USA	IDN	KHM	LAO	MYS	PHL	SGP	THA	VNM	XSE
Agr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil_pcts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CMnf	13	2	211	249	28	45	22	108	13	0	0	6	2	3	7	2	0
Dwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LMnf	0	0	6	9	1	2	1	4	0	0	0	0	0	0	0	0	0
Osg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pcf	0	0	3	7	1	1	0	3	1	0	0	0	0	0	0	0	0
Svces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trans_Comm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Util_Cns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	13	2	220	265	29	47	23	115	13	0	0	6	3	3	8	2	0

VITAE

VITAE

Name:	Komwit Siritorn
Date of Birth:	October 15st, 1975
Place of Birth:	Phatthalung Province, Thailand
Address:	23/330 Lumpinivill Condo fl.17
	Suttisarn-Vinitchai Rd. Samsannai
	Phayathai Bangkok Thailand 10400
Educational Background:	
1994-1998	B.Sc. (Computer Science)
	Faculty of Science, Prince of Songkla University
2003-2006	M.Econ. (Business Economics)
	Faculty of Economics, Dhurakij Pundit University