A General Equilibrium Perspective on Energy and Environmental Policies in ASEAN

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Declaration

This thesis contains no material that has been presented for a degree at this or any other university. To the best of my knowledge and belief, it contains no copy or paraphrase of work published by another person, except where explicitly acknowledged.

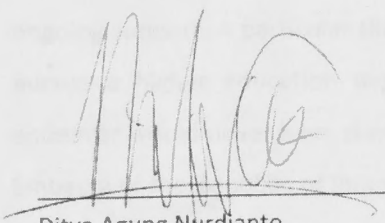
All chapters were carried out under the guidance of my Supervisor, Associate Professor Budy Prasetyo Resosudarmo. Chapters 1, 3, 5, 6, and 7 represent work undertaken by myself. An earlier version of Chapter 2 has been accepted for a forthcoming publication in *Environmental Economics and Policy Studies*, co-authored by me and Dr. Resosudarmo. My contribution is approximately 80 percent of the chapter, which covers the literature review, data gathering, result analysis, and composition of the chapter. Chapter 4, which deals with the computer programming, is also a joint work between me and Dr. Resosudarmo. Countless hours of consultation and discussion were undertaken with Dr. Resosudarmo while writing the GAMS syntax. As a whole, my contribution is approximately 70 percent of the chapter, which covers writing the program, harmonizing the database, and composing the chapter.

As for the database described in Chapter 3, it is excluded from this thesis due to length limitation. It is, however, available as a softcopy upon request.

All five main chapters in the thesis have been presented in various seminars at the Australian National University and several academic conferences. These conferences include the Economy and Environment Program for Southeast Asia (EEPSEA) 30th Biannual Workshop in Bali (November 2008), the 2nd Indonesian Regional Science Association (IRSA) International Institute Conference in Bogor (July 2009), EEPSEA 32nd Biannual Workshop in Hanoi (November 2009), EEPSEA 33rd Biannual Workshop in Manila (May 2010), and the 10th IRSA Conference in Surabaya (July 2010).

This thesis has had the benefit of advice on proofreading, consistency, and clarity provided by Cristene Carey, a professional editor.

I am responsible for remaining errors and omissions.



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Abstract

Concern about fossil fuel resource depletion in the early 1970s has led to the development of theoretical and applied economic models of energy-economy linkages with a detailed representation of the energy market. More recently, the period of sharply increasing crude oil prices from 2004 and followed by a phase of sharply declining crude oil and petroleum product prices at the end of 2008 has reinvigorated energy-economy modeling efforts. Primary focus, however, no longer concentrates solely on the representation of scarce energy resources and their impacts on the economy. The argument that environmental degradation will reduce future benefits from economic activities has been widely accepted, so much so that integrated energy-environmental strategies and policies are required which need to take into account the complex interactions between climate, economic, and social systems.

As such, the first goal of this thesis is to develop methodologies to model economic activities in six selected member countries of the Association of Southeast Asian Nations (ASEAN) and link these activities to the environment. The second goal is to identify and understand the impact of energy and environmental reforms in these countries. With the aim of improving the environment, the success of each reform implementation largely depends on its effect on economic development and welfare distribution.

In order to achieve the first goal, the thesis develops an integrated social accounting matrix (SAM) for six member countries of ASEAN, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam, called the ASEAN-SAM. The thesis then uses the ASEAN-SAM to construct a unique static multi-sector, multi-household, and multi-country computable general equilibrium (CGE) model, called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model.

The model examines the relationship between production activities, household welfare, and pollution to capture the energy-economy-environment links. There are two major highlights of the IRSA-ASEAN model: first, it allows the exploration of the immediate impacts of a policy in one country on all other countries in the region; and second, it endogenizes various revenue recycling mechanisms, whether through increased government expenditure, lump sum cash transfer to households, and/or indirect tax reduction to industries.

The thesis fulfils the second goal by applying the IRSA-ASEAN model to look at the impact of an energy subsidy reduction and a carbon tax implementation. In the case of an energy subsidy reduction, the model eliminates existing energy subsidies, namely fuel subsidies in Indonesia and Malaysia as well as electricity subsidy in Indonesia. The thesis finds that the elimination of energy subsidies is an effective measure to reduce pollution in the form of carbon

dioxide (CO_2) emissions, generates economic expansion in these countries, and is progressive in nature.

In the second case, implementing a USD 10 per ton of CO_2 emissions sales tax on coal, petroleum products, and manufactured gas is also an effective measure to improve the environment in terms of CO_2 emissions reduction. However, this environmental improvement comes at a cost as gross domestic product (GDP) contracts in some countries if a carbon tax is uniformly applied. Vietnam stands to lose the most, while Philippines, Singapore, and Thailand are slightly adversely affected. Indonesia's and Malaysia's economies, on the other, actually expand. In terms of distributional impact, a carbon tax is strictly progressive in Vietnam and strictly regressive in Singapore. For Indonesia, Malaysia, Philippines, and Thailand a carbon tax is progressive for those below the 70^{th} to 90^{th} percentile income group, depending on the countries, and regressive for those in the right-end tail, or higher, income group.

The thesis finds that both an energy subsidy reduction and a carbon tax implementation are both effective measures to improve the environment. However, in terms of economic development, a carbon tax implementation appears to be a second-best policy alternative to an energy subsidy reduction, with the latter promoting a more efficient allocation of resources. The thesis also finds that recycling mechanisms do not affect the overall GDP and CO_2 reduction differently, but they do affect greatly the distributional impact of these policies. As such, energy and environmental reforms do not necessarily conflict with development and equity objectives. Nevertheless, a policy in these areas must be carefully designed to account for acceptability, feasibility, and utility.

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Glossary

ADB	Asian Development Bank
AEC	ASEAN Economic Community
AFTA	ASEAN Free Trade Area
APEC	Asia Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Center
ASEAN	Association of Southeast Asian Nations
BPS	*Badan Pusat Statistik* (Indonesian Statistics Agency)
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CO_2	Carbon Dioxide
COP	Conference of Parties
EIA	Energy Information Agency
ETS	Emissions Trading Scheme
EU	European Union
GAMS	General Algebraic Modeling System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTAP	Global trade Analysis Project
HDI	Human Development Index
IDN	Indonesia
IEA	International Energy Agency
I-O	Input-Output
IPCC	Intergovernmental Panel on Climate Change
IRSA	Inter-Regional System of Analysis
KM	Kilometers
KTOE	Kiloton of Oil Equivalent
MB/D	Million Barrels per Day
MBTU	One Thousand British Thermal Unit
$MTCO_2E$	Million Ton of CO_2 Equivalent
MYS	Malaysia
NEC	Not Elsewhere Classified
OPEC	Organization of Petroleum Exporting Countries
PHL	Philippines
ROW	Rest of the World
SAM	Social Accounting Matrix
SGP	Singapore
THA	Thailand
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VNM	Vietnam

Chapter 1: Introduction

1.1. Background and Motivation

Concern about fossil fuel resource depletion in the early 1970s has led to the development of theoretical and applied economic models of energy-economy linkages with a detailed representation of the energy market. Pioneering energy-economy modeling efforts focused primarily on the representation of scarce resources, such as oil, and its impact on world economies (Kemfert and Truong, 2009). More recently, not only the scarcity of energy resources, but also other natural resources in the environment played a major role in economic modeling. The complexity of models has increased considerably, especially in areas relating to global environmental issues, such as climate change and greenhouse gas (GHG) emissions resulting from consumption of fossil fuels.

The rising concern about the environment is driven by the overwhelming scientific evidence in which climate change presents a very serious global risk and demands an urgent global response. According to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, rising fossil fuel burning and land use changes have led to the emissions of increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrogen dioxide (N_2O); and a rise in these gases has caused a rise in the amount of heat from the sun held in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report in 2007 states that those GHG emissions have increased since the mid-19th century and are causing significant and harmful changes in the global climate. Higher emissions levels are producing changes in sea level and climate that will dramatically affect billions of coastal people as well as the quality of the global environment and the capacity of countries to sustain future economic growth. Left unaddressed, climate change represents a serious threat to economic wellbeing. As such, to prevent or mitigate against this likely event, integrated energy-environmental strategies and policies are required which need to take into account the complex interactions between climate, economic, and social systems.

1.2. Research Scope and Objectives

The ten member countries of the Association of Southeast Asian Nations (ASEAN), namely Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore,

Thailand, and Vietnam, are set to play an increasingly important role in global energy markets in the decades to come. They make up one of the world's most dynamic and diverse regions, with an economy as large as Canada and Mexico combined and a population that exceeds that of the European Union. Their energy consumption is already comparable to that of the Middle East and continues to grow rapidly from a comparatively low per-capita level, fuelled by rapid economic and population growth and continuing urbanization and industrialization. Coupled with the emergence of China and India on the global energy scene, these trends point to a refocusing of the global energy landscape towards Asia (IEA, 2009). But many challenges will need to be overcome if Southeast Asia is to fulfill its energy requirement to meet its growing needs, while at the same time addressing environmental and social concerns.

This thesis will look more closely at the inter-connectedness of energy, economy, and environment. Specifically, it will look at the relations between energy consumption, economic development, social welfare/equity, and environmental impact in terms of CO_2 emissions from fossil fuel combustion. The area of study will cover six of the ten ASEAN member countries – the five founding members, namely Indonesia, Malaysia, Philippines, Singapore, and Thailand, with the addition of Vietnam. The thesis will focus on two policy instruments related to energy-economy-environment issues using two case studies of: first, an energy subsidy reduction by the removal of fuel subsidies in Indonesia and Malaysia as well as a reduction in the electricity subsidy in Indonesia; and second, a carbon tax implementation in all six countries in which a sales tax based on CO_2 emissions is imposed on the consumption of fossil fuels, namely coal, petroleum products, and manufactured gas.

The primary limiting scope of this study is the static nature of the model that focuses on the distributional cost of energy and environmental policies. In other words, the thesis can answer the question of who pays for the financial or implementation cost of a certain policy both within and between countries given that the policy is non-dynamic. Due to methodological reasons, cases such as a gradual energy subsidy reduction over a certain period of time or periodic fund transfers for CO_2 emissions reduction are beyond the scope of this thesis.

The following are the specific objectives of the research:

1. to review current literature and findings on the global and regional energy supply and demand as well as the energy sector patterns, such as price and consumption, within various ASEAN member countries;
2. to study the possibility of enhancing regional cooperation on energy and environmental policies, particularly with regards to climate change and CO_2 emissions reduction;
3. to provide a quantitative estimate of the impact of energy and environmental policies in the form of an energy subsidy reduction and carbon tax implementation. This refers to economy-wide impact, including output, sectoral value-added, and prices;

4. to analyze the cost of energy and environmental policies with the two case studies above, namely an energy subsidy reduction and carbon tax implementation, and how it is distributed to households in order to examine whether the policy is progressive or regressive in nature; and
5. to assess the feasibility of energy and environmental policies and how these policies should be best implemented to achieve a multi-pronged goal of economic development, environmental improvement, and social equity. This includes how to design the policies as well as to compare various alternative revenue recycling mechanisms to mitigate adverse effects of these policies.

1.3. Methodology

The main method utilized to carry out the study in this thesis is a static, multi-sector, multi-household, and multi-country computable general equilibrium (CGE) model called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model for six ASEAN member countries, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.[1] In terms of modeling, the IRSA-ASEAN is a descendant of the Inter-Regional System of Analysis for Indonesia Five Regions (IRSA-Indonesia5) model developed by Resosudarmo *et al.* (2008) and from which it derived much of its notation. However, numerous features of the IRSA-ASEAN model also stem from other developments in CGE modeling over the last 20 years. Some of these sources of inspiration are direct and easily identified, including one of the first CGE models for Indonesia by Lewis (1991), GTAP model (Hertel, 1997), and Globe model (McDonald *et al.*, 2007) such that the IRSA-ASEAN model is a unique model on its own right, both structure-wise and purpose-wise.

As the IRSA-ASEAN model is a multi-country model, it solves at the country level, or in other words optimizations are done at this level. This approach allows price as well as quantity to vary independently between countries, which mean that variation in price as well as quantity in each country can be observed using this model. This approach enables the user of the model to observe the impact of a specific shock in one country to other countries, to the whole ASEAN economy, and to the country itself. Another important highlight of the IRSA-ASEAN model deals with the issue of double-dividend. Although the IRSA-ASEAN model can be used for a wide-range of policy simulations, e.g. trade and fiscal simulations, the main motivation behind its development in this thesis is to assess the economic impact of energy and environmental policies. As such, the IRSA-ASEAN model takes a step further with regards to the issues of energy and the environment by intrinsically and explicitly incorporating various recycling mechanisms.

[1] See Table 4.1 for the list of sets, which includes 26 production activities, 5 factors of production, 4 household groups, and other accounts.

In this regard, aside from the government increasing its expenditure, the energy subsidy reduction and carbon tax revenue can either be recycled directly to household, e.g. direct one-time lump-sum cash transfer to low-income households, or recycled back to the industry, e.g. indirect tax reduction, such that it creates a less distortionary tax system, or supposedly so.

For empirical results, the IRSA-ASEAN model uses the Social Accounting Matrix for ASEAN (ASEAN-SAM) which has been calibrated from the input-output (I-O)-based Global Trade Analysis Project (GTAP) Version 7 Data Base, with parameter values also obtained from this source. The database uses a common reference year of 2004 and a common currency of United States million dollars (USD million) for all six countries in the region. The database has been heavily modified using various country-specific datasets, e.g. social accounting matrices and household income/expenditure surveys, so as to provide greater insight and flexibility for policy analysis. Many other additional datasets are also required to build the so-called ASEAN-SAM. Also, the latest version of Generalized Algebraic Modeling System (GAMS) program is used to run the IRSA-ASEAN model.[2]

1.4. Expected Contribution

The expected contributions of this research are two-fold. The first relates to the understanding of inter-related issues of energy, economics, and the environment. This study will focus on selected countries in Southeast Asia; and hence, it will be among the first of few studies that provide quantitative estimates of energy and environmental policies in the region. To the author's knowledge, this will in fact be the first research on these issues that uses a regional approach; and additionally, it will also be the very first research on these issues for some of the selected countries.

By extension, and admittedly a rather ambitious one, this research hopes to help policymakers to decide not only what will be the best policy for their respective country but also to the region as well. With a common tool at their disposal, regional cooperation and coordination will hopefully be easier to achieve. This research will be able to help countries coordinate their policies in the spirit of cooperation that motivates the establishment of an ASEAN Community in 2015 by providing a common ground, or at the very least a starting point, for negotiation to achieve common prosperity.

The second expected contribution of this research relates to the methodology. This study constructs a social accounting matrix (SAM) for ASEAN, albeit for only six of the ten member countries, with a disaggregated household; and using the ASEAN-SAM, the study builds

[2] See Chapters 3 and 4 for a detailed technical description of the ASEAN-SAM database and IRSA-ASEAN model respectively.

a multi-country CGE model with the emphasis on energy and the environment. The ASEAN-SAM constitutes the first of its kind in terms of the number of countries involved, which countries are involved, and how the countries are connected to one another. In addition, since a SAM construction is rarely documented, particularly a multi-country SAM such as the ASEAN-SAM, the transparency in the description of this SAM construction will provide a reliable guideline for other researchers in improving or updating the ASEAN-SAM as well as creating their own SAM in the future. This also applies for the IRSA-ASEAN model, which is a unique model in its own right, with great potential for future research due to the transparency of its construction as well as the robustness and flexibility for other areas of interest, such as trade.

1.5. Outline of the Thesis

Chapter 1: Introduction

This chapter discusses the background and motivation of the research and follows with an explanation of the research scope and objectives, expected contributions, and organization of the thesis.

Chapter 2: ASEAN Energy Decomposition

This chapter addresses the issues of the establishment of an ASEAN Community and the economic challenges of this political decision. It focuses on the ASEAN integration from an energy policy perspective. The chapter identifies challenges faced by individual members from both outside and within the region. For a within-the-country analysis, Kaya Identity method of decomposition is used to analyze the energy patterns among ASEAN member countries by which energy consumption patterns can be examined, including energy intensity, energy sources, and sectoral energy demands. Analyzing these country-specific patterns is needed for coordination purposes if a region-wide policy is to be implemented. As such, this chapter provides a descriptive analysis such that all following chapters can be put into context.

Chapter 3: Constructing an ASEAN Social Accounting Matrix (ASEAN-SAM)

This chapter marks the beginning of the empirical study of this thesis through the construction of the database to be used in subsequent chapters for policy analysis related to energy and environmental issues. The first part of this chapter explains briefly the fundamentals of a social accounting matrix. The second part of the chapter deals with construction of the ASEAN-SAM by listing data sources and step-by-step descriptions of procedures required. The last part of the chapter presents a summary of the ASEAN-SAM to check for consistency. As for the ASEAN-SAM itself, it has been calibrated from the GTAP Version 7 Data Base and heavily modified using

various country-specific datasets, such as social accounting matrices, household income/expenditure surveys, population census, and statistics. Other sources have also been used for bilateral remittance estimates, international fuel prices, and development indicators. The ASEAN-SAM connects the selected six member countries through trade and investment as well as other financial transfers. As such, the ASEAN-SAM is the first step toward modeling an 'integrated' ASEAN.

Chapter 4: The Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) Model

This chapter details the construction of the CGE model to be used in the following empirical case studies, called the IRSA-ASEAN model. The IRSA-ASEAN model is a static, multi-sector, multi-household, and multi-country CGE model. It is a unique model constructed specifically by and in this thesis to understand the impact of, among others, coordinated and non-coordinated policies, i.e. energy subsidy elimination and carbon tax implementation, on the economic and environmental performance of each country in the model. Although it is robust enough to be an insightful tool for policy analysis in other issues, e.g. trade, the IRSA-ASEAN model contains a unique feature that is particularly useful for policies related to energy and environment, namely endogenized revenue recycling mechanisms. This chapter is intended to become a technical manual of a sort for the IRSA-ASEAN model, which describes the model structure that will help to better analyze empirical results in the following chapters.

Chapter 5: Case Study 1 – Energy Subsidy Reduction

This chapter is the first empirical case study to combine the ASEAN-SAM database with the IRSA-ASEAN model. As such, this chapter also includes a section describing some final adjustments required to combine the database with the model. This first empirical case study looks at the impact of an energy subsidy reduction in ASEAN in terms of economic development, environmental improvement, and welfare distribution. This chapter uses the IRSA-ASEAN model to show the impact of eliminating existing subsidies on fuels in Indonesia and Malaysia as well as eliminating existing electricity subsidy in Indonesia. The chapter explores the impact that such policies have had in terms of gross domestic product (GDP) change, CO_2 emissions, and whether the policies are progressive or regressive in nature. This chapter also explores varying mechanisms in which the newly generated revenue from the reduced subsidies is recycled back into the economy. Lastly, in cases where policies are implemented only in certain countries, cross-country impacts (if any) can also be observed immediately.

Chapter 6: Case Study 2 – Carbon Tax Implementation

This chapter analyzes the benefits and losses of cooperation among ASEAN members in mitigating their CO_2 emissions, particularly by implementing a uniform carbon tax across ASEAN. To achieve this goal, various scenarios in which a carbon sales tax is imposed on fossil fuel consumption, namely coal, petroleum products, and manufactured gas, with some comparative scenarios in which a carbon tax is implemented solely in one country such as Indonesia. As in the previous case study, this chapter explores the impact of such policies in terms of GDP change, CO_2 emissions, and whether the policies are progressive or regressive in nature with different revenue recycling mechanisms. However, this chapter also includes a micro-simulation in which households are further disaggregated into percentile groups, as previous grouping of households into four categories may be too broad for a sufficient analysis in this case study.

Chapter 7: Conclusion

The final chapter summarizes the thesis, discusses some limitation of the research, and prospects for future research. The chapter also discusses some implications and lessons learned for other countries and regions as well as calls for extending the research for others.

Chapter 2: ASEAN Energy Decomposition

Summary

Discussion on the establishment of an ASEAN Community has intensified in the last two decades. The prospect of its establishment is seemingly inevitable with the signing of the so-called Bali Concord II. And so, analytical research on the economic challenges of this political decision is urgently needed. This chapter addresses issues in the ASEAN integration from an energy policy perspective. It strives to understand the challenges faced by individual members when the ASEAN community is established. The chapter uses a modified Kaya Identity method of decomposition to analyze the energy patterns of ASEAN member countries by which energy consumption patterns can be examined, including energy intensity, energy sources, and sectoral energy demands. Analyzing these patterns is needed since a region-wide policy in the energy sector would be futile if it were to be implemented across the board without country-specific considerations. Cooperation in the energy sector requires great awareness and flexibility if it is to support the goal of an integrated ASEAN.

2.1. Introduction

According to the International Energy Agency, the ten countries of the Association of Southeast Asian Nations (ASEAN), namely Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, are set to play an increasingly important role in global energy markets in the decades ahead. They make up one of the world's most dynamic and diverse regions, with an economy as large as Canada and Mexico combined and a population that exceeds that of the European Union. Their energy consumption is already comparable to that of the Middle East and continues to grow rapidly from a comparatively low per-capita level, fuelled by rapid economic and population growth as well as continuing urbanization and industrialization. Coupled with the emergence of China and India on the global energy scene, these trends point to a refocusing of the global energy landscape towards Asia. But many challenges will need to be overcome if Southeast Asia is to secure access to the energy required to meet its growing needs at an affordable price and in a sustainable manner (IEA, 2009).

As such, this chapter strives to identify both current and potential challenges faced by ASEAN, particularly with regard to regional cooperation for the purpose of establishing an ASEAN Economic Community (AEC). In order to achieve this goal, this chapter first reviews the current state of the energy sector in ASEAN. This includes examining the global condition and how it affects the region, followed by looking at energy prices in ASEAN. The second part of this chapter describes the methodology, namely the modified Kaya Identity, used to analyze the

energy patterns and trends in ASEAN at the country level. The third part of this chapter shows the results followed by a summary and conclusion for policy-making purposes.

2.2. Overview of the ASEAN Energy Sector

On 8 August 1967, five countries in Southeast Asia declared the establishment of ASEAN in Bangkok, Thailand. These countries included Indonesia, Malaysia, Philippines, Singapore, and Thailand. Brunei Darussalam joined in 1984, followed by Vietnam in 1995, Laos and Myanmar in 1997, and Cambodia in 1999. At the 2003 ASEAN Summit, the Bali Concord II was signed, which agreed on establishing an ASEAN Community comprising three pillars, namely political and security cooperation (ASEAN Security Community), economic cooperation (ASEAN Economic Community), and socio-cultural cooperation (ASEAN Socio-Cultural Community) by 2020. On 13 January 2007, in response to the increasing challenges in the region, ASEAN Leaders decided to accelerate the establishment of the ASEAN Community to 2015.

Nevertheless, despite the high level of optimism among ASEAN leaders, there exists an equal amount of skepticism surrounding this goal, particularly in the area of economic cooperation. One reason for the existing skepticism in the ASEAN economic integration process is attributed to the length of time the cooperation has taken to achieve its current level of integration. Though the cooperation itself started in 1967, it was not until the mid-1970s that the integration process actually began to take place. Even then, it was not until the late 1980s and early 1990s that ASEAN began implementing various schemes, e.g. ASEAN Free Trade Area (AFTA) and ASEAN Industrial Cooperation (AICO) Scheme, that the ASEAN economic integration process began to take shape (Naya and Plummer, 1997).

Other challenges include technical difficulties related to the term 'single-market' economy, which the ASEAN Economic Community (AEC) aspires to. Although ASEAN as a whole will likely benefit from becoming a single, fully-integrated economy, the definition and means of achieving it have not been clearly defined (Lloyd, 2005; Hew and Soesastro, 2003). The term 'single-market' as used in the Bali Concord II, clearly calls for the elimination of 'border measures', full National Treatment of 'beyond-the-border measures', and 'harmonization of measures', this essentially means that the economies of ASEAN behave as one. Although there is a common appreciation of the opportunities this route offers, there exist significant challenges as it depends on governments not only undoing the policy impediments to integration but also doing the institutional development that supports structural change (Findlay *et al.*, 2007).

Among the sectoral issues within ASEAN, the issue of cooperation on energy policy to achieve energy security in the region has become one of the important topics (Len, 2007). As energy security is highly related to the economy and economic growth, any changes, or even

perceived changes, in the energy markets obligate governments to take adaptive measures to avert potential adverse effects. Arguably, China's increased demand for energy, specifically oil, has contributed significantly to some of the recent changes in the global energy markets. China's, and to a certain extent India's, economic growth and structural reformation are recognized as the main driving factors behind the surging oil prices (Leong, 2007). This is exacerbated by the fact that on the supply side, global oil production capacity has been strained due to the lack of investment, further intensifying the competition to secure energy availability (Wu and O'Kray, 2007).

One of the most noticeable effects of the scrambling for energy resources is the growing rivalry between China and the United States (Leverett and Bader, 2005). Accordingly, Ernsberger (2007) notes the fact that the United States and China are the two largest consumers of energy as well as the two largest energy producers in the world. Similarly, both countries also consume more energy than they can produce, particularly in oil and natural gas. In 2004, the United States already consumed 20.52 million barrels per day (mb/d) while it only produced around 7.67 mb/d. It is estimated that by the year 2025, the United States' demand will reach 28 mb/d while the most optimistic scenario estimates that by then the United States will only be able to produce 32 percent of its need. On a relatively smaller scale, China faces exactly the same problem. While it consumed 6.38 mb/d of oil in 2004, China's oil production will peak at 3.7 mb/d in 2010. As a point of reference, according to the Organization of the Petroleum Exporting Countries (OPEC, 2007), the world oil production in 2005 amounted to only 83.3 mb/d.

There have been some suggestions on how the energy cooperation can take its form within the ASEAN community. Symon (2006) and Len (2007) identify areas of cooperation related to the energy sector that ASEAN can focus upon, such as multilateral cooperation among regional organizations to attain energy security. Karki *et al.* (2005) suggest developing trans-ASEAN gas pipelines and electricity grids, creating regional energy markets, and adopting common efficiency standards as potential solutions for a sustainable energy development in the region. As such, the current global situation has also encouraged cooperation among ASEAN countries to develop programs and forums related to energy security in the region – this include, among others, the Energy Security of ASEAN (ESPA), Trans-ASEAN Gas Pipeline (TAGP), and ASEAN Power Grid (APG). The TAGP aims to interconnect the gas pipeline infrastructure of ASEAN Member States and to enable gas to be transported across the borders of the Member States. The APG, on the other hand, ensures that gas for power is also being optimized with other potential sources of energy.

In terms of implementation, the original TAGP aims to develop a regional gas grid by 2020, by linking the existing and planned gas pipeline networks of the ASEAN member countries. The updated plan involves the construction of 4,500 kilometers of pipelines, mainly undersea

and worth USD 7 billion. Eight bilateral gas pipeline interconnection projects, with a total length of approximately 2,300 km, are currently operating. They are: i) P. Malaysia – Singapore in 1991, ii) Yadana, Myanmar to Ratchaburi, Thailand in 1999, iii) Yetagun, Myanmar to Ratchaburi, Thailand in 2000, iv) West Natuna, Indonesia to Singapore in 2001, v) West Natuna, Indonesia to Duyong, Malaysia in 2001, vi) South Sumatra, Indonesia to Singapore in 2003, vii) Malaysia-Thailand Joint Development Area – Malaysia via Songkla in 2004, and viii) Malaysia-Singapore in 2006. These interconnections form a part of the backbone of energy security and sustainability of supply objectives of ASEAN, and will be accelerated to 2015. They will serve as a key driver of growth to the various energy consuming sectors of the ASEAN economies (ASEAN, 2010).

ASEAN has adopted a strategy that encourages interconnections of 15 identified projects, first on cross-border bilateral terms, then gradually expanding to sub-regional basis and finally to a totally integrated Southeast Asian power grid system. Currently, the APG is in progress with four on-going interconnection projects and an additional 11 projects are planned for interconnection through 2015. The investment requirement of the APG is estimated at USD 5.9 billion. A potential total saving of about USD 662 million in new investment and operating costs is estimated to result from the proposed interconnection projects (ASEAN, 2010). In the future, cooperation may be expanded to include the Asia-Pacific Partnership on Clean Development and Climate, which may become a means for linking energy and climate change objectives (ASEAN, 2008).

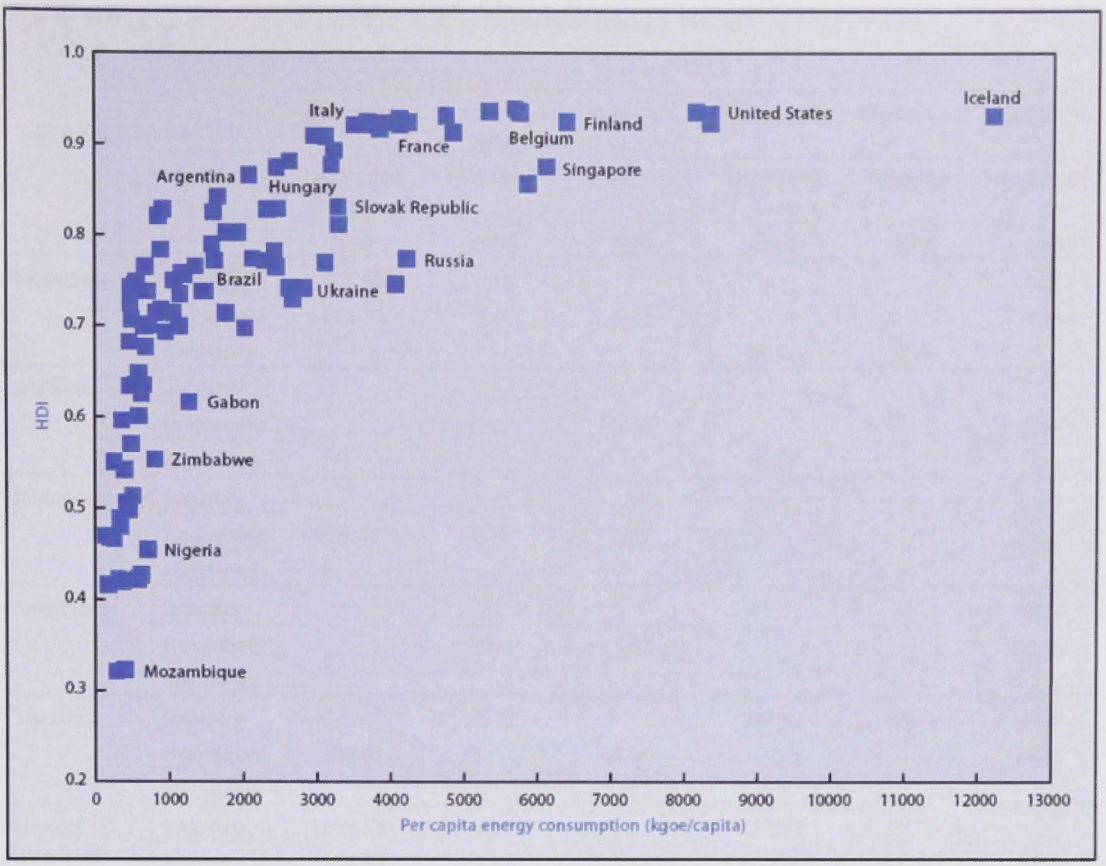
Putting aside the question whether economic integration and cooperation to achieve energy security for the region is something ASEAN leaders truly desire, the question of the feasibility of such an endeavor is an entirely different question (Peng 2000). As noted by Salazar and Das (2007), Green (2007), Severino (2007) as well as Narjoko and Amri (2007), there exists a great divide among ASEAN member countries in terms of development and market regimes. Even the founding member countries, in terms of income per capita, population, and geographical size, are widely varied.

This following section will focus mainly on fossil fuel energy sources and analyzes patterns of energy prices and demand in ASEAN countries through the Kaya Identity method of energy decomposition. The goal is to highlight challenges in implementing energy cooperation programs and policies in the region, as an important requirement to be able to successfully implement any energy cooperation program or policy is to take into account differences in the structure of energy demand among the ASEAN countries. Cooperation in the energy sector requires great awareness and flexibility if it is to support the goal of establishing an ASEAN Community.

2.2.1. Global Energy Trend and Energy Security

Today, fossil fuel remains the primary source of energy throughout the world. Oil, natural gas, and coal have a combined share of 80 percent of the total energy and they are the predominant energy sources. Oil and natural gas alone make up 60 percent of the energy sources, primarily used as fuels, whereas coal is more related to power generation to meet the electricity demand (Seng, 2007). This pattern is unlikely to change as Asia Pacific Energy Research Centre (APERC, 2006) notes that the growing demand for energy through 2030 will mostly be met by conventional resources. As such, the continued heavy reliance on fossil fuel is likely to raise concerns on the issue of energy security as energy is essential to economic progress, growth, and development.

Meanwhile, the World Energy Assessment Overview report by the United Nations Development Program (UNDP, 2005) reaffirms the existing linkages between energy with, among others, economy, social, and health issues; and (vice versa) access to energy is essential to human activities, development, and economic growth. Not surprisingly, the report shows a positive correlation between a country's Human Development Index (HDI) and per capita energy consumption (Figure 2.1). Inevitably, as a country improves its HDI, its per capita energy consumption will increase. It is hence expected that world energy consumption will keep increasing and so whether or not a country can secure its energy needs is an increasingly important issue. For at least until the near future, securing the supply of fossil fuel is the critical issue.



Source: UNDP (2004).

Figure 2.1. HDI and per Capita Energy Use in 1999/2000

Energy security itself can be defined using two basic concepts: availability and pricing. For importing countries, energy security is the certainty of market demand in terms of quantity and predictable prices, while for the exporting countries, energy is translated into the availability of energy at all times, in sufficient quantities, and at affordable prices (Len, 2007). UNDP (2000) also adds environment into the issues of energy security by defining it as "*a term that applies to the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices, without unacceptable or irreversible impact on the environment*".

2.2.2. Energy Prices within ASEAN

The first noticeable fact of the energy sector within ASEAN countries is that some energy prices are considerably different due to various distortion policies within these countries. Table 2.1 shows selected prices of energy for some ASEAN member countries, namely Indonesia, Malaysia, Philippines, Singapore, and Thailand, as well as for some non-ASEAN member countries for benchmarking, namely the United Kingdom as a European Union (EU) representative, Japan, Korea, and United States. Energy products are limited to kerosene, diesel, gasoline, gas, coal, and electricity for the years 2006 and 2007.

Table 2.1. Selected Energy Prices

		Kerosene	Automotive Diesel	Premium Unleaded	Natural Gas	Steam Coal	Electricity
		USD/1000 liters	USD/liter	USD/liter	USD/10*7 kcal	USD/ton	US$/kWh
		2007	2007	2007	2006	2006	2006
Indonesia	Industry	638.88	0.64				0.07
	Household	218.74	0.67	0.65			0.06
	Electricity				66.54	36.66	
Malaysia[1]	Industry						
	Household		0.76[2]	0.74[3]			0.06[4]
	Electricity				70.67[5]		
Philippines[6]	Industry						
	Household	809.26[7]	0.72[8]	0.82[9]			0.17[10]
	Electricity						
Singapore	Industry						0.10
	Household		0.74	1.10			0.14
	Electricity						
Thailand	Industry		0.74		217.51	44.24	0.08
	Household	838.31		0.85			0.08
	Electricity						
United Kingdom	Industry	689.58	1.65		383.79	88.97	0.12
	Household	800.52	1.94	1.88	643.81	360.63	0.19
	Electricity				275.01	70.09	
Japan	Industry	508.99	0.82		435.27	65.15	0.12
	Household	674.02	1.01	1.19	1238.40		0.18
	Electricity						
Korea	Industry	1009.92			495.20	57.62	0.07
	Household	1002.64	1.37	1.64	641.42		0.10
	Electricity				477.05	51.60	
United States	Industry	545.05	0.76		302.04	52.12	0.06
	Household	696.88	0.76	0.77	528.16		0.10
	Electricity				274.59	38.76	

Source: International Energy Agency (IEA, 2008) and various other sources.

[1] USD 1 = RM 3.61955

[2] Actual price is RM 2.70 per liter after a 40 percent price hike on 4 June 2008 (Reuters India, 2008; Herald Tribune, 2008).

[3] Actual price is RM 2.58 per liter after a 63 percent price hike on 4 June 2008 (Reuters India, 2008; Herald Tribune, 2008).

[4] Actual price is RM 0.218 per kWh for all usage below 200 kWh per month before and after price hike on 1 July 2008 (Coal Gossip, 2008).

[5] Actual price is RM 6.40 per mbtu before an increase to 14.31 RM per mbtu on 4 June 2008 (Business Times, 2008).

[6] USD 1 = P 49.0570.

[7] Actual price is P 39.70 per liter as of May 2007 (Ho, 2007).

[8] Actual price is P 35.15 per liter as of May 2007 (Ho, 2007).

[9] Actual price is P 40.20 per liter as of May 2007 (Ho, 2007).

[10] Average price in 2007 (Adriano, 2008).

Taking a quick look at the cross-country prices of kerosene, Indonesia's price for a household appears to be highly distorted even compared to the price of kerosene sold to the country's industry. The household price of kerosene is three times cheaper due to a large government subsidy. This subsidy was given because low-income households in Indonesia used kerosene for cooking before the government's move to switch cooking fuel to natural gas amidst the soaring oil price, starting in 2005 (Herald Tribune, 2007).

Meanwhile, it appears that there is no great disparity in diesel prices among ASEAN member countries. Noticeably, the diesel prices in Indonesia are slightly lower than in Malaysia, Philippines, Singapore, and Thailand. According to the Energy Information Agency, Indonesia historically has maintained consumption subsidies for domestic retail fuel consumers, with products being sold at a discount below world market prices (EIA, 2008a). Surprisingly, diesel prices in the United States closely resemble prices in Southeast Asia as opposed to the United Kingdom. Bearing in mind that the Philippines does not subsidize its fuel; these prices would probably reflect the competitive prices (EIA, 2008b). Higher prices in United Kingdom, Japan, and Korea could reflect government's tax on fuel with a lower price for the industrial sector in United Kingdom and Japan.

A similar pattern shows up again in the gasoline price, although the Philippines shows a much higher price than any of the other ASEAN member countries. The Philippines is mostly a deregulated market, except for the price setting of petroleum products where oil companies are required to seek the government's consent. There is an informal cap on weekly price increases of 50 centavos per liter, especially on diesel. However, this compromise broke down in May 2008 when the price of crude oil skyrocketed (EIA, 2008b). Most surprising of all is the price of gasoline in the United States which is lower than the Philippines. This indicates the possibility of a price distortion as gasoline price in the United States is also a sensitive political issue.

As for natural gas, prices in Indonesia and Malaysia also indicate price distortion due to government subsidy. Although both Indonesia and Malaysia have large reserves of natural gas, they usually cannot entirely account for the much lower prices in these countries. Not unexpectedly, Malaysia had to increase the price of natural gas in June 2008 by 124 percent as the world oil price soared (Business Times, 2008).

Coal prices on the other hand, are quite similar across countries with those countries well-endowed with coal showing similar prices. One common pattern that appears from United Kingdom, Japan, and United Sates is that coal prices for electricity generation are lower than prices for the industrial and household sectors. Lastly, electricity prices in ASEAN countries are as expected with Indonesia, Malaysia, and Thailand showing a much lower price than Philippines and Singapore. Quite surprisingly, Korea and United States also show similar prices for their industrial sectors, which indicate existing price distortions there as well.

Overall, comparing energy prices among Indonesia, Malaysia, Philippines, Singapore, and Thailand shows that price distortions appear to exist heavily in Indonesia and Malaysia, and to a lesser extent in Thailand. These distortions appear to arise from government subsidies as energy prices in these countries are much lower than in the others. If ASEAN integrates and energy prices are equalized between member countries, Indonesia and Malaysia are the two countries that will most likely have to make the greatest adjustments. Whether the net effect is positive or negative is something that remains to be seen.

2.3. Methodology in Decomposing Energy Consumption

The typical goal to decompose energy consumption in a country is to reveal the energy intensity or energy efficiency in that country. Technically, energy efficiency can be defined by the first law of thermodynamics, which measures the relationship between the total amount of energy inputs and useful energy outputs. Whereas, energy intensity measures the quantity of energy required to perform a particular activity, such as the production of output, energy efficiency is effectively the inverse of this ratio, but aims to measure 'how well' the energy is used to produce output. The calculation of indicators, either in physical or monetary units, varies according to the nature of the analysis to be undertaken. Generally, indicators calculated in monetary units are applied to the analysis of energy efficiency at a macroeconomic level, while energy efficiency indicators denominated in physical units are more suited to detailed sub-sectoral analysis (APERC, 2000).

Aside from being an indicator of energy efficiency, the concept of energy intensity, $I = E / GDP$, is an especially useful measure for analyzing energy consumption trends in a number of countries. Such usefulness can be gauged by the following equation obtained from the definition of *I*:

$$\frac{\Delta I}{I} = \frac{\Delta E}{E} - \frac{\Delta (GDP)}{(GDP)} \qquad [2.1]$$

If gross domestic product (GDP) grows, the only method of offsetting the resulting increase in energy growth, and the emissions of pollutants and greenhouse gases associated with it, is to have decreasing energy intensity. The evolution of energy intensity over time reflects the combined effects of structural changes in the economy, built into the GDP, as well as changes in the mix of energy sources and efficiency of energy use, built into the primary energy consumed *E* (Goldemberg, 2006).

Meanwhile, Percebois (1979) makes a distinction in defining energy intensity, namely in terms of primary energy and in terms of useful energy, i.e. the energy really available at the output end of the energy-using devices. Regardless of which of the two definitions is used, there are two things that must be considered when analyzing changes in energy intensity, namely issues related to changes in the structure of production and those arising from the substitution of energy forms with different efficiencies.

In its application, energy intensity studies are important as it is useful for energy policy makers to know by how much energy demand will grow in the face of major changes in economic structure and the system of economic management (Markandya *et al.*, 2006). Admittedly, there are difficulties associated with using energy intensity for country and policy analysis, particularly when it is used directly for cross-country comparison.

Bosseboeuf *et al.* (1997) identifies several difficulties in comparing energy intensities between different economies, which include data used not being homogenous in definition and measurement; ratios and indicators calculated for assessing energy efficiency differing from one country to another; interpretation of similar ratios diverging considerably; and even concepts of efficiency, conservation, savings, and rational use having different definitions among countries.

Furthermore, Freeman *et al.* (1997) also finds that aside from limitations on the availability and quality of data, trends in energy intensity based on value of output, e.g. value of production, can diverge sharply from trends in energy intensity based on volume of output, e.g. tons of output. Discrepancies between value- and volume-based indicators of energy intensity arise from the way data are constructed as well as measurement errors in price deflators and simple definitional differences between various measures. Another problem is the separation of energy efficiency effects from structural effects (Phylipsen *et al.*, 1998).

APERC (2000) concludes that solutions to the former problems lie in a progressive harmonization of data; definition of a common methodology for energy efficiency assessment; and establishment of an appropriate mechanism to confront on a regular basis the experiences of various countries in the field of energy efficiency policies and to harmonize interpretations. Meanwhile, the latter problem can be solved by disaggregating production data to increase the number of indicators.

The importance of disaggregation arises from the fact that energy intensity cannot be added. In addition, energy intensity changes at different rates in different sectors as it responds to different stimuli. Therefore, energy intensity as an energy efficiency indicator needs to be viewed at a disaggregated level (Sitompul, 2006). Furthermore, trends in energy intensity may not reflect underlying trends in technical efficiency, but instead may reflect such factors as structural changes (Freeman, 1997). Thus, composition effects have led to several attempts to decompose trends in energy intensity into structural and energy efficiency components.

2.3.1. Basic Form of Index Decomposition Analysis

As mentioned in the previous section, the two main objectives of a decomposition study of energy consumption are to study the impacts of structural change on energy use, or the shifts in the energy composition, and energy efficiency improvements (Sitompul, 2006). To serve these purposes, i.e. to gain insights into the mechanisms of change in energy consumption, a technique that has been widely employed is decomposition analysis. In the literature, the majority of the studies utilize the index number technique to perform decomposition, a research area which is known as the index decomposition analysis.

Using index decomposition analysis to study trends of energy use began in the late 1970s. Many different methods have been adopted by international organizations, national agencies, researchers, and analysts. In method selection, the researcher or analyst is expected to consider four criteria: (a) theoretical foundation, (b) adaptability, (c) ease of use and implementation, and (d) ease of understanding and result presentation (Liu and Ang, 2007).

In the last two decades, the majority of studies conducted in decomposition analysis have commonly used two methods known as the Laspeyres/Paasche index approach and the Divisia index method. These two methods are built upon the basic form of decomposition method and newer methods being developed, including the Fisher Ideal index decomposition as well as the complete decomposition method (Ang, 1994; Sun, 1998; Ang and Zhang, 2000; Ang and Liu, 2001; Choi and Ang, 2003; Sun, 2003; Boyd and Roop, 2004; Sitompul, 2006).

The following equation expresses the basic form for decomposition analysis:

$$E(u,t) = \frac{E(u,t)}{Y(u,t)} \bullet \frac{Y(u,t)}{Y(t)} \bullet Y(t) \qquad [2.2]$$

with the following definition of variables in which energy consumption is measured in an energy unit, e.g. kiloton of oil equivalent (ktoe), and output in a monetary unit, i.e. billion USD.

$E(u,t)$	= energy consumption in sector u	
$E(t)$	= total energy consumption in time t	$= \sum E(u,t)$
$Y(u,t)$	= output of sector u	
$Y(t)$	= total output	$= \sum Y(u,t)$
$S(u,t)$	= output share of sector u	$= Y(u,t) / Y(t)$
$I(u,t)$	= energy intensity of sector u	$= E(u,t) / Y(u,t)$
$I(t)$	= aggregate energy intensity	$= E(t) / Y(t)$

From Equation 2.2, the aggregate energy consumption can be written as:

$$E(t) = \sum_u I(u,t) \bullet S(u,t) \bullet Y(t) \qquad [2.3]$$

or

$$\frac{E(t)}{Y(t)} = \sum_u I(u,t) \bullet S(u,t) = I(t) \qquad [2.4]$$

$I(t)$ is the aggregate energy intensity, which indicates that a change in $I(t)$ may occur from changes in the sectoral energy intensity $I(u,t)$ and/or from changes in the production mix (sectoral share of industrial output) $S(u,t)$. Decomposition analysis in energy consumption is basically aimed at identifying these two effects, which can be used to explain the energy policy implications resulting from the changes occurring in industrial energy consumption (Ang, 1994; Ang and Zhang (2000); Sitompul, 2006).

Suppose the aggregate energy varies from $I(0)$ in time 0 to $I(T)$ in time T. Such a change may be expressed in two ways:

$$D_{tot} = I(T) / I(0) = D_{str} D_{int} \qquad [2.5]$$

and

$$\Delta I_{tot} = I(T) - I(0) = \Delta I_{str} - \Delta I_{int} \qquad [2.6]$$

The equations above are referred to as multiplicative decomposition and additive decomposition respectively. D_{str} and ΔI_{str} give the estimated impacts of structural change, whereas D_{int} and ΔI_{int} give the estimated impacts of sectoral intensity (Ang and Zhang, 2000).

2.3.2. Kaya Identity

The original utilization of Kaya Identity is to explicitly link energy consumption and the environment. The decomposition is based on the so-called *IPAT* equation established in the early 1970s that identifies three factors that create an environmental impact. Thus, impact (I) is expressed as the product of: (1) population, P; (2) affluence, A; and (3) technology, T (Chertow, 2001; Ma and Stern, 2008).

$$\text{IMPACT } (I) = \text{POPULATION } (P) \times \text{AFFLUENCE } (A) \times \text{TECHNOLOGY } (T) \qquad [2.7]$$

The Kaya Identity is a variant of the *IPAT* identity, which has been specifically applied in the studies of energy-related carbon, CO_2, emissions (Kaya, 1990). The Kaya Identity establishes a relationship between population growth, per capita value added, energy per unit of value added, and CO_2 emissions per unit of energy on one side of the equation, and total carbon dioxide emissions on the other. Thus,

$$CO_2 = (CO_2/E) \times (E/GDP) \times (GDP/P) \times P \qquad [2.8]$$

where *E* represents energy consumption, *GDP* the gross domestic product or value added, and *P* population. Changes in CO_2 can be described by changes in these four factors (Nakicenovic, 1997; Albrecht *et al.*, 2002; Kawase, 2006; Raupach *et al.*, 2007).

The method of index decomposition analysis (IDA) is then applied to the relevant identity. These methods have been well developed and widely applied in the past two decades, including the LMDI method as it has the advantages of path independence, ability to handle zero values, and consistency in aggregation (Ma and Stern, 2008).

Furthermore, the *IPAT*-Kaya approach is also flexible, quite parsimonious, and rather easy to use. It allows an explanatory analysis of the relative influence of the different factors in the level of emissions and variation between time periods. It can also be used to forecast future CO_2 emissions levels when all the factors considered are known. However, this approach has limitations. One is that is it is just a multiplicative identity; as such, although it always holds, it assumes proportionality between the effects of different factors, *ceteris paribus* (Lozano and Gutiérrez, 2007).

2.3.3. Modified Kaya Identity for Energy Decomposition

As with several previous works, this study also combines Kaya Identity with index decomposition analysis. The decomposition formula utilized in this particular chapter limits itself on the energy aspects of the identity to provide detailed pictures in energy decomposition. The decomposition formula is as follows:

$$E^F(f,u,t) = Y(t) \bullet \frac{E^S(t)}{Y(t)} \bullet \frac{E^T(u,t)}{E^S(t)} \bullet \frac{E^I(u,t)}{E^T(u,t)} \bullet \frac{E^{IF}(u,t)}{E^I(u,t)} \bullet \frac{E^F(f,u,t)}{E^{IF}(u,t)} \qquad [2.9]$$

where

f = index for fossil fuel primary energy source, i.e. coal, oil, and gas
u = index for electricity and non-electricity
t = index for year

Y = gross domestic product
E^S = total energy supply
E^T = energy supply from electricity *vis-à-vis* non-electricity
E^I = total energy input
E^{IF} = energy input from fossil fuel
E^F = fossil fuel input

or

$$E^F(f,u,t) = Y(t) \bullet es \bullet et \bullet ei \bullet eif \bullet ef \qquad [2.10]$$

where *es* is the overall energy intensity at time t for each country; *et* is the share of electricity; *ei* is the inverse energy efficiency, i.e. input per output in electric power generation and in non-electric power generation; *eif* is the input share of fossil fuel; and *ef* is the input share of fossil fuel by primary energy sources, i.e. coal, oil, and gas.

Energy intensity (*es*) basically measures the quantity of energy required per production of output. In the following sections, it is measured in kiloton of oil equivalent (ktoe) per USD billion. This ratio is essentially the inverse of energy efficiency ratio where a smaller value indicates a 'more efficient' use of energy as it means that less energy is required to produce the same amount of production output, which in the following section is measured in monetary value, i.e. USD billion.

Meanwhile, *et* indicates the share of electricity *vis-à-vis* the share of non-electricity. This share explains how much of the primary energy supply, e.g. coal, oil, and gas, is used for electricity generation as opposed to how much is directly being consumed by final consumers, e.g. fuel consumed for private automobiles and others.

As for the inverse energy efficiency (*ei*), it is a ratio most useful in the electricity sector as the amount of output can be directly measured. In the non-electricity sector, the inverse efficiency is assumed to take the value of one as the measurement of output varies depending on the sector being observed. As such, the inverse energy efficiency is used primarily in the electricity in the following sections as it is the most relevant sector for this indicator to be used upon.

Following upon the 'chain' of the formula, *eif* indicates the share of fossil fuel being used as opposed to non-fossils, e.g. biomass, hydropower, solar, wind, and others, in the electricity sector. It is, of course, possible for *eif* to indicate the share of fossil fuel in the non-electricity sector, e.g. industrial sector, residential sector, and transportation sector. However, it would be entirely much more useful to look directly at the input share of fossil fuel by primary energy sources (*ef*) for the non-electricity sector. The same cannot be said for the electricity sector

where *eif* is as useful as *ef* because it shows alternatives available in large-scale policy- or decision-making process. For example, whether 'going nuclear' is a viable alternative to a 'clean-coal' plant in terms of, among others, cost and public safety.

As such, the modified Kaya Identity as shown by Equation [2.9] and Equation [2.10] provides an extremely important tool by which to measure and analyze what would otherwise an insurmountable amount of data. The formula provides a set of parameters by which comparisons can be made whether within and across a sector, as well as within and across countries.

Furthermore, it is not necessary to utilize every share or ratio for every sector in every country in the formula as doing so will create too many redundancies. One of the greatest values of the formula lies in the fact that it allows the use of only certain parts of the formula for analytical purposes. This 'pick-and-choose' method is still important as the actual values themselves are not very important in and of itself. Only when the values are actually being compared, whether across sectors or countries, they do in fact provide important analytical insights.

In the following sections, the formula is applied to decompose the total energy consumption of a country or region, as well as a certain sector in the country. Among others, the formula is used to decompose energy use by the industrial or household sector only. As such, the modified Kaya Identity is extremely important as it provides 'boundaries', i.e. a set of parameters, by which cross-sectoral and cross-country analysis can be conducted and examined.

2.3.4. Data Source and Variable Definitions

This study uses data produced by the International Energy Agency (IEA, 2007a; IEA, 2007b) and World Development Indicators (World Bank, 2008) to decompose and analyze the energy intensity and dynamics of the seven selected ASEAN member countries[1], namely Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, and Thailand from 1990 to 2005 as well as Vietnam from 1995 to 2005[2]. For benchmarking purposes, EU-15[3] is also included.

Other sources of dataset were considered and discarded at the outset. The least feasible alternative is to construct a dataset from the individual country's energy and statistical agencies. However, as Bosseboeuf *et al.* (1997) points out, problems with this alternative arise from the varying definitions and measurements between countries, which would simply make this

[1] Referred to as ASEAN countries hereon, taking out Cambodia, Laos, and Myanmar due to data restriction.
[2] Vietnamese data prior to 1994 is unreliable as energy use from non-fossil fuel is less reliable.
[3] EU-15 is an aggregation of European countries, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

method impractical and time-consuming for cross-country analysis. Thus, harmonizing the data would simply create additional measurement errors.

Thus, a feasible alternative to the use of IEA data would be one that is compiled by a single source, such the Energy Information Administration (EIA) of the United States Government, World Resources Institute (WRI), and Global Development and Environment (GDAE) Institute. Each of these alternative sources has been considered, however, they all fall short compared to the data provided by IEA in terms of disaggregation. Also, EIA lacks the extensiveness of the data compared to IEA, while WRI and GDAE contain missing years in the annual report of each country. As such, for this study, IEA provides the best possible option for ASEAN energy decomposition.

The GDP data for individual countries have been obtained from the World Bank. The figures are expressed in 2000 Purchasing Power Parity (PPP) dollars in order to make the GDP variable comparative across countries. Hence, the unit of measure used for GDP is 'billion USD at 2000 prices and PPPs'.

Meanwhile, data taken from the IEA are in four dimensions, namely time, country, product, and flow. The time dimension is quite straightforward – only data from 1990 onwards are used for all countries so as to make the results relevant and comparable with current years, with the exception of Vietnam where data are from 1995 onwards.

The country dimension is also quite straightforward – only seven out of ten ASEAN member countries are decomposed due to data limitations for Cambodia, Laos, and Myanmar. In the case of EU-15, these countries' data are aggregated and treated as a single country for both practical and philosophical reasons. This is possible because the GDP variable is comparable across countries and the energy consumption, E, in each country uses the same unit of measurement, kiloton of oil equivalent (ktoe).

As for the product dimension, the variables have been aggregated accordingly into five distinct categories, namely coal, oil, gas, non-fossils, and electricity. Again, it possible here to aggregate the products as they have all been converted into a common unit of measurement. Note that for coal, oil, and gas, these include their derivatives as well, e.g. crude oil and diesel are both included under the oil category.

Meanwhile, non-fossils include every other energy sources, such as nuclear, wind, solar, biomass, *etc.* The category electricity is somewhat different as it is actually a product that is not naturally produced; and coal, oil, gas, and non-fossils are required to produce it. It is possible to find this variable as the IEA also includes 'electricity' in the flow dimension as well as in the amount of electricity generated.

The flow dimension itself consists of the supply sector, transformation sector, energy sector and distribution losses, and final consumption. Meanwhile, the supply sector is made up of production, imports, exports, bunkers, stock changes, and total primary energy supply (TPES). The TPES is in turn made up of production plus imports minus exports minus 'international marine bunkers' plus/minus stock changes; and these are also equal to the aggregation of the first three sectors plus transfers and statistical differences.

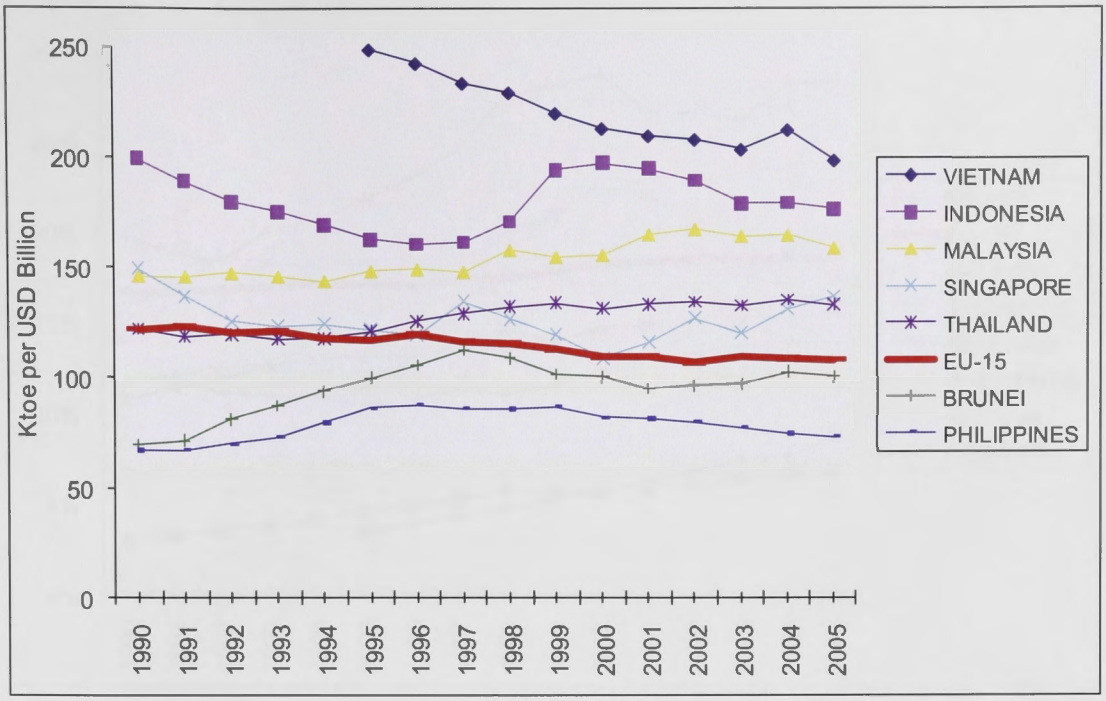
The transformation sector comprises the conversion of primary forms of energy to secondary and further transformation, e.g. coking coal to coke, crude oil to petroleum products, and heavy fuel oil to electricity. However, one item has been disaggregated, i.e. the electricity sector, which consists of main activity producer electricity plants and autoproducer electricity plants. Both types of plants refer to plants which are designed to produce electricity only and may be privately or publicly owned. Furthermore, the energy sector covers the amount of fuel used by the energy producing industries and distribution losses refers to losses in gas distribution, electricity transmission, and coal transport.

Lastly is final consumption which equals the sum of consumption in the end-use sectors. Energy used for transformation and for own-use by the energy producing industries is excluded. Final consumption reflects for the most part deliveries to consumers (IEA, 2007b). As for the end-users themselves, they are categorized into industrial, residential, transportation, and other sectors, i.e. final consumers.

2.4. Energy Decomposition of ASEAN-6 plus Vietnam

There are several observations to the made regarding energy decomposition. The first thing to observe is the energy intensity among ASEAN countries, namely ASEAN-6 plus Vietnam. Figure 2.2 illustrates their trends of energy intensity (energy use/GDP) measured in ktoe per billion of USD. Aside from ASEAN countries, this figure also includes EU-15[4] as a benchmark. This figure shows two important details. First, it reveals that ASEAN countries are more energy intensive than the more developed EU-15, with the exceptions being Brunei and Philippines. Second, Figure 2.2 also indicates a trend toward convergence over time. EU-15, which by average is more developed than ASEAN countries, shows a more stable path since 1990, whereas relatively more energy intensive countries, namely Vietnam and Indonesia, undergo a sharper decline. One deviation from these observations comes from Singapore whose energy intensity rises dramatically in 2000 and 2003; although starting from 1990, it is still declining over time.

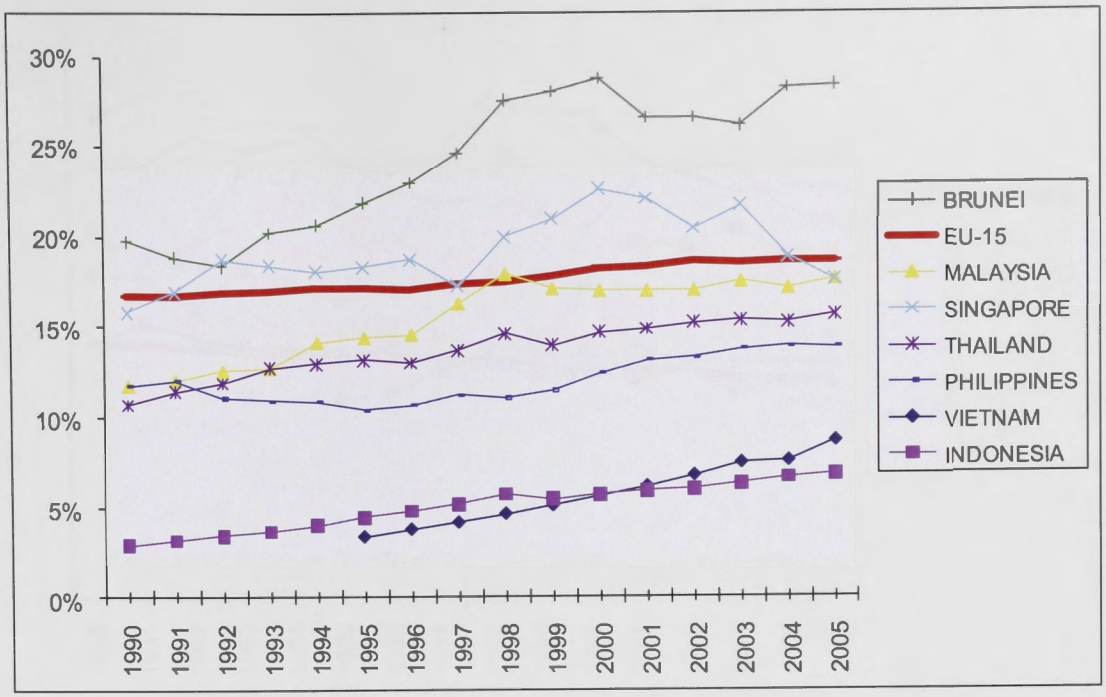
[4] EU-15 is an aggregation of European countries, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.



Source: IEA (2007a), (2007b), and author's calculation.

Figure 2.2. Energy Intensity of EU-15 and ASEAN-6 plus Vietnam in 1990-2005

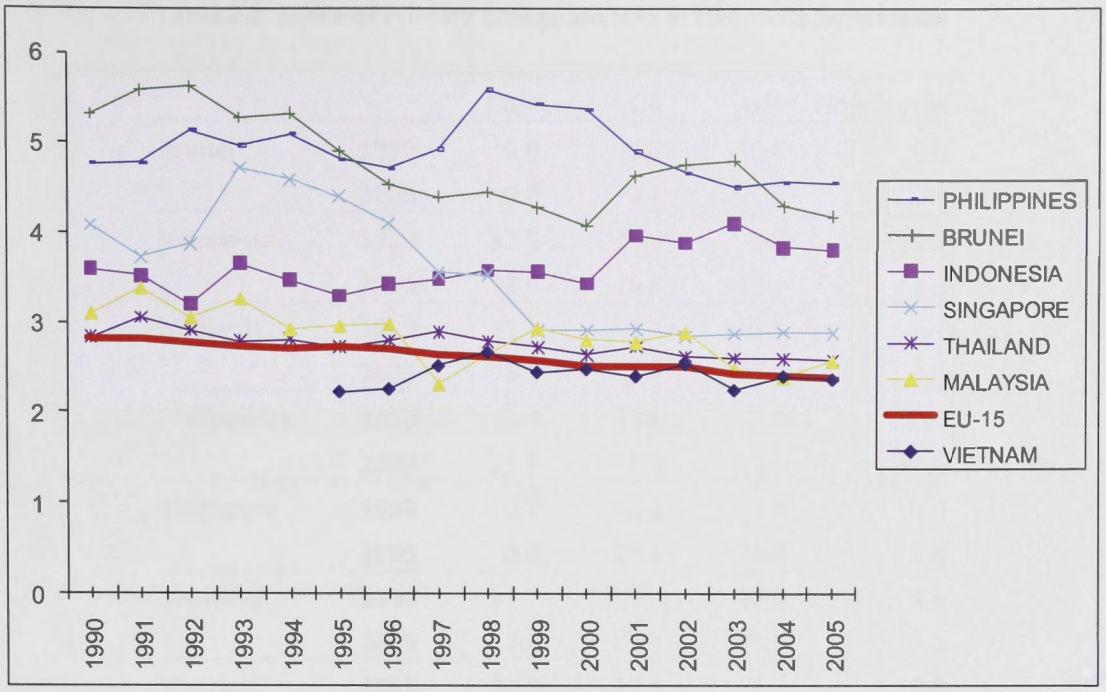
Second, this study also observes the share of energy consumed by the electricity sector; i.e. the share of electricity consumption in comparison to other primary energy sources consumed by final consumers. Figure 2.3 shows the share of electricity consumption from the total energy consumption and compares once more the ASEAN countries with EU-15. For the most part, the figure shows that the share of electricity consumption is increasing during the 1990-2005 period, albeit still below 30 percent of the total energy use. The electricity sector in Brunei, Malaysia, and Singapore has the highest share of energy consumption, followed closely by Thailand and Philippines. With the exception of Brunei, these countries share a similar pattern with EU-15. Meanwhile, the electricity sector uses only a small share of energy consumption in Vietnam and Indonesia with only 8.8 percent and 6.9 percent respectively in 2005. A note of caution is needed here. In the case of Indonesia, and to a certain extent Vietnam, the amount of electricity generation by autoproducers is unknown in that the electricity sector refers only to the amount sold to the public electricity grid (IEA, 2007a). As such, energy consumption in Indonesia and Vietnam is most likely higher than illustrated below, with Vietnam's share rising more sharply than most others between 1995 and 2000.



Source: IEA (2007a), (2007b), and author's calculation.

Figure 2.3. Share of Electricity Consumption from Total Energy Consumption

Third is the inverse efficiency, i.e. the input-output ratio, of the electricity sector. In other words, in Figure 2.4, the higher the ratio the more inefficient the country is in comparison to others. Not so surprisingly, all ASEAN countries in the figure are less efficient than EU-15 with Vietnam as the only exception. Philippines, Brunei, and Indonesia are the most inefficient countries in ASEAN in terms of energy used to generate electricity. These three countries use about 50 percent more input to produce the same amount of electricity as did the others in 2005. In fact, Indonesia is becoming less efficient, with the highest loss of efficiency in 2000. One note of caution is that at this point, no information is provided as to the type of energy used to generate electricity. Thus, no judgment can be made based on this figure alone in relation to 'clean' and 'unclean' energy use in the electricity sector. For now, the figure below simply shows that Singapore, Thailand, Malaysia, and Vietnam are relatively more efficient in this sector. Also, the input-output ratio of EU-15 may slightly be higher in reality as electricity output from combined heat and power (CHP) plants is included, which accounts for 10-20 percent of electricity produced, while their input is excluded. This is because it is not known how much of the input in CHP plants is used for electricity generation and how much is used for heat production.



Source: IEA (2007a), (2007b), and author's calculation.

Figure 2.4. Inverse Efficiency of the Electricity Sector (Input per Output)

Fourth, Table 2.2 shows the share of primary energy use in the electricity sector, which in turn shows dependency on fossil fuel. Both Brunei and Singapore use fossil fuel as the only source of energy to generate electricity. They are closely followed by Malaysia and Thailand; and later, by Indonesia and Vietnam. Interestingly, Vietnam shows a large increase in the use of fossil fuel from 1995 to 2005. In the case of the Philippines, only half of its electricity generation uses fossil fuel in 2005. However, to claim the Philippines as the least polluting country in ASEAN is a bit premature as the country has increased its use of coal by tenfold in order to decrease its use of oil. This is not surprising as the price of oil has increased sharply since 2004, forcing countries to reduce their use of oil. This holds true for all countries in Table 2.2, including EU-15.

Table 2.2. Share of Primary Energy Sources in Electricity Generation

		Coal	Oil	Gas	Non-Fossils
Brunei	**1990**	0.0	0.6	99.4	0.0
	2005	0.0	0.7	99.3	0.0
Indonesia	**1990**	32.5	45.6	3.8	18.2
	2005	44.9	26.3	10.1	18.8
Malaysia	**1990**	11.7	56.3	25.6	6.4
	2005	26.2	3.2	67.9	2.8
Philippines	**1990**	5.4	33.6	0.0	60.9
	2005	25.5	7.5	15.0	52.0
Singapore	**1990**	0.0	100.0	0.0	0.0
	2005	0.0	26.7	73.3	0.0
Thailand	**1990**	27.2	27.3	40.9	4.6
	2005	17.4	7.3	70.2	5.1
Vietnam	**1995**	33.0	17.1	7.7	42.3
	2005	22.5	7.2	50.8	19.5
EU-15	**1990**	38.7	8.3	4.4	48.6
	2005	29.0	3.9	12.1	54.9

Source: IEA (2007a), (2007b), and author's calculation.

Furthermore, it is quite alarming that none of the ASEAN countries shows any trend toward reducing its reliance on fossil fuel. In fact, Indonesia, Malaysia, and Philippines have chosen coal as an alternative to oil in order to generate electricity. In terms of carbon emissions, coal produces the most pollution of all energy sources, followed by oil and gas. This problem is exacerbated by the lack of development and lack of use of non-fossil fuel energy sources, such as hydro, solar, wind, biomass, and others, all of which are certainly cleaner. On the other hand, gas appears to be a feasible alternative to oil with Brunei and Singapore showing the greatest reliance on it. Nevertheless, bear in mind the numbers in the table represent shares and not nominal values of fossil fuel use. Although only half of EU-15's electricity relies on fossil fuel, in nominal term, EU-15 uses 231 and 28 times more fossil fuel than Brunei and Singapore respectively in the electricity sector.

Table 2.3, on the other hand, shows the direct primary energy consumption by final consumers, i.e. non-electricity sectors (industrial, residential, transportation, and others). The table shows heavy use of oil in all countries although Indonesia, Philippines, Thailand, and Vietnam also rely on non-fossils for energy sources. Ironically, this phenomenon rather implies a development gap rather than environmentally-conscious societies typically associated with the more developed EU-15 countries. The high use of non-fossils in ASEAN is mainly attributed to the use of biomass as an energy source instead of the more capital-intensive energy sources

such as hydro, solar, or wind power. Meanwhile, countries such as Brunei and Singapore have not changed much in 15 years with the predominant use of oil.

Table 2.3. Share of Primary Energy Sources Used by Final Consumers

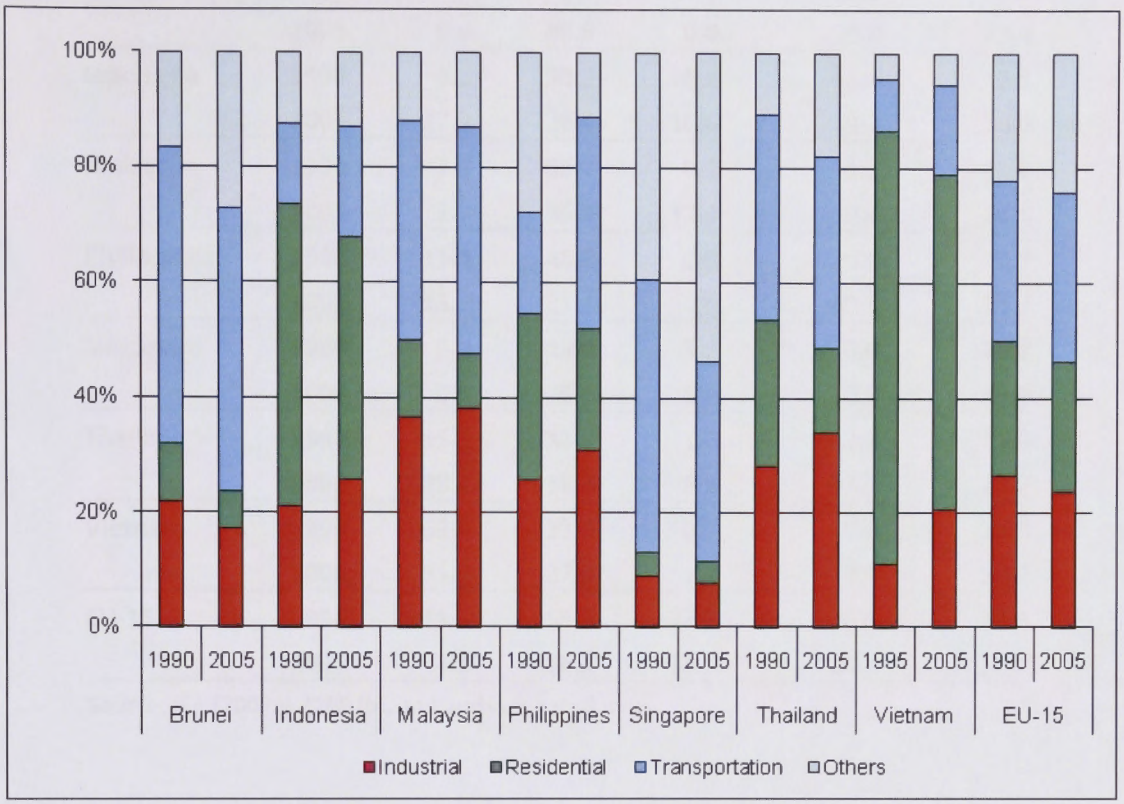
		Coal	Oil	Gas	Non-Fossils
Brunei	**1990**	0.0	94.9	0.0	5.1
	2005	0.0	96.9	0.0	3.1
Indonesia	**1990**	0.8	35.9	8.6	54.7
	2005	7.7	42.1	10.2	39.9
Malaysia	**1990**	3.2	78.1	8.5	10.1
	2005	3.6	71.3	19.9	5.2
Philippines	**1990**	3.3	54.2	0.0	42.5
	2005	5.5	58.7	0.0	35.9
Singapore	**1990**	0.0	98.9	1.1	0.0
	2005	0.0	99.2	0.8	0.0
Thailand	**1990**	4.8	61.0	0.9	33.4
	2005	11.9	65.2	3.3	19.6
Vietnam	**1995**	9.6	15.9	0.1	74.4
	2005	14.5	29.0	0.2	56.2
EU-15	**1990**	9.7	60.9	23.0	6.4
	2005	2.7	59.1	27.8	10.5

Source: IEA (2007a), (2007b), and author's calculation.

2.4.1. Sectoral Decomposition of Energy Consumption

Unlike in the previous section, the following looks at the demand-side of energy consumption, focusing particularly on the final consumption of energy. Figure 2.5 decomposes the final energy consumption by sectoral use in each country. The sectors are divided into four categories, namely industrial, residential, transportation, and others. 'Others' here refers to sectors not included in the three categories, such as commercial and public services, agriculture, forestry, fishery, and military use. Figure 2.5 shows that for small countries such as Brunei and Singapore, industrial and residential sectors are relatively small users of energy with the transportation sector being the single largest consumer of energy. Meanwhile, Indonesia and Vietnam again share the same pattern in which the residential sector is largest user of energy, probably explainable by their relatively large populations, followed by the industrial sector and transportation sector. As for Malaysia, Philippines, and Thailand, they share a similar pattern in energy consumption with high use in the industrial sector followed closely by the transportation

sector. EU-15, on the other hand, shows a relatively equal use of energy among the four sectors with very minor changes in the energy consumption pattern from 1990 to 2005.



Source: IEA (2007a), (2007b), and author's calculation.

Figure 2.5. Energy Consumption by Sector

Next, Table 2.4 decomposes the energy use further by examining the types of energy used in the industrial sector, namely coal, oil, gas, non-fossils, and electricity. Comparing across countries, the table confirms Brunei as an oil-rich country as its industrial sector relies primarily on oil as its energy source. All other countries show a reduction in the use of oil with the exception of Vietnam and EU-15. Surprisingly, Vietnam actually increases its reliance on oil while at the same time reduces its reliance on coal, whereas EU-15 increases gas use and decreases coal use. This is in contrast to Indonesia and Thailand where coal use increases to compensate for a reduction in oil use in the industrial sector. More alarmingly, the use of non-fossil fuel also decreases in both countries. As for Malaysia, Philippines, and Singapore, they follow a more traditional path by reducing their use of oil and relying more on gas, non-fossil fuel, and electricity, with little change in the use of coal.

Table 2.4. Energy Consumption by the Industrial Sector

		Coal	Oil	Gas	Non-Fossils	Electricity
Brunei	**1990**	0.0	79.2	0.0	0.0	20.8
	2005	0.0	86.6	0.0	0.0	13.4
Indonesia	**1990**	3.8	30.2	15.4	43.4	7.1
	2005	27.9	26.6	16.6	18.2	10.6
Malaysia	**1990**	7.8	66.7	8.5	1.2	15.7
	2005	7.7	36.8	32.4	0.6	22.5
Philippines	**1990**	11.4	48.9	0.0	20.0	19.7
	2005	13.7	21.2	0.0	49.5	15.7
Singapore	**1990**	0.0	18.0	5.2	0.0	76.8
	2005	0.0	5.1	5.1	0.0	89.8
Thailand	**1990**	15.2	32.0	1.6	33.2	17.9
	2005	29.4	18.3	6.9	23.7	21.7
Vietnam	**1995**	62.6	23.9	0.7	0.0	12.8
	2005	51.7	27.0	1.1	0.0	20.2
EU-15	**1990**	19.5	18.7	27.0	6.5	28.3
	2005	7.9	16.0	33.7	10.1	32.2

Source: IEA (2007a), (2007b), and author's calculation.

Lastly, Table 2.5 shows the types of energy used in the residential sector where Brunei shows yet again its heavy use of oil. As for other ASEAN countries, the residential sector appears to rely heavily on non-fossil fuel, with the exception of Singapore. Vietnam, surprisingly, shows an increasing use of coal by the residential sector although still at less than 5 percent. As for Vietnam's high use of non-fossil fuel, further examination shows that this is largely made up of primary solid biomass, which is defined as any plant matter used directly as fuel or converted into other forms before combustion. This covers a multitude of woody materials generated by industrial process or provided directly by forestry and agriculture, e.g. firewood, wood chips, bark, sawdust, shavings, and animal materials/wastes, and in the case of Thailand, charcoal as well (IEA, 2007a). EU-15, on the other hand, has largely abandoned the use of coal in the residential sector while preferring the use of gas instead, and has had no change in the use of other energy sources.

Table 2.5. Energy Consumption by the Residential Sector

		Coal	Oil	Gas	Non-Fossils	Electricity
Brunei	**1990**	0.0	35.6	0.0	0.0	64.4
	2005	0.0	35.8	0.0	0.0	64.2
Indonesia	**1990**	0.0	14.8	0.0	83.4	1.8
	2005	0.0	16.6	0.0	77.0	6.3
Malaysia	**1990**	0.0	36.1	1.6	62.3	0.0
	2005	0.0	20.9	0.1	41.8	37.1
Philippines	**1990**	0.0	26.3	0.0	62.2	11.6
	2005	0.0	17.0	0.0	59.7	23.3
Singapore	**1990**	0.0	15.4	10.8	0.0	73.8
	2005	0.0	0.0	7.2	0.0	92.8
Thailand	**1990**	0.0	11.7	0.0	79.5	8.8
	2005	0.0	19.5	0.0	57.8	22.7
Vietnam	**1995**	2.1	0.7	0.0	95.2	2.1
	2005	3.3	2.7	0.0	87.7	6.3
EU-15	**1990**	8.1	26.5	30.9	13.5	21.0
	2005	0.9	20.7	42.8	11.6	24.0

Source: IEA (2007a), (2007b), and author's calculation.

A final comment should be made with regards to the transportation and other sectors. The figure for the transportation sector is not included as it consists solely of oil and oil products for ASEAN countries. Only Singapore and Malaysia show any significant use of gas in the transportation sector in 2005, albeit still less than 1 percent. Likewise, there are signs of increasing use of gas and electricity in the transportation sector in EU-15, however, these also make up only a small share at less than 2 percent. Meanwhile, 'others' sector includes too many 'small' sectors with varying patterns; and thus, an analysis would be trivial as the category is not quite comparable across countries.

2.5. Concluding Remarks

This chapter aims to address the issues in the ASEAN integration from an energy policy perspective. It uses a modified version of Kaya Identity by augmenting it with an energy decomposition index. Although purposely limited to the energy aspects, this is more than sufficient to identify and understand the challenges faced by individual members when the ASEAN community is established.

In brief, the structure of energy consumption and prices vary among ASEAN countries. This is evidenced as energy prices in ASEAN member countries vary widely. The existence of

price distortions in some countries, e.g. Indonesia and Malaysia, arise from fact that these countries significantly subsidize their domestic energy prices. In the case of Indonesia, the price of kerosene for household appears to be highly distorted even compared to the price of kerosene sold to the country's industry. The household price of kerosene is three times cheaper due to a large government subsidy. A similar pattern also appears in diesel prices in which prices in Indonesia are slightly lower than in Malaysia, Philippines, Singapore, and Thailand. Indonesia historically has maintained consumption subsidies for domestic retail fuel consumers, with products being sold at a discount below world market prices.

As for natural gas, prices in Indonesia and Malaysia also indicate price distortion due to government subsidy. Although both Indonesia and Malaysia have large reserves of natural gas, they usually cannot entirely account for the much lower prices in these countries. Not unexpectedly, Malaysia had to increase the price of natural gas in June 2008 by 124 percent as the world oil price soared. Lastly, electricity prices in some ASEAN countries are as expected with Indonesia, Malaysia, and Thailand showing a much lower price than Philippines and Singapore, which indicate existing price distortions in this sector as well.

Overall, comparing energy prices among Indonesia, Malaysia, Philippines, Singapore, and Thailand shows that price distortions appear to exist heavily in Indonesia and Malaysia, and to a lesser extent in Thailand. These distortions appear to arise from government subsidies as energy prices in these countries are much lower than in others. If ASEAN integrates and energy prices are equalized between member countries, Indonesia and Malaysia are the two countries that will most likely have to make the greatest adjustments. Whether the net effect is positive or negative is something that remains to be seen.

With regard to the level of energy consumption, this also varies widely between countries as some of the less developed countries consume more energy per economic output, i.e. have higher energy intensity, with a converging trend appearing. This trend toward convergence over time also shows that relatively more energy intensive countries, namely Vietnam and Indonesia, are undergoing a sharper decline. With the exceptions of Brunei and Philippines, ASEAN countries are also more energy intensive than the more developed EU-15. This means that to produce the same amount economic output, most ASEAN countries require more energy input than the more developed EU-15. As such, this shows that there is much room for improvement in most ASEAN countries with their respective energy sector.

As for the electricity sector, the share of electricity consumption in all ASEAN countries is increasing, implying a higher demand for energy in the future. In terms of efficiency in the electricity sector, Philippines, Brunei, and Indonesia are the least efficient, while Singapore, Thailand, Malaysia, and Vietnam are somewhat comparable to the more efficient EU-15. Philippines is the only ASEAN country that does not rely heavily on fossil fuel in the electricity

sector, whereas the fossil fuel share in the others is above 80 percent. There has been a switch from oil to gas as the predominant source of electricity generation in EU-15, and in an alarming contrast, to coal in ASEAN. Energy consumption by final consumers is dominated by oil and gas with an increasing use of coal in Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

Lastly, the residential sector is the largest final consumer of energy in Indonesia and Vietnam, whereas transportation is the largest in Brunei, Malaysia, Philippines, Singapore, and Thailand.

As such, the existing variations within the structure of energy prices and consumption indicate the possibility of 'winners' and 'losers' should a region-wide collaboration in the energy sector be implemented across the board. One conclusion that can be drawn from the decomposition is the undeniable existence of development, demographical, geographical, and natural resources endowment gaps among ASEAN countries resulting in the varying energy supply and demand patterns in the region. These factors affect greatly the energy production and consumption patterns, resulting in non-uniformity in the energy decomposition results.

This chapter, therefore, argues that a region-wide policy in the energy sector would be futile if it were to be implemented across the board without country-specific considerations. Cooperation in the energy sector requires great awareness and flexibility if it is to support the goal of an integrated ASEAN, as each country significantly differs from the others. Nevertheless, the situation also allows for ASEAN countries to complement one another. Thus, in order to support the goal of establishing an ASEAN community, energy policy cooperation should be geared more toward identifying these areas of complementarities *vis-à-vis* adopting a single, region-wide energy policy. In this regard, implementations of sub-regional cooperation as exemplified by the TAGP and APG may provide the correct solution. Energy supply agreements between two, or more, ASEAN countries could become a much more effective and feasible alternative to the region rather than a region-wide approach.

Chapter 3: Constructing an ASEAN Social Accounting Matrix

Summary

This chapter focuses on the construction of an ASEAN Social Accounting Matrix (ASEAN-SAM). The first part of this chapter explains briefly the fundamentals of a social accounting matrix. The second part of the chapter deals with the construction of the ASEAN-SAM by listing data sources and step-by-step description of the procedures required. Lastly, this chapter presents a summary of the ASEAN-SAM to check for consistency. The resulting SAM will be used in subsequent chapters for policy analysis related to energy and the environment using a computable general equilibrium model to be called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN).

3.1. Introduction

This chapter focuses on the construction of an ASEAN Social Accounting Matrix (ASEAN-SAM) for the computable general equilibrium model in subsequent chapters. The purpose of this chapter is to enable the database to be replicated by others and modified accordingly to fulfill others' needs, as well enabling updates of the database. The first part of this chapter explains briefly the fundamentals of a social accounting matrix. The second part of the chapter deals with the construction of the ASEAN-SAM by providing data sources and step-by-step descriptions of the procedures taken. The last part of this chapter presents an empirical summary of the ASEAN-SAM to check for consistency as well as some preliminary analysis using the database.

3.2. What is a Social Accounting Matrix?

A social accounting matrix (SAM) is a traditional double accounting economic matrix in the form of a partition matrix that records all economic transactions between agents in the economy, especially between sectors in production blocks, sectors within institution blocks (including households), and sectors within production factors (Pyatt *et al.*, 1977; Pyatt and Round, 1977; Pyatt *et al.*, 1984; Round, 2003). It is a solid database system, since it summarizes all transaction activities in an economy within a certain period of time, thus giving a general picture of the socio-economic structure of an economy and illustrating its income distribution situation.

The basic framework of a SAM is a 4x4 partition matrix. The accounts in a SAM are grouped into endogenous and exogenous accounts. The use of a SAM for modeling involves the important task of deciding which of the accounts in the SAM table are endogenous and exogenous. It is customary to consider the government, rest of the world, and capital accounts as exogenous. Meanwhile, factors of production, institutions, and production activities accounts

are endogenous (Sadoulet and de Janvry, 1995). Endogenous accounts are normally those that depend on a country's economic activity, while exogenous accounts are independent of economic activity and payments, e.g. exports, investment, and government expenditure. These are normally referred to as injections into the economic system. Conversely, exogenous expenditures are normally referred to as leakages.

In Figure 3.1, the main endogenous accounts are divided into three blocks: production factor, institutional, and production activity blocks. The row shows income, while the column shows expenditure. Sub-matrix $\boldsymbol{a}_{ij}$ (or $\boldsymbol{z}_i$) shows the income of the account in row *i* from the account of column *j*. Vector y_i shows the total incomes of all accounts and vector y_j ' shows the total expenditure account of all accounts. In addition, SAM requires that the vector y_i is the same as vector y_j '. In other words, y_j 'is a transpose of y_i, for every *i* = *j* (Defourney and Thorbecke, 1984). A balanced SAM is defined as such when this condition is fulfilled.

			EXPENDITURES				
			Endogenous Accounts			*Exogenous Account*	TOTAL
			Factors	Institutions	Production Activities		
RECEIPTS	*Endogenous Accounts*	Factors	0	0	a_{13}	z_1	y_1
		Institutions	a_{21}	a_{22}	0	z_2	y_2
		Production Activities	0	a_{32}	a_{33}	z_3	y_3
	Exogenous Account		v_1	v_2	v_3	x	z
	TOTAL		y_1'	y_2'	y_3'	z'	

Source: Defourney and Thorbecke (1984)

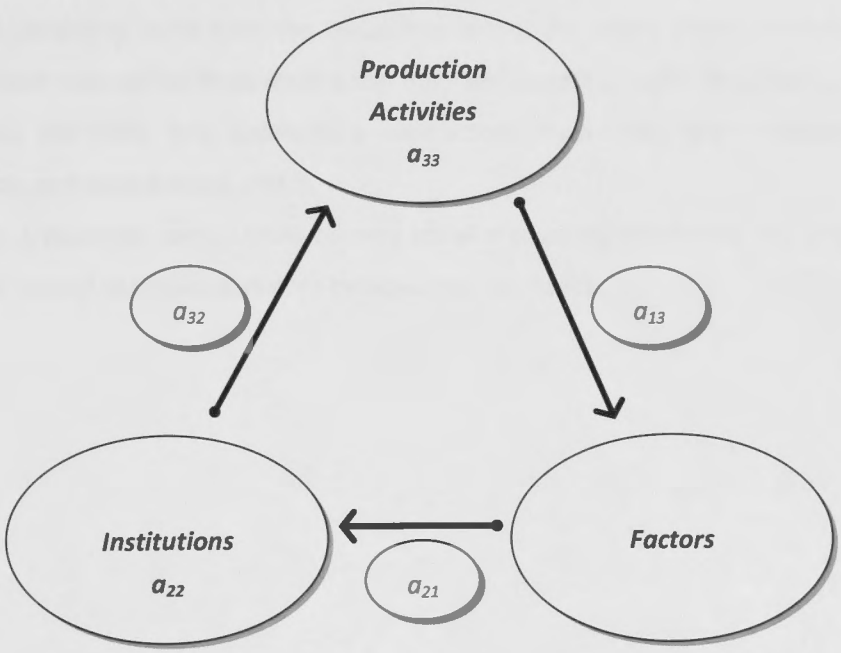
Figure 3.1. A Social Accounting Matrix

As an illustration, sub-matrix a_{13} in Figure 1 shows the amount of production factors used in production activities, which equates to the value added in the production sector, e.g. wages and salaries paid for the use of labor in production activities. Meanwhile, sub-matrix a_{21} shows the transfer payment from production factors to various institutions, namely households,

firms, and governments. For example, some farmers in the agricultural sector belong to the small-farmer association; as such, a certain amount of funds will flow from farmers (as a production factor) to the association (as an institution). Sub-matrix a_{22} shows transfer payments between institutions, such as subsidy payments from the government to households, or from firms to households, as well as transfer payments from one household to another.

On the other hand, sub-matrix a_{32} shows the demand for goods and services by institutions. In other words, this sub-matrix shows the amount of money paid by institutions to the production sector to buy the consumed goods and services. As for sub-matrix a_{33}, it shows the intra- and inter-industry demand for goods and services, specifically in the production sector. Lastly, aside from the aforementioned sub-matrices, a SAM also records economic activities in the financial sector as well as economic transactions with foreign countries, which are captured in the exogenous accounts.

Figure 3.2 illustrates how economic activities/transactions occur within an economy in which the arrows represent monetary flows.



Source: Defourney and Thorbecke (1984)

Figure 3.2. Economic Transactions between Agents

In general, a SAM provides information on the social structure within an economy, particularly information related to production structure, production factor conditions, household income distribution, and expenditure pattern of institutions. It is an important tool for analyzing social concerns, e.g. welfare implications of an exogenous change in institutional income, because it emphasizes origins and distribution of income as well as of expenditure. It also emphasizes disaggregation of institutions depending on study objectives, e.g. disaggregation of

households if the objective is to study income origins and distribution to different socio-economic groups of households (Matete, 2006). Accordingly, a SAM is the best approach to generate a general equilibrium analysis (Thorbecke, 1985).

3.2.1. Inter-Regional/Multi-Country Social Accounting Matrix

A social accounting matrix can also be constructed to include multiple regions or countries. In this type of SAM, blocks within an economy may receive transfers from various blocks in other economies, and vice versa. In order to know how these economies are inter-connected, it is necessary to construct macroeconomic SAMs for each of the member economies. The individual macroeconomic SAMs must then be joined into a single macroeconomic SAM (Resosudarmo *et al.,* 1999; Jellema *et al.*, 2004; McDonald and Thierfelder, 2004; Matete, 2006; Yusuf, 2007, Resosudarmo *et al.,* 2009).

In the case of a multi-country SAM, this involves converting the macroeconomic SAMs into a single currency using exchange rates then including trade flows among the member countries and subtracting these from the respective rest of the world (ROW) accounts. Also, factor-service flows and capital flows among the member countries might be added as well as inter-institutional transfers, with appropriate subtractions made from the respective ROW accounts (Reinert and Roland-Holst, 1997).

Figure 3.3 illustrates such a multi-country social accounting matrix. For the time being, transactions are limited to those conducted between two countries.

			EXPENDITURES									
	MC-SAM Classifications		Country 1				Country 2				ROW	TOTAL
			Fact.	Inst.	Prod.	O. A.	Fact.	Inst.	Prod.	O. A.		
RECEIPTS	Country 1	Factors	A_{11}				A_{12}				Z_1	Y_1
		Institutions										
		Productions										
		Other Accounts										
	Country 2	Factors	A_{21}				A_{22}				Z_2	Y_2
		Institutions										
		Productions										
		Other Accounts										
	Rest of the World		V_1				V_2					
	TOTAL		Y_1'				Y_2'					

Figure 3.3. Structure of a Multi-Country SAM

Variables within the endogenous accounts matrix are written as follows:

$$a_{ij}^{rs} \text{ where } i,j = 1,\ldots,n;\ r,s = 1,2 \qquad [3.1]$$

If $a_{ij}^{11} \in A_{11}; a_{ij}^{22} \in A_{22}; a_{ij}^{12} \in A_{12};$ and $a_{ij}^{21} \in A_{21}$, then the endogenous accounts matrix can be illustrated in a block matrix form as follows:

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \qquad [3.2]$$

where A_{11} and A_{22} are the inter-block flows within a country, while A_{12} and A_{21} are the inter-block flows between country 1 and country 2.

In this type of SAM, international trade is the key inter-country link, even when trade issues are not the main focus. However, 'current account' relations between countries overshadow their counterpart 'capital account' relations partly because of the issues being studied, but also because the numerical modeling of financial and asset-related flows is less well-developed. Data on bilateral flows of merchandise trade are also easier to obtain than similar data for capital flows. Nevertheless, empirical studies show that the multi-country model

produces non-trivial differences in the estimated impacts of policy experiments compared to a single country model, or even to a less integrated multi-country model (Hertel *et al.*, 1997; McDonald and Sonmez, 2004).

3.2.2. Structure of the ASEAN-SAM

The ASEAN-SAM that will be constructed has a similar structure to that shown in Figure 3.3. Table 3.1 provides a detailed list of sets that make up the components for the ASEAN-SAM. Factors of production consist of two types of labor, Unskilled and Skilled, and three types of non-labor factors, namely Land, Natural Resources, and Capital. As for institutions, there are six types: Corporate, Government, and four types of household, which are Rural-Low, Rural-High, Urban-Low, and Urban High. Note that the terms Low and High refer to households with income below and above the average respectively. Meanwhile, economic activities are divided into 57 production sectors. Lastly, other accounts consist of Indirect, Import, and Export Taxes as well as Savings-Investment.

The above-mentioned blocks are identical across all endogenous regions, i.e. in all six ASEAN member countries, henceforth called ASEAN[1]. As for Rest of the World, it has a different set of classifications. For example, it lacks an institutional block and includes all other exogenous accounts. These differences are further explained in the following section.

[1] Although Brunei, Cambodia, Laos, and Myanmar are official members ASEAN, they have been excluded due to severe limitation of available data.

Table 3.1. Detailed List of Sets

Production Sectors		Other Accounts
Paddy rice	Motor vehicles and parts	Indirect Tax
Wheat	Transport equipment *nec*	Import Tax
Cereal grains *nec*	Electronic equipment	Savings-Investment
Vegetables, fruits, and nuts	Machinery and equipment *nec*	
Oil seeds	Manufacturing *nec*	**Regions**
Sugar cane and sugar beet	Electricity	
Plant-based fibers	Gas manufacture distribution	Indonesia
Crops *nec*	Water	Malaysia
Cattle, sheep, goats, and horses	Construction	Philippines
Animal products *nec*	Trade	Singapore
Raw milk	Transport *nec*	Thailand
Wool silk-worm cocoons	Sea transport	Vietnam
Forestry	Air transport	Rest of the World[2]
Fishing	Communication	
Coal	Financial services *nec*	
Oil	Insurance	
Gas	Business services *nec*	
Minerals *nec*	Recreation and other services	
Meat: cattle, sheep, goat, and horse	Public administration, defense, health, and education	
Meat products *nec*	Dwellings	
Vegetable oils and fats		
Dairy products	**Factors**	
Processed rice		
Sugar	Unskilled Labor	
Food products *nec*	Skilled Labor	
Beverages and tobacco products	Land	
Textiles	Natural resources	
Wearing apparel	Capital	
Leather products		
Wood products	**Institutions**	
Paper products and publishing		
Petroleum and coal products	Rural-Low Household	
Chemical, rubber, and plastic products	Rural-High Household	
Mineral products *nec*	Urban-Low Household	
Ferrous metals	Urban-High Household	
Metals *nec*	Corporate	
Metal products	Government	

[2] Note that Rest of the World has a different set of classifications. It also includes all other exogenous accounts.

Meanwhile, Figure 3.4 provides a simplified schematic of the ASEAN-SAM with only two countries included. Note that inter-block flows within Country 1 and Country 2, i.e. A_{11} and A_{22}, are structurally identical; while inter-block flows between countries, i.e. A_{12} and A_{21}, are also are also analogous to one another. Although countries may have different economic structures, e.g. existence/absence of consumer sales tax – a common form can still be found by using the relatively simpler structure as a benchmark should additional data be unavailable, i.e. lowest common denominator form.

			EXPENDITURES									
		MC-SAM	Country 1				Country 2				ROW	TOTAL
		Classifications	Fact.	Inst.	Prod.	O. A.	Fact.	Inst.	Prod.	O. A.		
RECEIPTS	Country 1	Factors			a_{13}^{11}							y_1^1
		Institutions	a_{21}^{11}	a_{22}^{11}		a_{24}^{11}		a_{22}^{12}				y_2^1
		Productions		a_{32}^{11}	a_{33}^{11}	a_{34}^{11}		a_{32}^{12}	a_{33}^{12}	a_{34}^{12}	z_3^1	y_3^1
		Other Accounts		a_{42}^{11}	a_{43}^{11}				a_{43}^{12}	a_{44}^{12}	z_4^1	y_4^1
	Country 2	Factors							a_{13}^{22}			y_1^2
		Institutions		a_{22}^{21}			a_{21}^{22}	a_{22}^{22}		a_{24}^{22}		y_2^2
		Productions		a_{32}^{21}	a_{33}^{21}	a_{34}^{21}		a_{32}^{22}	a_{33}^{22}	a_{34}^{22}	z_3^2	y_3^2
		Other Accounts			a_{43}^{21}	a_{44}^{21}		a_{42}^{22}	a_{43}^{22}		z_4^2	y_4^2
	Rest of the World			v_2^1	v_3^1			v_2^2	v_3^2		x	z
	TOTAL		$y_1^{1\prime}$	$y_2^{1\prime}$	$y_3^{1\prime}$	$y_4^{1\prime}$	$y_1^{2\prime}$	$y_2^{2\prime}$	$y_3^{2\prime}$	$y_4^{2\prime}$	z'	

Figure 3.4. Simplified Schematic of the ASEAN-SAM

In Figure 3.4, a_{21}^{11} represents household income payment, e.g. household's revenue from labor income and capital interest. Next, a_{21}^{11} represents inter-institutional payment, such as government subsidy and income tax; a_{32}^{11} institutional payment for goods and services consumed; and a_{42}^{11} represents institutional savings. Meanwhile, a_{42}^{11} represents input factor payment for its use in production activities, e.g. labor wage and capital rent; a_{33}^{11} represents intermediate input production activities; and a_{43}^{11} represents indirect tax payment. a_{24}^{11} basically

represents government tax income, namely indirect and import taxes; while a_{34}^{11} represents purchases of goods and services for investment purposes. Note that up to this point, these cells represent *within* country activities. For example, goods and services purchased in these cells represent *domestic* goods and services. As such, everything from a_{21}^{22} to a_{34}^{22} in country 2 is the same as everything from a_{21}^{11} to a_{34}^{11} in country 1 by analogy.

Furthermore, cross-country activities are represented by the *other* diagonal matrices. a_{22}^{21} represents inter-institutional payment, i.e. household remittance from country 1 to country 2; and a_{32}^{21} represents imported goods and services purchased by institutions in country 1 from country 2. a_{33}^{21} also represents imported goods and services purchased from country 2, however, these are used as intermediate inputs by the production activities in country 1. As for a_{43}^{21}, it represents import tariff paid by country 1 to country 2 for goods and services exported from country 1 to country 2 as represented by a_{22}^{12}, a_{32}^{12}, a_{33}^{12}, and a_{34}^{12}. It is important to note that import tariff is paid by the exporting country to the importing country, such that the tariff rate in country 2 is represented by a_{43}^{21} divided by the summation of a_{22}^{12}, a_{32}^{12}, a_{33}^{12}, and a_{34}^{12}; and *not* by a_{43}^{12} divided by the summation of a_{22}^{12}, a_{32}^{12}, a_{33}^{12}, and a_{34}^{12}. Lastly, a_{34}^{21} represents imported goods and services from country 2 to country 1 used for investment purposes; and a_{44}^{21} represents net payment transfer. This payment is in the form of capital, though this is different from the 'capital' used in factors of production. This net payment transfer is needed for a *balanced* balance of payment due to, among others, bilateral trade deficit.

Before moving on to the next section, and all subsequent chapters, it is important at this point to understand the difference between intermediate goods and services *vis-à-vis* final goods and services. Intermediate goods and services are goods and services that are produced through and purchased for production activities, also known as intermediate inputs. Meanwhile, final goods and services are goods and services that are produced through production activities and purchased by final consumers, e.g. households, firms, and governments.

As such, a certain good or service produced can both be an intermediate good or service and a final good and service. For example, petroleum and coal products purchased by a household, e.g. diesel for a personal transport vehicle, would be considered a final good; whereas petroleum and coal products purchased by the electricity sector, e.g. diesel to generate electricity, would be considered an intermediate good.

Furthermore, the terms intra-regional and extra-regional simply refer to whether the goods and services are produced and purchased within the same country or in different

countries respectively. Therefore, intra-regional trade would refer to domestic goods and services, while extra-regional trade would refer to exports and imports of goods and services.

Through Figure 3.4, intermediate goods and services can easily be observed, represented by a_{33}^{11} , a_{33}^{12}, a_{33}^{21} , and a_{33}^{22}, as these are goods and services purchased for production activities. a_{33}^{11} and a_{33}^{22} also represent intra-regional trade within country 1 and country 2 respectively, while a_{33}^{12}, and a_{33}^{21} represent extra-regional trade between country 1 and country 2. Meanwhile, goods and services purchased by all the other sectors, represented by a_{32}^{11} , a_{34}^{11} , a_{32}^{12}, a_{34}^{12}, a_{32}^{21} , a_{34}^{21} , a_{32}^{22}, and a_{34}^{22}, are final goods and services with the difference between intra-regional and extra-regional being analogous to those in intermediate goods and services.

3.2.3. Data Sources

For the purpose of building the ASEAN-SAM in this chapter, the bulk of the database is derived from the Global Trade Analysis Project (GTAP) 7 Data Base. The GTAP 7 Data Base is the global database representing the world economy for a given reference year, i.e. 2004 for this latest version of the database. In the standard GTAP 7 Data Base, there are 57 commodities, 5 factors, and 113 regions. The commodities range from paddy to dwelling, while the factors are categorized into skilled labor, unskilled labor, capital, land, and natural resources. Meanwhile, the 113 regions are defined as aggregates of 226 countries using the GTAP standard country list (Narayanan G. *et al.*, 2008).

The GTAP 7 Data Base is the seventh major public release of the GTAP Data Base since the Project began in 1992 and uses 2004 as its reference year. The domestic databases or input-output (I-O) tables are combined with international datasets on macroeconomic aggregates, bilateral trade, energy, agricultural input-output, and protection for the new reference year (Narayanan G. and Dimaranan, 2008).

The primary data sources for the GTAP 7 Data Base are the regional input-output (I-O) tables, initially in national currency units, which are then scaled-up by the ratio of the gross domestic product (GDP) calculated from the I-O tables to external data, i.e. 2004 Real GDP in million of USD. Then, data on GDP aggregates, i.e. private consumption, gross capital formation, and government consumption, are used to update the values of these aggregates in the regional I-O tables (Aguiar and Dimaranan, 2008).

One potential transformation of the GTAP Data Base is its conversion from a format based on a form of input-output table with additional sub-matrices for trade and other transactions that are presented as a series of multi-dimensional sub-matrices into a single three

dimensional SAM format, henceforth known as the Global SAM. In other words, this SAM is basically an extension of the original input-output model with additional actors, e.g. households, government, and rest of the world, to the production sectors and presenting a complete flow of resources for the whole economy. In general terms, the Global SAM structure follows the conventions of the 1993 United Nations' System of National Accounts, albeit with adjustments in light of the limited data on intra-institutional accounts (McDonald and Thierfelder, 2004). The programs that carry out the transformation of the GTAP Data Base into the Global SAM format are freely available. Appendix 3.1 illustrates the Global SAM of a representative region.[3]

At this stage, the resultant SAMs are 'incomplete'. As such, there are two main reasons behind the modifications of these SAMs. The first reason has to do with the fact that the Global SAM is built from a country's input-output dataset such that it is bound to be less extensive than a 'true' SAM. This is readily apparent where institutional transfers are concerned. Only Private Household and Government are listed under institutions in the Global SAM. Additionally, Regional Household is created to compensate for the lack of information inherent in the GTAP 7 Data Base with regards to institutions. Although theoretically sound, empirically, this makes little sense.

The second reason for modifying the resultant SAMs lies in the inter-institutional international transfers. Each SAM basically represents an individual region which focuses heavily on the commodities sector, which is expected as it is built upon the input-output model of an individual country. As such, inter-regional transactions are focused on traded commodities, whereas inter-institutional international transfers are lacking.

As such, although GTAP and Global SAM have their own models, this study utilizes only the database. This study develops its own model, called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN).[4] This is simply because it is thus more relevant for economic-wide analytical purposes. Among others, highlights of this alternative model are the inclusions of income distributions among socio-economically disaggregated households and inter-institutional international transfers, i.e. remittance.[5]

Therefore, in order to ensure conformity between the Global SAM data and IRSA-ASEAN model, additional datasets have to be used. Following is a list of the additional datasets required to build the so-called ASEAN-SAM:

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[3] In the newer GAMS program for GTAP version 7, there are two notable terminological changes to those used in Appendix 3.1, namely Import Margins becomes Transport Margin and Rest of the World becomes Trade Margins.

[4] The new model shares some similarities with the Inter-Regional System of Analysis for Indonesia in Five Regions (IRSA-Indonesia5). See Resosudarmo *et al.* (2008) for the latter model.

[5] The next chapter will discuss the IRSA-ASEAN model in greater details.

Indonesia

1. 2005 Social Accounting Matrix; and
2. 2005 Inter-Regional Social Accounting Matrix (Resosudarmo *et al.*, 2008).

Malaysia

1. 2004/2005 Household Expenditure Survey;
2. 2004 Distribution and Use of Income Accounts and Capital Account;
3. 2000 Population and Housing Census; and
4. 1970 Social Accounting Matrix (Pyatt *et al.*, 1984).

Philippines

1. 2006 Family Income Expenditure Survey;
2. 2000 Social Accounting Matrix (Cororaton and Corong, 2009); and
3. 1997 Family Income Expenditure Survey.

Singapore

1. 2008 Yearbook of Statistics; and
2. 2002/2003 Report on the Household Expenditure Survey.

Thailand

1. 2008 Key Statistics;
2. 2002 Household Socio-Economic Survey; and
3. 1998 Social Accounting Matrix (Li, 2002).

Vietnam

1. 2004 Living Standard Survey; and
2. 1997 Social Accounting Matrix (Nielsen, 2002).

Others

1. 2010 World Development Indicators;
2. 2008 ASEAN Statistical Yearbook;
3. 2005 ASEAN Statistical Yearbook;
4. 2005 Bilateral Remittance Estimates (Ratha and Shaw, 2007); and
5. 2004 Combustion-Based CO_2 Emissions Data for GTAP Version 7 (Lee, 2008).

There is a good reason for using GTAP as the main dataset instead of using an official country-specific SAMs in the construction of the ASEAN-SAM. This is because an official SAM is not always available for every country, or does not even exist at all, as in the case of Singapore. Even for countries for which a SAM is constructed (both officially and unofficially), one is not available for every year, e.g. the latest publicly available SAM for Malaysia is 1970. As such,

SAMs from different countries would most likely use different reference years, not to mention currencies and categorical definitions, e.g. different commodities and household disaggregation. In this regard, GTAP provides a common ground to which a SAM for one country can be created relatively easily and compared to another. Nevertheless, country-specific SAMs are still used to enrich the database and ensure compatibility with the model.

Lastly, with regard to the final data source used, the combustion-based CO_2 emissions data, the data is kept as a separate matrix. Although this is not explicitly included in the ASEAN-SAM, it is still an integral part of the ASEAN-SAM for modeling purposes. This separate matrix is essential when conducting energy and environmental policy impact analysis.

As to the data on the combustion-based CO_2 emissions itself, Lee (2008) calculates the data from GTAP energy volume data in order to ensure an internal consistency in terms of classification of uses as well as consistency between values and volumes. Unit of CO_2 emissions is gigagram (Gg), while unit of energy consumption is ton of oil equivalent (toe). The Tier 1 method of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC *et al.*, 1997) is adopted in the calculation to estimate CO_2 emissions from the energy consumption.

By far the largest source of CO_2 emissions is from the oxidation of carbon when fossil fuels are burned, which accounts for 70-90 per cent of total anthropogenic CO_2 emissions. When fuels are burned, most carbon is emitted as CO_2 immediately during the combustion process. Some carbon is released as CO, CH_4, or non-methane hydrocarbons, which oxidize to CO_2 in the atmosphere within a period from a few days to 10-11 years. The IPCC methodology accounts for all of the carbon from these emissions in the total for CO_2 emissions.

The estimation process can be divided into six steps that lead to figures for CO_2 emissions from fuel combustion.

1. Estimate consumption of fuels by fuel/product type.
2. Convert the fuel data to a common energy unit, i.e. terajoule (TJ), if necessary.
3. Select carbon emission factors for each fuel/product type and estimate the total carbon content of the fuels.
4. Estimate the amount of carbon stored in products for long periods of time.
5. Account for carbon not oxidized during combustion.
6. Convert emissions of carbon to full molecular weight of CO_2.

In reality, CO_2 emissions, as well as other greenhouse gases, depend on the fuel type used, combustion technology, operating conditions, control technology, as well as on maintenance and age of the equipment. If countries have more exact national emission factors, these factors should be used instead of the default factors. Also, countries wanting to do more

detailed emission estimations may use the Tier 2 method, or even the Tier 3 method. However, since it is unlikely that many countries will have this detailed data, the Tier 1 method ignores these refinements and classifies fossil fuel combustion into coal, oil, and gas.

The purpose of a Tier 1 method, as adopted by Lee (2008), is to assist countries that cannot access detailed fuel use and technology data to develop emission inventories. The Tier 1 method enables at least rough emission estimations of CO_2, CH_4, N_2O, NO_x, CO, and NMVOC using energy statistics, as well as of SO_2 by using additional assumptions on the sulphur content of the fuels. The Tier 1 method should be used in cases where no detailed information is available on fuel type, technology, and operating conditions (IPCC *et al.*, 1997).

3.3. Constructing the ASEAN-SAM

The construction of the ASEAN-SAM for modeling purposes in following chapters is divided into three phases. These phases are outlined in this section. The first phase involves the preparation of the GTAP Version 7 Data Base. Phase 2 lists the steps required to transform the individual Global SAM into a standard form. Lastly, Phase 3 is when all individual SAMs are combined to form the ASEAN-SAM.

3.3.1. Phase 1: Pre-SAM

In the original GTAP 7 Data Base, there are 57 commodities, 5 factors, and 113 regions. For the purpose of this study, factors are not aggregated. They are left in their original categories in order to provide as many details as possible for analytical purposes. On the other hand, commodities are aggregated into 26 sectors due to the technical difficulties of dealing with such a large number of commodities in the modeling. Also, countries are aggregated into seven regions, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, and Rest of the World. The first six regions are in this study defined as ASEAN.[6]

The transformation of a database to a SAM format does involve some complications, such as resolving differences in the terminology used in the GTAP literature and SAM literature as well as addressing technical issues such as ensuring that all commodities are valued at a common price. Fortunately, McDonald and Thierfelder (2004) provides both the technical note and General Algebraic Modeling System (GAMS) program. What this program does is to create a balanced SAM for each region. For the purposes of this study, seven SAMs are created based on the aggregation of the regions. Note that intra-regional transaction flows in the Rest of the

[6] Other ASEAN members, namely Brunei, Cambodia, Lao, and Myanmar, are not included in this chapter, and by extension in all following chapters, as their data are sorely lacking.

World region are not needed. Only accounts that deal with other regions are necessary for the ASEAN-SAM.

3.3.2. Phase 2: Global SAM

The first 15 steps required to prepare each SAM before merging them all into one are as follows:

1. *Aggregating Taxes*

   There are seven blocks for taxes in the Global SAM with Trade Taxes consisting of Export and Import Taxes. Five other taxes can be 'lumped' together as Indirect Taxes; they are Import Sales Taxes, Domestic Sales Taxes, Factor Taxes, Production Taxes, and Export Tax. This means aggregating five blocks into one block by row and column.

2. *Creating Production Activities*

   Production Activities in the ASEAN-SAM consist of three blocks, namely Imported Commodities, Domestic Commodities, and Activities. Imported Commodities should be left alone for now, whereas Domestic Commodities and Activities can simply be aggregated in the same way as taxes. The only noteworthy difference is the erasure of the Supply Matrix. As this is a diagonal matrix, the Supply Matrix can simply be excluded from the SAM without any complications.

3. *Dealing with Regional Household*

   Conceptually, Regional Household consists of Private Household and Government Household. It is a relatively easy task to separate these to components. Row components can simply be transferred in its entirety directly to either Private Household or Government. Distributed Factor Incomes from Factors are transferred entirely to Private Household, whereas taxes and duties are transferred directly to Government. Column-wise, it is not quite as simple.

   Although Private Household Income and Government Income can be entirely dropped off from the SAM as they are included as components of Distributed Factor Incomes along with duties and taxes, additional information is needed to balance the SAM. The key lies in Savings. Knowing a government's fiscal balance and using its ratio to GDP for the reference year is essential. In this regard, the ASEAN Statistical Yearbook is sufficient to fulfill this requirement.

Once known, the ratio can then be used to find the nominal value for Government Savings and differentiate it from Private Household Savings. For the purpose of balancing the SAM, total Private Household Income is held constant with adjustments being made in the Government transfer to Private Household, i.e. Net Government Transfer.

4. *Creating Firms*

Adding a new block for Firms is quite straightforward for countries for which recent SAMs are available, i.e. Indonesia, Philippines, Thailand, and Vietnam. This is particularly true as only Private Household Savings, Private Household Factor Incomes, and Net Government Transfer need to be disaggregated. These can be done by taking the ratio of the two institutions.

In the case of Singapore, the Household Income Expenditure Survey is sufficiently complete to disaggregate these components. As for Malaysia, Savings and Net Government Transfer are disaggregated using ratios obtained from the Income and Capital Accounts Distribution. However, for lack of a better data, Private Household Factor Incomes disaggregation uses the 1970 SAM. The use of such an old dataset may be debatable. However, until the 2000 Malaysian SAM becomes publicly available this will have to suffice.

Note that the entirety of Private Demand goes to Private Household as Firms' demand has already been taken into account by Intermediate Inputs. Bear in mind as well that the Firms block does not receive any Distributed Factor Incomes from Unskilled Labor and Skilled Labor as only Private Household can provide these Factors. Also, assumptions have to be made as sets for Factors may differ from the Global SAM, e.g. Natural Resources may have to use the same ratio as Capital, Land, or Non-Labor Factors in its disaggregation between Private Household and Firms.

At this point, a short explanation is needed with regard to the construction of the ASEAN-SAM. Up to now, steps taken above can also be applied generically for any Global SAMs. In other words, the reasoning behind the steps taken hold true for non-ASEAN countries, without any significant fundamental differences from any official country SAMs. Conversely, steps taken hereon are aimed at making these SAMs, and in turn the ASEAN-SAM, compatible with the IRSA-ASEAN model, while bearing in mind economic characteristics of ASEAN countries.

5. *Removing Direct Taxes*

In the Global SAM, Direct Taxes receive payments from Factors and send payments to Government. This can be simplified with Factors sending payments directly to Government. This is very straightforward and does not require any adjustments elsewhere. Once this is done, the column and row of Direct Taxes can be expunged.

6. *Transferring Indirect Taxes*

As indicated in Step 1, Indirect Taxes also include Sales Taxes, Factor Taxes, and Production Taxes. These taxes are paid by Production Activities, Private Household, Government, and Capital. In order to conform to the IRSAM, only Production Activities pay Indirect Taxes, as Sales Taxes do not apply in Indonesia. To resolve this, Sales Taxes in the other three blocks must be 'returned'. This problem is solved by adding payments made to Indirect Taxes the other three blocks' demand. Column-wise, this method does not change the total expenditure of these three blocks. The next stage would be to increase payments from Production Activities to Indirect Taxes by the total amount of Sales Taxes paid by the three blocks.

7. *Transferring Labor Payments*

Similar to Step 4 in which only Private Household receives payments from both Unskilled and Skilled Labors, the same condition also applies for Government. As such, labor payments to Government are transferred to Private Household. In order to maintain a balanced SAM, adjustment needs to be made in the transfer payment from Government to Private Household, i.e. Net Government Transfer.

8. *Transferring Depreciation*

One small 'quirk' of the Global SAM is the existence of Depreciation, which is a direct payment from Factors to Savings-Investment[7]. To simplify the SAM, Depreciation is added to Factor payments to Firms. This is balanced by adding Depreciation to Firms payments to Savings-invesment created in Step 4.

9. *Disaggregating Private Household*

This step is the final step before combining individual country SAMs into the ASEAN-SAM. Incidentally, this is also the hardest step in terms of external data requirements. This step is optional, even with regard to the IRSA-ASEAN model. However,

[7] In the Global SAM, the Savings-Investment block is called the Capital block as shown in Appendix 3.1. The terminology is changed to avoid confusion with Capital as a component of Factors.

disaggregating Private Household by socio-economic groups would simply provide much richer results for analytical purposes.

As such, Private Household is disaggregated into four different groups, namely Rural-Low, Rural-High, Urban-Low, and Urban-High. The terms 'rural' and 'urban' are quite straightforward, although for Singapore, neither Rural-Low or Rural-High exists as all of its population lives in an urban area. As for Thailand, the country uses the terms 'non-municipal' and 'municipal' areas in its surveys. For the purpose of uniformity, those terms are treated exactly as 'rural' and 'urban' areas respectively without any complications. One minor adjustment to this is the 'Greater Bangkok' area, which is sometimes separated in surveys. In cases where this area exists, it is added into 'urban' area. Meanwhile, the terms 'low' and 'high' neither refer to the poverty line nor half of the population. The terms instead refer to those below and above the average income per capita or (whenever possible) the average income per household respectively.

The key in disaggregating Private Household lies in three areas, namely determining Private Demand, Savings, and Distributed Factor Incomes. This is then balanced by the Government Transfer. In most cases, the demand pattern for imported goods and services is the same as domestic goods and services. This is due to the lack of data as household expenditure surveys do not differentiate between imported goods and services with domestic goods and services, nor should it matter much as, arguably, deciding *what* product to buy is more important than deciding *which* product to buy based on origins. Nevertheless, the substitution between imported and domestic is included in GTAP as it has differentiated imported *vis-à-vis* domestic commodities

In the case of Indonesia, disaggregation of Private Household can be done in one stage using the 2005 SAM. Urban and rural areas are explicitly defined as such in the 2005 SAM although adjustments still have to be made for the low and high categories. This is because, aside from areas, household and labor blocks are categorized by professions instead of income per capita. However, the accompanying document lists the average income per capita for each profession such that assumptions can be made to disaggregate household income groups (BPS, 2008). These assumptions are also used as the labor block in the 2005 SAM is aggregated, whereas in GTAP, and by extension the ASEAN-SAM, labor is disaggregated into Unskilled and Skilled labors.

For Vietnam, disaggregation of rural and urban is carried out using information from the 1997 SAM, while disaggregation of income groups uses information from the 2004 Living Standard Survey (LSS). The 2006 LSS also exists, however, it is not used because the GTAP reference year is also 2004 and the 2006 survey no longer separates rural and urban areas. Thailand basically uses the same method as Vietnam although it

relies also on the Household Socio-Economic Survey (HSES) for the disaggregation between rural and urban areas. Meanwhile, Singapore uses the Household Expenditure Survey (HES) to disaggregate income groups only, as it is assumed that rural area does not exist in the country.

Disaggregation of the Private Household the Philippines is similar to the method used for Thailand. However, its disaggregation uses two reference years of the same survey, namely the Household Income Expenditure Survey (HIES), instead of one. This is because the 1997 HIES separates rural and urban areas, while the 2006 HIES separates income groups. In contrast, the 2000 and 2003 HIES do neither. One added assumption in the case of Philippines is that the ratio of income groups is the same for both urban and rural areas. In other words, the proportion of those below and above the income per capita in rural and urban areas is the same.

Last is the disaggregation of Malaysia. It is the hardest to do due to data constraints. Disaggregating Private Demand and Savings is similar to the case of Thailand, although the population census is needed in order to find the total values of household expenditure as they are presented in percentage form in the survey. A judgment call has to be made in determining each household share for disaggregating Distributed Factor Incomes as income statistics are generally unavailable to the public. As such, information on income distribution from World Development Indicators (WDI) has to be used with adjustments made to Net Government Transfer.

3.3.3. Phase 3: Combination SAM

The next stage is to combine these six country SAMs into one single multi-country SAM.

10. *Combining Country SAMs into a Multi-Country SAM*

To simplify this process, the square matrix containing Factors, Institutions, Indirect Taxes, and Savings-Investment blocks can be pasted and combined to make up the diagonal matrices. At this point, inter-country matrices can only be filled by Savings-Investment transfer. Note that this is a one-way flow, i.e. Net Savings-Investment, so as to avoid double-accounting problems. Other blocks, namely Imported Commodities, Import Taxes, Transport Margins, Export Margins, and Trade Accounts require some treatments. Also, Rest of the World is also included as the seventh region in the combined SAM.

11. *Transferring Other Accounts*

One component from Other Accounts is still missing, namely Import Taxes. In this regard, the row and column should be left alone and inserted to fill in the inter-country matrix. A note of caution is needed here as import tariffs refer to payment received by country 1 from country 2 for goods and services from country 2 to country 1. Referring back to the previous section, a_{43}^{21} corresponds to a_{22}^{12}, a_{32}^{12}, a_{33}^{12}, and a_{34}^{12}.

12. *Dealing with Imported Commodities*

This step essentially deals with the trade aspect of an inter-country link. As the Global SAM consists of balanced SAMs, there are two ways to obtain these values, from either the export or import side. However, because Imported Commodities are disaggregated it is better to look at trade link from imports rather than exports. Three blocks in the ASEAN-SAM receive Imported Commodities, namely Institutions, Production Activities, and Savings-Investment. In order to fill in these blocks, ratios obtained from Trade Margins can be used and then multiply them with Imported Commodities.

One important assumption resulting from this method is that substitution of a given product by country of origin only occurs at the country level. Thus, once a product enters the country, it becomes part of a pool of products and domestic consumers can no longer differentiate the country of origin. As such, for example, if 40 percent of all imported paddy in Indonesia comes from Vietnam then 40 percent of imported paddy purchased by each household group also comes from Vietnam.

Bear in mind that Imported Commodities send payment to Indirect Taxes. Thus, Indirect Taxes should be disaggregated by countries using the same ratios from Trade Margins then add these values to Import Taxes, as all taxes paid by foreign goods and services are classified as Import Taxes. To balance this, simply subtract the total value of Indirect Taxes paid by Production Activities abroad from Indirect Taxes payments to Government in the diagonal matrix, while adding the same value to Import Taxes payments to Government.

13. *Removing Transport Margins and Export Margins*

As for Transport Margins and Export Margins, these two blocks can be inserted into the combined matrix without too much complication. Simply take into account countries of origin and destination. Note that once this is done, total values for Transport Margins and Export are exactly the same. As such, redefine the Export Margins column as Transport Margins then remove the original Transport Margins column and Export

Margins row. As Imports of Transport Services is a diagonal matrix, removing the previously mentioned column and row requires no further adjustment.

Removing Transport Margins is done by transferring payments to Transport Margins by Production Activities into Intermediate Inputs. These values are then transferred to Capital in the diagonal matrix, which increases its transfer to Firms. In turn, the entirety of Transport Margins is transferred back into Savings-Investment by Firms. Finally, simply remove the Transport Margins row and column for each country.

At this juncture, the combined SAM should be balanced. Any existing imbalances are caused by human errors. Double-check that all six SAMs resultant from Step 9 are balanced. If so, redo Step 10 to Step 13. Otherwise, retrace each step before Step 9 and make sure that between each step, the SAMs are balanced.

14. *Adding Remittance*

In the ASEAN-SAM, remittance is the component that basically makes up inter-institutional international transfers, or in other words, transfers between households in different countries. Bilateral Remittance Estimates provide these values although they have to be adjusted by the ratio of GTAP GDP to World Bank 2005 GDP. The resulting bilateral remittance values between the six countries chosen can then be used in the ASEAN-SAM.

The method of inserting these values is quite straightforward. Use the bilateral remittance value between two countries and subtract household transfer to Savings-Investment in the receiving country. This is then followed by subtracting the total remittance value from Net Savings-Investment and adding the same value in the household transfer to Savings-Investment in the sending country. Lastly, add remittance to the inter-household transfer within the inter-country matrix. This procedure is also valid if started from the inter-household transfer within the inter-country matrix.

Difficulties do not arise from the procedure. They arise from the decision on how to disaggregate total remittance among household groups. No data exists to resolve this problem, and thus arbitrary decisions based on common sense must be taken. This will be further discussed in the next section when the resultant ASEAN-SAM is discussed.

15. *Finishing the ASEAN-SAM*

This marks the final step in the construction of the ASEAN-SAM. It consists of, among others, moving all negative values by transposing them to avoid problems with the GAMS program. Lastly, check import tariff rates as these values might change slightly

due to rounding off and treatments of exogenous accounts, e.g. transport cost. Lastly, final balancing may be necessary due to rounding off in which case it is recommended that these residuals are added into the exogenous accounts, i.e. Rest of the World. Otherwise, the ASEAN-SAM should already be balanced.

The last thing to consider is the disaggregation of CO_2 emissions. Note that this is strictly optional and depends on the model to be used. Also, this dataset is not included in the ASEAN-SAM and it is kept as a separate matrix. Nevertheless, in order to make this dataset compatible with the ASEAN-SAM, disaggregation of Private Household must be carried out.

For Co_2 emissions, simply disaggregate Private Household using household group expenditure ratios for the following commodities: Coal, Oil, Gas, Petroleum and Coal Products, Electricity, and Gas Manufacture Distribution. Note, however, Electricity does not actually emit any CO_2 emissions. Also, Oil, Gas, and Petroleum and Coal Products are combined to comply with the ASEAN-SAM as definitions differ slightly between the two datasets. Nevertheless, the resulting classifications for fossil fuel combustion are coal, oil, and gas, i.e. gas manufacture distribution.

3.4. Summary Results

This section presents some highlights from the resulting ASEAN-SAM. It starts off by checking for inconsistencies in the ASEAN-SAM. Table 3.2 does so by comparing macroeconomic data from the original database with those derived from the resulting ASEAN-SAM. The top row for each country shows the original data whereas the bottom row shows data from the ASEAN-SAM. Also, from here on, all nominal values are in million of USD.

Table 3.2. Macroeconomic Data

	Private Consumption	Fixed Investment	Government Expenditure	Export	(Import)	GDP
Indonesia	174,751	49,317	20,035	87,546	76,947	254,702
	174,751	*49,317*	*20,035*	*89,212*	*78,612*	*254,703*
Malaysia	37,373	17,316	11,641	154,900	106,330	114,899
	37,373	*17,316*	*11,641*	*154,873*	*106,302*	*114,901*
Philippines	58,937	14,118	8,754	51,493	48,825	84,476
	58,936	*14,118*	*8,754*	*51,491*	*48,822*	*84,476*
Singapore	55,286	31,396	13,912	166,879	160,659	106,814
	55,286	*31,396*	*13,911*	*168,038*	*161,818*	*106,813*
Thailand	86,874	40,344	16,129	121,157	102,807	161,698
	86,874	*40,344*	*16,129*	*121,174*	*102,823*	*161,698*
Vietnam	29,139	15,073	2,798	32,654	36,637	43,026
	29,139	*15,073*	*2,798*	*32,660*	*36,643*	*43,027*
Rest of the World	24,731,806	8,562,155	6,992,848	9,874,941	9,957,366	40,204,384
Total	25,174,166	8,729,719	7,066,115	10,489,570	10,489,570	40,970,000

Source: GTAP Version 7 Data Base and author's calculation. Unit is in 2004 USD million.

Overall, the macroeconomic indicators are mostly consistent with the original GTAP 7 database. The most obvious thing to check at first is, of course, GDP. For most countries, the differences arise only from the final unit. This is quite acceptable as it is most likely due to rounding. Looking at the GDP breakdown, it is clear that the largest discrepancies arise in the trade data. Bear in mind, however, that trade data contains the largest matrix dimension with 26 commodities by 26 sectors by 6 inter-country links. As such, residuals are more prevalent here than in any other blocks. Also, some differences arise as some accounts are exogenized in the ASEAN-SAM, e.g. export margins and transportation cost. Nevertheless, their effects cancel out each other and the values of GDP, Private Consumption, Government Expenditure and Fixed Investment are consistent.

Moreover, another purpose for constructing the ASEAN-SAM is to look at the impacts of an economic policy on households disaggregated by socio-economic groups, namely Rural-Low, Rural-High, Urban-Low, and Urban-High. Table 3.3 breaks down Private Consumption in order to examine the expenditure patterns of these households. Note that goods and services have been aggregated further into 14 categories for the simple reason of convenience.

Table 3.3. Household Expenditure Patterns

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Indonesia	Rural	Low	35.92	5.34	3.13	2.73	13.74	1.32	6.64	7.20	0.72	14.17	2.50	4.46	2.06	0.07	100
		High	22.87	3.12	3.68	4.66	18.50	2.21	10.39	9.12	1.53	13.34	3.13	3.26	4.07	0.12	100
	Urban	Low	21.75	3.25	2.92	3.94	23.47	2.19	8.81	8.34	1.27	13.21	3.54	3.48	3.74	0.10	100
		High	18.28	2.73	2.71	4.03	20.06	2.93	11.37	10.19	1.67	13.11	4.51	3.06	5.22	0.14	100
Malaysia	Rural	Low	30.72	8.50	5.80	7.56	2.63	2.94	24.15	3.08	0.55	8.66	2.79	0.26	2.36	0.00	100
		High	13.05	4.54	5.36	4.36	1.52	1.69	36.40	12.33	0.75	9.42	6.00	0.36	4.21	0.01	100
	Urban	Low	21.76	7.10	5.67	8.89	3.10	3.46	26.44	5.07	0.86	10.07	4.27	0.31	3.00	0.01	100
		High	9.33	3.08	3.65	6.22	2.17	2.42	37.98	11.85	1.01	9.17	8.07	0.45	4.62	0.01	100
Philippines	Rural	Low	41.58	7.32	3.13	2.10	4.54	2.37	5.65	3.17	1.05	17.70	1.19	1.81	8.28	0.11	100
		High	25.84	3.88	3.78	2.24	6.94	2.53	9.27	6.79	2.25	18.19	3.39	5.71	9.06	0.11	100
	Urban	Low	34.98	4.94	2.86	2.52	6.18	2.84	6.13	5.80	1.92	19.25	2.16	2.38	7.92	0.13	100
		High	19.42	2.34	3.08	2.40	8.43	2.71	9.09	11.11	3.68	17.67	5.48	6.73	7.73	0.12	100
Singapore	Urban	Low	8.74	2.87	4.13	0.79	8.33	2.01	16.09	7.46	1.64	28.09	3.46	11.34	5.06	0.00	100
		High	5.27	1.14	3.67	0.44	7.23	1.11	14.77	13.93	1.16	25.86	3.71	10.68	11.05	0.00	100
Thailand	Rural	Low	24.12	6.10	12.02	4.86	10.23	2.88	11.26	4.71	0.42	14.47	3.54	0.82	3.95	0.61	100
		High	12.18	4.85	12.21	6.29	7.01	1.96	12.15	17.03	1.33	13.00	5.43	1.01	5.01	0.55	100
	Urban	Low	15.93	8.61	7.52	4.43	7.98	3.24	11.16	8.46	1.87	16.34	6.23	1.68	5.88	0.69	100
		High	6.71	2.78	9.41	7.27	8.11	2.21	10.31	19.99	2.07	13.87	8.48	1.84	6.36	0.58	100
Vietnam	Rural	Low	36.53	7.59	12.99	3.08	0.01	5.53	12.14	6.56	0.22	0.82	0.67	6.98	6.45	0.43	100
		High	26.62	7.59	10.80	3.60	0.01	8.27	13.15	8.41	0.37	1.22	4.12	7.48	8.08	0.27	100
	Urban	Low	24.84	7.07	8.62	4.00	0.01	4.15	16.12	10.23	0.45	0.83	2.35	10.32	10.70	0.32	100
		High	16.17	6.11	6.17	4.03	0.01	5.36	15.15	11.54	0.66	1.07	12.43	9.55	11.58	0.18	100

Source: Author's calculation.

Note that:

1 Food	9 Communication
2 Beverages and Tobacco	10 Trade
3 Clothing and Footwear	11 Recreation Services and Culture
4 Petroleum and Coal Products	12 Public Administration, Defense, Health, and Education
5 Housing	
6 Water, Electricity, and Gas	13 Business and Financial Services
7 Furnishings, Household Equipment, and Maintenance	14 Miscellaneous Goods and Services
	15 Total
8 Transport	

In Table 3.3, the first noticeable pattern is that share of food consumption decreases as income increases. Those in lower income groups tend to spend most of their income on food. Meanwhile, the opposite holds true for Trade in which those within higher income groups trade more. One important result from these two phenomena is that even without knowing the exact average income for each household group, it can be inferred within a country which household group has a higher average income per household.

As for energy and environmental policy implications, there are three related sectors in the table, namely Petroleum Products, Transport, and Utilities. Petroleum Products appears to be similarly used by all household groups in most countries, except for Indonesia and Thailand. Meanwhile, the use of transportation increases progressively with income in all countries. At the same time, utility consumption patterns are quite different between countries. As such, should a regional policy in energy be adopted across the board, its impact would be quite significantly different between countries. Arguably, an undertaking in which such a policy is adopted is doomed to fail from the start unless country-specific considerations are granted, e.g. a compensation scheme for low-income groups.

Meanwhile, Table 3.4 shows a breakdown of household income sources. Basically, households receive income from labors, both Unskilled and Skilled Labors, Land, Natural Resources, Capital, Government Transfer, and Remittance. Also, aggregating incomes and subtracting Savings yields Private Consumption.

The most interesting thing to note here is Government Transfer. Note that a positive sign shows a net transfer from the government, i.e. subsidy, whereas a negative sign shows a net transfer to the government. In other words, a negative sign under Government Transfer means that the household is giving more than it receives from the government in terms of cash transfer. Surprisingly, in Indonesia, Philippines, Thailand, and Vietnam, the lowest income group receives less government help than some higher income groups. One possible explanation is geography. Those in the lowest income group, i.e. Rural-Low, receive less help from the

government because they cannot be reached due to their location. Those living in the remote areas with few government facilities are most likely to fall into this household income group.

Furthermore, by inverse logic, those in the highest income group, i.e. Urban-High, are also less likely to receive government handouts than are those in Urban-Low and Rural-Low groups. Also, classifying those living in urban areas by income group is much easier to do, such that capture, or 'leakage', from a government policy to help low income groups is less likely to occur. This holds true for all countries, except for Vietnam.

Table 3.4. Household Incomes

			Labors		Land	Natural	Capital	Gov't.	Remit.	(Savings)	Total
			Unskilled	Skilled		Res.		Transfer			
Indonesia	Rural	Low	7,250	212	274	181	1,952	21,535	298	4,923	26,777
		High	26,261	4,756	2,093	1384	14,928	35,932	29	15,384	70,000
	Urban	Low	7,519	1,818	995	657	7,093	32,577	216	7,041	43,833
		High	35,582	12,464	1,018	673	7,260	-11,230	74	11,700	34,141
Malaysia	Rural	Low	2,484	793	19	80	520	2,275	29	1,624	4,622
		High	7,452	2,378	57	241	1,561	-323	143	6,009	5,403
	Urban	Low	7,457	2,379	58	241	1,562	4,989	87	5,307	11,718
		High	22,370	7,138	173	724	4,687	-477	316	18,038	16,691
Philippines	Rural	Low	827	339	396	104	1,178	1,139	138	410	3,711
		High	4,721	1,938	788	207	6,702	3,172	68	2,172	15,424
	Urban	Low	2,313	950	543	143	2,895	1,007	140	946	7,044
		High	13,214	5,424	1,079	284	16,467	2,539	146	6,393	32,760
Singapore	Rural	Low	0	0	0	0	0	0	0	0	0
		High	0	0	0	0	0	0	0	0	0
	Urban	Low	7,278	4,376	10	7	5,998	7,410	0	4,461	20,616
		High	21,134	12,707	30	20	17,417	-7,500	0	8,438	35,370
Thailand	Rural	Low	3,316	1,354	673	9	750	10,719	61	848	16,035
		High	5,912	2,415	1,031	133	5,582	12,079	1	1,800	25,353
	Urban	Low	6,213	2,537	588	193	2,448	5,496	21	1,478	16,017
		High	12,837	5,243	911	676	14,527	-2,335	4	2,380	29,483
Vietnam	Rural	Low	4,502	500	558	468	0	1,675	5	152	7,555
		High	5,634	1,673	1,297	1,088	0	3,652	0	242	13,103
	Urban	Low	1,234	449	36	31	0	1,229	2	162	2,820
		High	1,545	1,502	85	71	0	2,720	0	262	5,660

Source: Author's calculation. Unit is in 2004 USD million.

Table 3.5 provides disaggregated bilateral remittance estimates modified from the work of Ratha and Shaw (2006). The table shows that households in Indonesia receive about USD 617 million from Indonesians working abroad in 2004 within the region. These payment transfers come from Indonesians working in Malaysia, Philippines, Singapore, and Thailand. Note that

Indonesia also receives remittances from other countries outside of ASEAN, e.g. Middle East. However, these transactions are not listed and disaggregated as these would all be *lumped* together in the exogenous account along with other transactions from the rest of the world.

Meanwhile, Malaysia receives transfers from Singapore and Thailand, whereas the Philippines receives transfers from Malaysia and Thailand. Lastly, Thailand receives from Malaysia and Vietnam from Thailand. Interestingly, there are no remittance transfers from Indonesia and Vietnam, while Singapore does not receive any remittance from other countries in the region. However, this does not imply the absence of workers' migration within these countries but simply mean that the amount being transferred is not significant.[8]

There is, however, an underlying assumption being imposed when bilateral remittance estimates are disaggregated. There is no readily available data on inter-institutional transfers such that author's judgment and knowledge (limited as they are) of each country's economic characteristics are the main basis for disaggregating remittance estimates.

[8] The cut-off value is US$ 1 million in Ratha and Shaw (2007).

Table 3.5. Bilateral Remittance Estimates in 2004

		Malaysia				Philippines	Singapore		Thailand		Total	
		Rural-Low	Rural-High	Urban-Low	Urban-High	Urban-Low	Urban-Low	Urban-High	Rural-Low	Urban-Low		
Indonesia	Rural-Low	92.43		145.94		1.78	56.93			0.59	297.68	616.55
	Rural-High		29.19								29.19	
	Urban-Low	72.97		97.29		0.89	44.28			0.3	215.74	
	Urban-High				48.65			25.3			73.95	
Malaysia	Rural-Low						28.69			0.56	29.25	575.53
	Rural-High							143.46			143.46	
	Urban-Low						86.08			1.11	87.19	
	Urban-High							315.62			315.62	
Philippines	Rural-Low	29.29		107.38					0.27	0.8	137.74	492.37
	Rural-High		68.33								68.33	
	Urban-Low	48.81		87.86					0.8	2.4	139.87	
	Urban-High				146.43						146.43	
Thailand	Rural-Low	43.97		16.54							60.52	87.07
	Rural-High		1.31								1.31	
	Urban-Low	15.67		5.22							20.9	
	Urban-High				4.35						4.35	
Vietnam	Rural-Low								1.63	3.26	4.89	7.33
	Urban-Low								0.81	1.63	2.44	
Total		303.14	98.83	460.25	199.43	2.67	215.99	484.39	3.51	10.65		
		1061.65					700.37		14.16			

Source: Ratha and Shaw (2007) and author's calculation. Unit is in 2004 USD million.

3.5. Concluding Remarks

Even with its limitations, the GTAP Version 7 Data Base provides a good starting point to construct a social accounting matrix for any country and, in turn, a multi-country SAM, e.g. ASEAN-SAM. Nevertheless, caution must be applied as compromises have to be made in the construction of a SAM from I-O data. This chapter provides the beginnings of a manual on how to augment the database by including additional information from external database. The result is a consistent and balanced database with more possibilities for policy analysis, particularly those related to income distribution and institutional studies.

It should be noted, however, that this chapter should by no means discourage further adjustments to this database. Rather, this chapter encourages further fine-tuning of the database to better suit the purpose of other researchers – fine-tuning to the database including, but not limited to, updating the data to a more current year. Although obvious, a note of caution must be taken when considering this type of update as it requires the entire ASEAN-SAM database to be updated and not just parts of it, if consistency is to be maintained. Another adjustment that can be made is with regards to aggregating and disaggregating blocks in order to better answer the various research questions in a relevant manner.

Given this, there are two important outcomes from this chapter: first, an entirely new, robust and, more importantly, consistent ASEAN-SAM has been constructed for policy analysis and modeling; second, it provides the necessary tool and knowledge to adjust the ASEAN-SAM, and perhaps even creating an entirely new SAM for other regions and countries. The following chapters will use this ASEAN-SAM, and any further adjustments made will be explained accordingly.

Appendix 3.1. Transactions in a Representative Region

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Imported Commod	Domestic Commod	Activities	Factors	Regional Household	Private Household	Trade Taxes	Import Sales Taxes	Domestic Sales Tax	Factor Taxes	Production Taxes	Direct Taxes	Govt	Capital	Import Margins	Export Margins	Rest of World
1	Imported Commodities			Intermediate Inputs			Private demand							Government demand	Investment demand			
2	Domestic Commodities			Intermediate inputs			Private demand							Government demand	Investment demand		Exports of Transport Services	Exports of Goods and Services
3	Activities		Supply matrix															
4	Factors			Payments to Factors														
5	Regional Household				Distributed Factor Incomes			Import Duties and Export duties	Import Sales Taxes	Domestic Sales Taxes	Factor Use Taxes	Production Taxes	Income Taxes					
6	Private Household					Private Household income												
7	Trade Taxes	Import Duties	Export duties															
8	Import Sales Taxes			Sales Taxes - Imports			Sales Taxes - Imports							Sales Taxes - Imports	Sales Taxes - Imports			
9	Domestic Sales Tax			Sales Taxes - Domestic			Sales Taxes - Domestic							Sales Taxes - Domestic	Sales Taxes - Domestic			
10	Factor Taxes			Factor Use Taxes														
11	Production Taxes			Production Taxes														
12	Direct Taxes				Factor Income Taxes													
13	Government					Government income												
14	Capital				Depreciation	Savings											Trade balance	Trade balance
15	Import Margins	Transport margins on imports																
16	Export Margins															Imports of transport services		
17	Rest of World	Imports of Goods and Services																

Source: McDonald and Thierfelder (2004).

Chapter 4: The Inter-Regional System of Analysis for ASEAN

Summary

The Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) is a static, multi-country, computable general equilibrium (CGE) model. It is a unique model constructed to understand the impact of coordinated and non-coordinated policies, e.g. energy subsidy reduction and carbon tax implementation, on the economic and environmental performances of six of the ten member countries of ASEAN, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Although it is robust enough to be an insightful tool for policy analysis in other issues, e.g. trade, the IRSA-ASEAN model contains a unique feature that makes it particularly valuable for policies related to environment and energy sectors, namely endogenized revenue recycling mechanisms. This chapter is intended to become a technical manual for the IRSA-ASEAN model that will help to better analyze empirical results in following chapters.

4.1. Introduction

This is another technical chapter that focuses on the construction of the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) computable general equilibrium (CGE) model. The IRSA-ASEAN model is a unique model in its own right with the sole purpose of modeling the Southeast Asian region – using selected ASEAN member countries. This chapter primarily deals with the technical aspect of the model – the empirical results will be discussed in later chapters. The purpose of this chapter is to explain the model so that it can be understood and replicated by others as well as modified to fulfill future analytical needs.

Accordingly, the chapter can be divided into three main parts. The first part briefly explains the fundamentals of a computable general equilibrium model with an overview of the IRSA-ASEAN model. The second part of the chapter deals with construction of the IRSA-ASEAN model by providing a detailed technical guide with equation-by-equation descriptions of the model. The last part of this chapter presents a summary of the IRSA-ASEAN model and how it will be used for empirical analysis in subsequent chapters once combined with the IRSA-ASEAN database from the previous chapter.

4.2. A Computable General Equilibrium (CGE) Model for Analysis

Along with econometric models, computable general equilibrium (CGE) or applied general equilibrium (AGE) models have become a standard tool for policy analysis in many countries. Johansen (1960) was a pioneer in the field of multi-sectoral equilibrium models. However, it was not until the early seventies, perhaps stimulated by Scarf's (1967) work on the computation of

equilibria, that several research groups (e.g. three at the World Bank) began to build general equilibrium models (Breuss, 1991).

As summarized by Shoven and Whalley (1992), the Walrasian general equilibrium model provides an ideal framework for appraising the effects of policy changes on resource allocation and for assessing who gains and loses, both policy impacts are not well covered by empirical macro models. The term 'general equilibrium' corresponds to the well-known Arrow-Debreu model developed in 1954. The main characteristics of the model are as follows. The number of consumers in the model is specified. Each consumer has an initial endowment of *N* commodities and a set of preferences, resulting in demand functions for each commodity. Market demands are the sum of each consumer's demands. Commodity market demands depend on all prices, continuous, non-negative, homogeneous of degree zero (i.e. no money illusion), and satisfy Walras' law in which at any set of prices, the total value of consumer expenditure equals consumer income.

On the production side, technology is described by either constant returns-to-scale activities or non-increasing returns-to-scale production functions. Producers maximize profits. The zero homogeneity of demand functions and the linear homogeneity of profits in prices (i.e. doubling all prices doubles profits), imply that only relative prices are of any significance in such a model. The absolute price level has no impact on the equilibrium outcome. Equilibrium in this model is characterized by a set of prices and levels of production in each industry such that the market demand equals supply for all commodities. Since producers are assumed to maximize profits, this implies that in the constant-returns-to-scale case, no activity or cost-minimizing technique for production functions does any better than break even at the equilibrium prices (Shoven and Whalley, 1992).

A *computable* general equilibrium (CGE) model uses realistic economic data to observe how an economy reacts to any possible changes in, among others, input market, technology, and government policy. There are various types of CGE models. Single-country models are used to study the structural consequences of exogenous shocks, questions of income distribution, and sectoral effects of tax reforms. The standard national CGE model is a type of CGE model that is mainly concerned with a single country and analyzes its economic structure at the national level. The data source for this type of CGE model usually comes either from the national input-output (I-O) table or the social accounting matrix (SAM). It typically has no sub-national features, thus, aggregating the entire country into one single economy.

This model is also a disaggregated model in the sense that it allows for multi-product industries and multi-industries products. It incorporates detailed estimates of elasticities of substitution between domestically produced products and similar imported products. This type of model usually contains detailed modeling of margin industries and allows the freedom to

reclassify variables between the exogenous and endogenous categories. Much recent research is devoted to constructing both inter-temporal and recursive dynamic CGE models. Such overlapping generations (OLG) models are used to analyze policy changes on economic growth and the allocation of resources, e.g. tax policy and environmental policy. Several attempts have been made to capture features of imperfect competition and increasing returns to scale. Other single-country models include financial CGE models, which looks specifically at the financial impact of a policy change (Shoven and Whalley, 1992; Resosudarmo *et al.*, 2008). More recently, environmental problems and questions of economic growth have gained favor with CGE models.

Many single country CGE models have been developed for Southeast Asia countries alone, particularly for Indonesia, such as a model by Lewis (1991), one of the first CGE model for Indonesia; Indorani by Abimanyu (2000), an Indonesian adaptation of the ORANI-G model developed by the Centre of Policy Studies at Monash University used to analyzed trade policies on the environment; financial CGE model by Azis (2000) that consists of real and financial sectors of the Indonesian economy; environmental CGE model by Resosudarmo (2002), the first published inter-temporal dynamics CGE model based on a SAM table; Wayang by Warr (2005), a modified version of ORANI-G with innovative treatments of the agricultural sector; recursive model by Oktaviani *et al.* (2005), a recursive dynamic ORANI-G model; and a model by Yusuf and Resosudarmo (2007), which has 100 rural household and 100 urban household groups and disaggregates energy sectors, as well as incorporates GHG emissions (Resosudarmo *et al.* 2008).

CGE models of other countries in the region include, among others, models for Brunei by Duraman and Asafu-Adjaye (1999); an adaptation of the ORANI-G model for Cambodia by Oum (2009); Malaysia by Jaafar *et al.* (2008); the Philippines by Corong and Cororaton (2006) and Savard (2010); an adaptation of the Global Trade Project Analysis (GTAP) model for Singapore by Siriwardana and Iddamalgoda (2003); Thailand by Karunaratne (1998); and Vietnam by Chan and Dung (2001) as well as Fujii and Roland-Holst (2005).

Multi-country models, on the other hand, deal with cross-boundary issues including, but not limited to, world trade questions. This type of model is mainly concerned with creating a CGE model that captures the country/region/global economy by incorporating many countries into the model. The number of countries in this type of model ranges from two all the way to a global model. Countries, which consist of multiple sectors, are typically inter-connected through trade. The model can then be used to conduct policy analysis on, among others, the impact of tariffs, tax changes, and capital movements on the global economy or a particular country/region economy (Resosudarmo *et al.*, 2008). Starting with Harris (1984) who estimated the welfare effects of the free trade arrangement between the U. S. and Canada, these types of models are being used to study the sectoral consequences of the completion of the single market on European Community (EC) countries (Harrison *et al.*, 1989; Smith and Venables,

1988), and the European Free Trade Association (EFTA) countries (Norman, 1989; Haaland, 1990) as well as the effects on EC and EFTA countries combined (Norman, 1990). Other early works include Whalley (1985) as well as Deardorff and Stem (1986) who use world trade models to quantify the effects of a multilateral reduction of tariffs within General Agreements on Tariffs and Trade(GATT) on the welfare of individual countries and the world as a whole (Shoven and Whalley, 1992).

Among more recent works, the most widely used is probably the Global Trade Analysis Project (GTAP) model housed in the Department of Agricultural Economics at Purdue University. This is an I-O-based comparative static model with a multi-region, multi-sector general equilibrium model using perfect competition and constant return to scale assumptions (Hertel, 1997). The World Bank also maintains a global CGE model, the LINKAGE. The LINKAGE model is a recursive dynamic global CGE model capturing population and labor dynamics as well as the role of savings and investment on capital accumulation and productivity in multiple countries (Lee *et al.* 2004; Lee and Mensbrugghe, 2004; Mensbrugghe, 2005). Another prominent model is the Globe model which has been calibrated using data derived from the GTAP database. Aside from its SAM-based features, this model is distinctive as it uses a 'dummy' region, known as Globe, that allows for the recording of inter-regional transactions where either the source or destination are not identified. Examples of such transactions include trade and transportation margins and data on remittances. The Globe construct provides a general method for dealing with any transactions data where full bilateral information is missing (McDonald *et al.*, 2007).

4.2.1. Comparative Static and Dynamic Analysis

Models differ depending on the type of analysis being conducted, i.e. how a change in a policy affects the initial equilibrium of the economy. In a comparative static approach, it is examined how a change in policy changes the endogenous variables. The concern is with discerning the difference between the initial and final equilibrium of the economy and not with the transition required to move from the initial equilibrium to the final one. In other words, how do prices, production, trade, and welfare differ between the initial and final equilibrium of the economy.

The usual procedure in the application of static models is to calibrate the model to data for a benchmark year yielding a benchmark equilibrium of the model. Then, policy analysis is performed by applying the policy in the model and computing a counterfactual equilibrium. The results from the two static equilibria are compared to reveal the implications of the policy. One natural candidate to the ceteris paribus, i.e. all else being equal, approach is to construct a base case scenario with a corresponding base case forecast equilibrium to be compared to a forecast equilibrium with the intended policy included.

Perhaps the main criticism of the static model is that its core formulation is closely tied to the Walrasian ideal of equilibrium (Dervis et al., 1982). In a pure neoclassical setting, producers and consumers react passively to prices in order to determine their demand and supply schedules. Markets are therefore assumed to clear through the interaction of relative prices, such that equilibrium is achieved in both goods and factor markets. However, it might be argued that that certain institutional and structural rigidities within the economy result in cases of persistent disequilibrium or deviations from neoclassical theory (Thurlow, 2004).

In a dynamic setting, not only the base case scenario would matter, but the temporal ordering and timing of different policies make a difference for economic transitions. Another aspect of time in economic modeling is the time it takes for the modeled economy to adjust toward an equilibrium, i.e. a steady state. In static models this question is dealt with by adjusting the assumptions made in the model to fit the intended time range wherein the model is applied. For example, in a short term model the assumption of immobility of the labor force between regions may be adopted, whereas in a long term model the labor force may be assumed mobile between regions.

Nevertheless, this approach may fail to capture some of the costs and benefits associated with the transition and so overstate or understate the benefits from the change in a policy. For example, for the benefits of trade liberalization to be realized, resources have to be moved from uncompetitive sectors to sectors where they can be more productively used. But this reallocation process may require workers to be retrained. Workers may also suffer temporary spells of unemployment during the transition. Capital that is specialized to the contracting sectors of the economy may not be transferable to the expanding sectors without expensive retooling. All the costs associated with this reallocation of resources will not be included in a comparative static analysis (Sundberg, 2005).

Dynamic analysis, on the other hand, examines not only the nature of the final equilibrium but also the evolution of the economic system from the initial to the final state. In theory, dynamic models will be able to capture some of the costs associated with adjustments to changes in a policy. They also allow other 'dynamic' effects to be included in the analysis, which can dramatically change the estimates of the effect of a policy. Two important examples of these dynamic factors are capital accumulation and technological change. With a dynamic equilibrium analysis, it is possible to examine whether changes in a policy affect the rate of investment or accelerate the pace of technological innovation (Piermartini and Teh, 2005).

Nevertheless, despite the shortcomings of comparative static models, most simulation models are of this sort. The reason is that static models can be useful for checking the micro-consistency of macroeconomic accounts and are computationally much easier. Dynamic models are more theoretically complex and computationally more difficult to solve. Existing numerical

methods for calculating a solution, i.e. algorithms, may have difficulty in arriving at the equilibrium values of the model if the models are highly complex. The steady solutions of dynamic models are also often closer to comparative static results of static models (Bhattarai and Okyere, 2005).

Dynamic models are nowhere near the goal of predicting the future. A model can more or less predict what will happen if and only if there are no shocks and structural changes in an economy. In addition, assumptions have to be made about the rate of economic growth for several decades into the future, the rate of time preference, the growth rate of population, inflation, depreciation, and others. All these necessary assumptions bring the model very far from the reality. But policy-makers still need to make their decisions and economists need to provide answers about the future. Therefore, dynamic general equilibrium models are important tools for economic policy evaluation. But, a good static model is much more useful than a bad dynamic one; and good dynamic models are quite rare (Paltsev, 2004).

4.2.2. Overview of the IRSA-ASEAN Model

The IRSA-ASEAN model is a multi-country CGE model and is a descendant of the Inter-Regional System of Analysis for Indonesia Five Regions (IRSA-Indonesia5), developed by Resosudarmo *et al.* (2008) in such a way that it bears similarities with the latter in terms of notational use. However, numerous features of the IRSA-ASEAN model also stem from other developments in CGE modeling over the last 20 years; some of these sources of inspiration are direct and easily identified, including one of the first CGE models for Indonesia by Lewis (1991), the GTAP model (Hertel, 1997), and the Globe model (McDonald et al., 2007), such that the IRSA-ASEAN model is a unique model on its own right, both structure-wise (SAM-based) and purpose-wise (energy and environment issues in ASEAN). The IRSA-ASEAN model is a multi-country model that solves at the country level, meaning that optimizations are done at this level. This approach allows price as well as quantities to vary independently by countries, which means that the variation in price as well as in quantity in each country can be observed using this model. This approach enables the user of the model to observe the impact of a specific shock in one country to other countries, the whole ASEAN economy, and the country itself. Figure 4.1 provides an illustration of the IRSA-ASEAN model.

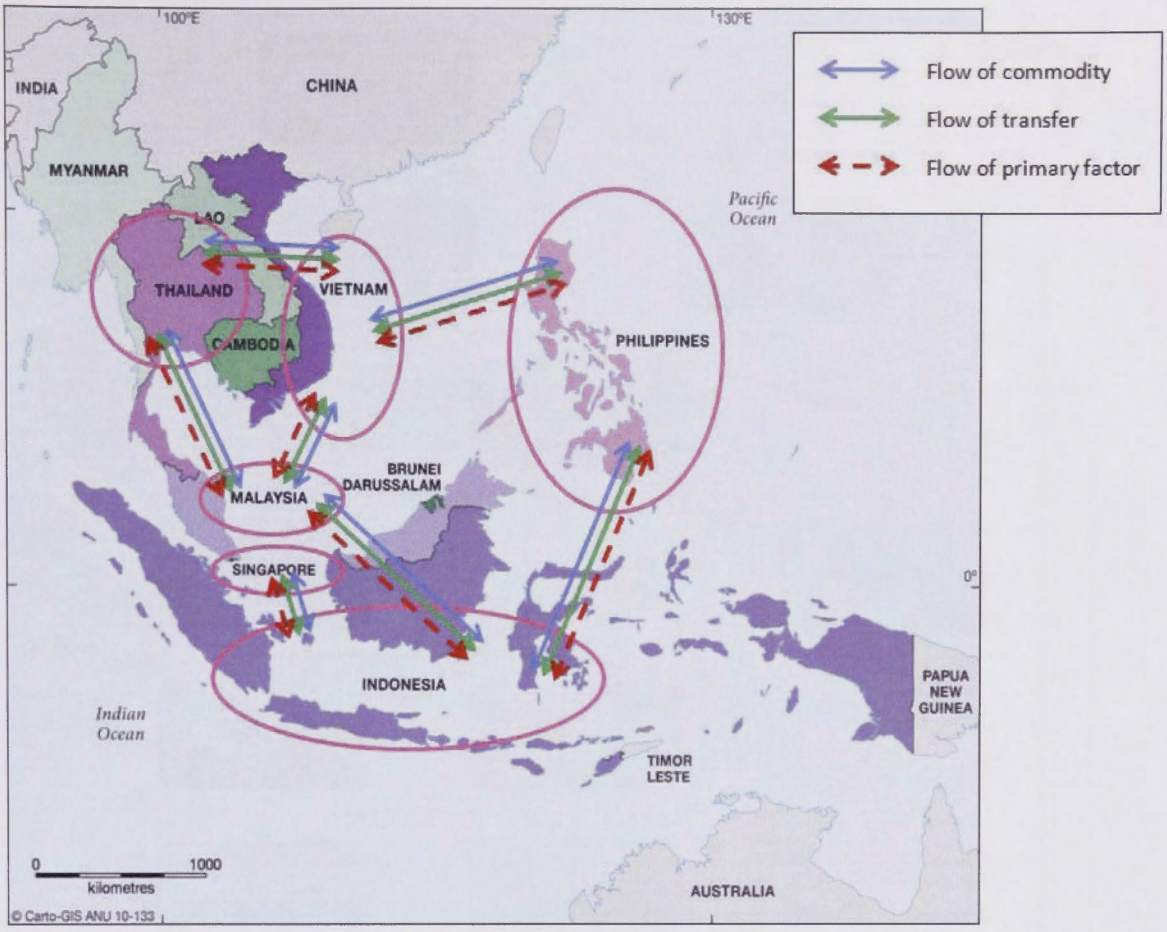


Figure 4.1. The IRSA-ASEAN Model

Figure 4.1 provides a graphical representation of the IRSA-ASEAN. The IRSA-ASEAN consists of six of ASEAN's member countries, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. As optimization is done at the country level and, taking into account the 'sovereignty' element of each country, the model uses neither a bottom-up nor a top-down approach.[1] Each country is connected through the flow of commodity – i.e. trade of goods and services, as well as the flow of transfer (i.e. remittance and savings-investment). The model also allows direct transfer of primary factors production, however, due to data scarcity, this last feature is not included in the empirical study.

As a consequence of the sovereignty element in the IRSA-ASEAN model, each country has its own balance of payments as well as savings and investment accounts. Each country deals directly with other countries in terms of trading and is allowed its own set of tariff barriers. For examples, in the IRSA-ASEAN model, each country can export/import goods and services directly to/from the rest of the world (ROW). Figure 4.2 provides an illustration of the production structure of the IRSA-ASEAN model.

[1] This is in line with real world evidence in which ASEAN, unlike the EU, is not a supranational organization.

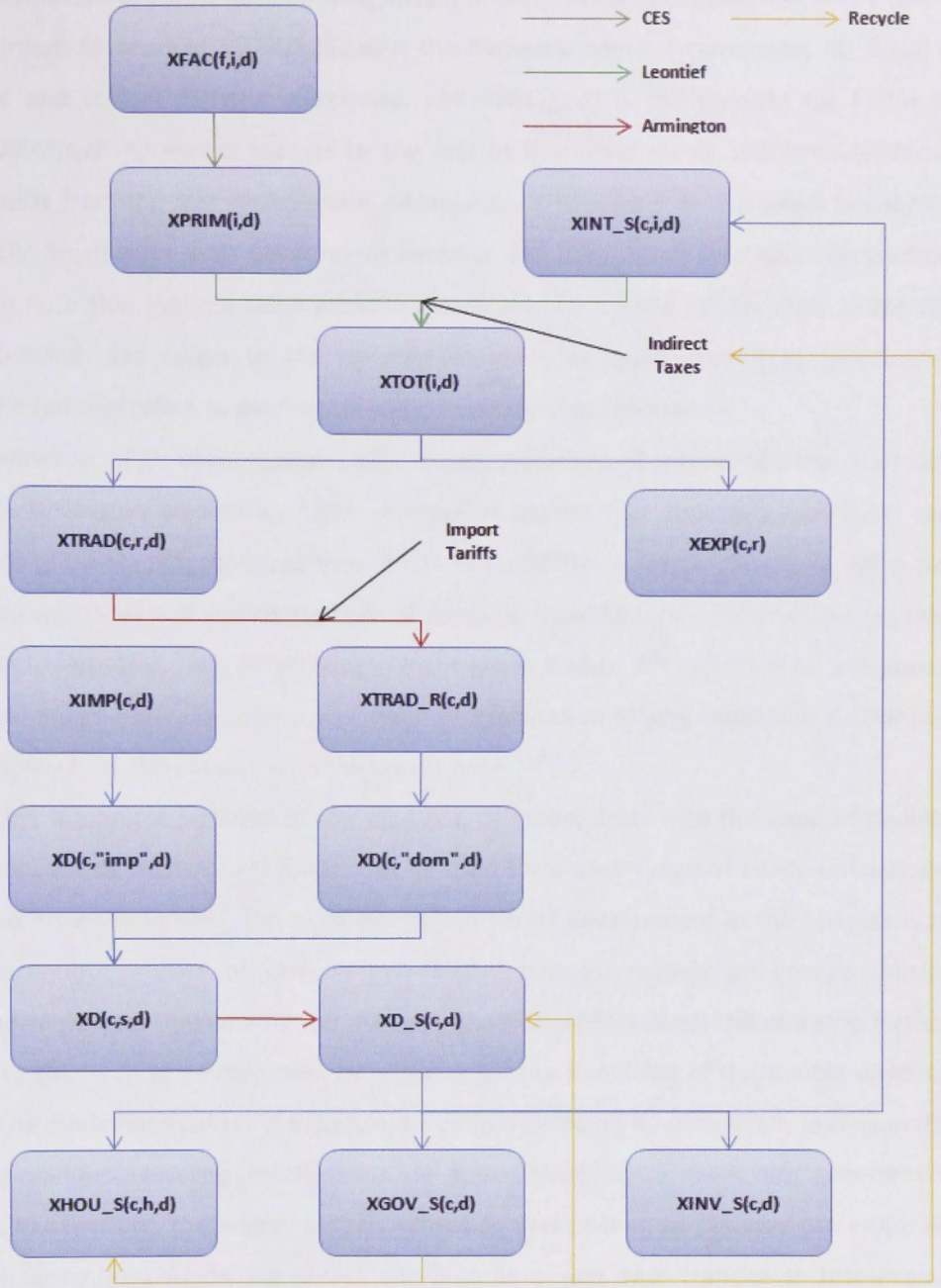


Figure 4.2. Production Structure of the IRSA-ASEAN Model

The following defines the subscript[2] notations in Figure 4.2:

- *c* commodity;
- *d* country destination of commodity;
- *f* factor of production;
- *h* household;
- *i* industry;
- *r* country source of commodity; and
- *s* source of commodity, composite between *'dom'* [3] and *'imp'*[4].

[2] See Appendix 4.1 for the full list of set definitions.

Meanwhile, *XTOT(i,d)* is output, *XINT_S(c,i,d)* is the intermediate good, and *XPRIM(i,d)* is the primary input. Meanwhile, *XTRAD_R(c,d)* is the domestic demand composite, *XD_S(c,d)* is the domestic and import demand composite, and *XFAC(f,i,d)* is the demand for factor of production. *XEXP(c,r)* represents exports to the rest of the world, while the term *XIMP(c,d)* refers to imports from the rest of the world. Meanwhile, XHOU_S(c,h,d) represents household demand, XGOV_S(c,d) represents government demand, and XINV_S(c,d) represents investment demand. Also note that indirect taxes affect production output while import taxes affect the composite demand. *CES* refers to the constant elasticity of substitution (CES) production function, while *Leontief* refers to the fixed proportion production function.

Furthermore, in an open economy CGE model, the standard assumption that is usually applied is the Armington assumption.[5] This assumption implies that imperfect substitutes can have different prices in different countries (Plassmann, 2005). A major benefit of using the Armington assumption is that it permits prices of immobile input factors to differ across regions. If markets are competitive, then differences in input prices lead to differences in output prices. The Armington assumption also provides an intuitive explanation of why consumers do not buy output exclusively from the country with the lowest price.

Another important highlight of the IRSA-ASEAN model deals with the issue of double-dividend. Although the IRSA-ASEAN model can be used for a wide-range of policy simulations, e.g. trade and fiscal simulations, the main motivation for its development in this chapter is to assess the economic impact of environment-related policies, namely an energy subsidy reduction and carbon tax implementation. As such, the IRSA-ASEAN model takes a step further with regard to the issue of environment by allowing for the possibility of the double-dividend hypothesis. The model internalizes the double-dividend hypothesis by intrinsically and explicitly incorporating various recycling mechanisms. In this regard, aside from the government increasing its expenditure, the energy subsidy reduction and carbon tax revenue can either be recycled directly to households, e.g. direct one-time lump-sum cash transfer to low-income households, or recycled back to the industry, e.g. indirect tax reduction, such that it creates a less distortionary tax system, or hypothetically so.[6]

For empirical results, the IRSA-ASEAN model uses the Social Accounting Matrix for ASEAN (ASEAN-SAM) which has been calibrated from the input-output (I-O)-based Global Trade Analysis Project (GTAP) Version 7 Data Base with parameter values, e.g. value-added and Armington elasticities, also obtained from this source. The database uses a common reference year of 2004 and a common currency of United States million dollars (USD million) for all six

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[3] The word *'dom'* refers to domestic, i.e. intra-ASEAN goods and services.
[4] The word *'imp'* refers to import, i.e. extra-ASEAN goods and services.
[5] The term comes from the name Paul Armington, an International Monetary Fund (IMF) economist.
[6] The 'double-dividend' hypothesis will also be discussed in greater details in Chapter 5.

selected countries in the region. The database has been heavily modified using various country-specific datasets, e.g. social accounting matrices and household income/expenditure surveys, so as to provide greater insight and flexibility for policy analysis. Also, the latest version of the Generalized Algebraic Modeling System (GAMS) program is used to run the IRSA-ASEAN model.

The following lists the additional datasets required to build the so-called ASEAN-SAM. For Indonesia, the additional data needed are (1) 2005 Social Accounting Matrix and (2) 2005 Inter-Regional Social Accounting Matrix (Resosudarmo *et al.*, 2008); Malaysia, (1) 2004/2005 Household Expenditure Survey, (2) 2004 Distribution and Use of Income Accounts and Capital Account, (3) 2000 Population and Housing Census, and (4) 1970 Social Accounting Matrix (Pyatt *et al.*, 1984); Philippines, (1) 2006 Family Income Expenditure Survey, (2) 2000 Social Accounting Matrix (Cororaton and Corong, 2009), and (3) 1997 Family Income Expenditure Survey; Singapore, (1) 2008 Yearbook of Statistics and (2) 2002/2003 Report on the Household Expenditure Survey; Thailand, (1) 2008 Key Statistics, (2) 2002 Household Socio-Economic Survey, and (3) 1998 Social Accounting Matrix (Li, 2002); Vietnam, (1) 2004 Living Standard Survey and (2) 1997 Social Accounting Matrix (Nielsen, 2002). Other data sets needed are the 2010 World Development Indicators, 2008 ASEAN Statistical Yearbook, 2005 ASEAN Statistical Yearbook, 2005 Bilateral Remittance Estimates (Ratha and Shaw, 2007), and 2004 Combustion-Based CO_2 Emissions Data for GTAP Version 7 (Lee, 2008).

The procedures to be followed when constructing the ASEAN-SAM for modeling purposes are divided into three phases. The first phase involves the preparation of the GTAP Version 7 Data Base and transforming it into individual Global SAMs; i.e. Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. Phase 2 is a set of steps required to transform each individual Global SAM into a standard SAM form. Phase 3 is when all individual SAMs are combined to form the ASEAN-SAM. Some adjustments are needed to combine these individual SAMs. Table 4.1 provides a detailed list of sets of the ASEAN-SAM.[7]

[7] See Chapter 3 for a detailed step-by-step procedure on the construction of the ASEAN-SAM.

Table 4.1. List of Sets

Production Sectors[8]		Regions
Agriculture	Trade	Indonesia
Farming	Transportation	Malaysia
Forestry	Communication	Philippines
Fishing	Financial services	Singapore
Coal	Public administration, defense,	Thailand
Oil	health, and education	Vietnam
Gas	Dwellings and other services	Rest of the World
Minerals *nec*		
Food and beverages	**Factors**	**Institutions**
Textile and leather products		
Wood and paper products	Unskilled Labor	Rural-Low Household
Petroleum and coal products	Skilled Labor	Rural-High Household
Chemical, rubber, and	Land	Urban-Low Household
plastic products	Natural resources	Urban-High Household
Mineral products *nec*	Capital	Corporate
Metal products		Government
Manufacturing	**Other Accounts**	
Electricity		
Gas manufacture distribution	Indirect Tax	
Water	Import Tax	
Construction	Savings-Investment	

4.3. Construction of the IRSA-ASEAN Model[9]

Referring back to Figure 4.2, the principal activity of any industry is to turn inputs into outputs. In this model, the relationship between inputs and outputs is formalized by a nested CES-Leontief production function in each production sector. The structure of the production function is the same for all sectors. Unlike the basic model of CGE, this model assumes that inputs of production are divided into two categories: the composite of primary factors, i.e. unskilled labor, skilled labor, land, natural resources, and capital; and the intermediate goods. The source of the composite primary factors only comes from the domestic[10] market, but the source of intermediate goods can come from both domestically produced intermediate goods and imported[11] intermediate goods. The nested CES-Leontief production function plays an important role in dealing with the complication of inputs. Within this setup, industries have a separable

[8] Due to technical limitations, Production Sectors have been aggregated from 57 into 26 sectors. See Chapter 5 for details.
[9] See Appendix 4.2 for the full list of model equations in GAMS syntax.
[10] Again, the word 'domestic' refers to within ASEAN region. And thus, used interchangeably.
[11] Analogously, the word 'import' refers to extra ASEAN region, i.e. rest of the world.

optimization problem between minimization cost for composite primary factors and minimization cost for intermediate goods.

At the first stage, industries face two different optimization problems: choosing the combination of their primary factors i.e. unskilled labor, skilled labor, land, natural resources, and capital; and their choice of the composite intermediate goods to optimize cost efficiency. At the second stage, each industry minimizes its production cost by choosing the most efficient level of composite primary factors, sometimes called value added, and composite intermediate goods using Leontief production function.[12]

4.3.1. Demand for Primary Factors

At the first stage, with only five factors of production, a constant elasticity of substitution (CES) function can be used to determine the demand for primary factors. The primary factors' optimization problem for each industry is represented as follows:

$$\min_{\{XFAC_{f,i,d}\}} f\left(XFAC_{f,i,d}\right) \text{ s.t. } XPRIM_{i,d} = CES\left[XFAC_{f,i,d} \mid \sigma_i\right] \qquad [4.4]$$

with

$$f\left(XFAC_{f,i,d}\right) = \sum_f (PFAC_{f,d} \cdot XFAC_{f,i,d}) \qquad [4.5]$$

$PFAC_{f,d}$ is a factor price[13], $XFAC_{f,i,d}$ is the demand for primary factor, $XPRIM_{i,d}$ is the composite of primary factors, and $CES\left[XFAC_{f,i,d} \mid \sigma_i\right]$ is a CES functional form that represents the relationship between primary factors. σ_i is the elasticity of substitution for each industry.

Following the derivation by Resosudarmo *et al.* (2008), the solution to Equation 4.4 is as follows:

$$XFAC_{f,i,d} = \alpha_{i,d}^{\frac{-\rho}{\rho+1}} \cdot XPRIM_{i,d} \cdot \delta_{f,i,d}^{\frac{1}{\rho+1}} \cdot \left(\frac{PFAC_{f,d}}{PPRIM_{i,d}}\right)^{\frac{-1}{\rho+1}} \qquad [4.6]$$

[12] Although significantly different in the overall model structure, mathematical and technical notations of the IRSA-ASEAN model are similar to the IRSA-Indonesia5 model developed by Resosudarmo *et al.* (2008).

[13] We are in the perfectly competitive world, where everybody in the economy is a price taker. Therefore, there is no subscript *i* for price because all industries face the same primary factor prices.

where $PPRIM_{i,d}$ is the price of composite primary factors paid by industry i in country d [14], $\alpha_{i,d}$ is the shift parameter of value-added, $\delta_{f,i,d}$ is the share parameter of value-added, and $\rho_{i,d}$ is a parameter of valued-added derived from the elasticity of substitution. The removal of subscripts for $\rho_{i,d}$ in Equation 4.6 is done for the sake of simplicity.

Meanwhile, market clearing for factors is as follows.

$$(\sum_{i} XFAC_{f,i,d}) + XFACRO_{f,d} = (\sum_{h}\sum_{r} XFACS_{r,h,d,f}) + (\sum_{r} XFGR_{r,d,f}) + (\sum_{r} XFCO_{r,d,f}) + XFRO_{d,f} \quad [4.7]$$

where $XFACRO_{f,d}$ is the demand for factors by the rest of the world, $XFACS_{r,h,d,f}$ is the supply of factors by households, $XFGR_{r,d,f}$ is the supply of factors by governments, $XFCO_{r,d,f}$ is the supply of factors by corporate, and $XFRO_{d,f}$ is the supply of factors by the rest of the world. The left-hand side variables in the above equation are treated as exogenous.

4.3.2. Output of Production

At the second stage, a firm's objective is to maximize profit through a Leontief production function. The Leontief production function determines the relationship between all the inputs (a composite of primary factors and intermediate goods) to outputs represented as follows:[15]

$$XTOT_{i,d} = \min\left(XPRIM_{i,d}, XINT\_S_{c,i,d}\right) \quad [4.1]$$

where $XTOT_{i,d}$ is output for industry *i* at destination country *d*, $XPRIM_{i,d}$ is the primary factors composite, and $XINT\_S_{c,i,d}$ is the intermediate good. The use of the primary factors composite and intermediate goods is assumed to be proportional to the output level of the produced commodity.

$$XPRIM_{i,d} = \alpha_{i,d}^{prim} \cdot XTOT_{i,d} \quad [4.2]$$

$$XINT\_S_{c,i,d} = \alpha_{c,i,d}^{int} \cdot XTOT_{i,d} \quad [4.3]$$

[14] The price of composite primary factors for each industry is different since each industry has a different combination of primary factors.

[15] This production function was introduced by a Russian-American economist, Wassily Leontief. He was a pioneer in the development of input-output analysis. In an input-output analysis, production is assumed to take place with fixed-proportions technology.

where $\alpha^{int}_{c,i,d}$ is the proportion of intermediate goods used to produce the output and $\alpha^{prim}_{i,d}$ is the proportion of composite primary factors used to produce the output.

Admittedly, one important outcome, and perhaps limitation, to this setup is that *endogenous* substitution between intermediate inputs is not allowed. This is mainly due to a technical limitation in which convergence, i.e. solution, to a model that allows endogenous substitution between intermediate goods is difficult to achieve once a 'shock' is introduced. In other words, GAMS cannot solve the model as there are too many equations due to the number of commodities multiplied by the number of countries in the IRSA-ASEAN model.

However, the model allows *exogenous* substitution. To put it briefly, a constant can be introduced into Equation 4.3 (e.g. 0.9 for the coal sector) which basically means that a less amount of coal (approximately 10 percent) is needed to achieve the same amount of output. By extension, the share uses of other inputs have increased, i.e. substitution effect, as well as share uses of primary factors, i.e. efficiency effect. As such, in this way, substitution and efficiency effects can be observed in the model despite the use a Leontief production function.

4.3.3. Zero Profit Conditions and Market Clearing for Commodities

At optimum, the total amount of commodity *c* supplied is produced by satisfying the first order necessary condition (FONC) of its optimization problem, where the marginal revenue of producing the commodity equals its marginal cost. This condition can also be represented by the optimum of its dual problem that holds under a zero profit condition. Zero profit condition is the situation where total revenue from producing the commodity equals its total cost. The total revenue is represented by the arguments on the left-hand side of Equation 4.4 and the total cost is shown on the right-hand side.

$$(1-itxr_{i,d}+tco2_d)\cdot PDOM_{i,d}\cdot XTOT_{i,d}=PPRIM_{i,d}\cdot XPRIM_{i,d} + \sum_c\left[(1+stx_{c,d})\cdot PQ\_S_{c,d}\cdot XINT\_S_{c,i,d}\right] \quad [4.4]$$

where $itxr_{i,d}$ is the indirect tax rate, $tco2_d$ is the indirect tax reduction rate recycled from the energy subsidy reduction or carbon tax revenue, and $stx_{c,d}$ is the sales tax rate when a carbon tax is implemented. Note that in the absence of an energy subsidy reduction or a carbon tax implementation or, $tco2_d$ and $stx_{c,d}$ are empty sets.

In an equilibrium condition, all the output supplied for commodity *c* from region *r* $\left(XTOT_{c,r}\right)$ must equal the sum of the demand for commodity *c* at all domestic destinations

$\left(XTRAD_{c,r,d}\right)$ and the demand for commodity *c* from outside the region $\left(XEXP_{c,r}\right)$, i.e. rest of the world.

$$XTOT_{c,r} = (\sum_{d} XTRAD_{c,r,d}) + XEXP_{c,r} \quad [4.5]$$

4.3.4. Inter-Regional Trade and Import

Using the CES aggregation function, we can establish the demand of commodity *c* with source country *r* to destination country *d*.

$$\min_{\{XTRAD_{c,r,d}\}} f\left(XTRAD_{c,r,d}\right) \text{ s.t. } XTRAD\_R_{c,d} = CES\left[XTRAD_{c,r,d} \mid \sigma_{c,d}\right] \quad [4.6]$$

with

$$f\left(XTRAD_{c,r,d}\right) = \sum_{r}\left[(1 + itxm_{c,r,d}) \cdot PDOM_{c,d} \cdot XTRAD_{c,r,d}\right] \quad [4.7]$$

where $PDOM_{c,r}$ is the producer price for commodity *c* at source country *r*, $XTRAD_{c,r,d}$ is the demand of commodity *c* from source country *r* to destination country *d*, and $CES\left[XTRAD_{c,r,d} \mid \sigma_{c,d}\right]$ is a CES functional form representing the demand for commodity *c* from all source countries to a destination country *d*, with $\sigma_{c,d}$ as the elasticity of substitution for commodity *c* from a different source country *r* at a destination country *d*.

This optimization problem leads to the following solution:

$$XTRAD_{c,r,d} = \alpha_{c,d}^{\frac{-\rho}{1+\rho}} \cdot XTRAD\_R_{c,d} \cdot \delta_{c,r,d}^{\frac{1}{\rho+1}} \cdot \left[\frac{(1 + itxm_{c,r,d}) \cdot PDOM_{c,r}}{PQ_{c,"dom",d}}\right]^{\frac{-1}{\rho+1}} \quad [4.8]$$

where $PQ_{c,"dom",d}$ is the domestic purchaser's price for commodity *c* at country *d* as $itxm_{c,r,d}$ is the import tariff for commodity *c* from country *r* to country *d*.

4.3.5. Demand for Commodities

For within ASEAN, the demand for commodity *c* is established through a CES aggregation of the commodity from source country *r* to a destination country *d* $\left(XD_{c,"dom",d}\right)$ identical to $XTRAD\_R_{c,d}$, such that, the following identity holds:

$$XTRAD\_R_{c,d} = XD_{c,"dom",d} \quad [4.9]$$

Meanwhile, demand for commodities from outside of ASEAN holds the following identity:

$$XIMP_{c,d} = XD_{c,"imp",d} \quad [4.10]$$

where $XIMP_{c,d}$ is the demand for commodity *c* from outside of ASEAN to destination country *d*.

$XD_{c,"dom",d}$ and $XD_{c,"imp",d}$ are then combined using a CES aggregator.

$$\min_{\{XD_{c,s,d}\}} f\left(XD_{c,s,d}\right) \text{ s.t. } XD\_S_{c,d} = CES\left[XD_{c,s,d} \mid \sigma_{s,d}\right] \quad [4.11]$$

where

$$f\left(XD_{c,s,d}\right) = \sum_{s}(PQ_{c,s,d} \cdot XD_{c,s,d}) \quad [4.12]$$

The same explanation applies for Equations 4.6 and 4.7. However, attention must be given to the subscript *s* = {*'dom'*, *'imp'*} the above equations. The subscript represents the source of the commodity, where *'dom'* represents domestic sources, i.e. imports from within ASEAN, and *'imp'* stands for imports from outside of ASEAN.

The solution for the above optimization problem is:

$$XD_{c,s,d} = \alpha_{c,d}^{\frac{-\rho}{1+\rho}} \cdot XD\_S_{c,d} \cdot \delta_{c,r,d}^{\frac{1}{\rho+1}} \cdot \left(\frac{PQ_{c,s,d}}{PQ\_S_{c,d}}\right)^{\frac{-1}{\rho+1}} \quad [4.13]$$

where $XD\_S_{c,d}$ is the demand for commodity *c* from composite sources, i.e. domestic countries, and imported from outside of ASEAN, at destination country *d*. Meanwhile, $PQ_{c,s,d}$ is the purchaser's price of commodity *c* from source country *s* at destination country *d*, whereas $PQ\_S_{c,d}$ is the purchaser's price of commodity *c* from composite sources at destination country *d*.

Part of the total demand for commodity *c*, $XD\_S_{c,d}$, is then used as an intermediate input $\left(XINT\_S_{c,i,d}\right)$. The remainder will be consumed by households $\left(XHOU\_S_{c,h,d}\right)$, governments $\left(XGOR\_S_{c,d}\right)$, and investment purposes $\left(XINV\_S_{c,d}\right)$. That is:

$$XD\_S_{c,d} = \left(\sum_{i} XINT\_S_{c,i,d}\right) + \left(\sum_{h} XHOU\_S_{c,h,d}\right) + XGOR\_S_{c,d} + XINV\_S_{c,d} \quad [4.14]$$

4.3.6. Household Optimization

Final users of commodity *c* consist of households, governments, and investments. In this model, all three share a common solution to their respective optimization problem. Each chooses its combination of commodities based on a constant budget share. Similarly, each household maximizes its utility:

$$\max_{\{XHOU\_S_{c,h,d}\}} U_{h,d} = f\left(XHOU\_S_{c,h,d}\right)$$
$$\text{s.t. } EH_{h,d} = \sum_{c}\left[(1+stx_{c,d})\cdot PQ\_S_{c,d}\cdot XHOU\_S_{c,h,d}\right] \quad [4.15]$$

The utility function gives a linear expenditure system in which the demand for one specific commodity *c* for household *h* at destination *d* is defined as follows:

$$\beta_{c,h,d}\cdot EH_{h,d} = (1+stx_{c,d})\cdot PQ\_S_{c,d}\cdot XHOU\_S_{c,h,d} \quad [4.16]$$

where $\beta_{c,h,d}$ is the budget share parameter. $EH_{h,d}$ is the household disposable income that comes from the following identity condition:

$$EH_{h,d} = (1-\sum_{hh}\sum_{r} strhh_{hh,r,h,d})\cdot(1-savh_{h,d})\cdot(1-ytaxh_{h,d})\cdot YH_{h,d} \quad [4.17]$$

where $strhh_{hh,r,h,d}$ is the share parameter for inter-household transfer, e.g. remittance, $savh_{h,d}$ is the share parameter for household savings, and $ytaxh_{h,d}$ is the share parameter for household income tax. Meanwhile, $YH_{h,d}$ is the pre-tax household income that comes from the following identity:

$$\begin{aligned} YH_{h,d} = & \sum_{f}\sum_{r}(YFAC_{f,r}\cdot SFACHH_{r,h,d,f}) \\ & + \sum_{r}(strgrh_{h,r,d}\cdot YGR_{r}) + \sum_{r}(strcohh_{h,r,d}\cdot YCO_{r}) \\ & + \sum_{hh}\sum_{r}\left[strhh_{h,d,hh,r}\cdot(1-savh_{hh,r})\cdot(1-ytaxh_{hh,r})\cdot YH_{hh,r}\right] \\ & + strco2h_{h,d}\cdot TCH_{d} \end{aligned} \quad [4.18]$$

$YFAC$ is the total factor income, $SFACHH$ is the share factor income of household, YGR is the government revenue, YCO is the corporate revenue, while $strgrh_{h,r,d}$ and $strcohh_{h,r,d}$ are the share transfer to household respectively. Note that only households receive income from both unskilled and skilled labors. Lastly, TCH is the nominal energy subsidy reduction or carbon tax revenue recycled back to households and $strco2h_{h,d}$ is the share parameter. Two important things to note here are that the third line in Equation 4.18 adds up to

how much the household *receives* from other households; while in Equation 4.17, the summation of $strhh_{hh,r,h,d}$ adds up to how much the household *gives* to other households. Lastly, the fourth line in Equation 4.18 refers to the second recycling mechanism aside from the $tco2_d$ mechanism in the previous section.

4.3.7. Government Optimization

Similarly, the government also needs to find its optimum combination of commodities from different sources. As such, the government also chooses its combination of commodities based on a constant budget share, subject to its budget constraint.

$$\beta_{c,d} \cdot EGR_d = PQ\_S_{c,d} \cdot XGOR\_S_{c,d} \quad [4.19]$$

where $\beta_{c,d}$ is the budget share parameter for government consumption. Note that the budget share parameter in Equation 4.19 is different from the share parameter in Equation 4.16, which refers to the budget share parameter of household consumption. Meanwhile, EGR is government expenditure. As stated, Equation 4.19 is subject to government income defined by the following identity:

$$\begin{aligned} YGR_d = & \sum_i \left[(itxr_{i,d} - tco2_d) \cdot PDOM_{i,d} \cdot XTOT_{i,d} \right] \\ & + \sum_f \sum_r (SFACGR_{r,d,f} \cdot YFAC_{f,r}) + \sum_h (ytaxh_{h,d} \cdot YH_{h,d}) \\ & + \sum_c \sum_r (itxm_{c,r,d} \cdot PDOM_{c,d} \cdot XTRAD_{c,r,d}) \\ & + \sum_c (itxn_{c,d} \cdot PFIMP_{c,d} \cdot XIMP_{c,d} \cdot EXR_d) \end{aligned} \quad [4.20]$$

Briefly explained, the first line in Equation 4.20 refers to government income from indirect tax minus the amount of revenue recycled back to the industry. The second line refers to government income from factors of production that it owns, i.e. land, natural resources, and capital, as well as income tax. The third line refers income generated from import tariffs on goods and services from countries within ASEAN, while the fourth line refers to income generated from import tariffs on goods and services from countries outside the region, i.e. rest of the world.

Equations 4.19 and 4.20 are linked by the following identity:

$$EGR_{h,d} = (1 - \sum_h \sum_r strgrh_{h,d,r}) \cdot YGR_d + TCG_d - SGR_d \quad [4.21]$$

Equation 4.21 shows that government expenditure on goods and services must first be reduced by the total government subsidy to households and government savings, SGR. It is important to

note that government subsidy in Equation 4.20 is not an empty set regardless of whether or not an energy subsidy is eliminated and a carbon tax is implemented. Also, government savings can be a negative value, which will then represent a government deficit. Lastly, TCG is the third mechanism by which the government can recycle carbon tax revenue in which the government increases its consumption. Note that in this case, all the revenue held by the government is recycled back to the economy through an increase in its expenditure and none is used to increase/decrease government saving/deficit.

In the case of an energy subsidy reduction, although the equation is identical, the signs are slightly different in Equations 4.20 and 4.21. For sectors where a government subsidizes the industry, indirect tax rate represented by $itxr_{i,d}$ has a negative value. As such, when an energy subsidy is eliminated, government income automatically increases. In variants where some of that extra revenue is transferred back to households and industries, TCG must be a negative value to avoid double-accounting. In other words, TCG must be a negative value equal to the amount of revenue recycled back to households and industries.[16]

4.3.8. Investment and Export Demands

Two additional demands for commodity *c* arise from investment and export. For the former case, investment demand adheres to the following identity:

$$PQ\_S_{c,d} \cdot XINV\_S_{c,d} = \lambda_{c,d} \cdot (SAV_d - \sum_r TRSAVINV_{r,d}) \qquad [4.22]$$

where $\lambda_{c,d}$ is the share parameter and SAV_d is the aggregate savings in country *d* from household, government, corporate, and transfer savings. A savings transfer, $TRSAVINV$, refers to a net transfer of savings-investment between countries.[17]

As for investment, i.e. XINV_S(c,d), a fixed share coefficient to determine the amount of new capital invested in each production sector is used, analogous to household demand. Admittedly, this is a simplification of the issue and an additional function or two would be required in a dynamic model. However, given that the IRSA-ASEAN is a static comparative model, this simple function is sufficient given that no analysis with regard to relative expected return of investment is made.

This model also allows foreign demand for locally-produced goods to be price-sensitive. If the local price of a good rises relative to the world price, export demand will fall. That is:

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[16] This feature will be explained further in a later section that deals with revenue recycling mechanism.
[17] Although a bit uncommon, the nominal exchange rate is needed to reconcile the data derived from the GTAP database and the CGE model.

$$XEXP_{c,r} = \alpha_{c,r}\left(\frac{P_{c,r}}{\pi_r P^w_{c,r}}\right)^{\varepsilon_{c,r}} \quad [4.23]$$

where $\alpha_{c,r}$ is a shift parameter, $P_{c,r}$ is domestic price, π_r is nominal exchange rate[18], and $\varepsilon_{c,r}$ is the elasticity of demand. In words, exports of commodity *c* are a declining function of the price in foreign currency, relative to the world price.

4.3.9. Balance of Payments and Model Closures

One final important account before model closures deals with the balance of payment. As this is a multi-country model without the existence of a supranational entity, each country has its own set of balance of payment. In order words, total transfer payment coming into the country must equal total transfer payment going out of the country.

$$\begin{aligned} ERO_d = & \sum_r TRSAVINV_{d,r} + SRO_d \\ & + \sum_h \sum_{hh} \sum_r \left[strhh_{h,d,hh,r} \cdot (1 - savh_{hh,r}) \cdot (1 - ytaxh_{hh,r}) \cdot YH_{hh,r} \right] \\ & + \sum_c (PDOM_{c,d} \cdot XEXP_{c,d}) \\ & + \sum_c \sum_r (PDOM_{c,d} \cdot XTRAD_{c,d,r}) \quad , \quad XTRAD_{c,r,d} \neq XTRAD_{c,d,r} \end{aligned} \quad [4.24]$$

Equation 4.24 shows that total payment inflow comes from: the total value of savings-investment transfers (i.e. financial transfers) coming from other ASEAN countries, $\sum_r TRSAVINV_{d,r}$, and rest of the world, SRO; international inter-household transfers (e.g. remittance; total export value to rest of the world); and total export value goods and services to other ASEAN countries.

By definition, payment coming in must equal payment going out. Payment outflow is defined as follows:

$$\begin{aligned} YRO_d = & \sum_r TRSAVINV_{r,d} \\ & + \sum_h \sum_{hh} \sum_r \left[strhh_{h,r,hh,d} \cdot (1 - savh_{hh,d}) \cdot (1 - ytaxh_{hh,d}) \cdot YH_{hh,d} \right] \\ & + \sum_c (PFIMP_{c,d} \cdot XIMP_{c,d} \cdot EXR_d) \\ & + \sum_c \sum_r (PDOM_{c,d} \cdot XTRAD_{c,r,d}) \quad , \quad XTRAD_{c,r,d} \neq XTRAD_{c,d,r} \end{aligned} \quad [4.25]$$

[18] This leads to a limitation of the model in which nominal exchange rate only exists between each ASEAN country with the rest of the world, which is also applied to Equation 31. Exchange rate movement between ASEAN countries are not taken into consideration in this model due to the complexity it will entail.

Equation 4.24 must equal Equation 4.25 in order to have a *balanced* balance of payment, such that the two equations are similar in form with important differences in the subscripts. Other things to note include the absence of any transfer of savings-investment to rest of the world. As previously mentioned, transfers of savings-investment between country refer to the *net* transfers such that SRO is not needed as to avoid double accounting. Also, total import value from rest of the world is calculated at local currency unit, and thus the necessity for the nominal exchange rate.[19]

Lastly, closure is an assumption to close the mathematical system/model where closing the system means the number of equations equal to the number of unknown variables. If these conditions are not fulfilled then the model cannot be solved. In order to close IRSA-ASEAN model, the following closures, among others, are introduced to guarantee that the system is solvable:

1. All factor supplies are exogenous;
2. Unskilled and skilled labors are mobile;
3. Land, natural resources, capital are immobile;
4. All household and corporate savings rates are exogenous;
5. All shares of inter-institutional transfer rates are exogenous;
6. World import prices are exogenous;
7. Indirect tax and import tariff rates are exogenous; and
8. Output price index is set as a *numeraire*.

4.3.10. Carbon Pricing Mechanism[20]

The carbon pricing mechanism is a unique feature of the IRSA-ASEAN model in which CO_2 emissions data is held as a separate matrix, and yet, intrinsically and explicitly integrated in the model. Emissions basically come from the household and industrial sectors, albeit some service sectors emit zero emissions as shown through the following equations.

$$XCOH_{e,h,d} = cch_{e,h,d} \cdot XHOU\_S_{e,h,d} \quad [4.26]$$

and

$$XCOI_{e,i,d} = cci_{e,i,d} \cdot XINT\_S_{e,i,d} \quad [4.27]$$

[19] Another reason for the nominal exchange rate is *technical* in nature, which is it allows movement in the balance of payments when running the model using GAMS.

[20] The carbon pricing mechanism is explained before the energy subsidy reduction because the equations involved are more complex. As such, construction priority for the second case study took precedence before the first case study to ensure the feasibility of the model.

$XCOH_{e,h,d}$ is the total CO_2 emissions from households consumption of fossil fuels, i.e. coal, petroleum products, and gas, denoted by the subscript *e*. Similarly, $XCOI_{e,i,d}$ is the total CO_2 emissions from the industrial use of fossil fuels. Now, $cch_{e,h,d}$ and $cci_{e,i,d}$ are the carbon-content-intensity for each household and industrial sector, which converts consumption in USD million into kiloton of CO_2 emissions. It then follows that carbon-content-intensity is the highest for coal, followed by petroleum products and, least of all, gas. This holds true for all country although carbon-content-intensity may differ across households, industries, and countries.

With regard to carbon pricing, the most important equation deals with setting the rates for the carbon tax.

$$stx_{e,d} = cotax_d \cdot (\sum_i XCOI_{e,i,d} + \sum_h XCOH_{e,i,d}) \\ / PQ\_S_{e,d} \cdot (\sum_i XINT\_S_{e,i,d} + \sum_h XHOU\_S_{e,h,d}) \quad [4.28]$$

$stx_{e,d}$ is the sales tax for the consumption and use of fossil fuels born by households and industries, while $cotax_d$ is the level of carbon tax, e.g. USD 10 per ton of CO_2 emissions. Note that the governments neither produce CO_2 emissions nor pay for it. Revenue generated from the carbon tax is as follows:

$$TCTR_d = \sum_c (stx_{c,d} \cdot PQ\_S_{c,d} \cdot \sum_h XHOU\_S_{c,h,d}) \\ + \sum_c (stx_{c,d} \cdot PQ\_S_{c,d} \cdot \sum_i XINT\_S_{c,i,d}) \quad [4.29]$$

The following equations determine how revenue generated from Equation 4.29 are recycled back into the economy through three different mechanisms, namely household cash transfer, industrial tax reduction, and government expenditure increase respectively:

$$TCH_d = \alpha h_d \cdot TCTR_d \quad [4.30]$$

$$TCI_d = \alpha i_d \cdot TCTR_d \quad [4.31]$$

$$TCG_d = \alpha g_d \cdot TCTR_d \quad [4.32]$$

$$\alpha h_d + \alpha i_d + \alpha g_d = 1 \quad \text{and} \quad 0 \le \alpha h_d, \alpha i_d, \alpha g_d \le 1 \quad [4.33]$$

Equation 4.33 is in actuality not so much an equation as it is a *share* condition *exogenously* determined to ensure that the amount of revenue generated equals the amount of revenue recycled back into the economy.

Lastly, for the case of indirect tax reduction, one final equation is added.

$$TCI_d = tco2_d \cdot \sum_i (PDOM_{i,d} \cdot XTOT_{i,d}) \quad [4.34]$$

In a few words, Equation 4.31 establishes the indirect tax reduction rate in each country. As $tco2_d$ is a uniform rate across industries within a country, in cases where there is no indirect tax, this then becomes an industrial subsidy. Additionally, the nominal value of the tax reduction is proportional to the industry size. Although this mechanism implies that carbon-intensive industries (e.g. electricity sector) also receive tax reductions, bear in mind that a carbon tax is still in effect, which means that the policy is not ineffective. In fact, this mechanism allows for the possibility of a rebound effect to occur, albeit this may create technical problems in cases where the net effective tax is relatively small and the carbon tax value is relatively high.[21]

4.3.11. Subsidy Reduction Mechanism

The recycling mechanism in an energy subsidy reduction scenario is in actuality quite similar to the carbon pricing recycling mechanism. However, the main difference lies in the fact that Equation 4.29 is unused in this scenario. Instead of generating a new revenue from carbon tax, the revenue is *fixed* equal to the amount of revenue generated from the energy subsidy reduction as shown by the following identity:

$$TCTR_d = \sum_c \left[(itxr_{i,d}^{new} - itxr_{i,d}^{old}) \cdot PDOM_{i,d}^{old} \cdot XTOT_{i,d}^{old} \right] \quad [4.35]$$

Following this change, the conditional rule for Equation 4.33 has to be modified as follows:

$$\alpha h_d + \alpha i_d + \alpha g_d = 0 \quad \text{and} \quad 0 \leq \alpha h_d, \alpha i_d \leq 1 \quad \text{and} \quad -1 \leq \alpha g_d \leq 0 \quad [4.36]$$

Equation 4.36 may appear somewhat confusing. However, suppose now that the government decides to retain all the revenue generated to increase its consumption, then αh_d = 0, αi_d = 0, and αg_d = 0. This in turn affects Equation 4.20 in which government income increases as the energy subsidy is eliminated. In turn, all of this revenue is used to increase government expenditure in Equation 4.21 without any reduction at all, as neither households nor industries are given a share of the revenue generated.

Suppose now that the government decides to transfer half of the subsidy reduction to households in the form of a single lump sum payment, and the other half to increase its own consumption, then αh_d = 0.5, αi_d = 0, and αg_d = -0.5. This in turn affects Equation 4.30 followed by Equation 4.18 for the household case, which means that household income increases by the amount of revenue transferred by the government. Bear in mind that for the

[21] This technical difficulty will be discussed further in the following empirical section.

government part, because of the negative government share sign then TCG is a negative value. However, the overall government consumption may still increase in Equation 4.21 because the decrease is smaller (i.e. half) than the increase in government income, as reflected by Equation 4.20, due to the subsidy reduction.

4.4. Financial Flow of the IRSA-ASEAN Model

Following the equations described in the previous section, Figure 4.3 illustrates the financial flow of the IRSA-ASEAN model. Admittedly, this is a simplified schematic as it provides details of the flow within one country, with only one other country representing all the others, including rest of the world. Nevertheless, Figure 4.3 provides a useful tool to see how changes occur throughout the economy, i.e. impact path analysis. In other words, it summarizes the IRSA-ASEAN model.

Some highlights from Figure 4.3 include the three different mechanisms by which carbon tax revenue can be recycled back into the economy. The first mechanism is when the government uses all revenue generated to proportionally increase its expenditures. The second mechanism is when government chooses to redistribute some, or all, of the revenue generated to low-income households in both rural and urban areas in the form of a one-time lump-sum direct cash transfer to each household group. Note that high-income households in both rural and urban areas do not receive such a transfer. The third mechanism is more complicated in terms of practical and technical implementation. This mechanism occurs when the government recycles the revenue back to the industrial sector in the form of an indirect tax reduction proportional to the sectoral output size. Understandably, the larger the industry, the greater the nominal reduction will be. There are, of course, a number of possible combinations of these three mechanisms and this will explained further in the policy simulations in subsequent chapters.

One final note with regards to the recycling mechanisms is the fact that different combinations of these mechanisms are possible. Indeed, it unlikely that in the real world situation, a government would choose to adopt solely one of these mechanisms. Accordingly, policy simulations conducted in following chapters take this into account and create a number of combinations.

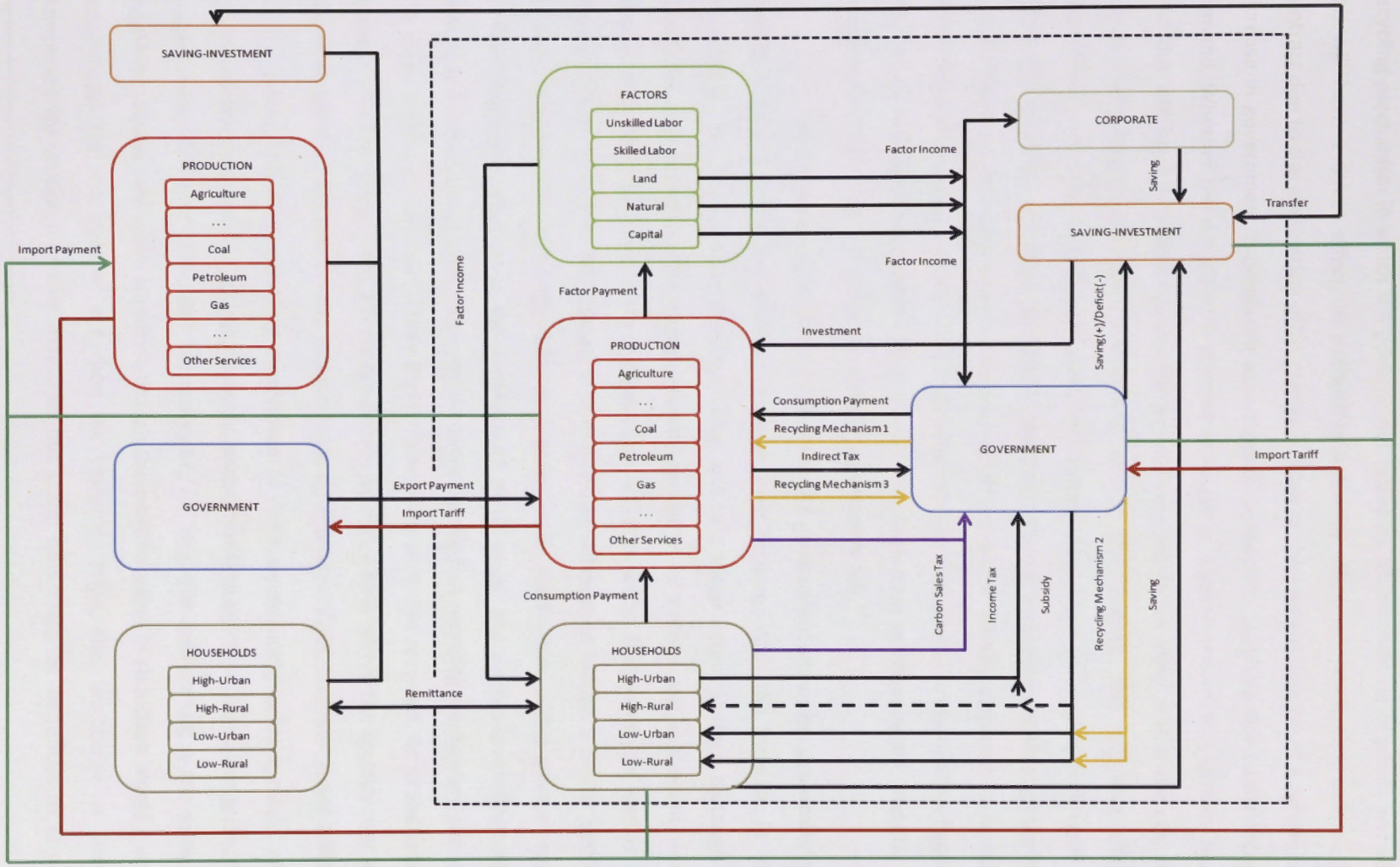


Figure 4.3. Financial Flow of the IRSA-ASEAN Model

Another important highlight from Figure 4.3 is how it shows the path effect of each mechanism once an energy subsidy is eliminated or a carbon tax is implemented. For the first recycling mechanism in which the government increases its expenditure of goods and services, this will have a direct effect on production activities. Although production activities might contract due to the elimination of an energy subsidy or the implementation of a carbon tax, the increase in government expenditure also expands production activities due to the increase in demand. Whether the net effect is positive or negative is yet unknown. It is certain, however, that this will have an effect on the demand for primary factor input within the country and intermediate input from both within and outside the country. This will also affect the government of other countries through the increase/reduction of total import tariff value. Within the country itself, aside from the feedback effect to the government through the indirect tax, a change to primary factor input demand affects factor income payment to households, corporate, and the government. This in turn affects these institutions' consumption of goods and services as well as savings, which then affects the production activities again, and the whole cycle repeats itself until the effect is no longer significantly felt.[22]

The second recycling mechanism in which the government shows its 'generosity' to low-income households will immediately increase their income. With the increase in income, households can then increase their spending, and to a lesser extent savings, although this is somewhat dampened by the energy subsidy reduction or carbon tax implementation. This change, however, will directly affect production activities within the country as well as abroad through import demand. This change in production activities then follows a similar path as the first recycling mechanism. A slight difference arises in this mechanism, with a more direct effect to households abroad, due to the existence of remittances, and savings-investment account. Note that for the former, which also applies as well to the first recycling mechanism, changes are felt directly through remittance only if remittances are sent, not received. As to the latter, the change in savings-investment affects production activities both within the country and abroad. Financial transfer between savings-investment in different countries, however, is not affected.[23]

Lastly, the third recycling mechanism is done by reducing indirect taxes, which is effectively the equivalent of giving a subsidy, proportional to the industry size in terms of total output value. The rate of indirect tax reduction, i.e. negative indirect tax, is the same for all industrial sectors within the country although the nominal value of reduction would then differ accordingly. For the case of a carbon tax implementation, this 'assistance' is somewhat dampened for carbon-intensive industries but could potentially be beneficial to other less-

[22] The stability of this system has been proven by Leontief through his I-O table which shows that marginal propensity to consume is less than one. Anecdotally, these changes will eventually, literally 'run out of steam'. In which case, a new equilibrium is then achieved.

[23] This is more of a technical limitation of the model than a real world limitation.

polluting sectors. As for the case of an energy subsidy reduction, this 'assistance' is somewhat dampened only for industries that have their subsidies eliminated, e.g. coal and electricity sectors, but could potentially be beneficial to other sectors. The impact flow to the economy follows a similar pattern as in the first mechanism. However, the magnitude of the impact may significantly differ due to its direct nature in the production activities of commodities. Theoretically, the double-dividend hypothesis, if it exists, should appear more prominently through this mechanism as it supposedly creates a less distortionary tax system in the economy. Whether this holds true or not, running the numbers is required.

4.5. Concluding Remarks

The IRSA-ASEAN model described here represents a single period equilibrium. None of the arguments in various equations involve lagged variables or expected future variables, so the model is genuinely static. It determines a flow equilibrium based on signals for the current period based only on initial conditions captured in the base year database. As such, the interpretation of the results involves a very simple notion of time, 'long-enough'. Whether that period is short, medium, or long depends on assumptions about elasticities and factor mobility in the model.

As a tool for policy analysis, the IRSA-ASEAN model is more than sufficient to provide a region-wide, bird's-eye view of the economy and gives a unique perspective due to its multi-country nature. It is robust enough to provide useful insights into the economy-wide impact of various policies ranging from, but not limited to, trade, environment, and taxes. Even its static nature can easily be adapted into both inter-temporal and recursive dynamic models given enough additional data, which are unfortunately well beyond the scope of this thesis. Nevertheless, the static nature of the IRSA-ASEAN model for short and medium term policy may provide more relevant solution as policy-makers in developing countries are arguably much more interested in the short and medium term gains rather than long term benefits.

Furthermore, another highlight of the IRSA-ASEAN model is its ability to be used as an analytical tool for international policy coordination. The main goal of this model, and by extension this entire thesis, is to understand the impact of coordinated and non-coordinated policies, i.e. energy subsidy reduction and carbon tax implementation, on the economy and environmental performance of each country within ASEAN. Although, as previously stated, the IRSA-ASEAN model is not limited to the exploration of these issues; its uniqueness lies in the fact that it explores these issues and does so by looking with a region-wide perspective, namely ASEAN. How accurate the model and results it produce will remain to be seen and explored further in the following two chapters.

Appendix 4.1. Set Definitions

```
$TITLE IRSA-ASEAN

$ontext
* Set Definitions

Countries
IDN                Indonesia
MYS                Malaysia
PHL                Philippines
SGP                Singapore
THA                Thailand
VNM                Vietnam
ROW                Rest of the World

Factors
FFUNSKLAB          Unskilled labor
FFSKLAB            Skilled labor
FFCAPITAL          Capital
FFLAND             Land
FFNATLRES          Natural resources

Institutions
HHRULOW            Urban-Low household
HHRUHIGH           Urban-High household
HHURLOW            Rural-Low household
HHURHIGH           Rural-High household
CORP               Corporate
GOVT               Government

Orginal Production Sectors (57 Sectors Before Aggregation)
PDR                Paddy rice
WHT                Wheat
GRO                Cereal grains nec
V_F                Vegetables, fruits, and nuts
OSD                Oil seeds
C_B                Sugar cane and sugar beet
PFB                Plant-based fibers
OCR                Crops nec
CTL                Cattle, sheep, goats, and horses
OAP                Animal products nec
RMK                Raw milk
WOL                Wool silk-worm cocoons
FRS                Forestry
FSH                Fishing
COA                Coal
OIL                Oil
GAS                Gas
OMN                Minerals nec
CMT                Meat: cattle, sheep, goats, and horse
OMT                Meat products nec
VOL                Vegetable oils and fats
MIL                Dairy products
PCR                Processed rice
SGR                Sugar
OFD                Food products nec
B_T                Beverages and tobacco products
TEX                Textiles
WAP                Wearing apparel
LEA                Leather products
LUM                Wood products
PPP                Paper products and publishing
P_C                Petroleum and coal products
CRP                Chemical, rubber, and plastic prods
NMM                Mineral products nec
I_S                Ferrous metals
NFM                Metals nec
FMP                Metal products
MVH                Motor vehicles and parts
OTN                Transport equipment nec
ELE                Electronic equipment
OME                Machinery and equipment nec
OMF                Manufactures nec
ELY                Electricity
GDT                Gas manufacture distribution
WTR                Water
CNS                Construction
TRD                Trade
OTP                Transport nec
```

```
WTP                 Sea transport
ATP                 Air transport
CMN                 Communication
OFI                 Financial services nec
ISR                 Insurance
OBS                 Business services nec
ROS                 Recreation and other services
OSG                 Public administration, defense, health, and education
DWE                 Dwellings

Final Production Sectors (26 Sectors After Aggregation)
PDR                 Agriculture
CTL                 Farming
FRS                 Forestry
FSH                 Fishing
COA                 Coal
OIL                 Oil
GAS                 Gas
OMN                 Minerals nec
CMT                 Food and Beverages
TEX                 Textiles
LUM                 Wood products
P_C                 Petroleum and coal products
CRP                 Chemical, rubber, and plastic prods
NMM                 Mineral products nec
I_S                 Metal products
MVH                 Manufacturing
ELY                 Electricity
GDT                 Gas manufacture distribution
WTR                 Water
CNS                 Construction
TRD                 Trade
OTP                 Transportation
CMN                 Communication
OFI                 Financial services
OSG                 Public administration, defense, health, and education
DWE                 Dwellings and other services

Other Accounts
INDTAX              Indirect tax
IMPTAX              Import tax
SAVINV              Savings-Investment
OTHER               Other Exogenous Accounts (Rest of the World only)

$offtext

set
da                  all countries
/
IDN
MYS
PHL
SGP
THA
VNM
ROW
/

d(da)               countries
/
IDN
MYS
PHL
SGP
THA
VNM
/

n(da)               non-country
/
ROW
/

ac                  all sam account
/
FFUNSKLAB
FFSKLAB
FFLAND
FFNATLRES
FFCAPITAL
HHRULOW
```

```
HHRUHIGH
HHURLOW
HHURHIGH
CORP
GOVT
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
INDTAX
IMPTAX
SAVINV
OTHER
/

acd(ac)          country sam account
/
FFUNSKLAB
FFSKLAB
FFLAND
FFNATLRES
FFCAPITAL
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
CORP
GOVT
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
INDTAX
IMPTAX
SAVINV
/
```

```
f(acd)          factors
/
FFUNSKLAB
FFSKLAB
FFLAND
FFNATLRES
FFCAPITAL
/

id(acd)         country institutions
/
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
CORP
GOVT
/

tsd(acd)        country taxes
/
INDTAX
IMPTAX
/

fud(acd)        country final users
/
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
CORP
GOVT
SAVINV
/

fod(acd)        country factor owners
/
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
CORP
GOVT
/

acn(ac)         non-country account
/
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
INDTAX
IMPTAX
SAVINV
OTHER
/

m(acn)          imported commodities
```

```
/
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
/

in(acn)             non-country institutions
/
OTHER
/

tsn(acn)            non-country tax and subsidy
/
INDTAX
IMPTAX
/

fun(ac)             non-country final users
/
SAVINV
OTHER
/

fon(acn)            non-country factor owners
/
OTHER
/

s                   source
/
dom
imp
/

ur(acd)             country users
/
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
GOVT
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
```

```
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
SAVINV
/

h(ur)              households
/
HHRULOW
HHRUHIGH
HHURLOW
HHURHIGH
/

i(ur)              industries
/
PDR
CTL
FRS
FSH
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
ELY
GDT
WTR
CNS
TRD
OTP
CMN
OFI
OSG
DWE
/

agr(i)             agricultural industries
/
PDR
CTL
FRS
FSH
/

mnf(i)             manufacturing industries
/
COA
OIL
GAS
OMN
CMT
TEX
LUM
P_C
CRP
NMM
I_S
MVH
/

srv(i)             service industries
/
ELY
GDT
WTR
CNS
TRD
```

```
OTP
CMN
OFI
OSG
DWE
/

ee(i)              energy sectors
/
COA
OIL
GAS
P_C
GDT
ELY
/

nfe(ee)            non-feedstock energy sectors
/
COA
P_C
GDT
ELY
/

ce(ee)             carbon emitter sectors
/
COA
P_C
GDT
/

un(acn)            non-country users
/
SAVINV
OTHER
/

und(un)            domestic non-country users
/
SAVINV
OTHER
/

sv(un)             all saving
/
SAVINV
OTHER
/;

alias( i,c);
```

```
* run using this option: r=save\benchmkasean s=save\modelasean

option decimals = 6;

* the following parameters are derived from the benchmkasean.gms file

$ontext
parameter
 aint(c,i,d)              Leontief intermediate coefficient
 aprim(i,d)               Leontief primary factor coefficient
 itxr(i,d)                Indirect tax rate government
 itxm(c,r,d)              Import tariff rate from country r
 itxn(i,d)                Import tariff rate from ROW
 ytaxh(h,d)               household income tax rate
 strhh(hh,r,h,d)          share of inter-households transfer
 strhr(h,d)               share of household income transfers to ROW
 apcgr(d)                 government propensity to consume
 strgrh(h,d,r)            government transfer rate to household
 strgrgr(d,r)             inter-government transfers rate
 strgrr(d)                government transfer rate to row
 strcogr(r,d)             corporate transfer rate to government
 strcohh(h,d,r)           corporate transfer rate to households
 strcoro(d)               corporate transfer rate to row
 strcoco(r,d)             corporate transfer rate to corporate
 apcro                    ROW propensity to consume
 strrofa(f,d)             ROW share of payment from using factors
 strroco(d)               ROW transfer rate to corporate
 strrogr(d)               ROW transfer rate to government
 strroh(h,d)              ROW transfer rate to households

 delprim(f,i,d)           share parameter value-added CES
 alpprim(i,d)             shift parameter value added CES
 rhoprim(i,d)             parameter of value-added CES

 deltrad(c,r,d)           share parameter country-sourcing
 alptrad(c,d)             shift parameter country-sourcing
 rhotrad(c,d)             parameter of CES country-sourcing

 delarm(c,s,d)            share parameter CES Armington
 alparm(c,d)              shift parameter CES Armington
 rhoarm(c,d)              CES parameter Armington

 bdgsh(c,h,d)             household budget share
 bdgsgr(c,d)              budget share government
 expelas(c,r)             export elasticity

 strco2h(h,d)             share parameter for household revenue recycling

 NXP(i,d)                 non-positive output
;
$offtext

variable

*** 1) Variable Declaration

* endogenous variables
 PDOM(c,r)       Producer price at country of origin r
 PQ(c,s,d)       Purchaser price at country of destination d (composite-s)
 PQ_S(c,d)       Price of Import-Dom. composite

 XD(c,s,d)       Domestic-import sourcing (Mod)
 XD_S(c,d)       Domestic-import composite
 XINT_S(c,i,d)   Intermediate composite (import-dom)
 XHOU_S(c,h,d)   Household composite (import-dom)
 XTOT(i,d)       Output
 EH(h,d)         Household disposable income
 XEXP(c,r)       Export demand (Mod)
 XTRAD_R(c,d)    Demand composite over region r
 XFAC(f,i,d)     Demand for factor of production (composite-r)
 XFACRO(f,d)     Demand for factor by ROW
 PFAC(f,d)       Price of factors (composite-r)
 PPRIM(i,d)      Price of value added
 XPRIM(i,d)      Value added
 XTRAD(c,r,d)    Demand of com c from region r by region d

 YH(h,d)         Household total factor income
 YGR(d)          government revenue
```

```
EGR(d)          government expenditure
SGR(d)          government saving

YCO(d)          Corporate revenue
ECO(d)          Corporate expenditure
SCO(d)          Corporate saving
XIMP(c,d)       Total import of com. C

YRO(d)          Rest of the world revenue
ERO(d)          Rest of the world expenditure
SRO(d)          Rest of the world saving

SH(h,d)         Household saving
SAV(d)          Aggregate saving
EXR(d)          Nominal exchange rate

* Exogenous variables
XINV_S(c,d)     Investment demand (composite-s)
PFIMP(c,d)      World price of import
PFEXP(c,r)      World price of export
XGOR_S(c,d)     Government consumption

* miscellaneous variables
savh(h,d)       Household savings rate
savco(d)        Corporate savings rate
adjsav          Overall savings adj. factor
alpexp(c,r)     Export quantity shifter

lambda(c,d)     Share investment
PX              Producer's price index
TRSAVINV(d,r)   Savings-investment transfer

* ------------------ Carbon Related Variables ------------------------ *
XCOI(e,i,d)      CO2 Emissions by industry
XCOH(e,h,d)      CO2 Emissions by household

stx(c,d)         Sales tax rate
cotax(d)         Carbon tax (USD per ton)

TCTR(d)          Total revenue from carbon tax or subsidy reduction
TCH(d)           Recycled revenue to household
TCI(d)           Recycled revenue to industry
TCG(d)           Recycled revenue to government

alpcarbh(d)      Share of CO2 tax revenue to household
alpcarbi(d)      Share of CO2 tax revenue to industry
alpcarbg(d)      Share of CO2 tax revenue to government

tco2(d)          Indirect tax reduction rate

* --------- to assist flexible factor market closure ----------------- *

atot(i,d)        top-nest tech. change
XFACSUP(f,d)     factor supply
YFAC(f,r)        total factor income
WDIST(f,i,d)     factor price distortion
;

*** 2) variable initialization
PDOM.L(c,r) = PDOM0(c,r);
PQ.L(c,s,d) = PQ0(c,s,d);
PQ_S.L(c,d) = PQ_S0(c,d);

PXCINT.L(i,d) = PXCINT0(i,d);
XD.L(c,s,d) = XD0(c,s,d);
XD_S.L(c,d) = XD_S0(c,d);

XINT_S.L(c,i,d) = XINT_S0(c,i,d);
XHOU_S.L(c,h,d) = XHOU_S0(c,h,d);
XTOT.L(i,d) = XTOT0(i,d);
EH.L(h,d) = EH0(h,d);
XEXP.L(c,r) = XEXP0(c,r);
XTRAD_R.L(c,d) = XTRAD_R0(c,d);
XFAC.L(f,i,d) =  XFAC0(f,i,d);
XFACRO.L(f,d) = XFACRO0(f,d);
PFAC.L(f,d) =  PFAC0(f,d);
PPRIM.L(i,d) = PPRIM0(i,d);
XPRIM.L(i,d) = XPRIM0(i,d);
XTRAD.L(c,r,d) = XTRAD0(c,r,d);

YH.L(h,d) = YH0(h,d);
```

```
YGR.L(d) = YGR0(d);
EGR.L(d) = EGR0(d);
SGR.L(d) = SGR0(d);

YCO.L(d) = YCO0(d);
ECO.L(d) = ECO0(d);
SCO.L(d) = SCO0(d);
XIMP.L(c,d) = XIMP0(c,d);

YRO.L(d) = YRO0(d);
ERO.L(d) = ERO0(d);
SRO.L(d) = SRO0(d);
SH.L(h,d) = SH0(h,d);
SAV.L(d) = SAV0(d);
XINV_S.L(c,d) = XINV_S0(c,d);
EXR.L(d) = EXR0(d);

PFIMP.L(c,d) = PFIMP0(c,d);
PFEXP.L(c,r) = 1;

XGOR_S.L(c,d) = XGOR_S0(c,d);

savh.L(h,d) = savh0(h,d);

savco.L(d) = savco0(d);
adjsav.L = 1;

lambda.L(c,d) = PQ_S0(c,d)*XINV_S0(c,d)
              / SUM(cc,PQ_S0(cc,d)*XINV_S0(cc,d));
PX.L = 1;
alpexp.L(c,r) =  alpexp0(c,r);

TRSAVINV.L(d,r) = TRSAVINV0(d,r);

XCOI.L(e,i,d) = XCOI0(e,i,d);
XCOH.L(e,h,d) = XCOH0(e,h,d);

stx.L(c,d) = 0;
tco2.L(d) = 0;

TCTR.L(d) = 0;
TCH.L(d) = 0;
TCI.L(d) = 0;
TCG.L(d) = 0;

cotax.L(d) = 0;
alpcarbh.L(d) = 0;
alpcarbi.L(d) = 0;
alpcarbg.L(d) = 0;

atot.l(i,d) = 1;
XFACSUP.L(f,d) = XFACSUP0(f,d);
YFAC.L(f,r) = YFAC0(f,r);
WDIST.L(f,i,d) = WDIST0(f,i,d);

* ------------------------------------------------

equations

*** 3) equation declaration

* PRODUCTION SECTORS

* Production of output
 e_xtot(i,d)              zero profit condition
 e_xint_s(c,i,d)          intermediate input demand function
 e_xprim(i,d)             primary input demand function

* Production of primary input
 e_xfac(f,i,d)            demand for factors or production
 e_pprim(i,d)             zero profit condition

* EXPORT-IMPORT

* Import from origins r to regional market
 e_xtrad(c,r,d)           demand for commodities from country r in country d
 e_pq_dom(c,d)            price of region composite in country d

* Import from abroad to region d
 e_xd(c,s,d)              Armington condition for country d
```

```
 e_pq_s(c,d)              zero profit condition for import from abroad at
country d
 e_pq_m(c,d)              tariff for country import

* Export
 e_xexp(c,r)              export demand

* Market Clearing Condition
 e_ximp(c,d)              foreign import market clearing (Mod)
 e_xtrad_r(c,d)           market clearing for domestic demand at region d
 e_xd_s(c,d)              market clearing for commodity c at region d

* INSTITUTIONAL BEHAVIOR (Household, Governments, Corporate)

* Factors
 e_yfac(f,r)              total factor income

* Households
 e_yh(h,d)                household income
 e_eh(h,d)                household disposable income for consumption
 e_xhou_s(c,h,d)          household demand: LES model

* Government
 e_ygr(d)                 income of government
 e_egr(d)                 expenditure of government
 e_xgor_s(c,d)            government demand

* Corporate sector
 e_yco(d)                 income of corporate sector
 e_eco(d)                 expenditure of corporate sector

* INVESTMENT
 e_sh(h,d)                household saving
 e_sco(d)                 savings of corporate sector
 e_sav(d)                 aggregate saving
 e_xinv_s(c,d)            investment demand
 e_px                     producer's price index

* MARKET CLEARING
 e_pfac(f,d)              market clearing for factors
 e_pdom(c,r)              market clearing for commodities

* REST OF THE WORLD
 e_yro(d)                 payment outflow
 e_ero(d)                 payment inflow
 e_sro(d)                 Balance of Payment

* CO2 EMISSIONS
 e_xcoi(e,i,d)            co2 emissions by industry
 e_xcoh(e,h,d)            co2 emissions by households
 e_stx(e,d)               carbon tax to sales tax

 e_tctr(d)                total revenue from carbon tax or subsidy reduction
 e_tctrh(d)               recycled revenue to household
 e_tctri(d)               recycled revenue to industry
 e_tctrg(d)               recycled revenue to government

 e_tci(d)                 indirect tax reduction
;

*** 4) equation statement

* ------------------------- equations ------------------------------ *

* PRODUCTION SECTORS

* Production of Output
** demand of all inputs
 e_xint_s(c,i,d)..   XINT_S(c,i,d) =e= atot(i,d)*aint(c,i,d)*XTOT(i,d);
 e_xprim(i,d)..  XPRIM(i,d) =e= atot(i,d)*aprim(i,d)*XTOT(i,d);

** zero profit of production
 e_xtot(i,d)..
  (1-itxr(i,d)+tco2(d))*PDOM(i,d)*XTOT(i,d) =e=
  PPRIM(i,d)*XPRIM(i,d) + SUM(c,(1 + stx(c,d))*PQ_S(c,d)*XINT_S(c,i,d));

* Product of Primary Input
* demand for factors of production
 e_xfac(f,i,d)$XFAC0(f,i,d)..
    XFAC(f,i,d) =e=
       alpprim(i,d)**(-rhoprim(i,d)/(1+rhoprim(i,d)))
```

```
     * XPRIM(i,d)
     * (delprim(f,i,d)**(1/(rhoprim(i,d)+1))
     * (( (WDIST(f,i,d)*PFAC(f,d))/PPRIM(i,d) )
     ** (-1/(rhoprim(i,d)+1)) ));

** zero profit condition of primary inputs
 e_pprim(i,d)$XP(i,d)..
  PPRIM(i,d)*XPRIM(i,d) =e= SUM(f,(WDIST(f,i,d)*PFAC(f,d))*XFAC(f,i,d));


* ------------------------------------------------------------------- *

* EXPORT-IMPORT

** Import from origins r to country market
*** demand for commodities from country r in country d
 e_xtrad(c,r,d)..
    XTRAD(c,r,d) =e=
       alptrad(c,d)**(-rhotrad(c,d)/(1+rhotrad(c,d)))
     * XTRAD_R(c,d)
     * (deltrad(c,r,d)**(1/(rhotrad(c,d)+1))
     * ((((1+itxm(c,r,d))*PDOM(c,d))/PQ(c,"dom",d)) ** (-1/(rhotrad(c,d)+1))));

*** price of region composite in country d
 e_pq_dom(c,d)..
      PQ(c,"dom",d)*XTRAD_R(c,d) =e=
            SUM(r,(1+itxm(c,r,d))*PDOM(c,d)*XTRAD(c,r,d));

** Import from abroad to country d
*** Armington condition for country d
 e_xd(c,s,d)..
    XD(c,s,d) =e=
       alparm(c,d)**(-rhoarm(c,d)/(1+rhoarm(c,d)))
     * XD_S(c,d)
     * (delarm(c,s,d)**(1/(rhoarm(c,d)+1))
     * (( PQ(c,s,d)/PQ_S(c,d) ) ** (-1/(rhoarm(c,d)+1))));

*** zero profit condition for import from abroad at country d
 e_pq_s(c,d)..
         PQ_S(c,d)*XD_S(c,d) =e= SUM(s,PQ(c,s,d)*XD(c,s,d));

*** tariff for regional import
 e_pq_m(c,d)..   PQ(c,"imp",d) =e= (1 + itxn(c,d))*PFIMP(c,d)*EXR(d);

* Export
*** export demand at the national market
 e_xexp(c,r)$XEXP0(c,r)..
    XEXP(c,r) =e= alpexp(c,r)*[(PDOM(c,r)/EXR(r))/PFEXP(c,r)]**(-expelas(c,r));

* Market Clearing Condition
** Foreign import market clearing
 e_ximp(c,d)..
     XIMP(c,d) =e= XD(c,"imp",d);

** Market clearing for domestic demand at country d
 e_xtrad_r(c,d)..
   XTRAD_R(c,d) =e= XD(c,"dom",d);

** Market clearing for commodity c at country d
 e_xd_s(c,d)..
   XD_S(c,d) =e= SUM(i,XINT_S(c,i,d)) + SUM(h,XHOU_S(c,h,d))
              + XGOR_S(c,d)+ XINV_S(c,d);

* ------------------------------------------------------------------- *

* INSTITUTIONAL BEHAVIOR (Households, Government, Corporate)

* Total Factor Income
 e_yfac(f,r)..
   YFAC(f,r) =e= SUM(i,WDIST(f,i,r)*PFAC(f,r)*XFAC(f,i,r));

* Households
** household income
 e_yh(h,d)..
  YH(h,d) =e=  SUM((r,f),SFACHH(r,h,d,f)*YFAC(f,r))
           + SUM(r,strgrh(h,r,d)*YGR(r))
           + SUM(r,strcohh(h,r,d)*YCO(r))
           + SUM(hh,SUM(r, strhh(h,d,hh,r)
           * (1-savh(hh,r))*(1-ytaxh(hh,r))*YH(hh,r)))
           + strco2h(h,d)*TCH(d);
```

```
** household disposable income for consumption
 e_eh(h,d)..
   EH(h,d) =e= (1-SUM(hh,SUM(r,strhh(hh,r,h,d)))
              - strhr(h,d))
              * (1-savh(h,d)) * (1-ytaxh(h,d)) * YH(h,d);

** household demand
 e_xhou_s(c,h,d)..
    (1 + stx(c,d))*PQ_S(c,d)*XHOU_S(c,h,d) =e=
         + bdgsh(c,h,d)*EH(h,d)
;

* Regional Government
** income of regional government
 e_ygr(d)..
     YGR(d) =e= SUM(i,(itxr(i,d)-tco2(d))*PDOM(i,d)*XTOT(i,d))
              + SUM(r,strcogr(d,r)*YCO(r))
              + SUM((r,f),SFACGR(r,d,f)*YFAC(f,r))
              + SUM(h,ytaxh(h,d)*YH(h,d))
              + SUM(c,SUM(r,itxm(c,r,d)*PDOM(c,d)*XTRAD(c,r,d)))
              + SUM(c,itxn(c,d)*PFIMP(c,d)*XIMP(c,d)*EXR(d));

** expenditure of regional government
 e_egr(d)..
    EGR(d) =e= (1-(SUM(h,SUM(r,strgrh(h,d,r)))))
               * YGR(d) + TCG(d) - SGR(d);

** government demand
 e_xgor_s(c,d)..
    PQ_S(c,d)* XGOR_S(c,d) =e= bdgsgr(c,d) * EGR(d);

* Corporate sector
* income of corporate sector
 e_yco(d)..
     YCO(d) =e= SUM((r,f),SFACCO(r,d,f)*YFAC(f,r))
              + SUM(r,strcoco(d,r)*YCO(r));

* expenditure of corporate sector
 e_eco(d)..
     ECO(d) =e=  (SUM(r,strcogr(r,d))
              + SUM(h,SUM(r,strcohh(h,d,r)))
              + SUM(r, strcoco(r,d)) + strcoro(d)) * YCO(d);

* ------------------------------------------------------------------ *

* INVESTMENT

* household saving
 e_sh(h,d)..     SH(h,d) =e= savh(h,d)*(1-ytaxh(h,d))*YH(h,d);

* savings of corporate sector
 e_sco(d)..      SCO(d) =e= adjsav*savco(d)*YCO(d);

* aggregate saving
 e_sav(d)..
     SAV(d) =e= SUM(h,SH(h,d)) + SGR(d) + SCO(d)
          + EXR(d)*SRO(d) + SUM(r,TRSAVINV(d,r));

* investment demand
 e_xinv_s(c,d)..
    PQ_S(c,d)*XINV_S(c,d) =e= lambda(c,d)
                           * (SAV(d) - SUM(r,TRSAVINV(r,d)));

* producer's price index
 e_px..          PX =e= SUM((i,d), wgtpx(i,d)*PDOM(i,d));

* ------------------------------------------------------------------ *

* MARKET CLEARING

* market clearing for factors
 e_pfac(f,d)..
   SUM(i,XFAC(f,i,d)) +  XFACRO(f,d) =e= XFACSUP(f,d);


* market clearing for commodities
 e_pdom(c,r)$XP(c,r)..    XTOT(c,r) =e=
                 SUM(d,XTRAD(c,r,d)) + XEXP(c,r);

* ------------------------------------------------------------------ *
```

```
* REST OF THE WORLD

* BALANCE OF PAYMENT

* payment outflow (in $)
 e_yro(d)..
     YRO(d) =e= SUM(c,PFIMP(c,d)*XIMP(c,d)*EXR(d))
          + SUM(h,SUM(hh,SUM(r, strhh(h,r,hh,d)*(1-savh(hh,d))*(1-
ytaxh(hh,d))*YH(hh,d))))
          + SUM((c,r),PDOM(c,d)*XTRAD(c,r,d)$(XTRAD0(c,r,d) ne XTRAD0(c,d,r)))
          + SUM(r,TRSAVINV(r,d));

* payment inflow (in $)
 e_ero(d)..
      ERO(d) =e= SUM(h,SUM(hh,SUM(r, strhh(h,d,hh,r)*(1-savh(hh,r))*(1-
ytaxh(hh,r))*YH(hh,r))))
          + SUM((c,r),PDOM(c,d)*(XTRAD(c,d,r)$(XTRAD0(c,r,d) ne
XTRAD0(c,d,r))))
          + SUM(c,PDOM(c,d)*XEXP(c,d))
          + SUM(r,TRSAVINV(d,r))
          + SRO(d);

* Balance of Payment
 e_sro(d)$(YRO0(d) ne YRO0('IDN'))..       YRO(d) =e= ERO(d);

*-------------------------------------------------------------------------
* CO2 EMISSIONS

* CO2 emissions
 e_xcoi(e,i,d)..    XCOI(e,i,d) =e= cci(e,i,d)*XINT_S(e,i,d);
 e_xcoh(e,h,d)..    XCOH(e,h,d) =e= cch(e,h,d)*XHOU_S(e,h,d);

 e_stx(e,d)..       stx(e,d) =e= cotax(d)*[(SUM(i,XCOI(e,i,d))
                                  + SUM(h,XCOH(e,h,d)))]
                           / [PQ_S(e,d)*(SUM(i,XINT_S(e,i,d))
                                  + SUM(h,XHOU_S(e,h,d)))];

 e_tctr(d)..      TCTR(d) =e= SUM(c,stx(c,d)*PQ_S(c,d)*SUM(h,XHOU_S(c,h,d)))
                           + SUM(c,stx(c,d)*PQ_S(c,d)*SUM(i,XINT_S(c,i,d)));

 e_tctrh(d)..     TCH(d) =e= alpcarbh(d) * TCTR(d);

 e_tctri(d)..     TCI(d) =e= alpcarbi(d) * TCTR(d);

 e_tctrg(d)..     TCG(d) =e= alpcarbg(d) * TCTR(d);

 e_tci(d)..       tco2(d)*SUM(i,PDOM(i,d)*XTOT(i,d)) =e= TCI(d);

* ---------------------- end of equations ---------------------------- *

display cotax.L, stx.L ,XCOI.L, XCOH.L, XINT_S.L, XHOU_S.L, TCTR.L
;

* --------------------------- closure ------------------------------- *
 PX.FX = PX.L;
 PFIMP.FX(c,d) = PFIMP.L(c,d);
 PFEXP.FX(c,r) = PFEXP.L(c,r);
 savh.fx(h,d) = savh.L(h,d);
 savco.fx(d) = savco.L(d);
 adjsav.fx = adjsav.L;
 lambda.FX(c,d) =  lambda.L(c,d);
 XFACRO.FX(f,d) = XFACRO.L(f,d);
 itxr.fx(i,d) = itxr0(i,d);
 itxm.fx(c,r,d) = itxm0(c,r,d);
 itxn.fx(c,d) = itxn0(c,d);
 alpexp.fx(c,r) =  alpexp.L(c,r);
 XFACSUP.fx(f,d) = XFACSUP0(f,d);
 WDIST.fx(f,i,d) = WDIST0(f,i,d);
 SRO.FX(d) = SRO.L(d);

 atot.fx(i,d) = atot.l(i,d);

 TRSAVINV.fx(d,r) = TRSAVINV.l(d,r);

* ------------------ carbon tax closure ---------------------------- *
 cotax.fx(d) = cotax.l(d);
 stx.fx(c,d) = stx.l(c,d);
 stx.lo(e,d) = -INF;
 stx.up(e,d) = +INF;

 alpcarbh.fx(d) = alpcarbh.l(d);
```

```
alpcarbi.fx(d) = alpcarbi.l(d);
alpcarbg.fx(d) = alpcarbg.l(d);

SGR.FX(d) = SGR.L(d);

* ------------- Land & capital is immobile ------------------------- *

set fx(f) fixed factor / FFCAPITAL, FFLAND, FFNATLRES /;

XFAC.FX(fx,i,d)$XFAC.L(fx,i,d) = XFAC.L(fx,i,d);
WDIST.UP(fx,i,d)$XFAC.L(fx,i,d) = +INF;
WDIST.LO(fx,i,d)$XFAC.L(fx,i,d) = -INF;
XFACSUP.UP(fx,d) = +INF;
XFACSUP.LO(fx,d) = -INF;
PFAC.fx(fx,d) = PFAC.L(fx,d);

* ------------------ unemployed labor ------------------------------ *

set fl(f) unemployed labor / FFUNSKLAB, FFSKLAB /;
XFACSUP.FX(fl,d) = XFACSUP.L(fl,d);

* ------------------------ end of closure ----------------------------*

* ------------- variable not in the model is zero ------------------- *
PPRIM.FX(i,d)$NXP(i,d) = 1;
PDOM.FX(c,r)$NXP(c,r) = 1;
XFAC.FX(f,i,d)$(not XFAC0(f,i,d)) = 0;
XEXP.FX(c,r)$(not XEXP0(c,r)) = 0;

* ------------------------------------------------------------------- *
option iterlim = 0;
option limrow = 10000;

*** 6) Model statement

model IRCGEv1
/
e_xprim
e_xint_s
e_xtot
e_xfac
e_pprim
e_xtrad
e_pq_dom
e_xd
e_pq_s
e_pq_m
e_xexp
e_ximp
e_xtrad_r
e_xd_s
e_yfac
e_yh
e_eh
e_xhou_s
e_ygr
e_egr
e_xgor_s
e_yco
e_eco
e_sh
e_sco
e_sav
e_xinv_s
e_px
e_pfac
e_pdom
e_yro
e_ero
e_xcoi
e_xcoh
e_stx
e_tctr
e_tctrh
e_tctri
e_tctrg
e_tci
e_sro
/;

solve IRCGEv1 using MCP;
```

Chapter 5: Case Study 1 - Energy Subsidy Reduction

Summary

Energy security, the impact of energy use on the environment, fuel prices, and fuel poverty are all issues at the forefront of public attention. The main goal of this chapter is to analyze the impact of an energy subsidy reduction in ASEAN in terms of economic development, environmental improvement, and welfare distribution. To achieve this goal, this chapter uses a multi-country computable general equilibrium (CGE) for ASEAN, known as the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model, constructed in the previous chapter. An ASEAN Social Accounting Matrix (ASEAN-SAM) consisting of Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam has also been constructed as the main database for this CGE. This chapter finds that countries in which energy subsidies exist, i.e. Indonesia and Malaysia, stand to gain much from eliminating these subsidies. Gross domestic product (GDP) is likely to increase, with the added benefit of CO_2 emissions reduction. In terms of welfare distribution, this policy appears to be progressive in nature.

5.1. Introduction

Fuel prices, fuel taxation, and even subsidies for petrol and diesel fuel continue to rank high on the world's political agenda, particularly after the oil price volatility in 2007 and 2008. The period of very high crude oil prices in 2007 and 2008, followed by a phase of sharply declining crude oil and petroleum product prices at the end of 2008, highlighted the need for a critical investigation of the level of fuel prices as well as the nature and manner of adjustment of price levels. This includes the issue of moving from *ad hoc* pricing towards regular price reviews and to the elimination of direct and indirect subsidies (Ellis, 2010).

As such, this chapter analyzes the impact of eliminating energy subsidies, i.e. subsidies for fuel and electricity in ASEAN. The focus is on Indonesia and Malaysia where energy subsidies are most prevalent (Metschies, 2005). This chapter utilizes the Inter-Regional System Analysis for ASEAN (IRSA-ASEAN), a multi-country computable general equilibrium (CGE) model, to look at the economy-wide impact of implementing such a policy in terms of environmental improvement, economic development, and social equity.

The first part of this chapter provides a brief overview of energy economics in terms of both theoretical and empirical evidence. The second part of this chapter provides a technical review of the ASEAN-SAM and reconciling it with the IRSA-ASEAN model. The third part of the chapter presents the results and analysis of using the IRSA-ASEAN model to simulate various policy scenarios with regard to the energy subsidy reduction. Lastly, the final section provides a summary and conclusion for this chapter.

5.2. Energy Economics

Energy security, the impact of energy use on the environment, fuel prices, and fuel poverty are all issues at the forefront of public attention. The economics of energy is a vital element which contributes to the understanding of these complex issues and influences policymakers' thinking as energy policy is determined. As such, this has been followed by an increase in the study of energy economics, including empirical modeling of energy demand.

As summarized by Ran and Plourde (2009), there are at least four primary motivations for this rise in interest: first, there is the question of the magnitude of demand responses as a result of price changes and income changes. These responses can have important implications for policy analysis since any type of tax would generally raise the price and hence affect demand, as would increases in income. Second, there is a general interest in forecasting or predicting future energy needs. These forecasts are generally based on what has happened in the past, how past demand behavior depends on various factors, and expectations about how those factors might change in the future. Third, there is a general understanding that without energy there would be no production so that issues of the extent to which energy can be substituted in the production process, e.g. by labor and capital, have become an important consideration. Fourth, with increasing concern over greenhouse gas (GHG) emissions and climate change (largely associated with energy production and consumption), questions of how demand for energy can be curtailed or associated with fewer emissions have received increased prominence.

Nevertheless, before any empirical studies, e.g. modeling, are undertaken and analyzed, understanding of both theories as well as 'real world' evidence is necessary. As such, the following provides a brief theoretical review of energy economics and current energy trend.

5.2.1. A Brief Theoretical Review and the Rebound Effect

In reality there is no such subject as energy economics, because energy, although a meaningful concept in the physics or engineering sense, is not a commodity that can be bought and sold in the marketplace. However, individual fuels can be bought and sold. Therefore, 'energy economics' is really the economics of fuel markets, and the phrase 'energy economics' is used for convenience to represent all the useful economic concepts which arise in studying different fuels (Weyman-Jones, 2009). Meanwhile, these fuels, more aptly termed energy resources, can be classified as either depletable or non-depletable. A resource is considered depletable when the sum over time of all possible production is finite, or the stock of the resource is not replaceable in a reasonable timeframe. Fossil fuels, namely coal, crude oil, and natural gas, are examples of depletable resources. A resource is considered non-depletable if its stock can be

replenished within a reasonable timeframe, which include geothermal, wind, and solar (Medlock, 2009a).

Meanwhile, the energy industries are organized in different ways in different countries; many are investor owned, such as in the United States and United Kingdom, although state ownership is also common. Many are characterized by economies of scale and hence have considerable market power, which usually leads to them being regulated. In some of these fuel markets, it is cheaper to have one company do all the business rather than many. Examples are the national power and gas grid companies engaged in the activities of bulk transmission of electric power and natural gas, which are traditionally referred to as public utilities. Because these companies are believed to operate most cheaply or efficiently when there is only one of them in each market, they are called 'natural monopolies', e.g. gas and electricity. Consequently, there is a wide public interest in the possibility of regulating their behavior and the economics of regulation becomes an intrinsic part of energy economics (Weyman-Jones, 2009).

On the demand side, energy demand is a derived demand determined by its ability to provide some set of desired services. In particular, energy facilitates the provision of goods and services in industry and in the household. Demand in the long and short runs, however, is complicated by many factors. Economic development itself leads to changes in the structure of output that can alter the manner in which demand grows relative to income. Moreover, factors such as technological change and the effect of energy prices on the composition, efficiency, and utilization of energy sources must also be considered, not to mention the influence that policy can have on demand by altering costs. Understanding these influences is vital in developing policies aimed at dealing with some of the world's most pressing problems, such as climate change and access to affordable energy services (Medlock, 2009b).

Economic structure and technology are also critical determinants of energy demand. At the macro level, each influences energy intensity, where energy intensity is defined as the quantity of energy consumed per unit of economic output. Regarding economic structure, as an economy develops it will generally become more service oriented. To the extent that a unit of service output requires less energy input than a unit of manufacturing output, energy intensity will decline. Regarding technology, as more energy-efficient capital is deployed, the energy requirements for a given level of output decline, thus allowing economic activity to expand without an increase in energy demand. Nevertheless, although improvements in energy efficiency are seen as a key mechanism for reducing energy dependence and ensuring energy sustainability and security of supply goals, there are disputes about the way in which the economy responds to such efficiency improvements. An increase in energy efficiency reduces the price of energy, measured in efficiency units, and this has output, income and substitution

effects that tend to mitigate, and possibly offset totally, any energy savings. Mitigation is labeled as 'rebound' and an increase in energy use as 'backfire' (Allan *et al.* 2009).

As stated earlier, there is an increasing concern regarding environmental issues, such as carbon emissions and climate change, which are closely related to energy production and consumption. To achieve reductions in carbon emissions, most governments are seeking ways to improve energy efficiency throughout the economy. It is generally assumed that such improvements will reduce overall energy consumption, at least compared to a scenario in which such improvements are not made. But a range of mechanisms, commonly grouped under the heading of 'rebound effects' may reduce the size of the 'energy savings' achieved. Indeed, works by Khazzoom (1980), Greene (1992), Greene *et al.* (1999), Berkout *et al.* (2000), and Greening *et al.* (2000) suggest that the introduction of certain types of energy-efficient technology in the past has contributed to an overall increase in energy demand, an outcome that has been termed 'backfire'. This applies in particular to pervasive new technologies, such as steam engines in the nineteenth century, that significantly raise overall economic productivity as well as improve energy efficiency (Alcott, 2005).

These rebound effects could have far-reaching implications for energy and climate policy. While cost-effective improvements in energy efficiency should improve welfare and benefit the economy, they could in some cases provide an ineffective or even a counter-productive means of tackling climate change. It does not necessarily follow that all improvements in energy efficiency will increase overall energy consumption or, in particular, that the improvements induced by policy measures will do so. The nature, operation and importance of rebound effects are the focus of a long running debate within energy economics. On the micro level, the question is whether improvements in the technical efficiency of energy use can be expected to reduce energy consumption by the amount predicted by simple calculations. The increased consumption of energy services may be expected to offset some of the predicted reduction in energy consumption (Allan *et al.* 2009).

The 'direct rebound effect' was first identified by Khazzoom (1980) and has since been the focus of several empirical studies (Greening *et al.*, 2000). But even if there is no direct rebound effect for a particular energy service there are a number of other reasons why the economy-wide reduction in energy consumption may be less than simple calculations suggest. For example, the money saved on direct fuel consumption may be spent on other goods and services that also require energy to provide, called the 'indirect rebound effects'. Both direct and indirect rebound effects apply equally to energy efficiency improvements by consumers and the overall or economy-wide rebound effect from an energy efficiency improvement represents the sum of these direct and indirect effects. Rebound effects need to be defined in relation to a particular timeframe, i.e. short, medium, or long term, and system boundary for the relevant

energy consumption, i.e. household, firm, sector, or national economy. The economy-wide effect is normally defined in relation to a national economy, but there may also be effects in other countries through changes in trade patterns and international energy prices. Rebound effects may also be expected to increase in importance over time as markets, technology, and behavior adjust (Sorrell, 2009).

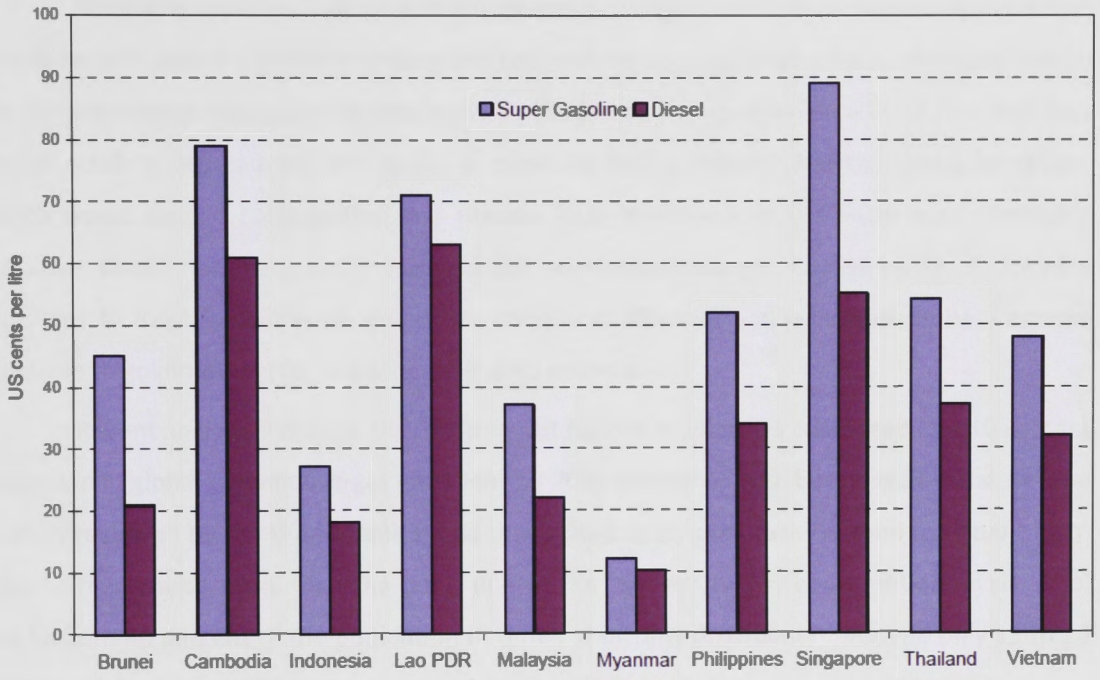
Nevertheless, the magnitude and significance of the rebound effect is still debatable, with values ranging from one percent to several hundred percent. Some works call them insignificant (Lovins, 1988; Schipper and Grubb, 2000; Greening *et al.*, 2000), others significant (Khazzoom, 1989; Greenhalgh, 1990; Greene, 1992; Brookes, 2000; Saunders, 2000; Sanne, 2002), and some even ignore the rebound effect entirely while asserting that efficiency is environmentally advisable (Vincent and Panayotou, 1997; Stern, 2006). As such, while energy economists recognize that rebound effects may reduce the energy savings from energy efficiency improvements, there is dispute over how important these effects are.

5.2.2. Fossil Fuel and Subsidy

Today's modern economy thrives on the consumption of fossil fuels. The global primary energy demand increased at an average annual rate of 2.0 percent from 1980 to 2005; and this demand has been met primarily by fossil fuels. In 2005, petroleum comprised 36.6 percent of total energy use, followed by coal at 26.5 percent and natural gas at 23.3 percent. It is likely that fossil fuels will continue to make up a dominant share of total primary energy use well into the future (Medlock, 2009b). Meanwhile, the world has also seen a sharp increase in oil prices over the last few years, especially since 2004. Five years ago, a barrel of crude oil cost about USD 25, prices then increased stepwise to USD 75 in 2006 and hit a new record in summer 2008 at approximately USD 145 per barrel. There was consumer reaction worldwide. Compared to industrial nations, the consequences of these price hikes are more severe and diverse for developing countries. Many of them are ill prepared to digest the shock and to properly re-shape their energy and transport policy and cope with higher energy prices in the long or even short-term (Ebert *et al.*, 2009). This is partly, if not entirely, due to the existence of subsidies.

Most ASEAN member countries have a high rate of oil usage in their Gross Domestic Product (GDP) and are net importers of oil. Transport fuel, oil powered electricity generation, and a reliance on kerosene for domestic use see oil price impacts flow through to many points in the economy. A structural feature of ASEAN economies that differs substantially across the region and has a significant impact on the transmission of an oil price shock is the regulation and taxation of gasoline and diesel at the retail level. Although the main initial direct impacts of an oil price shock are usually felt by consumers as domestic retail prices rise with the change in the

global markets, this is not necessarily the case in many ASEAN economies. Retail prices for oil products have in the past been regulated and heavily subsidized, particularly in Indonesia, Malaysia, Myanmar, and Brunei Darussalam, as shown by Figure 5.1. Perhaps not so surprisingly, those countries which have had the heaviest regulation in the past, namely Indonesia, Malaysia, and Vietnam, have been most able to afford to do so due to their oil exporting status, and state involvement in oil production; whereas the most oil dependant economies have allowed the market to determine the price, such as in the case of the Singapore actively discouraging the use of oil via high taxation (Downes, 2007).[1]



Source: Downes (2007).

Figure 5.1. Retail Prices for Gasoline and Diesel in 2004

According to the Organization for Economic Cooperation and Development (OECD, 2002), subsidies for the production and consumption of fossil fuels, and energy in general, exist in a wide variety of forms: direct budgetary transfers, such as grants to producers, grants to consumers, and low-interest or preferential treatment; preferential tax treatment, such as rebates or exemptions on royalties, duties, producer levies, and tax credits; trade instruments, such as quotas, technical restrictions, and trade embargoes; and energy-related services provided directly by government at less than full cost, such as direct investment in energy infrastructure as well as public research and development.

[1] See Chapter 2 for more discussion on energy prices and consumption patterns in ASEAN countries.

Subsidies can be justified in theory if they promote an overall increase in social welfare. However, the consensus of expert opinion is that fossil fuel subsidies have a net negative effect, both in individual countries and on a global scale. Fossil fuel subsidies alter fossil fuel prices, leading to market distortions with consequences that go well beyond the specific policy objective that the subsidy is intended to achieve. These distortions have wide environmental, economic, and social impacts; in many cases increasing energy consumption and GHG emissions, straining government budgets, diverting funding that could otherwise be spent on social priorities such as healthcare or education, and reducing the profitability of alternative energy sources (Ellis, 2010).

Removing fossil fuel subsidies is considered by many to be a win-win policy measure that would benefit both the global economy and the environment and therefore a 'no regret' option for climate-change mitigation (Burniaux *et al.*, 2009). In theory, eliminating fossil fuel subsidies would result in higher fossil fuel prices in countries that currently subsidize consumer prices, which would reduce consumption and thereby GHG emissions. At the same time, removing subsidies would remove a costly drain on the government budget. Consequently, eliminating subsidies to fossil fuels may be one of the most cost effective and least distortionary options available to governments for reducing their GHG emissions.

Recent analysis indicates that phasing-out fossil fuel subsidies could lead to a 10 percent reduction in global greenhouse-gas emissions by 2050 compared with business-as-usual. Several studies reviewed by the World Bank found that subsidies to fossil fuel use tend to benefit high-income households more than the poor, due to the former's higher consumption levels. Also, the bottom 40 percent of the population in terms of income distribution received only 15 to 20 percent of the fuel subsidies in developing countries (IEA *et al.*, 2010).

However, governments contemplating fossil fuel subsidy reform should carefully evaluate the environmental and economic benefits of doing so. It is possible that reforms could provoke some unintended negative environmental effects. In some poorer countries, subsidies related to fossil fuels can also improve the environment or the welfare of the poor if they encourage reduced reliance on biomass in areas at risk of deforestation, and fund research into ways to sequester carbon emissions from combustion (Ellis, 2010; IEA *et al.*, 2010).

In addition, there is concern that subsidy removal could have adverse social impacts, or that the social benefits may not be fairly distributed. By their very nature, subsidies redirect economic rents to certain stakeholders. Thus subsidy removal could, in the short-term, create some economic losers. IEA (1999) notes that even if there are some losers from subsidy reform, solutions that increase overall net economic and environmental well-being should still be implemented, and measures to compensate the losers considered. The money saved from subsidies could, in theory, be redirected to transfers or social programs that are better targeted

for the poor. The timing and speed of reform is also critical. Many countries, e.g. Indonesia, that have eliminated food or fuel subsidies in recent years have experienced large-scale civil unrest (Coady *et al.*, 2006; Ellis 2010).

Fossil fuel subsidy reform is likely to prove challenging for many countries, given the numerous economic, environmental and social changes reform could precipitate. Estimating the nature and scale of these changes is therefore critical to assessing the costs and benefits of subsidy reforms and to identifying what flanking measures may be needed to ensure that negative impacts are minimized (Ellis, 2010).

5.3. Implementing the IRSA-ASEAN Model

The Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model is a static, multi-country computable general equilibrium (CGE) model for six ASEAN countries, namely Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Although it is a descendant of the Inter-Regional System of Analysis for Indonesia Five Regions (IRSA-Indonesia5) developed by Resosudarmo *et al.* (2008) and as such it bears similarities with the latter in terms of notational use, numerous features of the IRSA-ASEAN model also stem from other developments in CGE modeling over the last 20 years. Some of these sources of inspiration are direct and easily identified, including one of the first CGE models for Indonesia by Lewis (1991) as well as the GTAP model (Hertel, 1997) and the Globe model (McDonald et al., 2007). Nevertheless, the IRSA-ASEAN model is a unique model on its own right, both structure-wise and purpose-wise.

As the IRSA-ASEAN model is a multi-country model, it solves at the country level, or in other words, optimizations are done at the country level. This approach allows price as well as quantity to vary independently by country, which means that variation in price as well as in quantity of each country can be observed using this model. This approach enables the user of the model to observe the impact of a specific shock in one country to other countries, the whole ASEAN economy, and the country itself. Also, as optimization is done at the country level and taking into account the 'sovereignty' element of each country, the model uses neither a bottom-up nor a top-down approach.[2] Each country is instead connected through the flow of commodities, i.e. trade of goods and services, as well as the flow of transfer, i.e. remittance and savings-investment. The model also allows direct transfer of primary factors production, however, due to data scarcity, this last feature is not included in the empirical study. As a consequence of the sovereignty element in the IRSA-ASEAN model, each country has its own balance of payments as well as savings and investment accounts. Each country deals directly with other countries in terms of trading and is allowed its own set of tariff barriers. For

[2] This is in line with real world evidence in which ASEAN, unlike the EU, is not a supranational organization.

examples, in the IRSA-ASEAN model, each country can export/import goods and services directly to/from rest of the world (ROW).

Another important highlight of the IRSA-ASEAN model deals with the issue of double-dividend. Although the IRSA-ASEAN model can be used for a wide-range of policy simulations, e.g. trade and fiscal simulations, the main motivation to its development in this chapter is to assess the economic impact of energy and environment-related policies, namely an energy subsidy reduction and carbon tax implementation. As such, the IRSA-ASEAN model takes a step further with regards to the issues of energy and the environment by allowing for the possibility of the double-dividend hypothesis. The model internalizes the double-dividend hypothesis by intrinsically and explicitly incorporating various recycling mechanisms. In this regard, aside from the government increasing its expenditure, the energy subsidy reduction and carbon tax revenue can either be recycled directly to households, e.g. direct one-time lump-sum cash transfer to low-income households, or recycled back to the industry, e.g. indirect tax reduction, such that it creates a less distortionary tax system, or hypothetically so.[3]

For empirical results, the IRSA-ASEAN model uses the Social Accounting Matrix for ASEAN (ASEAN-SAM) which has been calibrated from the input-output (I-O)-based Global Trade Analysis Project (GTAP) Version 7 Data Base with parameter values, e.g. value-added and Armington elasticities, also obtained from this source. The database uses a common reference year of 2004 and a common currency of United States million dollars (USD million) for all six countries in the region. The database has been heavily modified using various country-specific datasets, e.g. social accounting matrices and household income/expenditure surveys, so as to provide greater insight and flexibility for policy analysis. Also, the latest version of Generalized Algebraic Modeling System (GAMS) program is used to run the IRSA-ASEAN model.

The following lists the additional datasets required to build the so-called ASEAN-SAM. For Indonesia, the additional data needed are (1) 2005 Social Accounting Matrix and (2) 2005 Inter-Regional Social Accounting Matrix (Resosudarmo *et al.*, 2008); Malaysia, (1) 2004/2005 Household Expenditure Survey, (2) 2004 Distribution and Use of Income Accounts and Capital Account, (3) 2000 Population and Housing Census, and (4) 1970 Social Accounting Matrix (Pyatt *et al.*, 1984); Philippines, (1) 2006 Family Income Expenditure Survey, (2) 2000 Social Accounting Matrix (Cororaton and Corong, 2009), and (3) 1997 Family Income Expenditure Survey; Singapore, (1) 2008 Yearbook of Statistics and (2) 2002/2003 Report on the Household Expenditure Survey; Thailand, (1) 2008 Key Statistics, (2) 2002 Household Socio-Economic Survey, and (3) 1998 Social Accounting Matrix (Li, 2002); Vietnam, (1) 2004 Living Standard Survey and (2) 1997 Social Accounting Matrix (Nielsen, 2002). Other data sets needed are the

[3] The 'double-dividend' hypothesis will be discussed in greater details in Chapter 6 as it relates closely to environmental issues.

2010 World Development Indicators, 2008 ASEAN Statistical Yearbook, 2005 ASEAN Statistical Yearbook, 2005 Bilateral Remittance Estimates (Ratha and Shaw, 2007), and 2004 Combustion-Based CO_2 Emissions Data for GTAP Version 7 (Lee, 2008).

Procedures in constructing the ASEAN-SAM for modeling purposes are divided into three phases. The first phase involves the preparation of the GTAP Version 7 Data Base and transforming it into individual Global SAMs; i.e. Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Phase 2 is a set of steps required to transform each individual Global SAM into a standard SAM form. Phase 3 is when all individual SAMs are combined to form the ASEAN-SAM. Nevertheless, some more adjustments are than previously stated needed to run the model with the database.[4] These adjustments are needed to harmonize the database and model to overcome unforeseen, mostly technical, limitations that have arisen when policy simulations are conducted. The following explains these final adjustments.

5.3.1. ASEAN-SAM Final Adjustments

The final adjustments to the ASEAN-SAM basically fall under two categories, namely sectoral aggregation and indirect tax correction. In the original ASEAN-SAM as described in Chapter 3, there are 57 production sectors for all 6 countries and Rest of the World. Mathematically and intuitively speaking, the number of production sectors should not make much of a difference except for sectoral analytical purposes.

In order to overcome this technical difficulty, the ASEAN-SAM has been aggregated from 57 sectors into 26 sectors as shown in Appendix 5.1. Sectoral adjustment can be done quite simply by summing up all the values in corresponding blocks.[5] Two important things to note from the sectoral aggregation are: first, energy-related sectors are not aggregated for analytical purposes; and second, parameter values are obtained by allowing GTAP to do the aggregation. Also, the aggregation is applied for all countries symmetrically with only one exception, the Gas sector in Singapore. Values in this sector are summed into the Petroleum and Coal Products sector. Again, this is done for a technical reason.[6] Nevertheless, despite these sectoral aggregations, the consistency of the ASEAN-SAM is unimpaired although caution should be undertaken when a sectoral analysis is conducted with a more generalized conclusion for the aggregated sectors.

Meanwhile, the second group of final adjustments to the ASEAN-SAM deals with corrections being made to indirect tax in the Petroleum and Coal Products sector, assumed to

[4] See Chapter 3 and 4 for a detailed technical description of the ASEAN-SAM database and IRSA-ASEAN model.
[5] Refer back to Chapter 3 on how to add corresponding rows and columns.
[6] Without this adjustment, GAMS is unable to find a solution with an error report pointing to this sector. The relatively small sectoral value-added is the likely source of this problem.

substitute for the refinery sector in which gasoline, diesel, and kerosene are included. These corrections are needed to fine tune the ASEAN-SAM to represent real-world situation in which Indonesia and Malaysia subsidize their fuel products. Data from Metschies (2005) have been used to obtain a more precise value for fuel subsidies and incorporated into the ASEAN-SAM. Table 5.1 shows the fuel products and electricity tax value and rate. Note that a negative value or rate implies a subsidy instead of a tax. In accordance with the literature and data, Indonesia and Malaysia subsidize their fuel products, while Indonesia also subsidizes its electricity sector.[7]

Table 5.1. Energy Tax

		IDN	MYS	PHL	SGP	THA	VNM
	Government Revenue (in USD million)	96884.89	14231.62	13253.64	22069	38717.39	11319.26
Fuel Products	**Indirect Tax** (in USD million)	-9582.02	-1680.3	132.52	661.49	774.04	11.32
	Tax Rate (in percentages)	-53.09	-19.06	3.9	4.66	3.34	3.24
	Government Revenue (in percentages)	-9.89	-11.81	1	3	2	0.1
Electricity	**Indirect Tax** (in USD million)	-431.08	110.41	149.89	157.17	583.92	260.27
	Tax Rate (in percentages)	-4.96	2.43	3.54	5.1	6.63	6.39
	Government Revenue (in percentages)	-0.44	0.78	1.13	0.71	1.51	2.3

These adjustments to the ASEAN-SAM do not change the production activities of the ASEAN-SAM represented by the Input-Output table. However, these adjustments affect government revenue as well as government savings and investment. As a consequence, macroeconomic indicators are slightly changed, as shown in Table 5.2. The top row indicates the values after adjustments, while the italicized bottom row indicates the original values. The table shows that consumption is consistent, with changes occurring only in either export or import and the overall GDP. These changes are unavoidable as fine-tuning affects exogenous accounts, such exports to and imports from rest of the world. Nevertheless, imperfect as they are, these

[7] See Chapter 2 for more details.

changes are far more preferable as the alternative would involve changing the consumption patterns and production activities in each country, which would greatly compromise the reliability and consistency of the ASEAN-SAM.

Table 5.2. Macroeconomic Indicators in USD Million

	IDN	MYS	PHL	SGP	THA	VNM
Private Consumption	174,751	37,373	58,936	55,286	86,874	29,139
	174,751	*37,373*	*58,936*	*55,286*	*86,874*	*29,139*
Government Consumption	20,035	11,641	8,754	13,911	16,129	2,798
	20,035	*11,641*	*8,754*	*13,911*	*16,129*	*2,798*
Fixed Investment	49,317	17,316	14,118	31,396	40,344	15,073
	49,317	*17,316*	*14,118*	*31,396*	*40,344*	*15,073*
Export	89,212	154,873	51,491	169,961	121,174	32,660
	89,212	*154,873*	*51,491*	*168,038*	*121,174*	*32,660*
Import	88,496	107,987	48,969	161,818	108,691	36,666
	78,612	*106,302*	*48,822*	*161,818*	*102,823*	*36,643*
Gross Domestic Product	244,819	113,214	84,330	108,737	155,831	43,003
	254,703	*114,901*	*84,476*	*106,813*	*161,698*	*43,027*

5.3.2. Initial Values and Final Consistency Check

Before looking at the policy impact, it is best to first know what the initial values are. This is done for two reasons: first, to check empirically the consistency of the database and model; and second, to better understand the magnitude of the changes due to the implementation of a certain policy. Table 5.3 shows selected economic indicators and initial values used in the IRSA-ASEAN model, which uses 2004 as its reference year. As previously stated, the majority of these values are derived from GTAP Version 7 Data Base; while its corresponding CO_2 emissions database comes from Lee (2008). This holds true for macroeconomic indicators and sectoral disaggregation. However, additional data from Metschies (2005) has been used to reflect the existence of energy subsidies in Indonesia and Malaysia. Meanwhile, for the average income per capita, average expenditure per capita, population, and poverty incidence, additional data has been gathered from the ASEAN Statistical Yearbook and the World Development Indicators, with the closest reference year used in cases where the 2004 data is unavailable.[8]

[8] This mainly applies to poverty incidence, which is used solely for the purpose of determining the transfer share between rural low income household *vis-à-vis* urban low income household.

Table 5.3. Selected Economic Indicators and Initial Values

	IDN	MYS	PHL	SGP	THA	VNM
Macroeconomic Indicators						
(in USD million)						
Private Consumption	174,751	37,373	58,936	55,286	86,874	29,139
Government Consumption	20,035	11,641	8,754	13,911	16,129	2,798
Fixed Investment	49,317	17,316	14,118	31,396	40,344	15,073
Export	89,212	154,873	51,491	169,961	121,174	32,660
Import	88,496	107,987	48,969	161,818	108,691	36,666
Gross Domestic Product	244,819	113,214	84,330	108,737	155,831	43,003
Sectoral Disaggregation						
(in USD million)						
Agriculture	33,917	6,299	10,004	304	13,590	6,405
Manufacture	96,033	72,203	31,414	29,220	68,253	22,935
Service	124,752	36,397	43,059	77,289	79,855	13,687
Average Income per Capita						
(in USD)						
Rural-Low	460	1,225	215		634	212
Rural-High	1,857	3,506	1,375		1,531	549
Urban-Low	627	1,432	220	10,031	1,194	175
Urban-High	2,812	7,052	2,514	30,785	5,447	1,389
Average Expenditure per Capita						
(in USD)						
Rural-Low	388	844	193		602	207
Rural-High	1,522	1,601	1,205		1,429	539
Urban-Low	540	939	194	7,966	1,093	165
Urban-High	1,682	3,325	2,104	21,222	4,696	1,328
Population						
(in thousands)						
Rural	114,975	8,438	32,004		44,350	60,720
Urban	101,469	16,736	51,908	4,167	20,928	21,312
Poverty Incidence						
(in percentages)						
Rural	21.1	13.2	41.4		12.6	45.0
Urban	14.4	3.8	15.0		4.0	9.0
CO_2 Emissions	357,387	145,012	76,641	40,838	216,977	86,708
(in kilotons)						

A few highlights from Table 5.3 include the relative size of the economy in terms of GDP, with Indonesia being the largest followed by Thailand, Malaysia, Singapore, Philippines, and Vietnam. In terms of GDP per capita, on the other hand, Singapore is better off followed by Malaysia, Thailand, Indonesia, Philippines, and Vietnam. With regards to CO_2 emissions, Indonesia is the highest emitter followed Philippines, Malaysia, Vietnam, Thailand, and Singapore. Lastly, it might seem redundant to have both average income per capita and average expenditure per capita. Admittedly, looking at the initial values, parallels can be drawn between the two indicators. Using both indicators as proxies for welfare, with a small exception in Vietnam, those living in urban areas are generally better off than those living in rural areas. Also, based on these indicators, those in Urban-High categories are the richest followed by those in Rural-High then Urban-Low, with those in Rural-Low categories as worst off. The difference between these two indicators is their savings. However, more importantly, once the simulations are conducted, the results will use change *real* household expenditure rather *real* household income change as it is impossible to obtain the latter due to simultaneity in the equations. It is important to use the real change as it is a better proxy indicator to measure welfare change as it already takes into account change in prices.

5.4. Simulation Policies

With regards to policy simulations, this study focuses on the economic impact of carbon tax policies. This is done as even with only a single instrument, i.e. carbon tax, there are many ways in which this policy can be implemented and modeled. The simulations of the model are divided into two groups: one involves removing the fuel subsidy; and the other involves removing the electricity subsidy. The fuel subsidy reduction is further grouped into two categories based on how it is implemented, namely symmetric and asymmetric policies. A symmetric policy simply means that the chosen policy is implemented in both Indonesia and Malaysia. In contrast, an asymmetric policy means that the chosen policy is implemented in only Indonesia.[9] At this point, shocks are introduced only in Indonesia and Malaysia. In Chapter 6, when a carbon tax scenario is introduced, shocks occur in all the other countries as well. This is in line with real world situation in which energy subsidies are mostly prominent in only Indonesia and Malaysia.

Furthermore, although it may seems redundant to distinguish between the symmetric and asymmetric scenarios, one important highlight of the IRSA-ASEAN model is that it allows a change in one or more countries to immediately affect the remaining countries, albeit mainly through trade. In other words, herein lies the distinction between multi-country CGE models, e.g. IRSA-ASEAN model, and multiple countries CGE models, e.g. country-specific CGE model.

[9] In 2004, Indonesia reduced its energy subsidies due to pressure from the oil price increase. This asymmetric simulation in effect tries to capture that event.

Aside from the broad scenarios mentioned previously, the three recycling mechanisms are explored as well. These mechanisms deal with the revenue generated by the removal of energy subsidies by the government. The first recycling mechanism assumes that the government retains all the revenue generated and thereby increases its consumption proportionally where the total increase equals the energy subsidy reduction. In this case, whenever the government obtains this revenue, it 'recycles' the entire revenue back to the economy through increased government consumption. In other words, none of the revenue goes into government savings.

The second mechanism assumes that the government redistributes the revenue back to households in the form of a direct cash transfer to improve social welfare. In this variant, in order to conform to the real world, the government only redistributes cash to low income households in both rural and urban areas. Furthermore, transfer shares between rural-low and urban-low income households are weighted based on the poverty incidence, i.e. percentage of the population under the national poverty line. Effectively, with a greater poverty incidence in rural areas, low income households in these areas receive a greater share of the cash transfer compared to low income households in urban areas. Logically, of course, high-income households in both rural and urban areas do not receive these cash transfers.

Meanwhile, the third variant assumes that the government uses the revenue to reduce other distortionary taxes in order to achieve a double dividend. In the IRSA-ASEAN model, the government proportionally redistributes the revenue obtained back to the industries through a negative indirect tax. This scheme is intended to achieve a less distortionary tax system; although for some industries in which the indirect tax is already low, this scheme actually creates a new subsidy from the government to those industries.

In line with the real-world situation, only combinations of these three recycling mechanisms are implemented. In the case of a reduction in energy subsidies, it is unlikely that government would retain all the revenue without any form of compensation to either households or industries. To do so would be politically unfeasible in terms of public acceptance of the policy. It is also unlikely that the government would recycle the entirety of revenue to either households or industries. As such, the IRSA-ASEAN model tries to represent the real-world situation better by combining the first recycling mechanism with the second and third recycling mechanisms. In other words, the government retains a part of the revenue to increase its consumption and recycle the other part back to either households or industries.

Lastly, due to a technical limitation of the model when it comes to endogenous intermediate input substitution, there are two additional scenarios in which technological change is treated exogenously to illustrate possible outcomes from intermediate input

substitution, and by extension efficiency gain, in the energy sector.[10] These technological changes lead to 10 percent efficiency gain in coal use and 5 percent efficiency gain in oil products use. In other words, to produce the same amount of output, 10 percent less coal or 5 percent less oil products is needed than the original amount of input.[11] The following lists the simulations to be conducted.[12]

Scenario 1: Symmetrical Fuel Subsidy Reduction

Indonesia and Malaysia eliminate fuel subsidies:

1a. Each government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent back to low-income households in rural and urban areas; and

1b. Each government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent to industries.

Scenario 2: Asymmetrical Fuel Subsidy Reduction

Indonesia eliminates fuel subsidies:

2a. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent back to low-income households in rural and urban areas; and

2b. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent to industries.

Scenario 3: Electricity Subsidy Reduction

Indonesia eliminates electricity subsidy:

3a. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent back to low-income households in rural and urban areas; and

3b. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent to industries.

Variant 1: 10 Percent Coal Use Efficiency

Subsidy elimination is followed by a 10 percent efficiency gain in the use of coal in the respective country. This is implemented for all three scenarios and the two recycling mechanisms remain the same.

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[10] Please refer to Chapter 4 on exogenous *vis-à-vis* endogenous intermediate input substitution.
[11] Oil products refer to petroleum products, such as diesel, gasoline, and kerosene, not crude oil.
[12] See Appendix 5.5 for the GAMS syntax of the simulations.

Variant 2: 5 Percent Oil Products Use Efficiency

Subsidy elimination is followed by a 5 percent efficiency gain in the use of oil products in the respective country. This is implemented for all three scenarios and the two recycling mechanisms remain the same.

5.4.1. Macroeconomic Results

The summary results of emissions, macroeconomy, and expenditure are shown in Table 5.4, which shows both symmetric and asymmetric reduction of fuel subsidies, while Table 5.5 shows the effects of an electricity subsidy reduction in only Indonesia. Appendices 5.7 and 5.8 provide the same summary results but with a 10 percent efficiency gain in coal use and a 5 percent efficiency gain in petroleum products use for fuels and electricity subsidy reduction scenarios. It is important to note, however, all changes are calculated at the original price level such that their changes are *real* changes.

Table 5.4 shows the results of Scenario 1 and Scenario 2, the effects of eliminating fuel subsidies in Indonesia and Malaysia, i.e. symmetric, as well as in Indonesia alone, i.e. asymmetric. Overall, eliminating fuel subsidies immediately reduces carbon emissions for that particular country. In the case of Indonesia, eliminating fuel subsidies in Indonesia and Malaysia reduces carbon emissions by 7.51 percent and 7.74 percent depending on the recycling mechanism utilized. In the case of Malaysia, eliminating fuel subsidies in Indonesia and Malaysia reduces carbon emissions by 3.91 percent and 4.16 percent depending also on recycling mechanism utilized. Interestingly, eliminating fuel subsidies with or without Malaysia does not appear to change the carbon emissions reduction by much, if at all.

However, carbon leakage appears to occur to other countries. In other words, eliminating fuel subsidies will decrease carbon emissions but may increase carbon emissions in those countries that do not do so. This phenomenon occurs because as one country eliminates fuel subsidies, the fuel price increases in that particular country such that consumers will buy their fuel elsewhere, e.g. other countries. As a result, fuel consumption increases in the other countries such that their carbon emissions will increase. This holds true, to a small extent, for Philippines and Thailand; but it is most apparent when only Indonesia eliminates fuel subsidies. Malaysia's carbon emissions increase quite significantly. Logically, this is due to the fact that Malaysia is also a large producer of fuels, making Malaysia the best substitute source for fuels *vis-à-vis* Indonesia.

Table 5.4. Simulation Results of Scenario 1 and Scenario 2**

	CO_2	Real GDP	Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agric.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Household Symmetric									
Indonesia	-7.51	1.24	0.19	4.66	-0.84	12.13	6.09	-0.13	-4.94
Malaysia	-3.91	0.2	0.3	0.52	-0.44	12.77	2.56	-1.59	-1.73
Philippines	0.01	*	*	*	*	0.19	0.12	*	*
Singapore	-0.08	-0.05	0.02	-0.17	-0.01		-0.12		-0.06
Thailand	0.01	*	*	*	*	0.04	0.02	0.01	0.01
Vietnam	-0.01	*	0.01	0.01	-0.03	-0.13	-0.09	-0.16	-0.09
Industry Symmetric									
Indonesia	-7.74	1.23	0.07	5.68	-1.52	1.61	1.02	-0.33	-2.93
Malaysia	-4.16	0.18	0.1	0.73	-0.86	0.86	0.38	-0.81	-0.97
Philippines	*	*	*	*	*	-0.02	-0.01	-0.01	-0.01
Singapore	-0.08	-0.05	0.01	-0.16	-0.01		-0.11		-0.05
Thailand	0.01	*	*	*	*	*	0.01	0.01	0.01
Vietnam	-0.01	*	0.01	0.01	-0.03	-0.13	-0.09	-0.16	-0.09
Household Asymmetric									
Indonesia	-7.52	1.24	0.19	4.66	-0.84	12.07	6.06	-0.13	-4.94
Malaysia	0.12	*	*	-0.01	*	0.01	0.02	0.01	0.02
Philippines	*	*	*	*	*	*	*	*	*
Singapore	-0.07	-0.05	0.02	-0.16	*		-0.11		-0.06
Thailand	0.01	*	*	*	*	*	0.01	0.01	0.01
Vietnam	-0.01	*	*	*	-0.02	-0.12	-0.08	-0.14	-0.08
Industry Asymmetric									
Indonesia	-7.74	1.23	0.07	5.67	-1.52	1.6	1.01	-0.33	-2.89
Malaysia	0.12	*	*	-0.01	*	0.01	0.02	0.01	0.02
Philippines	*	*	*	*	*	*	*	*	*
Singapore	-0.07	-0.05	0.01	-0.15	-0.01		-0.11		-0.05
Thailand	0.01	*	*	*	*	*	0.01	0.01	0.01
Vietnam	-0.01	*	*	*	-0.02	-0.11	-0.07	-0.14	-0.08

* - Negligible Value

** - Fuel Subsidy Reduction in Indonesia and Malaysia (Scenario 1) and in Indonesia (Scenario 2)

More interestingly, however, is that the environmental gain comes hand-in-hand with an expansion to the GDP. As previously explained, theoretically, subsidy causes a distortion in economy by creating inefficiency in the allocation of resources. As such, eliminating the subsidy promotes efficiency in the allocation of resources; and as shown by the Table 5.4, it promotes economic expansion through an increase in the GDP for Indonesia and Malaysia in the symmetric scenarios and only Indonesia in the symmetric scenarios. More interestingly is the fact that other countries appear to suffer from both symmetrical and asymmetrical fuel subsidy reductions. This is logical as fuel subsidies are not only enjoyed by consumers in that particular country with the existing subsidies but also enjoyed by consumers in other countries through

trade both legally or illegally, i.e. smuggling. In this case, Singapore is the country to most likely be adversely affected as it relies on fuels from Indonesia and Malaysia. In this regard, it should be pointed out that Indonesia and Malaysia provide subsidies on the production of fossil fuels rather than subsidies on domestic consumption of fuels. In the latter case, importers would not have benefited from fuel subsidies in Indonesia and Malaysia, as experienced by Singapore.

Furthermore, the driving force behind the expansion of the GDP in Indonesia and Malaysia is the result of an expansion in the manufacturing sector, which is most likely caused by a more efficient allocation of resources due to the elimination of fuel subsidies. The agricultural sector benefits although to a lesser extent than the manufacturing industry. The service sector, on the other hand, appears to suffer due as it is an end-user of fuels such that it bears the brunt of the increase price of fuels. In other countries, the manufacturing sector in Singapore to suffer the most as it, again, relies on fuels coming from Indonesia and Malaysia. It is also interesting to note that Malaysia does not appear to suffer from a unilateral fuel subsidy reduction in Indonesia as it does not rely on Indonesia for fuels and can most likely fulfill its own domestic need. To a lesser extent, the same principle applies to Philippines, Thailand, and Vietnam.

As to the effects on household, clearly with the recycling mechanism in the form of a lump sum cash transfer to households, the two poorest household groups, i.e. Rural-Low and Urban-Low, are well compensated. Even without the lump sum cash transfer, i.e. with indirect tax reduction recycling mechanism, the two poorest household groups can actually still benefit from the indirect tax reduction as opposed to the two richest household groups. The reason is because the two poorest groups are likely to consume fewer fuels and their by-products compared to those in the higher income groups. As for other households in other countries, it is hard to draw obtain a generalized result as the effects on them largely depend on their consumption patterns, which is unique to each household group in each country. Although the less dependent they are on fuels in the subsidized fuels, the less adversely affected they will be.

Meanwhile, although recycling mechanisms do not affect the overall results to the environment and economy, they do significantly affect sectoral changes and household expenditures. When part of the subsidy reduction revenue is recycled back to low-income households in both rural and urban areas, the first thing to note is that these two household groups fare much better than otherwise. Those in the lower-income groups definitely benefit from the lump sum cash transfer by their respective government. As to the third recycling mechanism in which the government reduces indirect taxes, the first obvious thing to note is that low-income households are no longer compensated such that their expenditure consumption pattern changes and less likely to benefit than otherwise. All in all, eliminating fuel subsidies appear to have a progressive impact in line with the theory that energy taxes are progressive in developing countries and regressive in developed countries.

Changes in sectoral output are also somewhat as expected as industries with the largest output are likely to benefit more as the indirect tax reduction is proportional to the size of the industry. As such, the manufacturing sector is likely to benefit even more with the agricultural sector is less likely to benefit and the service sector more adversely affected. One final important thing to note is that although overall results do not change with the recycling mechanisms, for practical policy purposes, they become very important in terms of feasibility and acceptability.

Table 5.5. Simulation Results of Scenario 3**

	CO_2	Real GDP	Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Household									
Indonesia	-0.3	0.01	0.04	0.05	-0.03	0.54	0.26	-0.02	-0.31
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*	*	*	*	*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*
Industry									
Indonesia	-0.32	0.01	0.03	0.09	-0.06	0.07	0.03	-0.03	-0.21
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*		*		*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*

* - Negligible Value
** - Electricity Subsidy Reduction in Indonesia

Table 5.5, on the other hand, shows the results when Indonesia eliminates its electricity subsidy. In this scenario, unlike fuel subsidies, a unilateral elimination of electricity subsidy by Indonesia does not have a significant impact on other countries. Two reasons for behind this is because electricity is not usually traded directly between countries and the electricity subsidy itself is not as large as fuel subsidies such that the impact on Indonesia is much less compared to the previous scenario.

As for the within country effect, the elimination of electricity subsidy helps reduce carbon emissions in Indonesia. Meanwhile, GDP expands but only for a relatively small amount. As for sectoral changes, the service sector suffers the most, while the manufacturing sector benefits from the electricity subsidy reduction followed by the agricultural sector. Similarly, households impact also exhibit the same pattern as the previous scenario in which the impact is progressive with those with higher income more likely to be adversely affected than those with

lower income. Quite logically, providing a lump sum cash transfer to low-income households further improves their welfare although at the cost of those in the highest income group.

Furthermore, Appendices 5.3 and 5.4 show the results when technological changes are introduced in the form of efficiency gain for coal and petroleum products, i.e. fuels, use by 10 percent and 5 percent respectively. These technological improvements are introduced to compensate the lack of endogenous intermediate input substitution in the model. As such, these technological changes are introduced exogenously. In reality, these technological improvements can be seen as an industrial response, e.g. improving maintenance or better management, to the elimination of energy subsidies in which now industries have an incentive to reduce their use of coal and petroleum products while maintaining the same amount of output, i.e. efficiency gain. As such, both substitution and efficiency are reflected in the results.

The results in the appendices show that improvements in the use of coal and petroleum products will have positive effects to the economy. The GDP expands in Indonesia and Malaysia in all cases. Two other important highlights from the Appendices 5.3 and 5.4 are: first, a 5 percent efficiency gain in the use of petroleum products creates a larger positive effect on the economy than a 10 percent efficiency gain in the use of coal for the fuel subsidy reduction although not so apparent with the electricity subsidy reduction; and second, a 5 percent efficiency gain in the use of petroleum products creates a much larger positive effect to the environment.

Following those observations, a more efficient use of petroleum products may encourage households and industries to switch from the 'dirtier' coal to petroleum products. Aside from the economic gain, this also improves the gain in terms of CO_2 emissions reduction. Lastly, although energy efficiency has the possibility of creating a rebound effect, the phenomena is unlikely to occur in the region. It appears that the elimination of energy subsidies is more than sufficient to prevent this phenomenon from occurring.

5.4.2. Sectoral Impact

In order to understand why and how changes occur when energy subsidies are eliminated, a more detailed examination must be conducted at the sectoral level. Table 5.6 shows consumer prices in Indonesia and Malaysia. It is important to note that Table 5.6 also implicitly shows price movements from the original prices. For example, a coal price of 0.98 in Indonesia means that the price of coal has decreased by 2 percent in Indonesia, after fuel subsidies have been eliminated in Indonesia and Malaysia, in which households are given a lump sum cash transfer.

Table 5.6. Selected Sectoral Prices and Exchange Rates

	Fuel Subsidy Reduction*				Electricity Subsidy Reduction**			
	Household		Industry		Household		Industry	
	Indonesia	Malaysia	Indonesia	Malaysia	Indonesia	Malaysia	Indonesia	Malaysia
Commodity								
Agriculture	1	1	1.01	0.98	1	1	1	1
Farming	1.01	1.01	1.01	0.98	1	1	1	1
Forestry	1.01	1	1.06	0.98	1	1	1	1
Fishing	1.02	1.02	1.01	0.98	1	1	1	1
Coal	0.98	1	1.01	0.98	1	1	1	1
Oil	0.81	0.93	0.83	0.92	1	1	1	1
Gas	0.97	1	0.99	0.98	1	1	1	1
Minerals *nec*	0.98	1	1.02	0.99	1	1	1	1
Food and beverages	0.99	1	1	0.98	1	1	1	1
Textiles	0.98	1	1	0.98	1	1	1	1
Wood products	0.98	1	1	0.98	1	1	1	1
Petroleum and coal products	1.21	1.1	1.24	1.08	1	1	1	1
Chemical, rubber, and plastic products	0.98	1	1	0.98	1	1	1	1
Mineral products *nec*	0.99	1	1.01	0.98	1	1	1	1
Metal products	0.98	1	1	0.98	1	1	1	1
Manufacturing	0.98	1	1	0.98	1	1	1	1
Electricity	1.03	1.01	1.04	0.98	1.03	1	1.03	1
Gas manufacture distribution	0.95	1	0.98	0.98	0.99	1	0.99	1
Water	0.99	1.01	1	0.98	1.01	1	1.01	1
Construction	0.98	1	0.99	0.98	1	1	1	1
Trade	0.98	1	0.99	0.98	1	1	1	1
Transportation	1.03	1.02	1.04	1	1	1	1	1
Communication	0.98	1	1	0.98	1	1	1	1
Financial services	0.98	1	1	0.98	1	1	1	1
Public administration, defense, health, and education	0.95	1	0.96	0.98	1	1	1	1
Dwellings and other services	1.01	1	1	0.98	1	1	1	1

* - in Indonesia and Malaysia

** - in Indonesia

Table 5.6 shows that once fuel subsidies are removed, the price of petroleum and coal products increases immediately. Without a compensation mechanism to industries, the electricity sector and transportation sector suffer the most, followed by the fishing sector. Meanwhile, the price of crude oil in both Indonesia and Malaysia decreases the most. A logical way of explaining this phenomenon is that the price of commodities that use fuels as input increases, while the price of commodities that provide input for fuels decreases as a result of the fuel subsidy reduction. The pattern slightly changes when industries are compensated through an indirect tax reduction as there is now an added element to the price changes, aside from the fuel subsidy reduction. Sectoral size now matters, although the price of petroleum and coal products still increases the most and the price of crude oil decreases the most.

As for electricity subsidy reduction, the changes are not as significant. Significant changes do not occur because the electricity subsidy rate is relatively small compared to fuel subsidy such that the other commodity prices are not as affected. Nevertheless, the consumer price of electricity increases by 3 percent and only utility sector prices, i.e. water and gas manufacture distribution, are affected. Note also, that Malaysia is relatively untouched as the electricity subsidy reduction only occurs in Indonesia. Meanwhile, commodity prices in Philippines, Singapore, Thailand, and Vietnam are not included as they do not exhibit any significant changes, i.e. less than 1 percent, in all scenarios, which means that there is no price leakage.

Following the changes in commodity prices, production activities in turn changes as well. Figure 6.6 shows the real sectoral value-added changes in percentages for Scenario 1 in which fuel subsidies are eliminated in Indonesia and Malaysia. Note that changes are in percentages. From top to bottom, the first ten sectors are categorized as services, followed by 12 sectors categorized as manufacturing and 4 sectors categorized as agriculture.

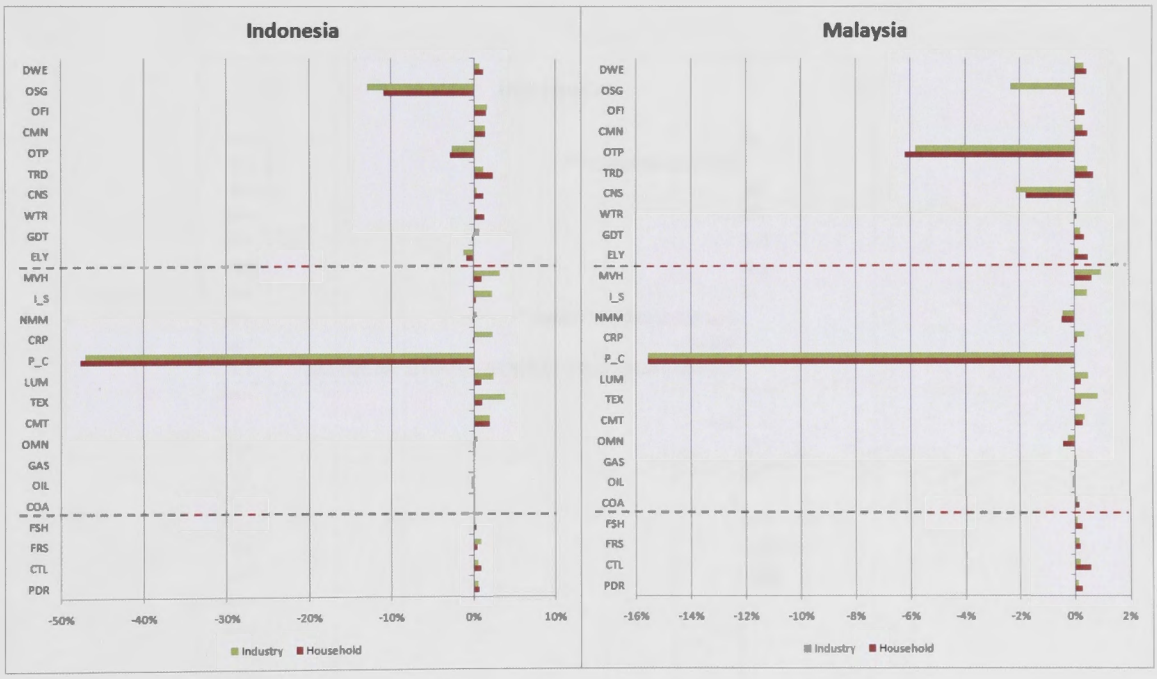


Figure 5.2. Sectoral Value-Added Change from a Fuel Subsidy Reduction

Figure 5.2 shows that in Indonesia, with the exception of the petroleum and coal products sector, all manufacturing sectors undergo a general expansion. Meanwhile, service sectors generally expand with the exception of the government-related, transportation, and electricity sectors. The agricultural sectors are not affected as much although they generally expand. To a lesser extent Malaysia also exhibits the same effect although contraction in

petroleum and coal products sector is much less compared to the same sector in Indonesia as the subsidy is not as great. Another implication of these sectoral value added changes is that households which rely on income from these contracting sectors are likely to suffer the most from an income reduction, which in turn reduces their ability to consume. Meanwhile, those in the in the expanding sectors will most likely gain income-wise, although price changes may still affect their consumption level.[13]

As for Figure 5.3, it shows the sectoral value-added changes when the electricity subsidy is eliminated in Indonesia. In this scenario, utility sectors are likely to undergo a contraction along with government-related services, whereas other service sectors may still expand. Meanwhile, the manufacturing, the metal products, and the petroleum and coal products sectors also undergo a contraction, while other sectors expand. It is interesting to note that mining industries, such as coal, crude oil, natural gas, and other mining sectors, are not affected by the subsidy reduction in the electricity sector as the subsidy reduction is likely too small to impact these relatively large industries. Lastly, the agricultural industries are likely to benefit, most probably due to an increased in the efficiency of resource allocation.

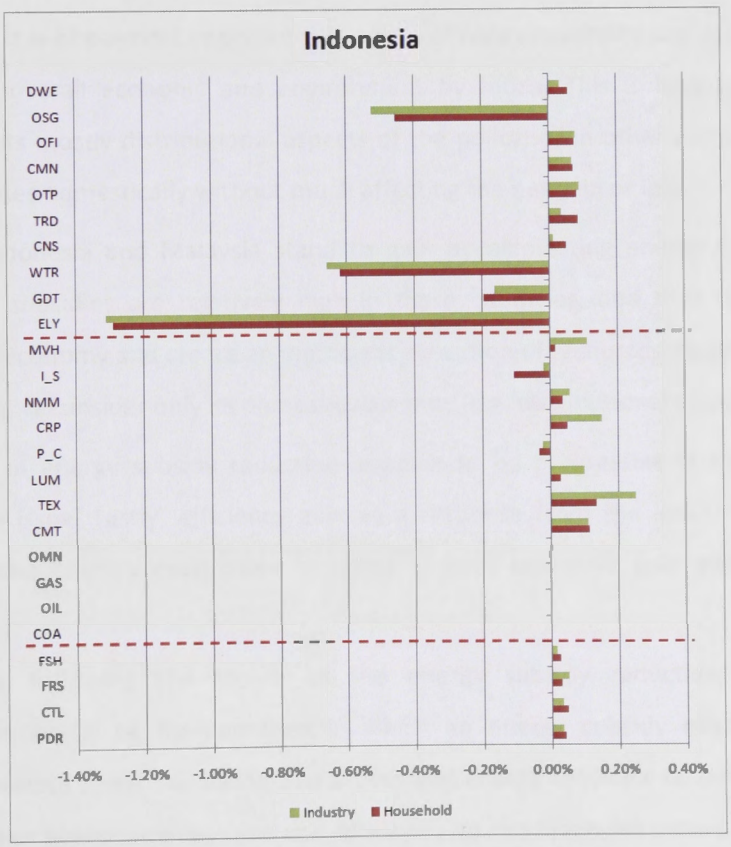


Figure 5.3. Sectoral Value-Added Change from Electricity Subsidy Reduction

[13] Appendix 5.4 shows the sectoral value-added changes in all countries, which shows that other countries are affected as well although much less significantly.

5.5. Concluding Remarks

There are two main goals to this chapter. The first one deals with the technical issues of reconciling the ASEAN-SAM with the model as well as actual implementation of the IRSA-ASEAN model. The second goal deals with the analysis of the impact of an energy subsidy reduction. With regard to the first goal, there are issues with both the ASEAN-SAM database and IRSA-ASEAN model that need to be addressed. Although admittedly far from perfect, this chapter provides a consistent and reliable solution to the issues, both for the empirical and technical difficulties.

As to the second goal, few conclusions can be drawn with regard to an energy subsidy reduction in ASEAN. First, in general, an energy subsidy reduction is an effective way of reducing carbon emissions in ASEAN. Even with only a few countries implementing this policy, there appears to be little fear of a carbon leakage. Furthermore, even with the generated revenues recycled back to the economy, an energy subsidy reduction does not seem to induce a rebound effect, i.e. more use of energy and so more emissions.

Second, it is not obvious that a country that eliminates its energy subsidies could always expect a double-dividend phenomenon to occur. Furthermore, the method of recycling the revenue, though it is of outmost importance in terms of policy feasibility and acceptability, does not change the overall economy and environment by much. This is because the recycling mechanism affects mostly distributional aspects of the policy; or in other words, it determines who gains and loses domestically without much affecting the net gain or loss.

Third, Indonesia and Malaysia stand to gain by eliminating energy subsidies. This is because energy subsidies are relatively high in these countries, and thus they create high distortion in the economy and create an inefficient allocation of resources. Regardless of others, each country should consider only its domestic concerns, e.g. distributional effect.

Fourth, an energy subsidy reduction appears to be progressive in nature, such that equity is not an issue. Lastly, efficiency gain as a response from the industrial sector could greatly benefit the country even more in terms of both economic gain and environmental improvement.

As such, following the results of the energy subsidy reduction, a clear policy recommendation would be for countries in which an energy subsidy exists should be to immediately eliminate them. The model has shown that energy subsidies do not only distort the economy such that economic expansion and efficiency do not reach full potential, but they also create a detrimental effect on the environment. However, policy in this area should also take into account the distributional impact of implementing such a policy. In other words, the policy should be carefully designed to take into account the possible adverse effects to certain

industrial sectors and segments of society so as to ensure the acceptability, feasibility, and implementability of the policy. In such cases, consideration should be given to compensating mechanisms which would not necessarily distort the economy nor reduce the overall the gain in terms of both economic and environmental improvements.

Appendix 5.1. Sectoral Aggregation

57 Production Sectors	26 Production Sectors
Paddy rice	Agriculture
Wheat	
Cereal grains *nec*	
Vegetables, fruits, and nuts	
Oil seeds	
Sugar cane and sugar beet	
Plant-based fibers	
Crops *nec*	
Cattle, sheep, goats, and horses	Farming
Animal products *nec*	
Raw milk	
Wool, silk-worm cocoons	
Forestry	Forestry
Fishing	Fishing
Coal	Coal
Oil	Oil
Gas	Gas
Minerals *nec*	Minerals *nec*
Meat: cattle, sheep, goats, and horse	Food and Beverages
Meat products *nec*	
Vegetable oils and fats	
Dairy products	
Processed rice	
Sugar	
Food products *nec*	
Beverages and tobacco products	
Textiles	Textiles
Wearing apparel	
Leather products	
Wood products	Wood products
Paper products and publishing	
Petroleum and coal products	Petroleum and coal products
Chemical, rubber, and plastic products	Chemical, rubber, and plastic products
Mineral products *nec*	Mineral products *nec*
Ferrous metals	Metal products
Metals *nec*	
Metal products	
Motor vehicles and parts	Manufacturing
Transport equipment *nec*	
Electronic equipment	
Machinery and equipment *nec*	
Manufactures *nec*	

Electricity	Electricity
Gas manufacture distribution	Gas manufacture distribution
Water	Water
Construction	Construction
Trade	Trade
Transport *nec*	Transportation
Sea transport	
Air transport	
Communication	Communication
Financial services *nec*	Financial services
Insurance	
Business services *nec*	
Public administration, defense, health, and education	Public administration, defense, health, and education
Dwellings	Dwellings and other services
Recreation and other services	

Appendix 5.2. Energy Subsidy Reduction GAMS Syntax

```
* run using this option: r=save\modelasean s=save\simenergysubsidy

* Taking Out Fuel Subsidies

 itxr.fx('P_C','IDN') = 0;
 itxr.fx('P_C','MYS') = 0;

* Taking Out Electricity Subsidy

* itxr.fx('ELY','IDN') = 0;

* Energy Sector Efficiency

*aint('COA',i,'IDN') = aint0('COA',i,'IDN') * .9;
*aint('P_C',i,'IDN') = aint0('P_C',i,'IDN') * .9;
*aint('P_C',i,'IDN') = aint0('P_C',i,'IDN') * .95;
*aint('COA',i,'MYS') = aint0('COA',i,'MYS') * .9;
*aint('P_C',i,'MYS') = aint0('P_C',i,'MYS') * .9;
*aint('P_C',i,'MYS') = aint0('P_C',i,'MYS') * .95;

* Revenue from Energy Subsidy Reduction

 TCTR.fx(d) = SUM(i,(itxr.l(i,d)-itxr0(i,d))*PDOM0(i,d)*XTOT0(i,d));

* Share of Indirect Tax Revenue

*$ontext
* Revenue Recycled to Households

 alpcarbh.fx(d) = .5;
 alpcarbi.fx(d) = 0;
 alpcarbg.fx(d) = -.5;
$offtext

ontext
* Revenue Recycled to Industries

 alpcarbh.fx(d) = 0;
 alpcarbi.fx(d) = .5;
 alpcarbg.fx(d) = -.5;
$offtext

* Important Note:
* alpcarbg.fx(d) = -.5 to be taken out from YGR to avoid double-accouting!

 option iterlim = 10000;

model IRCGEv2
 /
 e_xprim
 e_xint_s
 e_xtot
 e_xfac
 e_pprim
 e_xtrad
 e_pq_dom
 e_xd
 e_pq_s
 e_pq_m
 e_xexp
 e_ximp
 e_xtrad_r
 e_xd_s
 e_yfac
 e_yh
 e_eh
 e_xhou_s
 e_ygr
 e_egr
 e_xgor_s
 e_yco
 e_eco
 e_sh
 e_sco
 e_sav
 e_xinv_s
 e_px
 e_pfac
```

```
 e_pdom
 e_yro
 e_ero
 e_xcoi
 e_xcoh
 e_stx
* e_tctr
 e_tctrh
 e_tctri
 e_tctrg
 e_tci
 e_sro
 /;

solve IRCGEv2 using MCP;

$include reportasean.gms
$libinclude xldump repen outputasean.xls repen
$libinclude xldump repvia outputasean.xls repvia
$libinclude xldump repind outputasean.xls repind
$libinclude xldump repmac outputasean.xls repmac
```

Appendix 5.3. Simulation Results of Scenario 1 and Scenario 2 with Variants**

	CO_2	Real GDP	Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agic.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Household with Coal Gain									
Indonesia	-8.37	1.28	0.23	4.7	-0.79	12.16	6.13	-0.09	-4.88
Malaysia	-4.58	0.24	0.33	0.55	-0.38	12.84	2.63	-1.52	-1.66
Philippines	0.01	*	*	*	*	0.19	0.12	*	*
Singapore	-0.08	-0.05	0.02	-0.17	-0.01		-0.12		-0.06
Thailand	0.01	*	*	*	*	0.04	0.02	0.01	0.01
Vietnam	-0.01	*	0.01	0.01	-0.03	-0.13	-0.09	-0.16	-0.09
Industry with Coal Gain									
Indonesia	-8.6	1.28	0.11	5.72	-1.47	1.64	1.06	-0.28	-2.88
Malaysia	-4.84	0.22	0.14	0.76	-0.81	0.93	0.45	-0.75	-0.9
Philippines	*	*	*	*	*	-0.02	-0.01	-0.01	-0.01
Singapore	-0.08	-0.05	0.01	-0.16	-0.01		-0.11		-0.05
Thailand	0.01	*	*	*	*	*	0.01	0.01	0.01
Vietnam	-0.01	0	0.01	0.01	-0.03	-0.13	-0.09	-0.16	-0.09
Household with Oil Gain									
Indonesia	-9.95	1.72	0.61	4.95	-0.22	12.64	6.6	0.49	-4.22
Malaysia	-6.58	0.6	0.64	0.75	0.29	13.17	3	-1.09	-1.21
Philippines	0.01	*	*	-0.01	*	0.2	0.13	*	*
Singapore	-0.08	-0.05	0.02	-0.17	-0.01		-0.12		-0.06
Thailand	0.01	*	*	*	*	0.05	0.02	0.01	0.01
Vietnam	-0.01	*	0.01	0.01	-0.03	-0.13	-0.09	-0.16	-0.09
Industry with Oil Gain									
Indonesia	-10.2	1.71	0.49	5.97	-0.9	2.15	1.54	0.29	-2.22
Malaysia	-6.84	0.58	0.45	0.96	-0.14	1.26	0.81	-0.31	-0.46
Philippines	*	*	*	*	*	-0.01	*	-0.01	*
Singapore	-0.08	-0.05	0.01	-0.15	-0.01		-0.11		-0.05
Thailand	0.01	*	*	*	*	0.01	0.01	0.01	0.01
Vietnam	-0.01	*	0.01	0.01	-0.03	-0.13	-0.08	-0.16	-0.09

* - Negligible Value

** - Fuel Subsidy Reduction in Indonesia and Malaysia

10% Efficiency in Coal Use

5% Efficiency in Oil Use

Appendix 5.4. Simulation Results of Scenario 3 with Variants**

	CO_2	Real GDP	Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Household with Coal Gain									
Indonesia	-1.16	0.05	0.08	0.09	0.02	0.57	0.29	0.02	-0.25
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*		*		*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*
Industry with Coal Gain									
Indonesia	-3.03	0.53	0.51	0.39	0.64	1.18	0.87	0.63	0.32
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*		*		*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*
Household with Oil Gain									
Indonesia	-1.17	0.05	0.07	0.13	-0.01	0.1	0.06	0.01	-0.15
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*		*		*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*
Industry with Oil Gain									
Indonesia	-3.05	0.53	0.5	0.44	0.61	0.71	0.64	0.62	0.42
Malaysia	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	*	*	*	*	*		*		*
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	*	*	*	*

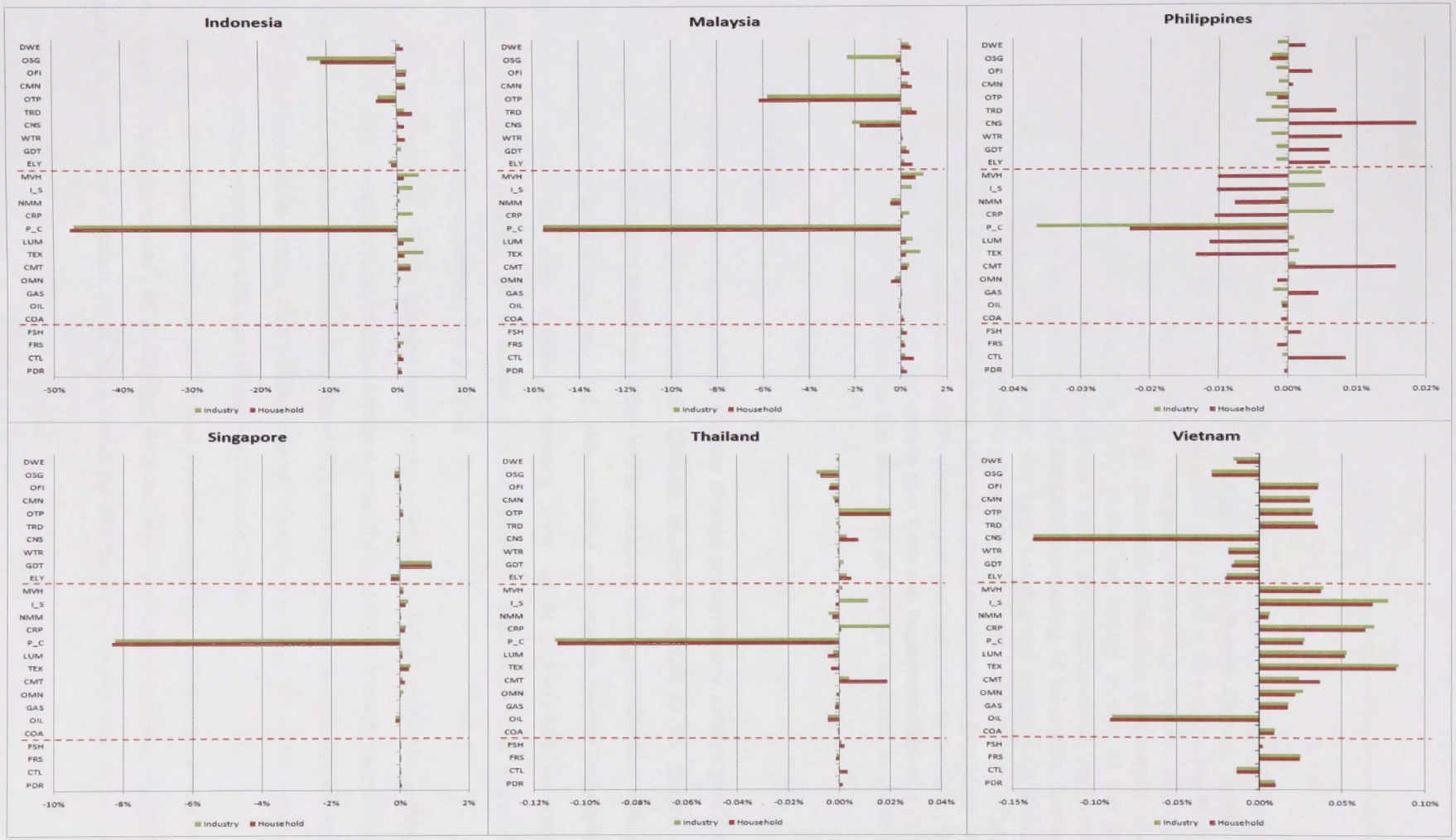
* - Negligible Value

** - Electricity Subsidy Reduction in Indonesia

10% Efficiency in Coal Use

5% Efficiency in Oil Use

Appendix 5.4. Sectoral Value-Added Change



Chapter 6: Case Study 2 - Carbon Tax Implementation

Summary

The establishment of an ASEAN Economic Community in 2015 has been on the agenda for quite some time. One issue that has recently emerged is that of climate change and this demands a response from each member of ASEAN. The main goal of this paper is to analyze the benefits and losses of cooperation among ASEAN members in mitigating their CO_2 emissions, particularly by implementing a uniform carbon tax across ASEAN. To achieve this goal, this chapter uses a multi-country computable general equilibrium (CGE) model for ASEAN, known as the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model, as constructed in the previous chapter. An ASEAN Social Accounting Matrix (ASEAN-SAM) consisting of Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam has also been constructed as the main database for this CGE. This chapter finds that the implementation of a carbon tax scenario is an effective means of reducing carbon emissions in the region. However, this environmental gain could come at a cost in terms of gross domestic product (GDP) contraction and reduction in social welfare. Nevertheless, Indonesia and Malaysia can potentially gain from the implementation of a carbon tax as it counteracts price distortions due to the existence of energy subsidies in these two countries.

6.1. Introduction

The scientific evidence is now overwhelming: climate change presents very serious global risks and it demands an urgent global response. Climate change is global in its causes and consequences, and international collective action will be critical in driving an effective, efficient, and equitable response on the scale required. This response will require deeper international cooperation in many areas, most notably in creating price signals and markets for carbon, spurring technology research, development and deployment, and promoting adaptation, particularly for developing countries (Stern, 2006).

Left unaddressed, climate change represents a serious threat to economic wellbeing. The world has now moved beyond the conventional view that economic growth objectives are incompatible with environmental objectives. Central to such principles is the appropriate pricing of carbon and the need to ensure that climate change mitigation policies across the board are both effective and economically efficient (Ministry of Finance, 2009).

As such, this chapter analyzes the impact of implementing a carbon tax, or a levy on carbon dioxide (CO_2) emissions[1], in Southeast Asia, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. As of 2010, these are the six of the ten member countries of

[1] In this chapter, the definition of a carbon tax is limited to a levy on the emission of carbon dioxide only; and thus, the term 'carbon tax' refers to CO_2 tax and is used interchangeably.

the regional cooperation known as the Association of Southeast Asian Nations (ASEAN).[2] This chapter utilizes the Inter-Regional System Analysis for ASEAN (IRSA-ASEAN) multi-country computable general equilibrium (CGE) model to look at the economy-wide impact of implementing such a tax in terms of environmental improvement, economic expansion, and social equity.[3]

The first part of this chapter provides a brief overview of current environmental issues at the global, regional, and national level with a particular emphasis on Indonesia. The second part of this chapter provides a brief review of the IRSA-ASEAN model. The third part the chapter presents the results and analysis of using the IRSA-ASEAN model to simulate various policy scenarios with regard to the implementation of a carbon tax in the region. Lastly, the final section provides a summary and conclusion for this chapter.

6.2. Environment as Part of the World

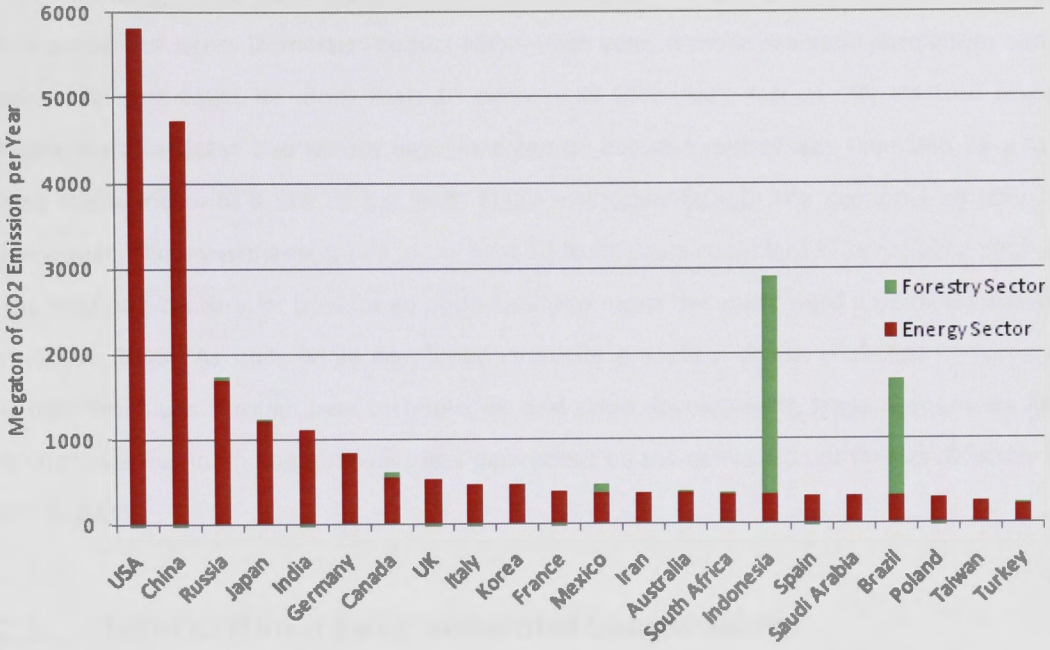
According to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrogen dioxide (N_2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change. The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2007).

Moreover, the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report in 2007 states that emissions of Greenhouse Gases (GHG's) have increased since the mid-19th century and are causing significant and harmful changes in the global climate. Higher emissions levels are producing sea level and climate changes that will dramatically affect billions of coastal people, the quality of the global environment, and the capacity of countries to sustain future economic expansion (IPCC, 2007).

The much cited Stern Report (2006) states that average temperatures could rise by 5 degrees Celsius from pre-industrial levels if climate change goes unchecked. Warming of 2 degrees Celsius could leave 15 to 40 percent of species facing extinction; while a warming of 3 or

[2] Brunei Darussalam, Cambodia, Laos, and Myanmar are not included due to a severe lack of data.
[3] The IRSA-ASEAN model uses 2004 as its reference year. See Chapters 3 and 4 for construction details.

4 degrees Celsius will result in many millions more people being flooded. Warming of 4 degrees Celsius or more is likely to seriously affect global food production. By the middle of the century, 200 million people may be permanently displaced due to rising sea levels, heavier floods and drought.



Source: Resosudarmo *et al.* (2009)[4]

Figure 6.1. Top Global Emitters of CO_2 in 2004

Figure 6.1 shows that the largest emitters of CO_2 in the world *were* the United States, followed by China, Indonesia, Brazil, Russia, and Japan in 2004. According to the United Nations (UN) Millennium Development Goals Indicators, China has now replaced the United States as the largest emitter of CO_2, while India has replaced Russia by 2007 (UN, 2010). More interestingly, however, is the sectoral source of emissions. In the case of the United States, China, Russia, and Japan, the energy sector contributes the largest share of CO_2 emissions. In contrast, despite existing concerns with the reliability of such data, CO_2 emissions in Indonesia and Brazil mainly come from the forestry sector.

Since the pre-industrial era, the concentration of atmospheric carbon dioxide (CO_2) has expanded by 35 percent, approximately 18 percent of which is due to deforestation and the degradation of forests. About 75 percent of this has been from the developing countries of Brazil, Indonesia, Malaysia, Papua New Guinea, Gabon, Costa Rica, Cameroon, Republic of Congo

[4] Data are taken from International Energy Agency (2007) for fossil fuel emission and World Resource Institute (2007) for deforestation emission. See Resosudarmo *et al.* (2009) for more details.

and Democratic Republic of Congo, which have large areas of tropical forest. The Food and Agricultural Organization (FAO) Global Forest Resource Assessment 2005 stated that an alarming 13 million hectares of tropical forest are lost per year, while a further 7.3 million hectares per year suffer various degrees of degradation. Global emissions from land use, land use change, and forestry have reached 1.65 gigatons of carbon per year (FAO, 2006).

According to the Stern Report (2006), unabated climate change could cost the world at least 5 percent of Gross Domestic Product (GDP) each year; if more dramatic predictions come to pass, the cost could be more than 20 percent of GDP. Each ton of CO_2 emitted causes damages worth at least US$ 85 but emissions can be cut at a cost of less than US$ 25 a ton. Shifting the world onto a low-carbon path could eventually benefit the economy by US$ 2.5 trillion a year. The investments made in the next 10 to 20 years could lock in very high emissions for the next half-century, or present an opportunity to move the world onto a more sustainable path (Stern, 2006). As such, while developed countries grapple with the challenge of reducing their high emissions through new technologies and clean development, tropical countries find their challenge lies in finding pathways less dependent on the conversion of forests (Ministry of Forestry, 2008).

6.2.1. International Environmental Cooperation

In 2003, the first legally binding international agreement on climate protection entered into force. This agreement goes back to the 3rd Conference of Parties (COP3) to the Climate Convention in 1997 in Kyoto, where industrialized nations committed themselves to reducing their emissions of GHG by roughly 5 percent on average, compared with their 1990 emissions levels, during the commitment period from 2008 to 2012. The so-called Kyoto Protocol was celebrated as a breakthrough in international climate policy, because it implied substantial emissions reductions for industrialized countries *vis-à-vis* business-as-usual emissions (Böhringer and Vogt, 2003).

The driving force behind the Kyoto Protocol lies in the idea that a global externality requires global cooperation, international emissions trading lowers costs for all nations, and emissions pricing is the key to the development of new climate-friendly technologies. Yet, there are some clear indications that this architecture has not worked so well. Most obviously, the United States was originally out of the system and developing countries have successfully avoided any discussion of commitments under the Protocol. There is also the reality that most Kyoto participants are well above their targets, with the exception of transition countries such as Russia and Poland, and countries that underwent unrelated structural changes such as the United Kingdom and Germany. Among countries that have implemented (or are on the way to

implementing) mandatory programs, only the European Union (EU) Emissions Trading Scheme (ETS) is designed to parallel Kyoto's cap-and-trade architecture. Other countries have pursued a combination of standards, voluntary programs, and technology incentives that seemingly hinge more on domestic political agendas and less on incentives created by the Protocol (Pizer, 2006).

In the latest string of meetings to address environmental issues globally, the 15th session of the Conference of Parties (COP15) was held in Copenhagen on 7-19 December 2009. After weeks of negotiating and uncertainty on who would be on board, an 11th hour agreement dubbed the Copenhagen Accord was finally drawn up on 18 December by a limited group of leading countries. On the next day, the Conference of Parties to the UN Framework Convention on Climate Change 'took note' of the accord (Clarke, 2009), a non-binding accord.

The Copenhagen Accord itself, nevertheless, recognized the scientific view that the increase in global temperature should be below 2 degrees Celsius. It also promised money up to US$100 billion annually by the year 2020 for mitigation and adaptation activities in developing countries. Another positive outcome of the accord includes the recognition of two new classes of country as opposed to 'developed' and 'developing' countries, namely countries that will be major emitters of GHG in the future and countries that are most vulnerable to the impacts of climate change. What was perhaps most striking about the dynamics of Copenhagen, however, was the unavoidable evidence of the shifting centers of geo-political power. No longer was it the EU or the Anglophone nations that carried the day, nor even the nations of the OECD. It was China, India, Brazil, and South Africa that became the makers and breakers of deals (Hulme, 2010).

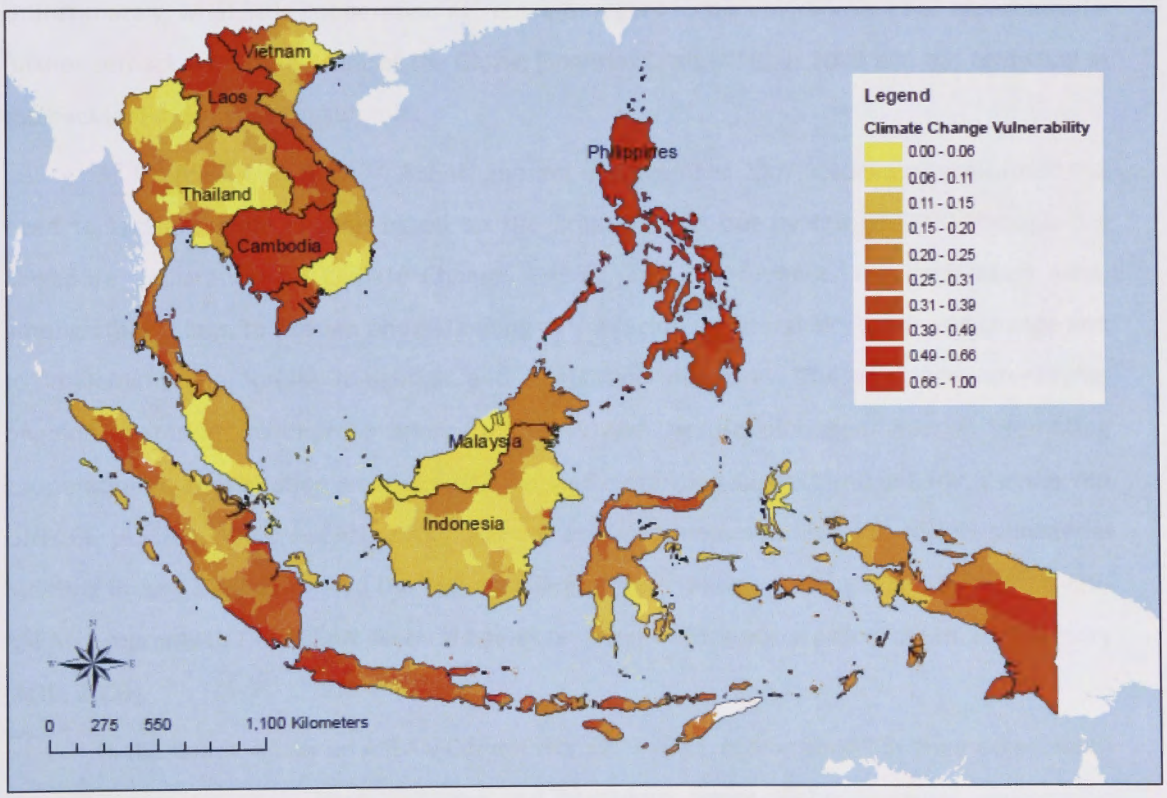
Copenhagen has shown the limitations of what can be achieved on climate change through centralization and multilateralism, in particular, with the top-down approach adopted by the UN. Meanwhile, sub-global forums, such as the G20, the Major Economies Forum, ASEAN Plus 3, Asia-Pacific Economic Cooperation (APEC), Organization of Petroleum Exporting Countries (OPEC), the Forest 11, OECD, and the BASIC Group countries (Brazil, South Africa, India, and China), provide promising venues for pursuing diplomatic agreement. If an agreement is not yet possible at a global level, the need for strong and effective international coordination becomes even more important, especially to progress technical issues and to enable comparison of outcomes (Ashton, 2010).

6.2.2. The Southeast Asian Perspective

Focusing on the Southeast Asian region, the region contributed 12 percent of the world's GHG emissions in 2000, amounting to 5,187 megatons of CO_2-equivalent, up 27 percent from 1990. The land use change and forestry sector were the biggest sources, contributing 75 percent of the

region's total, the energy sector 15 percent, and the agriculture sector 8 percent. However, ASEAN's total CO_2 emissions produced from the combustion of fossil fuels, manufacture of cement and gas flaring in 1995 was 'only' about 610 megaton of CO_2-equivalent, which increased to about 990 megaton in 2005. The total ASEAN CO_2 emissions are still much lower than that of Europe at 6,230 megatons and North America 6,450 megatons (ASEAN, 2009).

Unfortunately, according to the Asian Development Bank (ADB) 2009 Review, the region is especially vulnerable to climate change. The review identifies a number of factors that explain why the region is particularly vulnerable – as 563 million people are concentrated along coastlines measuring 173,251 kilometers (km) long, which ranks third behind North America and Western Europe, leaving them exposed to rising sea levels. At the same time, the region is heavily reliant on agriculture for its livelihood, with the sector accounting for 43 percent of total employment in 2004 and contributing about 11 percent of GDP in 2006, making it vulnerable to droughts, floods, and tropical cyclones associated with warming. Southeast Asia's high economic dependence on natural resources and forestry (it is one of the world's biggest providers of forest products) also puts it at risk. Any increase in extreme weather events and forest fires arising from climate change risk jeopardizing vital export industries.



Source: Yusuf and Francisco (2009)

Figure 6.2. Climate Change Vulnerability Map of Southeast Asia in 2005

Figure 6.2 shows the map of climate change vulnerability in Southeast Asia. Overall, most vulnerable areas include: all the regions of the Philippines; the Mekong River Delta region of Vietnam; almost all the regions of Cambodia; North and East Lao PDR; the Bangkok region of Thailand; and the west and south of Sumatra as well as western and eastern Java in Indonesia. The Philippines, unlike other countries in Southeast Asia, is not only exposed to tropical cyclones, especially in the northern and eastern parts of the country, but also to many other climate related hazards, especially: floods, such as in central Luzon and Southern Mindanao; landslides due to the terrain of the country; and droughts (Yusuf and Fancisco, 2009).

In terms of regional cooperation, environmental issues including climate change are mostly addressed through two of the most significant regional organizations, namely APEC[5] and ASEAN. Of the two, APEC extends its cooperation on selected sectors only (APEC, 2007a). According to the Sydney APEC Leaders' Declaration on Climate Change, Energy Security, and Clean Development in 2007, key areas of cooperation, among others, are: improving energy efficiency through the reduction of energy intensity of at least 25 percent by 2030; increasing forest cover by at least 20 million hectares by 2020, which would store approximately 1.4 billion tons of carbon, equivalent to 11 percent of annual global emissions in 2004; and working with industry to improve fuel efficiency and promote alternative fuel use in the transportation sector. Unfortunately, what little cooperation existed with regard to the environment has experienced a further setback with the advent of the Global Financial Crisis (GFC) in 2008 and has remained in the backseat in subsequent summits.

As for ASEAN, at the 13th ASEAN Summit in November 2007, its leaders reaffirmed the need to tackle climate change based on the principles set out by the UNFCCC through the Singapore Declaration on Climate Change, Energy, and Environment. The declaration aims, among other things, to deepen understanding of the region's vulnerability to climate change and to implement appropriate mitigation and adaptation measures. These include intensifying ongoing operations to improve energy efficiency and the use of cleaner energy, promoting cooperation in afforestation and reforestation, and continuing support and initiatives under the UNFCCC (ASEAN, 2007; ASEAN, 2009). Among concrete measures, the 41st ASEAN Ministerial Meeting in July 2008 delegated the responsibility of mainstreaming climate change actions into ASEAN programs to the ASEAN sectoral bodies on energy efficiency, transportation, and forestry (ADB, 2009).

In the Roadmap for an ASEAN Community 2009-2015, cooperation has been extended to managing transboundary haze pollution and hazardous waste. Other areas of cooperation include operating the ASEAN Network on Environmentally Sound Technology (ASEAN-NEST) that

[5] Only seven members of ASEAN are also members of APEC, namely Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.

will adopt region-wide environmental management/labeling schemes as well as intensify cooperation on joint research, development, deployment, and transfer of environmentally sound technology (EST); promoting sustainable use of coastal and marine environment, e.g. joint efforts to maintain and protect marine parks in border areas; and promoting sustainable management of natural resources and biodiversity, e.g. control transboundary trade in wild fauna and flora (ASEAN, 2009).

Nevertheless, there is indeed a gap between intention and action (Elliott, 2003). It is worth bearing in mind the nature of the decision-making process in ASEAN, which is consensus-based. In cases where consensus cannot be achieved the 'ASEAN Minus X' formula can be invoked, although some countries' lack of participation coupled with its non-binding nature might undermine these efforts. The 'ASEAN Way', characterized by consensus-based decision-making, strict principles of non-intervention, and the sanctity of state sovereignty, has helped maintain peace in the region; however, in the terms of implementing concrete projects, the Way presents itself as a challenge. Lastly, the diversity among ASEAN member countries in terms of economic development, geographical difference, population demography, and resource endowment poses a definite obstacle not only at the implementation level, but with regard to vision as well.

6.2.3. Indonesia's Commitments: Pre-Emptive or Premature?

Indonesia is the largest archipelagic state, which comprises of 18,110 islands stretching 5,110 km from east to west and 1,888 km from north to south. It has a coastline length of about 108,000 km and is situated at the confluence of four tectonic plates, namely the Asian Plate, Australian Plate, Indian Plate, and Pacific Plate, making it susceptible to earthquakes. Due to its geological and geographical factors, the region suffers from a range of climatic and natural hazards, such as earthquakes, typhoons, floods, volcanic eruptions, droughts, fires, and tsunamis, all of which are becoming more frequent and severe. In addition, the geophysical and climatic conditions shared by the region have also led to common and transboundary environmental concerns such as air and water pollution, urban environmental degradation, and haze pollution (ADB 2009; ASEAN 2009).

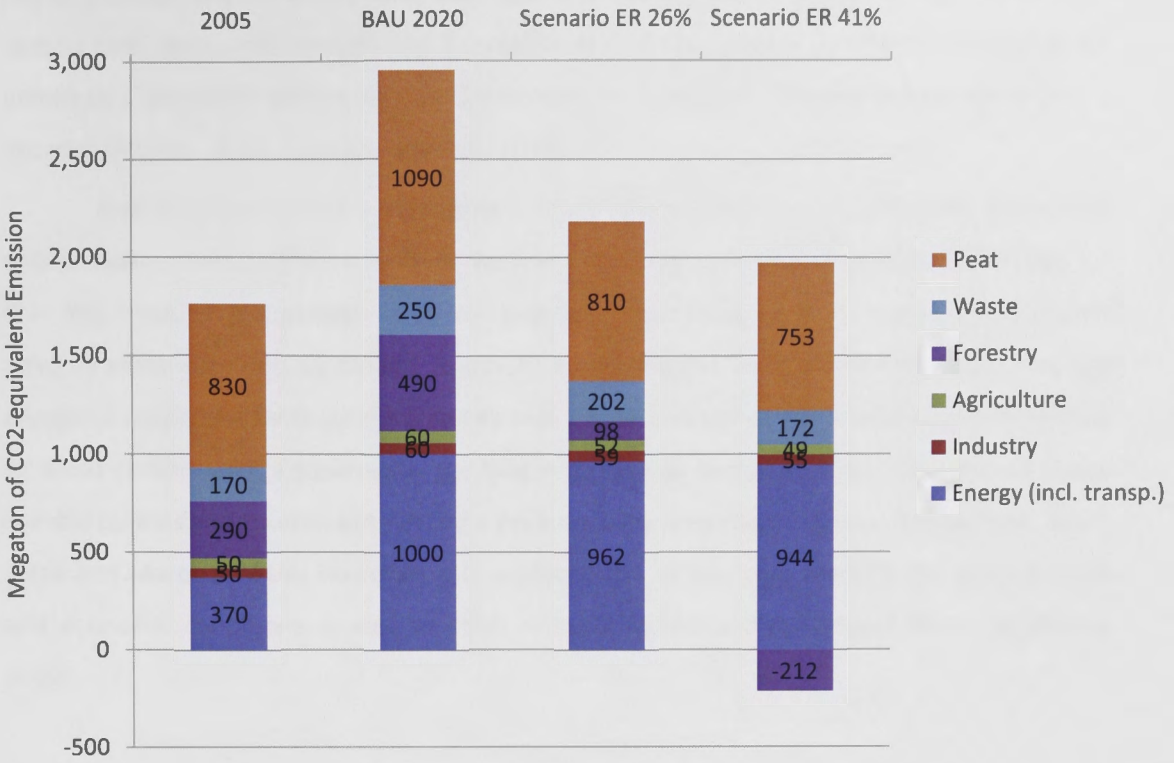
Indonesia stands to experience significant impacts from climate change. These include sea-level rise and saltwater inundation, droughts, increased frequency of extreme weather events, heavier rainfall events and flooding, and the spread of diseases. In turn, these may harm the country's agricultural, fishery and forestry industries, threatening both food security and livelihoods. Indonesia's rich biodiversity is also at risk (Jotzo *et al.*, 2009). Nevertheless, Indonesia itself is a significant emitter of greenhouse gases. Indonesia has become one of the

three largest emitters of greenhouse gases in the world. This is largely due to a significant release of CO_2 from deforestation. Yearly emissions in Indonesia from energy, agriculture, and waste combined are around 451 million tons of CO_2-equivalent ($MtCO_2e$). Yet, land use change and forestry (LUCF) alone is estimated to release about 2,563 $MtCO_2e$, mostly from deforestation[6] (Sari *et al.*, 2007).

To its credit, at the Pittsburgh G20 Leaders' Meeting in September 2009, President Yudhoyono implored fellow leaders to act on climate change and made a remarkable commitment. Indonesia pledges to devise an energy mix policy including land use, land use change, and forestry that will reduce its annual emissions by 26 percent from Business As Usual (BAU) by 2020. With international support, it pledges an emissions reduction by as much as 41 percent (Yudhoyono, 2009). As such, Indonesia has committed to reigning in GHG emissions, in a bid to do its share in an emerging global effort to mitigate climate change.

Figure 6.3 illustrates Indonesia's sectoral emissions in 2005. Quite obviously peatland, forestry, and energy make up the largest sectoral emitters of CO_2 in Indonesia. Under the BAU scenario, this composition will not change much by 2020. With continuing deforestation, the forest area in Indonesia will naturally decline by 2020, with a corresponding declining growth rate of CO_2 emissions from forest fires and less land clearing. The energy sector, on the other hand, is expected to grow continuously during this period, and thus its CO_2 emissions will at the fastest rate during this period, from approximately 370 megaton of CO_2-equivalent in 2005 to approximately 1,000 megatons of CO_2-equivalent in 2020.

[6] While data on the emissions from different sources does vary between studies, the overall conclusion is the same. Indonesia is a major emitter of GHGs.



Source: National Council on Climate Change (2009).

Figure 6.3. Indonesia's CO_2 Sectoral Emissions Shares

Looking at the 26 percent reduction scenario, the forestry sector's emissions share declines significantly. But under this scenario, Indonesia is able to maintain the size of its forest cover, as the primary reduction of CO_2 emissions will come from the prevention of deforestation. This in turn will make the energy sector the largest sectoral emitter of CO_2 by 2020. As such, although current CO_2 emissions from LUCF are much higher than that due to fossil fuel combustion, it is certain that in the future the situation will be reversed. Emissions from the energy sector, however small, are rapidly growing.

As mentioned, Indonesia is a fast emerging economy consisting of an increasingly affluent population which aspires to better living conditions and as a consequence, consumes more energy per capita. As the population continues to grow and becomes richer, energy use will also grow. The main drive behind the increasing CO_2 emissions in Indonesia is the increase in carbon intensity due to the increased use of coal as a source of energy, particularly for electricity generation (Resosudarmo *et al.*, 2009).

Emissions from the energy sector through the use of coal, oil, and gas currently account for only one quarter of Indonesia's emissions. Energy use in Indonesia is still far below the per capita global average, and even further below per capita energy consumption levels in developed countries. But Indonesia's fossil fuel emissions are catching up fast. Aggregate energy

use is growing roughly in line with GDP, and a growing share of energy is supplied by high-carbon coal, especially through the expansion of coal-fired power plants. If left unchecked, Indonesia's emissions profile will be dominated by emissions from fossil fuel within a few decades (Ahmad, 2010; Jotzo and Mazouz, 2010).

And thus, herein lies a conundrum, albeit one faced by many countries: Indonesia's energy supply needs to grow in order to facilitate economic growth and improve livelihoods, but it is also creating fast growth in carbon emissions that threaten those very goals. As such, possible options for curbing emissions growth are to improve energy efficiency and so use less energy to supply the same services, and to take the carbon out of the energy supply by shifting to lower-carbon energy sources. In the long run, climate change will require not only sector specific policies and reform, but putting a price on carbon emissions (Resosudarmo *et al.*, 2009; Jotzo and Mazouz, 2010). However, this approach has to take into account the existing social and economic conditions as well as other relevant factors at the national levels (Situmeang 2010).

6.2.4. Carbon Pricing as a (Possible) Solution

There are many opportunities to achieve emissions abatement within the economy. The challenge is to achieve overall abatement at least cost. Carbon pricing takes advantage of the market mechanism in deciding whether emissions reductions occur. A price is put on carbon emissions, raising the prices of goods that have associated carbon emissions in their production. Goods and services that embody high emissions will see higher increases in price than those that embody few emissions; and the price of low-emissions goods and services may fall. Consumers and producers will react to this price signal by switching toward lower-emissions alternatives. The economic reaction to the price signal automatically implements the lower-cost abatement options as opposed to, among others, promoting energy efficient technology, e.g. solar panel subsidy (Jotzo and Mazouz, 2010).

Market based responses to environmental externalities fall broadly into one of two categories: price or quantity instruments. An emissions tax is a price based instrument while a 'cap-and-trade' system is a quantity based instrument. In the absence of uncertainty either approach can be used to achieve a given environmental goal. If a tax is set on emissions, firms adjust emissions until the emissions fee is set equal to the marginal cost of abatement on emissions. Conversely if a cap and trade system is utilized firms buy and sell permits. The price of the permits is set by demand and supply conditions. Demand follows from individual firms' marginal cost of abatement functions while supply is set by the aggregate cap. In equilibrium each firm sets its marginal cost of abatement equal to the price of permits. In a world of certainty, tax and permit schemes should have equivalent results (Green, 2008; Metcalf, 2009).

Kaplow and Shavell (2002) argue that the potential superiority of the quantity instrument over the price instrument only holds under the restriction of linear tax systems. If non-linear taxes are allowed then the tax is uniformly superior. The superiority of the non-linear tax is that firms' responses to the tax reveals information about their marginal abatement cost functions, information that is not revealed by quantity controls (Metcalf, 2009). Another work conducted by McKibbin *et al.* (2008) also shows that with the existence of uncertainty, the international carbon tax is more economically efficient than the cap and trade scheme of the Kyoto Protocol. Thus, most economic analyses of policy choice under uncertainty favor prices on efficiency grounds (Weitzman, 1974; Pizer, 2002; Strand, 2010).

6.2.5. The Double Dividend Hypothesis

Environmental tax reforms have indeed become increasingly popular in recent years. One reason is increasing concern about the quality of the natural environment; environmental taxes are generally an efficient instrument for protecting the environment. A second reason involves the revenues from environmental taxes. These revenues can be used to cut other distortionary taxes. In this way, the government may reap a 'double dividend', i.e. not only a cleaner environment but also a less distortionary tax system. Furthermore, even if the double dividend hypothesis does not hold, an environmental tax reform may still be a so-called 'no-regret' option. In other words – even if the environmental benefits are in doubt, an environmental tax reform may still be desirable as it induces economic efficiency, also called an 'efficiency dividend' (Pearce, 1991; Goulder, 1995; Bovenberg, 1999; Glomm *et al.*, 2007).

Nevertheless, Schob (2005) argues theoretically that an environmental tax may have a multitude of possible effects which are sensitive to the underlying institutional framework. The interaction of environmental regulation with the pre-existing tax system, the labor market institutions, and aspects of international cooperation influences the results of such regulation. The sign and magnitude of both environmental and non-environmental dividends are determined by the institutional framework in which a green tax reform takes place, the technology of polluting goods, and other possible sources of economic inefficiency coming from sound policy recommendations. On top of all this, the trade-off between efficiency and distributional considerations needs careful evaluation when environmental policy proposals enter the political process, both with respect to the welfare implications and the question of implementability.

Empirical studies have also suggested that the double dividend theory in which a revenue-neutral tax shift may yield environmental gains at virtually no cost does not hold up. While there are significant environmental benefits associated with a tax shift, which may well exceed the costs for many policy choices, these gains are not generally costless. Nevertheless,

despite the mixed signals, both theoretical developments and recent trends suggest some optimism for the future of environment-related taxes. It has been argued that the revenue-raising environmental policies are more efficient than the non-revenue-raising policies because of the revenue-recycling effect (Morgenstern, 1995; Lai, 2009). Furthermore, the tax type, 'recycling policy', and economic model significantly influence the chance that a double-dividend effect can be obtained.

The term 'recycling policy' refers to revenue recycling, that is, using new revenues from environment-related taxes, e.g. carbon tax, to decrease pre-existing distortionary taxes. The mechanism consists of recycling revenues from environmental taxes on carbon products, energy consumption, or the use of natural resources in order to reduce taxes on other phases of the production process. The revenues might then be employed to reduce other distortionary taxes on the 'good' part of the economic process, including regulatory measures and technological research, resulting in more efficient energy use. Other forms of financial recycling are also possible, such as lump-sum transfers to households or industries, consisting of recycling the revenues to households or to the industries in the form of one-off payments, or interventions in corporate profit taxes and value added tax. Alternatively, if the government were instead to keep the revenues without recycling them within the system, a reduction in growth rate would likely take place (Patuelli *et al.* 2005). There is also increasing evidence that the way in which tax revenues are recycled may be more important than the question of whether the tax is introduced in a single country or jointly in several countries such that imposing a carbon tax, provided the revenues are recycled, is a sensible approach that could meet the country's economic, environmental, and social objectives (Welsch, 1996; Corong, 2008).

6.2.6. Regress and Rebound: The Limits

There are, of course, some *caveats* associated with the implementation of a carbon tax. Among such is the regressive nature of a carbon tax in which it imposes the heaviest on the lower income groups. Policy targeting CO_2 emissions from energy consumption also tend to be more regressive than a price on all emissions (Grainger and Kolstad, 2009). The literature suggests, however, that a carbon tax generally is, or is expected to be, regressive in developed economies and progressive in developing economies (Pearce, 1991; Verde and Tol, 2009).

Another note of caution deals with the so-called 'rebound effect'. To achieve reductions in carbon emissions, most governments are seeking ways to improve energy efficiency throughout the economy, including through the implementation of a carbon tax. It is generally assumed that such improvements will reduce overall energy consumption, at least compared to a scenario in which such improvements are not made. The rebound effect results in part from an increased consumption of energy services following an improvement in the technical efficiency

of delivering those services. This increased consumption offsets the energy savings that may otherwise be achieved. If the rebound effect is sufficiently large it may undermine the rationale for policy measures to encourage energy efficiency (Sorrell and Dimitropoulos, 2008; Sorrell 2009). Greening *et al.* (2000) differentiates the rebound effects into four categories: direct rebound effects; secondary fuel use effects; market-clearing price and quantity adjustments, or economy-wide effects; and transformational effects.

Indeed, various empirical studies and simulations have indicated that the rebound effect occurs in many countries. Brännlund *et al.* (2007) finds such evidence in Sweden in which the rebound effect can be considerable. That is, the initial emissions reduction due to an increase in energy efficiency is more than counteracted by changes in consumption. Thus, an exogenous increase in energy efficiency may not lead to lower energy consumption, and hence lower emissions. Similarly, a study conducted by Otto *et al.* (2008) on the Netherlands finds that the most cost effective climate policy includes a combination of research and development (R&D) subsidies and CO_2 emissions constraints, although R&D subsidies raise the shadow value of the CO_2 constraint, i.e. CO_2 price, because of a strong rebound effect from stimulating innovation. Likewise, the rebound effect is also observed in other countries including the United Kingdom (Barker *et al.*, 2007); Japan (Mizobuchi, 2008); and the United States of America and Western Europe (Holm and Englund, 2009). Numerous empirical studies suggest that these rebound effects are real and can be significant. However, while their basic mechanisms are widely accepted, their magnitude and importance are still disputed (Sorrell and Dimitropoulos, 2008).

6.3. Brief Review of the IRSA-ASEAN Model[7]

The IRSA-ASEAN model is a multi-country CGE model and is a descendant of the Inter-Regional System of Analysis for Indonesia Five Regions (IRSA-Indonesia5) developed by Resosudarmo *et al.* (2008) such that it bears similarities with the latter in terms of notational use. However, numerous features of the IRSA-ASEAN model also stem from other developments in CGE modeling over the last 20 years; some of these sources of inspiration are direct and easily identified, including one of the first CGE models for Indonesia by Lewis (1991), the GTAP model (Hertel, 1997), and the Globe model (McDonald et al., 2007). Nevertheless, the IRSA-ASEAN model is a unique model on its own right, both structure-wise and purpose-wise. The IRSA-ASEAN model is a multi-country model that solves at the country level, meaning that optimizations are done at the country level. This approach allows price as well as quantities to vary independently by countries, which means that variation in price as well as in quantity of

[7] See Chapters 3 and 4 for detailed technical descriptions on the construction method of the database and model.

each country can be observed using this model. This approach enables the user of the model to observe the impact of a specific shock in a country to other countries, the whole ASEAN economy, and the country itself.

The IRSA-ASEAN consists of six of ASEAN's member countries, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. As optimization is done at the country level, and taking into account the 'sovereignty' element of each country, the model uses neither a bottom-up nor a top-down approach.[8] Each country is instead connected through the flow of commodity, i.e. trade of goods and services, as well as the flow of transfer, i.e. remittance and savings-investment. The model also allows direct transfer of primary factors production, however, due to data scarcity, this last feature is not included in the empirical study. As a consequence of the sovereignty element in the IRSA-ASEAN model, each country has its own balance of payments as well as savings and investment accounts. Each country deals directly with other countries in terms of trading and is allowed its own set of tariff barriers. For examples, in the IRSA-ASEAN model, each country can export/import goods and services directly to/from rest of the world (ROW).

Another important highlight of the IRSA-ASEAN model deals with the issue of double-dividend. Although the IRSA-ASEAN model can be used for a wide-range of policy simulations, e.g. trade and fiscal simulations, the main motivation to its development in this chapter is to assess the economic impact of environment-related policies, namely carbon tax implementation and energy subsidy reduction. As such, the IRSA-ASEAN model takes a step further with regard to the issue of environment by allowing for the possibility of the double-dividend hypothesis. The model internalizes the double-dividend hypothesis by intrinsically and explicitly incorporating various recycling mechanisms. In this regard, aside from the government increasing its expenditure, the carbon tax revenue and energy subsidy reduction can either be recycled directly to households (e.g. direct one-time lump-sum cash transfer to low-income households) or recycled back to the industry (e.g. indirect tax reduction) such that it creates a less distortionary tax system, or supposedly so.

For empirical results, the IRSA-ASEAN model uses the Social Accounting Matrix for ASEAN (ASEAN-SAM) which has been calibrated from the input-output (I-O)-based Global Trade Analysis Project (GTAP) Version 7 Data Base with parameter values, e.g. value-added and Armington elasticities, also obtained from this source. The database uses a common reference year of 2004 and a common currency of United States million dollars (USD million) for all six selected ASEAN countries. The database has been heavily modified using various country-specific datasets, e.g. social accounting matrices and household income/expenditure surveys, so

[8] This is in line with real world evidence in which ASEAN, unlike the EU, is not a supranational organization.

as to provide greater insight and flexibility for policy analysis. Also, the latest version of Generalized Algebraic Modeling System (GAMS) program is used to run the IRSA-ASEAN model.

The following lists the additional datasets required to build the so-called ASEAN-SAM. For Indonesia, the additional data needed are (1) 2005 Social Accounting Matrix and (2) 2005 Inter-Regional Social Accounting Matrix (Resosudarmo *et al.*, 2008); Malaysia, (1) 2004/2005 Household Expenditure Survey, (2) 2004 Distribution and Use of Income Accounts and Capital Account, (3) 2000 Population and Housing Census, and (4) 1970 Social Accounting Matrix (Pyatt *et al.*, 1984); Philippines, (1) 2006 Family Income Expenditure Survey, (2) 2000 Social Accounting Matrix (Cororaton and Corong, 2009), and (3) 1997 Family Income Expenditure Survey; Singapore, (1) 2008 Yearbook of Statistics and (2) 2002/2003 Report on the Household Expenditure Survey; Thailand, (1) 2008 Key Statistics, (2) 2002 Household Socio-Economic Survey, and (3) 1998 Social Accounting Matrix (Li, 2002); Vietnam, (1) 2004 Living Standard Survey and (2) 1997 Social Accounting Matrix (Nielsen, 2002). Other data sets needed are the 2010 World Development Indicators, 2008 ASEAN Statistical Yearbook, 2005 ASEAN Statistical Yearbook, 2005 Bilateral Remittance Estimates (Ratha and Shaw, 2007), 2005 International Energy Prices (Metschies, 2005), and 2004 Combustion-Based CO_2 Emissions Data for GTAP Version 7 (Lee, 2008).

Procedures in constructing the ASEAN-SAM for modeling purposes are divided into three phases. The first phase involves the preparation of the GTAP Version 7 Data Base and transforming it into individual Global SAMs; i.e. Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. Phase 2 is a set of steps required to transform each individual Global SAM into a standard SAM form. Phase 3 is when all individual SAMs are combined to form the ASEAN-SAM. Some adjustments are needed to combine these individual SAMs.[9]

6.3.1. Household Disaggregation

In the ASEAN-SAM, households are disaggregated into four groups, namely Rural-Low, Urban-Low, Rural-High, and Urban-High. These groups are maintained as well in the model and throughout the various simulations conducted. Nevertheless, once a solution has been found for a particular simulation, household groups are disaggregated further through in a microsimulation. The microsimulation basically disaggregates household expenditure into one hundred groups based on population percentile groupings in both rural and urban areas. In other words, there are now one hundred household groups in the rural area and one hundred household groups in the urban area. Appendix 6.1 shows the GAMS syntax for the microsimulation.

[9] See previous chapters for more details on the database and model.

At this point, it should be noted that the microsimulation only disaggregates household expenditure, which is the main reason why this disaggregation has not been implemented on the ASEAN-SAM. The information required to disaggregate the entire household accounts, i.e. household savings, remittance, and others, for all six countries is simply an enormous task beyond the scope of this study. As such, the microsimulation ensures the consistency of all the simulation results and simply opens up another important dimension for analytical purposes.

Another important aspect to the household disaggregation is the method itself. For the case of Indonesia, disaggregation of household expenditure uses data from the IRSA-Indonesia5 model by Resosudarmo *et al.* (2008) in which all five regions of Indonesia, namely Sumatera, Java-Bali, Kalimantan, Sulawesi, and East Indonesia, are aggregated. Although the IRSA-Indonesia5 uses 2005 as the reference year, while the IRSA-ASEAN model uses 2004, it is logically assumed that household expenditure patterns should not change significantly within such a short period of time. The sectoral disaggregation is somewhat more complicated; fortunately, the IRSA-ASEAN model has fewer production sectors, with 26 sectors compared to the IRSA-Indonesia5 model with 35 sectors, thus finding a corresponding sector for the IRSA-ASEAN model requires no additional data source.

Meanwhile, a strong assumption has to be imposed upon every other country. Due to the scarcity of data, households in Philippines, Thailand, and Vietnam are assumed to have the same percentile share pattern as Indonesia as their economic developments are comparable. However, this is not the case for Singapore. As such, the percentile share pattern for Singapore uses only the urban area of Java-Bali region, as this is the most developed region in Indonesia. As for Malaysia, the percentile share pattern uses the aggregate for Sumatera and Java-Bali regions, with both rural and urban areas used correspondingly. Bear in mind that as the disaggregation is conducted separately as a microsimulation, it does not affect the overall results. In other words, although strong assumptions have to be applied, the consistency of the model is not compromised and the microsimulation simply adds a new analytical tool. Appendices 6.2 and 6.3 show the initial conditions resulting from the disaggregation of household expenditure that can be used to analyze the reliability of the disaggregation method.

Appendix 6.2 shows the log household expenditure per capita for all six countries in both rural and urban areas. In rural areas, the figure shows that Malaysia has the highest expenditure per capita followed closely by Thailand and Indonesia then Philippines, and Vietnam last. As for urban areas, Singapore is at the top followed farther down by Thailand and Malaysia. Indonesia and Philippines have a very similar pattern, followed again by Vietnam. These patterns reflect the level of economic development of each country with Singapore being the most developed and Vietnam as the least. Meanwhile, Malaysia, Thailand, Indonesia, and Philippines are somewhat more comparable to one another in terms of economic development.

Appendix 6.3, on the other hand, shows the household expenditure distribution. Although similar, Appendix 6.3 does not show the Gini distribution as it shows household expenditure rather than income distribution. Nevertheless, the same logical conclusion can be drawn, with expenditure disparity in rural areas the largest in Malaysia, followed by Thailand, Philippines, Indonesia, and Vietnam. As for urban areas, Singapore has the largest expenditure disparity followed by the same order of countries as in rural areas. Intuitively, the more developed the country is, the larger the disparity; and *vice versa*. Vietnam, being the least developed economy compared to the other five countries, has the least expenditure disparity; although nominal-wise, household consumption is the lowest, as shown in Appendix 6.2.

6.4. Policy Simulations: Carbon Tax Implementation

With regards to policy simulations, this study focuses on the economic impact of carbon tax policies. This is done since, even with only a single instrument (i.e. carbon tax), there are many ways in which this policy can be implemented and modeled. The simulations of the model are basically grouped into two scenarios based on how each is implemented, namely symmetric and asymmetric policies. A symmetric policy simply means that the chosen policy is implemented across the board in all six countries. In contrast, an asymmetric policy means that the chosen policy is only implemented in one or a few countries. Though it may seem redundant to distinguish these two categories, due to the nature of the database and model of the IRSA-ASEAN, a change in one or more countries immediately affects the remaining countries, albeit mainly through trade. In other words, here lies the distinction between multi-country CGE models (e.g. IRSA-ASEAN model) and the multiple countries CGE models (e.g. country-specific CGE model).[10]

Aside from the two broad scenarios mentioned previously, there are three recycling mechanisms for the policy that are explored as well. These mechanisms deal with the revenue generated from the carbon tax policy implemented by the respective government as explained previously. The first recycling mechanism assumes that the government retains all the revenue generated and thereby increases its consumption proportionally such that the total increase equals the carbon tax revenue. Note that whenever each government obtains this revenue, it 'recycles' the entire revenue back to the economy through increased government consumption. In other words, none of the revenue goes into government savings.

The second mechanism assumes that the government redistributes some of the revenue back to households in the form of a direct cash transfer to improve social welfare. In this variant, in order to conform to the real world, the government only redistributes cash to those of low

[10] In the asymmetric simulations, only Indonesia imposes a carbon tax. This is in line with Indonesia being at the forefront in the region for climate change mitigation through its announced commitment.

income households in both rural and urban areas. Furthermore, transfer shares between rural-low and urban-low income households are weighted based on the poverty incidence, i.e. percentage of population under the national poverty line. Effectively, with greater poverty incidence in rural areas, low income households in these areas receive a greater share of the cash transfer compared to low income households in urban areas. Logically, of course, high-income households in both rural and urban areas do not receive these cash transfers.

Meanwhile, the third variant assumes that the government uses part of the carbon tax revenue to reduce other distortionary taxes in order to achieve a double dividend. In the IRSA-ASEAN model, the respective government proportionally redistributes the revenue obtained back to the industries through a negative indirect tax. This scheme is intended to achieve a less distortionary tax system, although for some industries where indirect tax is already low, this scheme actually creates a new subsidy from the government to those sectors. The fourth and final mechanism combines the second and third mechanisms in which the government redistributes the revenue generated back to both households and industries.

Also, due to a technical limitation of the model when it comes to endogenized intermediate input substitution, there are two additional scenarios in which technological change is treated exogenously to illustrate possible outcomes from intermediate input substitution, and by extension efficiency gain, in the energy sector. These technological changes are a 10 percent efficiency gain of coal use and a 5 percent efficiency gain of oil use. The carbon tax itself is set at USD 10 per ton of CO_2 emissions following the previous work of the Ministry of Finance (2009) for fossil fuel use, i.e. coal, petroleum products, and gas.[11] Appendix 6.4 shows the full GAMS syntax for the carbon tax implementation.

Scenario 1: Symmetrical Carbon Tax Policies

A USD 10 per ton of CO_2 emissions tax in all six countries:

1a. Each government retains all carbon tax revenue to increase its consumption;

1b. Each government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent back to low-income households in rural and urban areas; and

1c. Each government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent to industries.

[11] Oil and Gas as defined in Lee (2008) are assumed to be used solely as feedstock such that their use does not emit CO_2.

Scenario 2: Asymmetrical Carbon Tax Policies

A USD 10 per ton of CO_2 emissions tax in Indonesia:

2a. Indonesian government retains all carbon tax revenue to increase its consumption;

2b. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent back to low-income households in rural and urban areas; and

2c. Indonesian government retains 50 percent of the revenue to increase its consumption and redistributes 50 percent to industries.

Scenario 3: Symmetrical Carbon Tax Policies

A USD 10 per ton of CO_2 emissions tax with 10 percent efficiency gain in the use of coal in all six countries. The three recycling mechanisms remain the same.

Scenario 4: Symmetrical Carbon Tax Policies

A USD 10 per ton of CO_2 emissions tax with 5 percent efficiency gain in the use of oil in all six countries. The three recycling mechanisms remain the same.

6.4.1. Macroeconomic Results

The summary of emissions, macroeconomy, and expenditure is shown in Table 6.1 for the symmetrical scenario for a USD 10 carbon tax without any efficiency gain. Appendix 6.5 summarizes the result for the asymmetrical scenario. Appendices 6.6 and 6.7 provide the same summary results but with a 10 percent efficiency gain in coal use and a 5 percent efficiency gain in oil use, respectively, for symmetrical scenarios. It is important to note, however, all changes are calculated at the original price level such that they are *real* changes.

Table 6.1 shows the results of Scenario 1, the implementation of a carbon tax at USD 10 per ton of CO_2 emissions on all countries. Overall, implementing a carbon tax even without any variants reduces carbon emissions. However, this gain for the environment comes at a cost in terms of contraction in the GDP as well as in real household expenditure for some countries, namely Philippines, Singapore, Thailand, and Viet Nam. Redistributing revenue generated to low-income households appears to alleviate the cost associated with the rising price of energy; but this comes at a cost in terms of greater GDP reduction in the manufacturing sector.

More interesting is how a carbon tax affects each country differently. Determining which countries stand to gain the most from a carbon tax scheme is actually quite as expected, regardless how the revenue generated will be redistributed. For Indonesia and Malaysia, a carbon tax has a positive effect on the overall economy. However, some sectors will more likely

be adversely affected than others, namely the manufacturing sector followed by the agricultural sector; whereas the service sector will actually benefit from the implementation of a carbon tax, assuming that the government retains all the revenue generated and recycles it all back all through its increase in expenditure.

All the other countries, on the other hand, exhibit a similar pattern to each other that is opposite to Indonesia and Malaysia. Although beneficial in terms of environmental improvement, the cost comes at a contraction to their respective economy. This is especially true for the case of Vietnam in which the country will most likely suffer the most in terms of economic contraction for all variants. For sectoral changes, these countries also exhibit the same pattern as Indonesia and Malaysia where the manufacturing sector will more likely be adversely affected, followed by the agricultural sector, with the service sector more likely to gain.

Table 6.1. Simulation Results of Scenario 1**

	CO_2	Real GDP	Real Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Government									
Indonesia	-3.7	0.25	-0.14	-0.32	0.75	-1.1	-1.27	-1.2	-0.18
Malaysia	-4.06	0.04	0.01	-0.18	0.46	-1.36	-1.54	-1.13	-1.35
Philippines	-2.99	-0.04	-0.08	-0.43	0.25	-0.77	-0.71	-0.77	-0.73
Singapore	-0.95	-0.01	0.02	-0.35	0.12		-0.32		-0.34
Thailand	-2.38	-0.14	-0.18	-0.74	0.32	-0.91	-0.64	-1.14	-1.06
Vietnam	-6.29	-0.33	-0.06	-1.12	0.87	-1.84	-1.83	-1.77	-1.55
Household									
Indonesia	-3.4	0.27	0.01	0.07	0.47	2.18	0.12	-1.32	-0.9
Malaysia	-3.74	0.06	0.17	0.07	0.02	7.16	-0.76	-1.36	-1.56
Philippines	-2.82	-0.03	0.05	-0.18	0.07	5.85	0.43	-0.88	-0.9
Singapore	-0.88	-0.01	0.04	-0.26	0.09		0.45		-0.37
Thailand	-2.08	-0.08	0.01	-0.38	0.14	3.69	0.39	-1.32	-1.53
Vietnam	-5.77	-0.22	0.14	-0.65	0.32	2.44	0.26	-1.81	-1.81
Industry									
Indonesia	-3.34	0.26	-0.02	0.55	0.12	-1.61	-1.66	-1.35	-0.32
Malaysia	-4.03	0.04	*	0.24	-0.33	-2.76	-2.61	-0.78	-0.99
Philippines	-3.35	-0.05	-0.09	-0.28	0.12	-1	-0.63	-1.02	-0.6
Singapore	-0.94	-0.01	0.05	-0.1	0.02		-0.51		-0.22
Thailand	-2.49	-0.14	-0.12	-0.38	0.04	-2.59	-1.35	-2.25	-0.77
Vietnam	-3.67	-0.22	0.24	0.24	-1.19	-1.9	-2.62	-1.85	-2.65

* - Negligible Value

** - Symmetric Carbon Tax at USD 10 per ton of CO_2 Emissions with No Efficiency Gain

In terms of overall change, it is quite obvious why Indonesia and Malaysia are most likely to benefit compared to the other countries. In Indonesia and Malaysia, fuels are subsidized[12] such that introducing a carbon tax is similar to reducing subsidies. In other words, a carbon tax actually promotes efficiency by creating a less distortionary tax system in which the double-dividend hypothesis and the no-regret option apply. Furthermore, expansion of the GDP in Indonesia and Malaysia is the result of an expansion in the service sector, which is most likely caused by a reallocation of resources as this sector produces the least amount of carbon emissions. The manufacturing sector, on the other hand, appears to suffer the most as it produces the largest amount of carbon emissions; and therefore, the most affected by a carbon tax implementation. The agricultural sector can either suffer or benefit from a carbon tax implementation depending on the recycling mechanism utilized in the respective country, albeit affected at a much a lesser extent either way than the manufacturing and service sectors.

Although the same sectoral pattern also occurs in the other countries, namely Philippines, Singapore, Thailand, and Vietnam, the end results differ with their respective economy actually contracting. This is because the other countries do not subsidize as much as Indonesia and Malaysia. As such, in these countries, introducing a carbon tax will most likely create a more distortionary tax system, with Vietnam suffering the most followed by Thailand, Philippines, and Singapore. It should be noted, however, that the term 'distortionary tax' does not refer to the carbon tax; the term instead refers to the indirect tax, e.g. production tax. The fact that Philippines and Singapore do not subsidize fuels at all[13] allows a more efficient adjustment to take place in their respective economies such that they do not suffer as much as Vietnam and Thailand.

Meanwhile, although recycling mechanisms do not affect the overall results in terms of emissions reduction and economic contraction, they do significantly affect sectoral changes and household expenditures. When part of the carbon tax revenue is recycled back to low-income households in both rural and urban areas, the first thing to note is that these two household groups are no longer as adversely affected as before. Those in the lower-income bracket are somewhat compensated by the changes as they are given a lump sum cash transfer by their respective governments. As household expenditure patterns are different from government expenditure patterns, this in turn changes the sectoral output as household consumption shares of manufacturing and agricultural goods are higher compared to services *vis-à-vis* government consumption share pattern. As such, the manufacturing and agricultural sectors are somewhat compensated by the increased consumption as opposed in the previous recycling mechanism.

[12] 'Fuel' refers to Petroleum and Coal Products sector. See Chapter 3 for more detail on the subsidy.
[13] See the fuel price section in Chapter 2.

As for the third recycling mechanism in which the government reduces indirect taxes, the first obvious thing to note is that households are no longer compensated so that their expenditure consumption pattern changes are more similar to the first recycling mechanism. However, changes in sectoral output are more erratic as different things are occurring at once, e.g. carbon sales tax, indirect taxes, and price changes.

One final important note is that the overall results do not change with the recycling mechanisms, which is actually both interesting and logical. This means that that no leakage occurs between countries and the recycling mechanisms only change domestic patterns. As such, in terms of overall achievement, recycling mechanisms do not matter although for practical policy purposes, they become very important in terms of feasibility and acceptability.

Appendix 6.5, on the other hand, shows the result of implementing a carbon tax solely in Indonesia. The results do not differ significantly from the previous table, however, the results emphasize the possibility that Indonesia could still actually gain from implementing a carbon tax unilaterally. This has a serious policy implication for Indonesia as it shows that Indonesia can gain from implementing a carbon tax regardless of whether other countries do so or not.

The more important question for Indonesia is how it chooses to redistribute the income. In this regard, although the overall benefits do not change significantly, recycling mechanisms do changes domestic 'winners' and 'losers'. Looking at the results, direct cash transfer may be the most feasible solution by minimizing the number of agents adversely affected by the carbon tax.

As to leakages, implementing a carbon tax unilaterally does not appear to significantly affect other countries. Nevertheless, Malaysia and Singapore are slightly more affected than the others as they are more integrated with Indonesia through trade and investment. However, both countries are affected differently, with a carbon leakage more likely to occur with Malaysia, although these changes are relatively very small.

Appendices 6.6 and 6.7 show the results when technological changes are introduced in the form of efficiency gain in terms of coal and petroleum products use by 10 percent and 5 percent respectively. These technological improvements are introduced to compensate for the lack of endogenous intermediate input substitution in the model. As such, these technological changes are introduced exogenously. In reality, these technological improvements can be seen as an industrial response (e.g. improving maintenance or better management) to the implementation of a carbon tax in which industries now have an incentive to reduce their use of coal and petroleum products while maintaining the same amount of output, i.e. efficiency gain. As such, both substitution and efficiency are reflected in the results.

The results in the appendices show that improvements in the use of coal and petroleum products will have positive effects to the economy. The GDP contraction in all countries due to the implementation of the carbon tax decreases. In cases where GDP actually increases,

improvements in energy use further expand the economy as well. Although in the case of coal use efficiency, Singapore is almost unaffected. This is logical as Singapore uses relatively very small amount of coal in the first place. Two other important highlights to note are: first, a 5 percent efficiency gain in the use of petroleum products creates a larger positive effect on the economy than a 10 percent efficiency gain in the use of coal; and second, a 5 percent efficiency gain in the use of petroleum products creates a much larger positive effect to the environment as well.

Following those observations, a more efficient use of petroleum products may encourage households and industries to switch from the 'dirtier' coal to petroleum products. Aside from the economic gain, this also improves the gain in terms of CO_2 emissions reduction. Lastly, although energy efficiency has the possibility of creating a rebound effect, the phenomena is unlikely to occur in the region. It appears that a carbon tax at USD 10 per ton of CO_2 emissions is more than sufficient to prevent this phenomenon from occurring.

6.4.2. Sectoral Results

In order to understand why and how changes occur when a carbon tax is implemented, particularly for a welfare analysis, a more detailed look must be conducted at the sectoral level. Table 6.2 shows selected sectoral prices. It is important to note that Table 6.4 also implicitly shows price changes as the original prices are set at 1. This implies, for example, that a coal price of 1.29 in Indonesia means that the price of coal has increased by 29 percent in Indonesia after a carbon tax of USD 10 per ton of CO_2 has been implemented in the form of sales tax to industries and households.

Table 6.2 shows that the once a carbon tax is implemented, the price of coal, petroleum products, and manufactured gas immediately increases. The price of coal increases the most followed by petroleum products and manufactured gas, as coal is the 'dirtiest' in terms of CO_2 content compared to the others. Changes in these commodity prices have a secondary effect, with the electricity and transportation sectors affected the most as these two sectors are the largest energy users. The logic is quite straightforward for the first two recycling mechanisms. However, the explanation is not quite as straightforward when looking at the third recycling mechanism.

When the third recycling mechanism is implemented, other changes occur simultaneously that affect prices. Indirect tax reductions directly affect production activities such that prices change differently compared to the other two recycling mechanisms. As indirect taxes differ greatly between countries, e.g. existence of fuel subsidies in Indonesia and Malaysia, the third recycling mechanism affects the same sectors differently across countries.

Table 6.2. Selected Sectoral Prices and Exchange Rates*

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Government						
Coal	1.29	1.24	1.25	1.30	1.24	1.22
Petroleum Products	1.10	1.11	1.13	1.07	1.08	1.15
Manufactured Gas	1.01	1.02	1.01	1.03	1.02	1.01
Electricity	1.03	1.03	1.03	1.02	1.02	1.01
Transportation	1.02	1.02	1.01	1.00	1.01	1.06
Exchange Rate	0.99	1.00	1.00	1.00	1.00	1.00
Household						
Coal	1.29	1.24	1.25	1.30	1.25	1.22
Petroleum Products	1.10	1.12	1.13	1.07	1.08	1.15
Manufactured Gas	1.01	1.02	1.01	1.03	1.01	1.01
Electricity	1.03	1.03	1.03	1.02	1.02	1.00
Transportation	1.02	1.02	1.01	1.00	1.01	1.06
Exchange Rate	0.99	1.00	1.00	1.00	1.00	1.00
Industry						
Coal	1.34	1.22	1.12	1.27	1.14	1.78
Petroleum Products	1.04	0.98	0.87	0.97	0.89	1.56
Manufactured Gas	1.06	1.00	0.87	0.99	0.91	1.55
Electricity	1.08	1.01	0.89	0.98	0.91	1.54
Transportation	1.06	1.00	0.88	0.97	0.91	1.62
Exchange Rate	1.04	0.98	0.87	0.97	0.89	1.56

* - Symmetric Carbon Tax at USD 10 per ton of CO_2 Emissions with No Efficiency Gain

Furthermore, aside from the forces exerted by indirect tax and subsidy changes, as well as implementation of a carbon sales tax, the exchange rate also changes. This change is most prominent in Vietnam where the country's currency depreciates greatly. Admittedly, this might be a technical limitation of the model. Nevertheless, the overall conclusion of the impact of a carbon sales tax does not change. Prices of coal, petroleum products, and manufactured gas are affected first and foremost, followed by price changes in the electricity and transportation sectors.

Following the changes in commodity prices, production activities in turn change as well. Figure 6.6 shows the real sectoral value-added changes in percentages for Scenario 1. Note that this figure does not show real output changes because it is more important at this stage to look at the industrial changes while avoiding any changes that arise from the export and import of

commodities. The distinction is important as households will be more affected by value-added changes, than output changes. Also, the changes are in percentages. Lastly, from top to bottom, the first ten sectors are categorized as services, followed by 12 sectors categorized as manufacturing and 4 sectors categorized as agriculture.

Figure 6.6 shows that the manufacturing sectors undergo a general contraction. Meanwhile, the agricultural sectors are not affected as much, whereas service sectors generally contract, with the exception of government-related sector. These imply that households that rely on income from the manufacturing sector are likely to suffer the most from an income reduction, and this in turn reduces their ability to consume. Meanwhile, those in the agricultural sector will most likely be unaffected income-wise, although price changes may still affect their consumption level. Those who are most likely to gain are households in the service sector, particularly government-related sectors such as defense, health, and education.

Bear in mind that it is not possible to see the overall impact on households in Figure 6.4 as it only shows the income side. To look at the overall impact on households, the direct impact of price changes on households must also be taken into account. Also, this figure assumes that government does not share the carbon tax revenue with either industries or households. Nevertheless, Figure 6.4 illustrates another important way that a carbon tax affects households aside from commodity price changes. The net impact on households, and by extension welfare effect, has actually been shown in Table 6.1.

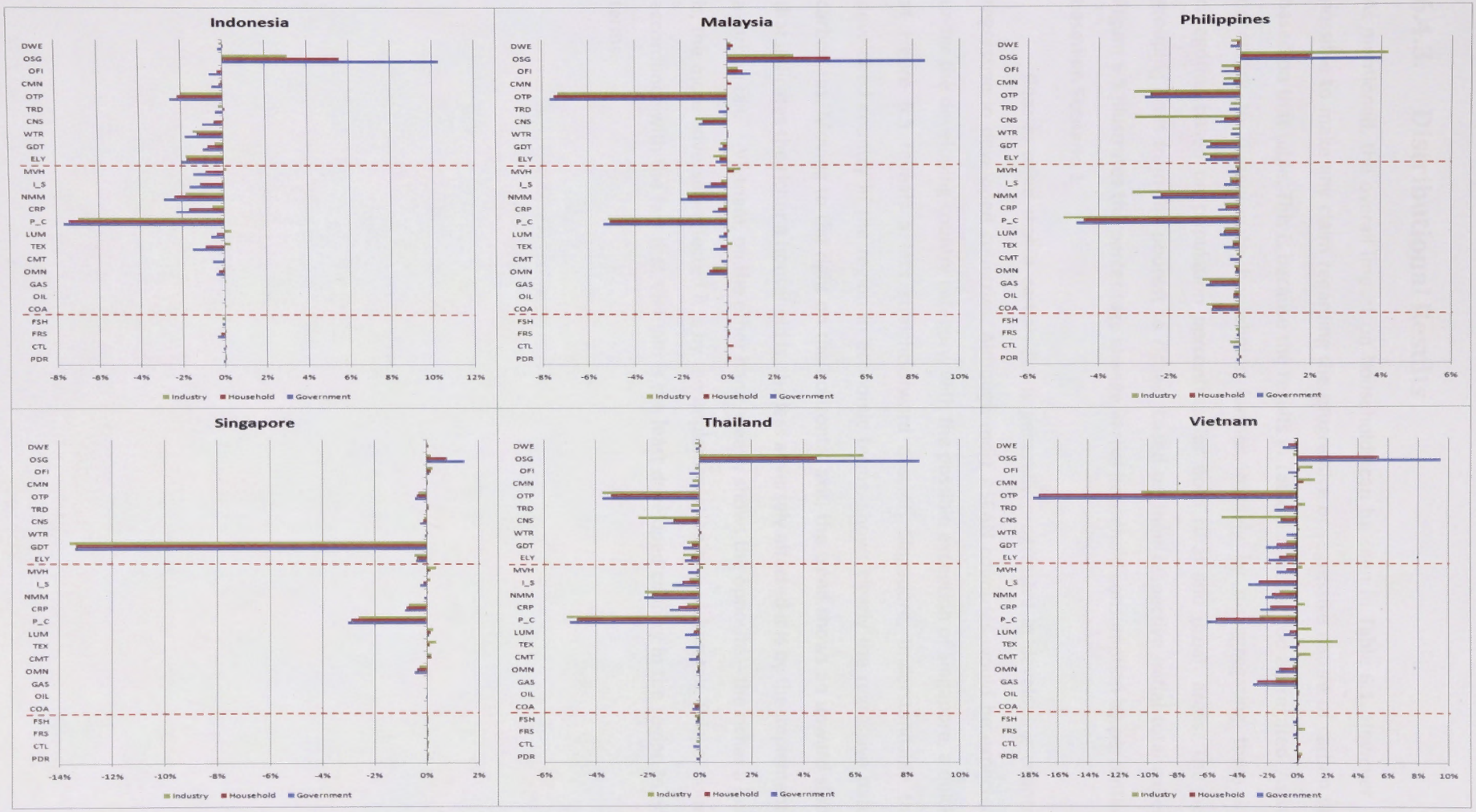


Figure 6.4. Real Sectoral Value-Added Changes in Percentages

6.4.3. Distributional Results

As mentioned, the overall impact on households can be seen in Table 6.1. However, it is not possible to make any claim regarding the progressive or regressive nature of carbon tax solely based on that table. This is because the results in Table 6.1 are far too aggregated. As such, it is necessary to disaggregate households further, namely by disaggregating them into 100 categories based on population percentiles for both rural and urban areas. The percentile grouping goes from the poorest to richest based on their respective initial total expenditure. Figure 6.5 illustrates the percentage change in real household consumption by percentile group, based on Scenario 1.

Bear in mind that a carbon tax is generally progressive in developing countries and regressive in developed countries. Although most ASEAN countries would be expected to fall under the developing country category, with the possible exception of Singapore, a quick glance at Figure 6.5 reveals a less straightforward answer. Singapore, understandably the most developed country in the region in economic terms, shows clearly the regressive nature of a carbon tax. Moving to the right on the horizontal axis, the trend shows an upward sloping line that indicates the richer a household is, the less adversely affected it is by the implementation of a carbon tax. Vietnam, on the other hand, clearly shows the opposite – the richer a household is, the more adversely affected it is by the implementation of a carbon tax. This, of course, is in accordance with the fact that Vietnam is the least developed country in the region in economic terms.

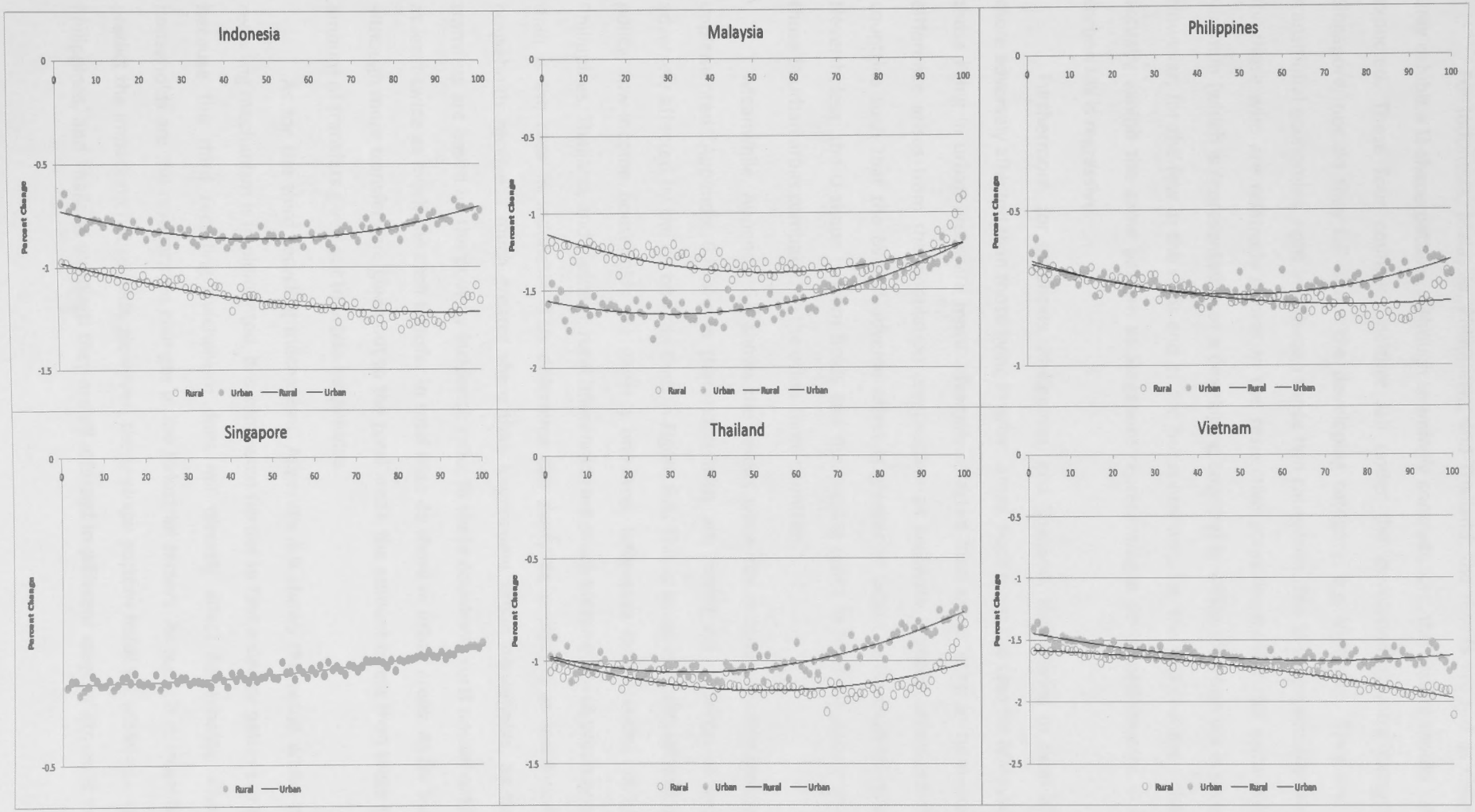


Figure 6.5. Real Household Expenditure Changes in Percentages

For Indonesia, Malaysia, Philippines, and Thailand, the results are not as clear in that they exhibit a U-shape pattern. Although seemingly contradictory, the results should have been expected. These four countries neither fall under the developed country category, e.g. Singapore, nor do they fall under the developing category, e.g. Vietnam. They are actually transitional economies, right in between those two categories. The U-shape actually shows that for those who are relatively poorer in the respective countries exhibit the same pattern as Vietnam (which is representative of a developing country) in which a carbon tax is progressive. However, for the few in the right end of the horizontal axis, i.e. the rich and the richest, they actually exhibit the same pattern as Singapore representing a developed country in which a carbon tax is regressive.

Furthermore, for Indonesia, Philippines, and Thailand, those living in rural areas are more adversely affected than those living in urban areas. Such is not the case for Malaysia where those living in urban areas are more adversely affected than those living in rural areas. This difference arises from the population composition as Malaysia is more urbanized than the countries such that the overall adverse effect is greater in urban areas than in rural areas. Nevertheless, the U-shape pattern holds and the turning point in Malaysia occurs sooner for those in urban areas compared to the other three countries.

Meanwhile, Appendix 6.8 shows the results when the second recycling mechanism is implemented. Appendix 6.8 shows that households are better off in terms of being less adversely affected by the carbon tax than in Figure 6.5. This is because in the second recycling policy, low-income households are given a one-time, lump-sum cash transfer. In Malaysia, Philippines, Thailand, and Vietnam, rural households are much better off than urban households than is the case in Indonesia. This difference can easily be explained as low-income rural households receive a much greater share than low-income urban households, as the share transfers are based on the poverty incidence ratio. In these countries, rural households receive at least twice as much the cash transfer in total than do those in urban areas. As for Indonesia, although more transfers are given out to the rural areas, the amount is less than twice the total amount of transfers given out to urban households.

As for the third recycling mechanism, Appendix 6.9 shows the result when the third recycling mechanism is implemented. It is somewhat harder to find a similar pattern in this case because the third recycling mechanism does not directly affect households. Changes to households are the resultant on changes in the industrial sectors. As such, it is much harder to predict the impact on households. However, the U-shape pattern holds for Indonesia, Malaysia, Philippines, and Thailand although they are all affected in different ways. Vietnam is beginning

to show the same U-shape pattern, while Singapore exhibits the same pattern as in the first recycling mechanism.

6.5. Concluding Remarks

The main goal of this chapter is to understand what are the impact of coordinated and non-coordinated carbon tax policies on the economy and environmental performance of each country within ASEAN. This question is a relevant one, since, first, though it has been slow, the establishment of an ASEAN community will most likely be happening soon, and the synchronization of various policies will be required; and second, some of ASEAN member countries are among the top polluters of CO_2 emissions and indeed so much so that they have to react immediately to control their emissions.

In order to answer the above question, a multi-country CGE model for ASEAN, known as the IRSA-ASEAN, has been constructed. An ASEAN-SAM has also been constructed previously as the main dataset for the CGE. This ASEAN-SAM is one of the first comprehensive data systems available for ASEAN, and hence the IRSA-ASEAN becomes one of the more comprehensive economic models for the region. Through the IRSA-ASEAN, several conclusions can be drawn with regard to the implementation of a carbon tax in ASEAN. First, in general, a carbon tax is an effective way of reducing carbon emissions. For most ASEAN countries, even if the revenues from this tax are recycled back to the economy, it does not seem to induce a rebound effect, i.e. more use of energy and so more emissions.

Second, it is not obvious that ASEAN countries could always expect a double-dividend phenomenon to happen when they implement a combination of carbon tax and recycling policy. It is quite likely that implementing a carbon tax will contract the economies of these countries. Recycling the carbon tax revenue, though it is of utmost importance in terms of softening the impact of this policy with regard to development and equity, does not always induce a double dividend phenomenon. Some of the main reasons for this are as follows. Current effective tax rates for these countries have been relatively low. And so, there is much room to reduce other taxes to compensate the effects of a carbon tax policy.

Third, as each country responds differently to the implementation of a carbon tax, particularly with regard to the revenue re-distribution, an across-the-board implementation will create 'winners' and 'losers'. Indonesia and Malaysia are the potential 'winners' as at the moment they are subsidizing their respective energy sectors such that a carbon tax actually acts as a compensating mechanism that will promote efficiency and a less distortionary tax system, or in this case one arising from energy sector subsidy. Vietnam is the likely 'loser' as the implementation of a carbon tax creates an additional distortionary tax with the only possible

gain being in terms of environmental improvement, which comes with a great cost in terms of relatively large economic reduction. Philippines, Singapore, and Thailand can still gain depending on what the respective governments do with the revenue. Although an economic reduction is unavoidable, the cost is not so great, and also comes with great benefit in terms environmental improvement and social equity.

Fourth, in terms of distributional impact, a carbon tax is strictly progressive in Vietnam and strictly regressive in Singapore. For Indonesia, Malaysia, Philippines, and Thailand a carbon tax is progressive for those in up to 70-90 percentile income group (depending on the country and areas) and regressive for those in the right-end tail, or higher, income group.

Fifth, efficiency gain in terms of energy use as a response from the industrial sector could also alleviate the adverse effects of the additional tax. Finally, Indonesia, as the highest CO_2 emitter among ASEAN members, is required to respond rapidly; however, whether other countries in the region implement a carbon tax or not, this does not change the outcomes for Indonesia by much. And so, waiting for such regional cooperation to happen is unnecessary and domestic considerations should be put first and foremost.

Overall, the implementation of a carbon tax is an effective mechanism to reduce CO_2 emissions. However, for countries such as Philippines, Singapore, Thailand, and Vietnam, this gain in the environment comes at a price in terms of economic contraction. While, the cost may be significant for Vietnam, it is not so great (as is the case for Philippines, Singapore, and Thailand) such that the implementation of a carbon tax might still be an option. For Indonesia and Malaysia, the implementation of a carbon tax yields a similar result as an energy subsidy reduction. Not only do they gain in terms of environmental improvement, they also gain in terms of economic expansion. As such, implementing a carbon tax could be a feasible policy in the region although the distributional impact in terms of sectoral losses and adverse effect to certain segments of society must be taken into consideration, complicated as they might be.

```
* run using this option: r=save\simco2 s=save\expenditure

set
hx       Household group
/
rural
urban
/

alias (hx, hhx)

parameter
 YHCAP(hx,d)              Income percapita in 2005 Rp
 POP(hx,d)                Population
;

table POP(hx,d)
            IDN         MYS         PHL         SGP         THA         VNM
rural  114974649    8438257    32003793           0    44350318    60719864
urban  101468591   16735541    51907568     4166700    20928337    21311836
;

 YHCAP('rural',d)$POP('rural',d) = [(YH0('HHRULOW',d)+YH0('HHRUHIGH',d))
                                  *(10**6)]/POP('rural',d);
 YHCAP('urban',d)$POP('urban',d) = [(YH0('HHURLOW',d)+YH0('HHURHIGH',d))
                                  *(10**6)]/POP('urban',d);

display YHCAP;

set p    / p1*p100 /; alias(p,pp);

parameter
 EHP0(hx,p,d)             Household total expenditure by percentile
 XHOU_SP0(c,hx,p,d)       Household cons. by percentile
 bdgshp(c,hx,p,d)         Budget share by percentile
;

* Get this from household survey data
parameter
 XHOU_SP0_RIDN(p,c)
 XHOU_SP0_UIDN(p,c)
 XHOU_SP0_RMYS(p,c)
 XHOU_SP0_UMYS(p,c)
 XHOU_SP0_RPHL(p,c)
 XHOU_SP0_UPHL(p,c)
 XHOU_SP0_RSGP(p,c)
 XHOU_SP0_USGP(p,c)
 XHOU_SP0_RTHA(p,c)
 XHOU_SP0_UTHA(p,c)
 XHOU_SP0_RVNM(p,c)
 XHOU_SP0_UVNM(p,c)
;

$libinclude xlimport XHOU_SP0_RIDN ruralexpenditure.XLS IDN!A1:AB101
$libinclude xlimport XHOU_SP0_UIDN urbanexpenditure.XLS IDN!A1:AB101
$libinclude xlimport XHOU_SP0_RMYS ruralexpenditure.XLS MYS!A1:AB101
$libinclude xlimport XHOU_SP0_UMYS urbanexpenditure.XLS MYS!A1:AB101
$libinclude xlimport XHOU_SP0_RPHL ruralexpenditure.XLS PHL!A1:AB101
$libinclude xlimport XHOU_SP0_UPHL urbanexpenditure.XLS PHL!A1:AB101
$libinclude xlimport XHOU_SP0_RSGP ruralexpenditure.XLS SGP!A1:AB101
$libinclude xlimport XHOU_SP0_USGP urbanexpenditure.XLS SGP!A1:AB101
$libinclude xlimport XHOU_SP0_RTHA ruralexpenditure.XLS THA!A1:AB101
$libinclude xlimport XHOU_SP0_UTHA urbanexpenditure.XLS THA!A1:AB101
$libinclude xlimport XHOU_SP0_RVNM ruralexpenditure.XLS VNM!A1:AB101
$libinclude xlimport XHOU_SP0_UVNM urbanexpenditure.XLS VNM!A1:AB101

 XHOU_SP0(c,'rural',p,'IDN') = XHOU_SP0_RIDN(p,c);
 XHOU_SP0(c,'urban',p,'IDN') = XHOU_SP0_UIDN(p,c);
 XHOU_SP0(c,'rural',p,'MYS') = XHOU_SP0_RMYS(p,c);
 XHOU_SP0(c,'urban',p,'MYS') = XHOU_SP0_UMYS(p,c);
 XHOU_SP0(c,'rural',p,'PHL') = XHOU_SP0_RPHL(p,c);
 XHOU_SP0(c,'urban',p,'PHL') = XHOU_SP0_UPHL(p,c);
 XHOU_SP0(c,'rural',p,'SGP') = XHOU_SP0_RSGP(p,c);
 XHOU_SP0(c,'urban',p,'SGP') = XHOU_SP0_USGP(p,c);
 XHOU_SP0(c,'rural',p,'THA') = XHOU_SP0_RTHA(p,c);
 XHOU_SP0(c,'urban',p,'THA') = XHOU_SP0_UTHA(p,c);
```

```
 XHOU_SP0(c,'rural',p,'VNM') = XHOU_SP0_RVNM(p,c);
 XHOU_SP0(c,'urban',p,'VNM') = XHOU_SP0_UVNM(p,c);

 EHP0(hx,p,d) = SUM(c,XHOU_SP0(c,hx,p,d));
 bdgshp(c,hx,p,d)$EHP0(hx,p,d) = XHOU_SP0(c,hx,p,d)/EHP0(hx,p,d);

parameter
 XHOU_S0CK(c,hx,d)
 sumbdgshp(hx,p,d);

 XHOU_S0CK(c,'rural',d)$(XHOU_S0(c,'HHRULOW',d)+XHOU_S0(c,'HHRUHIGH',d))
                  = SUM(pp,XHOU_SP0(c,'rural',pp,d))
                  /(XHOU_S0(c,'HHRULOW',d)+XHOU_S0(c,'HHRUHIGH',d));

 XHOU_S0CK(c,'urban',d)$(XHOU_S0(c,'HHURLOW',d)+XHOU_S0(c,'HHURHIGH',d))
                  = SUM(pp,XHOU_SP0(c,'urban',pp,d))
                  /(XHOU_S0(c,'HHURLOW',d)+XHOU_S0(c,'HHURHIGH',d));

 sumbdgshp(hx,p,d) = SUM(c,bdgshp(c,hx,p,d));

display XHOU_S0, EHP0, sumbdgshp, XHOU_S0CK;

parameter
 apc(hx,d)        propensity to consume
 apcp(hx,p,d)     propensity to consume percentile
 YHP0(hx,p,d)     Income percentile
 POPP(hx,p,d)     Population by percentile
;

 POPP(hx,p,d) = POP(hx,d)/100;

 parameter CHECKPOP(d);
 CHECKPOP(d) = SUM((hx,p),POPP(hx,p,d));

 display CHECKPOP;

 apc('rural',d)$(YH0('HHRULOW',d)+YH0('HHRUHIGH',d))
               = (EH0('HHRULOW',d)+EH0('HHRUHIGH',d))
               /(YH0('HHRULOW',d)+YH0('HHRUHIGH',d));
 apc('urban',d)$(YH0('HHURLOW',d)+YH0('HHURHIGH',d))
               = (EH0('HHURLOW',d)+EH0('HHURHIGH',d))
               /(YH0('HHURLOW',d)+YH0('HHURHIGH',d));

 display apc;

 apcp(hx,p,d) = apc(hx,d);
 YHP0(hx,p,d)$apcp(hx,p,d) = EHP0(hx,p,d)/apcp(hx,p,d);

 display apcp, YHP0;

parameter
 YHCAPP(hx,p,d)   Percapita income by centile
;

 YHCAPP(hx,p,d)$POPP(hx,p,d) = [YHP0(hx,p,d)*(10**6)]/POPP(hx,p,d);

parameter
  EHP(hx,p,d)          Household exps. by percentile
  SHP(c,hx,p,d)          Share of household exps. by percentile (constant)
  RCON(hx,p,d)         Real household consumption
  RCON0(hx,p,d)
;

alias (p,pp);

 SHP(c,'rural',p,d)$XHOU_SP0(c,'rural',p,d) = XHOU_SP0(c,'rural',p,d)
                  /(XHOU_S0(c,'HHRULOW',d)+XHOU_S0(c,'HHRUHIGH',d));
 SHP(c,'urban',p,d)$XHOU_SP0(c,'urban',p,d) = XHOU_SP0(c,'urban',p,d)
                  /(XHOU_S0(c,'HHURLOW',d)+XHOU_S0(c,'HHURHIGH',d));

 RCON('rural',p,d) = SUM(c,SHP(c,'rural',p,d)
                  *(XHOU_S.L(c,'HHRULOW',d)+XHOU_S.L(c,'HHRUHIGH',d)));
 RCON('urban',p,d) = SUM(c,SHP(c,'urban',p,d)
                  *(XHOU_S.L(c,'HHURLOW',d)+XHOU_S.L(c,'HHURHIGH',d)));
 RCON0('rural',p,d) = SUM(c,SHP(c,'rural',p,d)
                  *(XHOU_S0(c,'HHRULOW',d)+XHOU_S0(c,'HHRUHIGH',d)));
 RCON0('urban',p,d) = SUM(c,SHP(c,'urban',p,d)
                  *(XHOU_S0(c,'HHURLOW',d)+XHOU_S0(c,'HHURHIGH',d)));

parameter
```

```
 RCONCAP(hx,p,d)  Real consumption per capita
 RCONCAP0(hx,p,d)  Real consumption per capita
;

 RCONCAP(hx,p,d)$RCON(hx,p,d) = (RCON(hx,p,d)*10**6)/POPP(hx,p,d);
 RCONCAP0(hx,p,d)$RCON(hx,p,d) = (RCON0(hx,p,d)*10**6)/POPP(hx,p,d);

display SHP, RCON, RCONCAP;

parameter
 RCONRURAL(p,d)
 RCONURBAN(p,d)
 RCONRURAL0(p,d)
 RCONURBAN0(p,d)
 RCONCAPRURAL(p,d)
 RCONCAPURBAN(p,d)
 RCONCAPRURAL0(p,d)
 RCONCAPURBAN0(p,d)
 LOGRCONCAPRURAL(p,d)
 LOGRCONCAPURBAN(p,d)
 dRCONCAPRURAL(p,d)
 dRCONCAPURBAN(p,d)
 RCONCHECK(d)
;

 RCONRURAL(p,d) = RCON('rural',p,d);
 RCONURBAN(p,d) = RCON('urban',p,d);
 RCONCAPRURAL(p,d) = RCONCAP('rural',p,d);
 RCONCAPURBAN(p,d) = RCONCAP('urban',p,d);
 RCONRURAL0(p,d) = RCON0('rural',p,d);
 RCONURBAN0(p,d) = RCON0('urban',p,d);
 RCONCAPRURAL0(p,d) = RCONCAP0('rural',p,d);
 RCONCAPURBAN0(p,d) = RCONCAP0('urban',p,d);
 LOGRCONCAPRURAL(p,d)$RCONCAP('rural',p,d) = LOG10(RCONCAP('rural',p,d));
 LOGRCONCAPURBAN(p,d)$RCONCAP('urban',p,d) = LOG10(RCONCAP('urban',p,d));

 dRCONCAPRURAL(p,d)$RCONCAPRURAL0(p,d) = (RCONCAPRURAL(p,d)-RCONCAPRURAL0(p,d))
                                         /RCONCAPRURAL0(p,d)*100;
 dRCONCAPURBAN(p,d)$RCONCAPURBAN0(p,d) = (RCONCAPURBAN(p,d)-RCONCAPURBAN0(p,d))
                                         /RCONCAPURBAN0(p,d)*100;

 RCONCHECK(d) = SUM((hx,p),RCON(hx,p,d))/SUM((c,h),XHOU_S.L(c,h,d));

display RCONCHECK;

$libinclude xldump RCONRURAL outputhhexpend.xls RCONRURAL
$libinclude xldump RCONURBAN outputhhexpend.xls RCONURBAN
$libinclude xldump RCONCAPRURAL outputhhexpend.xls RCONCAPRURAL
$libinclude xldump RCONCAPURBAN outputhhexpend.xls RCONCAPURBAN
$libinclude xldump LOGRCONCAPRURAL outputhhexpend.xls LOGRCONCAPRURAL
$libinclude xldump LOGRCONCAPURBAN outputhhexpend.xls LOGRCONCAPURBAN
$libinclude xldump RCONCAPRURAL0 outputhhexpend.xls RCONCAPRURAL0
$libinclude xldump RCONCAPURBAN0 outputhhexpend.xls RCONCAPURBAN0
$libinclude xldump dRCONCAPRURAL outputhhexpend.xls dRCONCAPRURAL
$libinclude xldump dRCONCAPURBAN outputhhexpend.xls dRCONCAPURBAN

parameter
chkhou_s1(d)
chkhou_s2(d)
chkhou_s3(hx,d)
chkhou_s10(d)
chkhou_s20(d)
chkhou_s30(hx,d)
dchkhou_s1(d)
dchkhou_s2(d)
dchkhou_s3(hx,d)
drconrural(p,d)
drconurban(p,d)
chkrural(p,d)
chkurban(p,d)
;

chkhou_s1(d) = sum(p,RCONRURAL(p,d));
chkhou_s2(d) = sum(p,RCONURBAN(p,d));
chkhou_s3('rural',d) = sum(c,XHOU_S.L(c,'HHRULOW',d)+XHOU_S.L(c,'HHRUHIGH',d));
chkhou_s3('urban',d) = sum(c,XHOU_S.L(c,'HHURLOW',d)+XHOU_S.L(c,'HHURHIGH',d));

chkhou_s10(d) = sum(p,RCONRURAL0(p,d));
chkhou_s20(d) = sum(p,RCONURBAN0(p,d));
chkhou_s30('rural',d) = sum(c,XHOU_S0(c,'HHRULOW',d)+XHOU_S0(c,'HHRUHIGH',d));
```

```
chkhou_s30('urban',d) = sum(c,XHOU_S0(c,'HHURLOW',d)+XHOU_S0(c,'HHURHIGH',d));

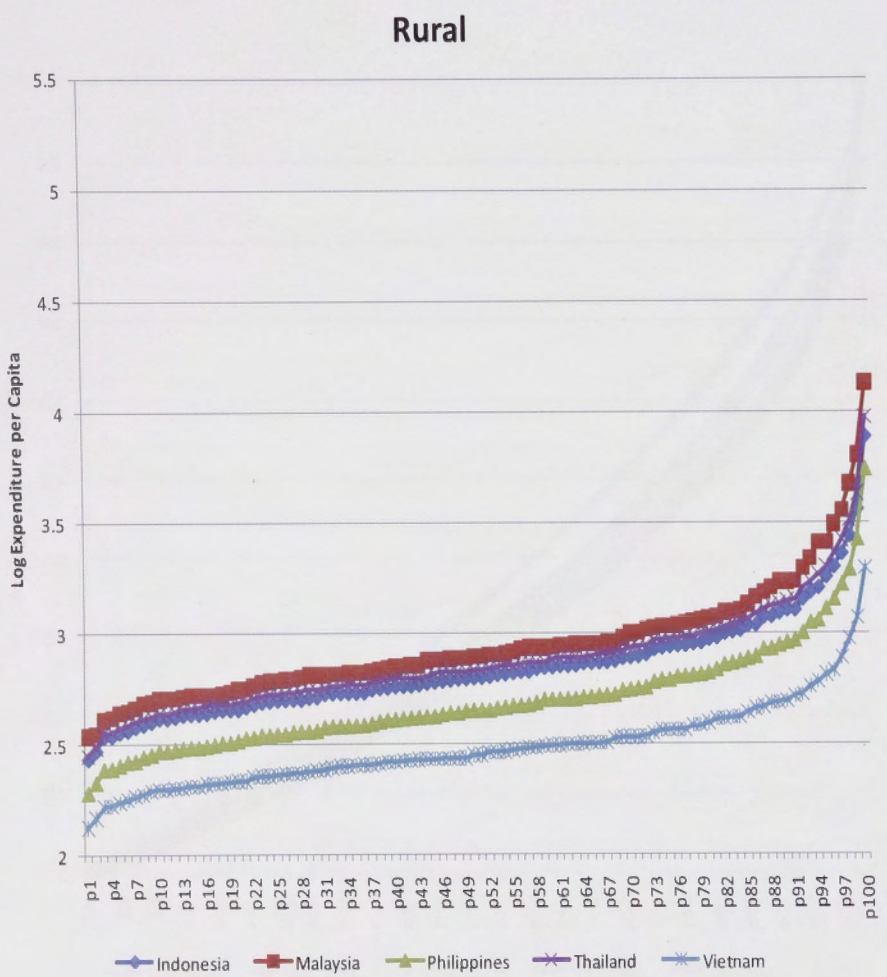
 dRCONRURAL(p,d)$RCONRURAL0(p,d) = (RCONRURAL(p,d)-RCONRURAL0(p,d))
                                   /RCONRURAL0(p,d)*100;
 dRCONURBAN(p,d)$RCONURBAN0(p,d) = (RCONURBAN(p,d)-RCONURBAN0(p,d))
                                   /RCONURBAN0(p,d)*100;

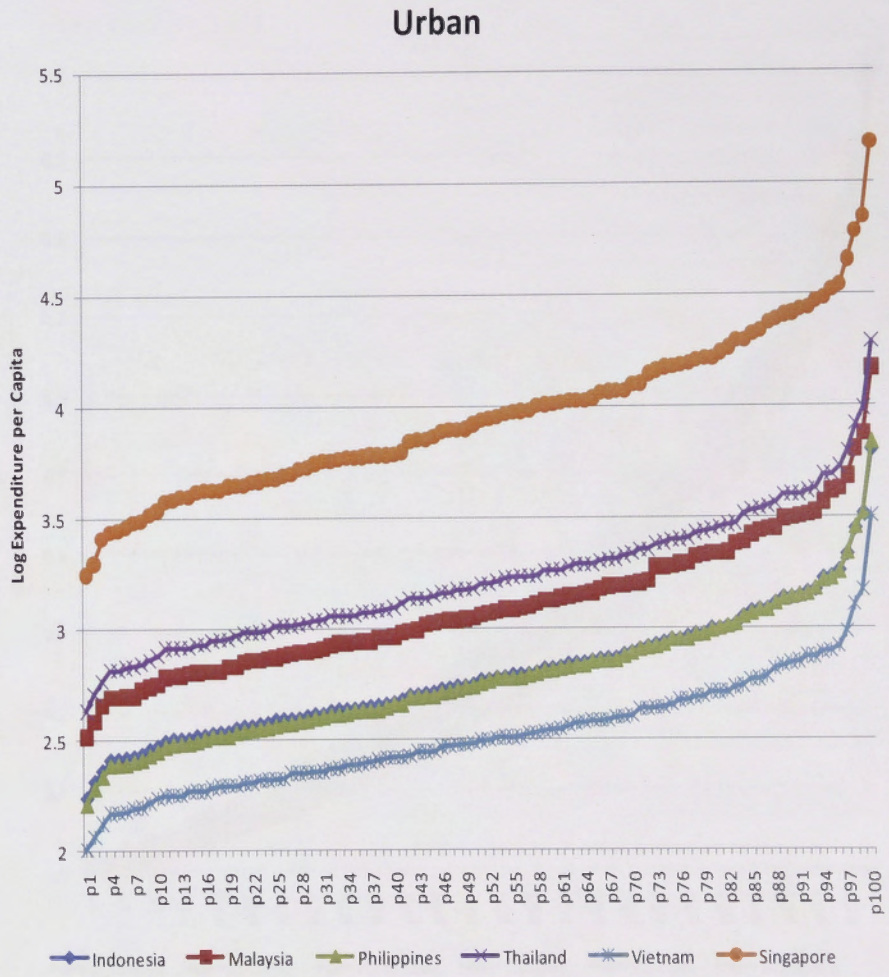
chkrural(p,d)$dRCONCAPRURAL(p,d) = dRCONRURAL(p,d)/dRCONCAPRURAL(p,d);
chkurban(p,d)$dRCONCAPURBAN(p,d) = dRCONURBAN(p,d)/dRCONCAPURBAN(p,d);

dchkhou_s1(d)$chkhou_s10(d) = (chkhou_s1(d)-chkhou_s10(d))/chkhou_s10(d)*100;
dchkhou_s2(d)$chkhou_s20(d) = (chkhou_s2(d)-chkhou_s20(d))/chkhou_s20(d)*100;
dchkhou_s3('rural',d)$chkhou_s30('rural',d) = (chkhou_s3('rural',d)
                      -chkhou_s30('rural',d))/chkhou_s30('rural',d)*100;
dchkhou_s3('urban',d)$chkhou_s30('urban',d) = (chkhou_s3('urban',d)
                      -chkhou_s30('urban',d))/chkhou_s30('urban',d)*100;

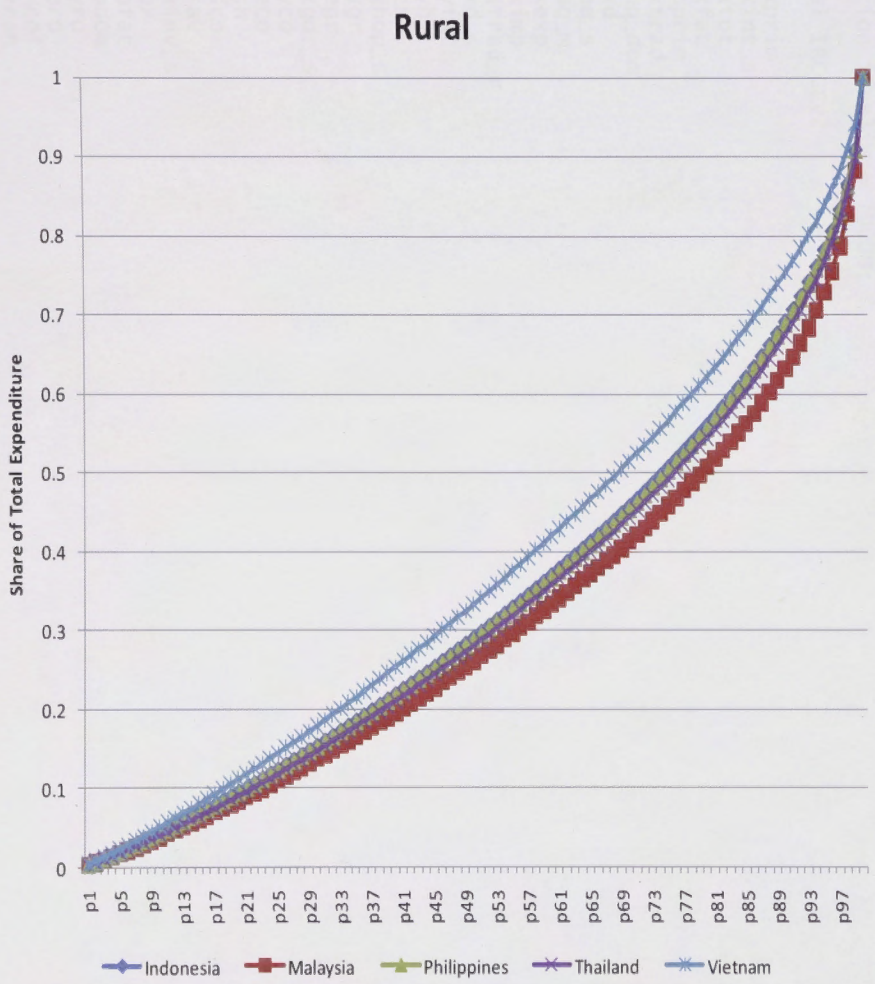
display chkhou_s10, chkhou_s20, chkhou_s30, chkhou_s1, chkhou_s2, chkhou_s3,
        dchkhou_s1, dchkhou_s2, dchkhou_s3, chkrural, chkurban;
```

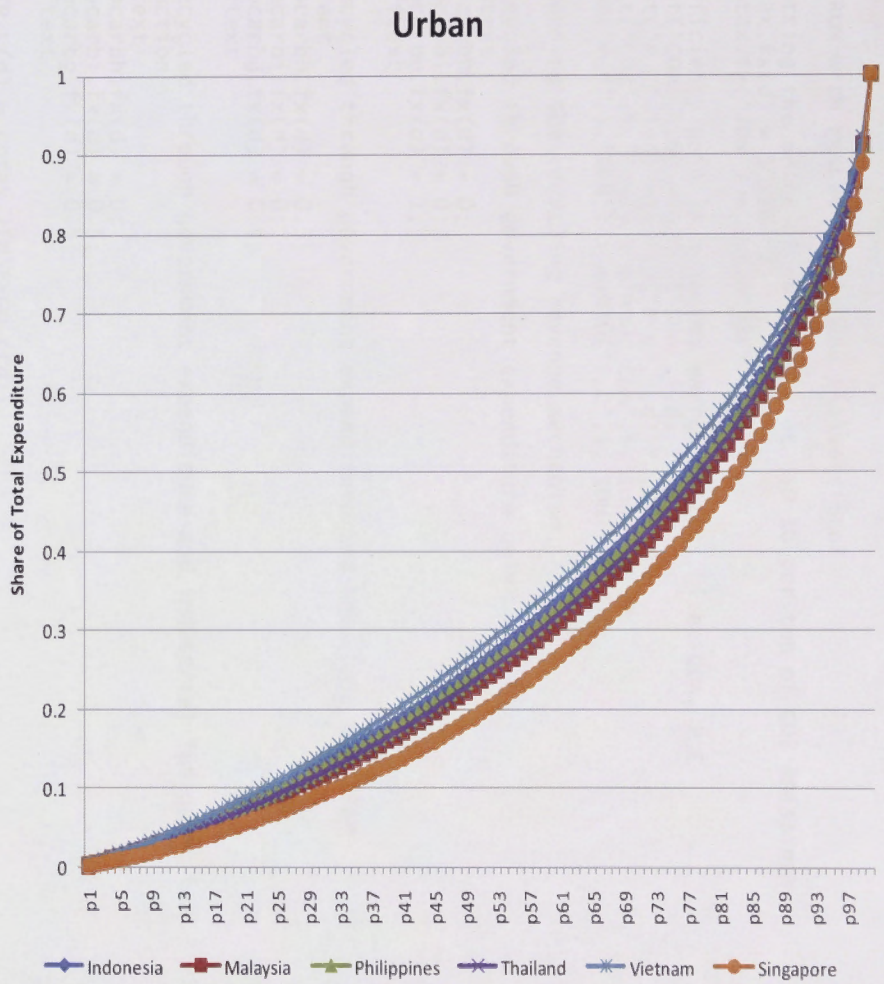
Appendix 6.2. Household Expenditure per Capita





Appendix 6.3. Household Expenditure Distribution





Appendix 6.4. Carbon Tax Implementation GAMS Syntax

```
*** RUN with r=save\modelasean s=save\simco2

* Setting the price of carbon tax at USD 10 per ton of CO2 emissions
 cotax.fx(d) = 10/10**3;
* cotax.fx('IDN') = 10/10**3;

* Efficiency gain in selected energy sectors, i.e. COA, P_C
*aint('COA',i,d) = aint0('COA',i,d) * .9;
*aint('P_C',i,d) = aint0('P_C',i,d) * .95;
*aint('COA',i,'IDN') = aint0('COA',i,'IDN') * .9;
*aint('P_C',i,'IDN') = aint0('P_C',i,'IDN') * .95;

* Choosing the recycling revenue mechanism

* Recycled through government expenditure only
*$ontext
 alpcarbh.fx(d) = 0;
 alpcarbi.fx(d) = 0;
 alpcarbg.fx(d) = 1;
*$offtext

* Recycled through government expenditure and household transfer
$ontext
 alpcarbh.fx(d) = 0.5;
 alpcarbi.fx(d) = 0;
 alpcarbg.fx(d) = 0.5;
$offtext

* Recycled through government expenditure and industrial indidrect tax
reduction
$ontext
 alpcarbh.fx(d) = 0;
 alpcarbi.fx(d) = 0.5;
 alpcarbg.fx(d) = 0.5;
$offtext

 TCTR.L(d) = cotax.l(d)*XCO.L(d);

 option iterlim = 10000;

model IRCGEv2
 /
 e_xprim
 e_xint_s
 e_xtot
 e_xfac
 e_pprim
 e_xtrad
 e_pq_dom
 e_xd
 e_pq_s
 e_pq_m
 e_xexp
 e_ximp
 e_xtrad_r
 e_xd_s
 e_yfac
 e_yh
 e_eh
 e_xhou_s
 e_ygr
 e_egr
 e_xgor_s
 e_yco
 e_eco
 e_sh
 e_sco
 e_sav
 e_xinv_s
 e_px
 e_pfac
 e_pdom
 e_yro
 e_ero
 e_xcoi
 e_xcoh
 e_stx
```

```
 e_tctr
 e_tctrh
 e_tctri
 e_tctrg
 e_tci
 e_sro
 /;

solve IRCGEv2 using MCP;

$include reportasean.gms
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$libinclude xldump repvia outputasean.xls repvia
$libinclude xldump repind outputasean.xls repind
$libinclude xldump repmac outputasean.xls repmac
```

Appendix 6.5. Simulation Results of Scenario 2**

	CO_2	Real GDP	Real Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Government									
Indonesia	-3.66	0.25	-0.14	-0.29	0.73	-1.09	-1.26	-1.19	-0.2
Malaysia	0.01	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	-0.01	-0.01	*	-0.04	0.01		-0.03		-0.03
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	-0.01	-0.01	-0.02	-0.01
Household									
Indonesia	-3.38	0.27	0.01	0.09	0.46	2.14	0.11	-1.32	-0.91
Malaysia	0.01	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	-0.01	-0.01	*	-0.04	*		-0.03		-0.02
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	-0.01	-0.01	-0.01	-0.01
Industry									
Indonesia	-3.49	0.26	-0.04	0.44	0.21	-1.64	-1.72	-1.4	-0.17
Malaysia	0.01	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	*	*
Singapore	-0.01	-0.01	*	-0.03	*		-0.03		-0.02
Thailand	*	*	*	*	*	*	*	*	*
Vietnam	*	*	*	*	*	-0.01	-0.01	-0.01	-0.01

* - Negligible Value

** - Asymmetric Carbon Tax at USD 10 per ton of CO_2 Emissions with No Efficiency Gain

Appendix 6.6. Simulation Results of Scenario 3**

	CO_2	Real GDP	Real Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Government									
Indonesia	-4.51	0.29	-0.11	-0.27	0.79	-1.06	-1.23	-1.14	-0.12
Malaysia	-4.71	0.08	0.05	-0.14	0.51	-1.28	-1.46	-1.06	-1.27
Philippines	-4.14	*	-0.04	-0.4	0.31	-0.71	-0.63	-0.7	-0.65
Singapore	-0.95	-0.01	0.02	-0.35	0.12		-0.32		-0.33
Thailand	-2.99	-0.1	-0.16	-0.68	0.36	-0.82	-0.52	-1.03	-0.93
Vietnam	-7.73	-0.2	0.03	-0.97	0.98	-1.68	-1.66	-1.67	-1.42
Household									
Indonesia	-4.22	0.31	0.05	0.11	0.52	2.19	0.16	-1.27	-0.84
Malaysia	-4.4	0.1	0.2	0.1	0.08	7.17	-0.69	-1.29	-1.48
Philippines	-3.97	0.02	0.09	-0.16	0.14	5.83	0.48	-0.8	-0.82
Singapore	-0.88	-0.01	0.04	-0.26	0.09		0.46		-0.37
Thailand	-2.69	-0.04	0.03	-0.32	0.18	3.75	0.5	-1.21	-1.39
Vietnam	-7.22	-0.1	0.22	-0.51	0.44	2.53	0.39	-1.71	-1.67
Industry									
Indonesia	-4.16	0.3	0.02	0.6	0.17	-1.56	-1.61	-1.3	-0.26
Malaysia	-4.68	0.08	0.04	0.27	-0.27	-2.68	-2.53	-0.71	-0.91
Philippines	-4.49	*	-0.05	-0.25	0.19	-0.94	-0.56	-0.94	-0.53
Singapore	-0.94	-0.01	0.05	-0.1	0.02		-0.51		-0.22
Thailand	-3.1	-0.1	-0.1	-0.32	0.08	-2.49	-1.23	-2.14	-0.64
Vietnam	-5.17	-0.09	0.33	0.37	-1.05	-1.75	-2.46	-1.76	-2.51

* - Negligible Value

** - Symmetric Carbon Tax at USD 10 per ton of CO_2 Emissions with 10% Energy Efficiency in Coal Use

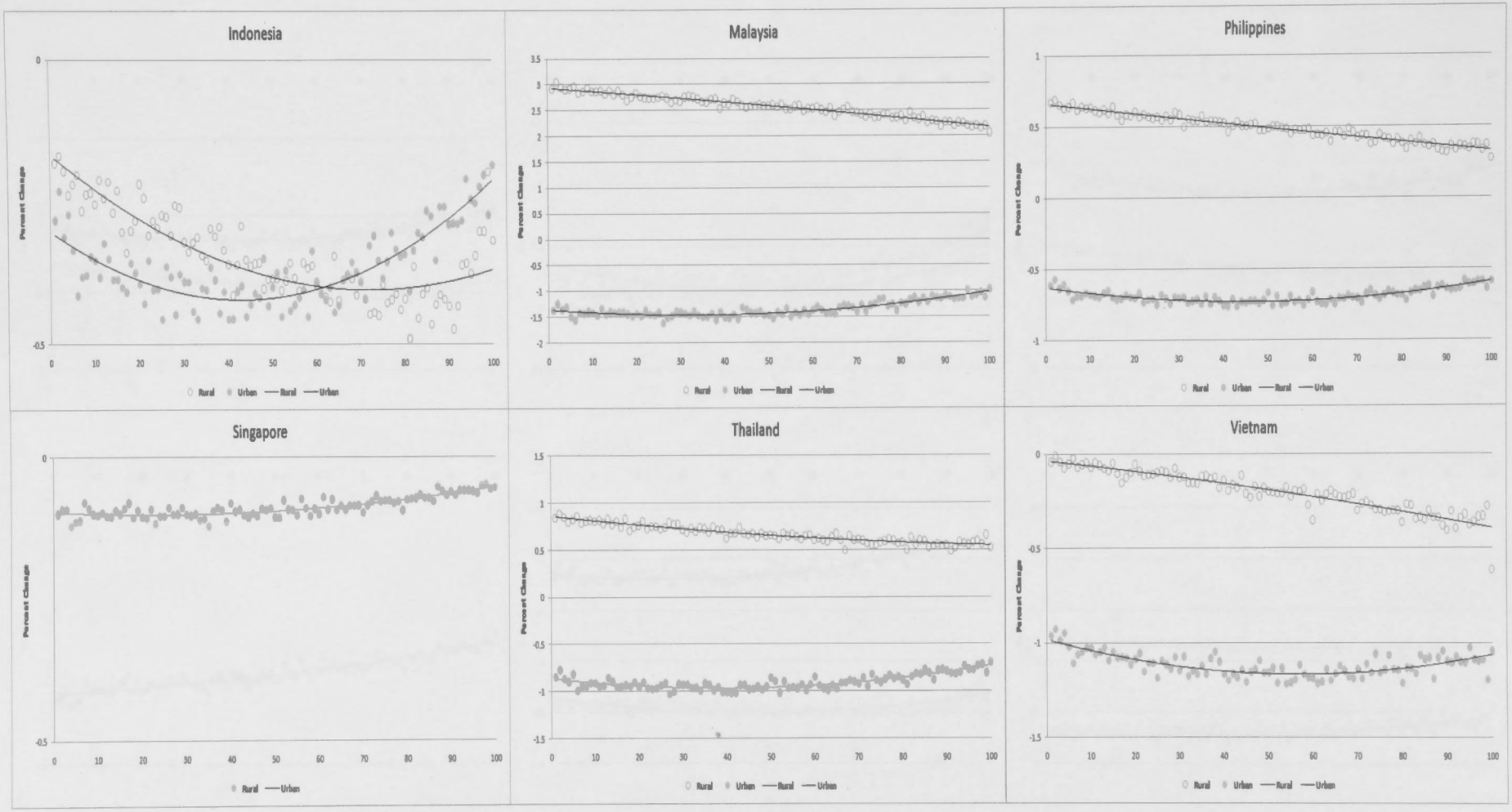
Appendix 6.7. Simulation Results of Scenario 4**

	CO_2	Real GDP	Real Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Government									
Indonesia	-6.36	0.75	0.31	0.03	1.38	-0.44	-0.64	-0.53	0.44
Malaysia	-6.76	0.44	0.36	0.07	1.16	-0.88	-1.04	-0.64	-0.84
Philippines	-5.97	0.19	0.13	-0.33	0.59	-0.56	-0.45	-0.51	-0.43
Singapore	-5.15	0.24	0.24	-0.07	0.36		-0.09		-0.04
Thailand	-5.2	0.59	0.5	-0.18	1.21	-0.33	0.14	-0.35	*
Vietnam	-8.15	0.08	0.28	-0.78	1.42	-1.35	-1.34	-1.34	-1.08
Household									
Indonesia	-6.07	0.77	0.46	0.4	1.11	2.75	0.71	-0.65	-0.26
Malaysia	-6.45	0.46	0.51	0.31	0.74	7.4	-0.28	-0.86	-1.04
Philippines	-5.81	0.21	0.26	-0.09	0.42	5.85	0.64	-0.61	-0.6
Singapore	-5.09	0.24	0.26	0.02	0.33		0.65		-0.08
Thailand	-4.91	0.65	0.68	0.17	1.03	4.14	1.14	-0.53	-0.45
Vietnam	-7.64	0.18	0.48	-0.32	0.88	2.85	0.7	-1.38	-1.33
Industry									
Indonesia	-6.03	0.76	0.43	0.87	0.78	-0.93	-1.02	-0.68	0.31
Malaysia	-6.73	0.44	0.35	0.47	0.4	-2.24	-2.08	-0.29	-0.49
Philippines	-6.31	0.18	0.12	-0.19	0.47	-0.77	-0.37	-0.74	-0.3
Singapore	-5.14	0.24	0.27	0.17	0.27		-0.27		0.06
Thailand	-5.31	0.59	0.56	0.17	0.93	-1.95	-0.55	-1.43	0.28
Vietnam	-5.57	0.2	0.59	0.56	-0.59	-1.42	-2.14	-1.43	-2.18

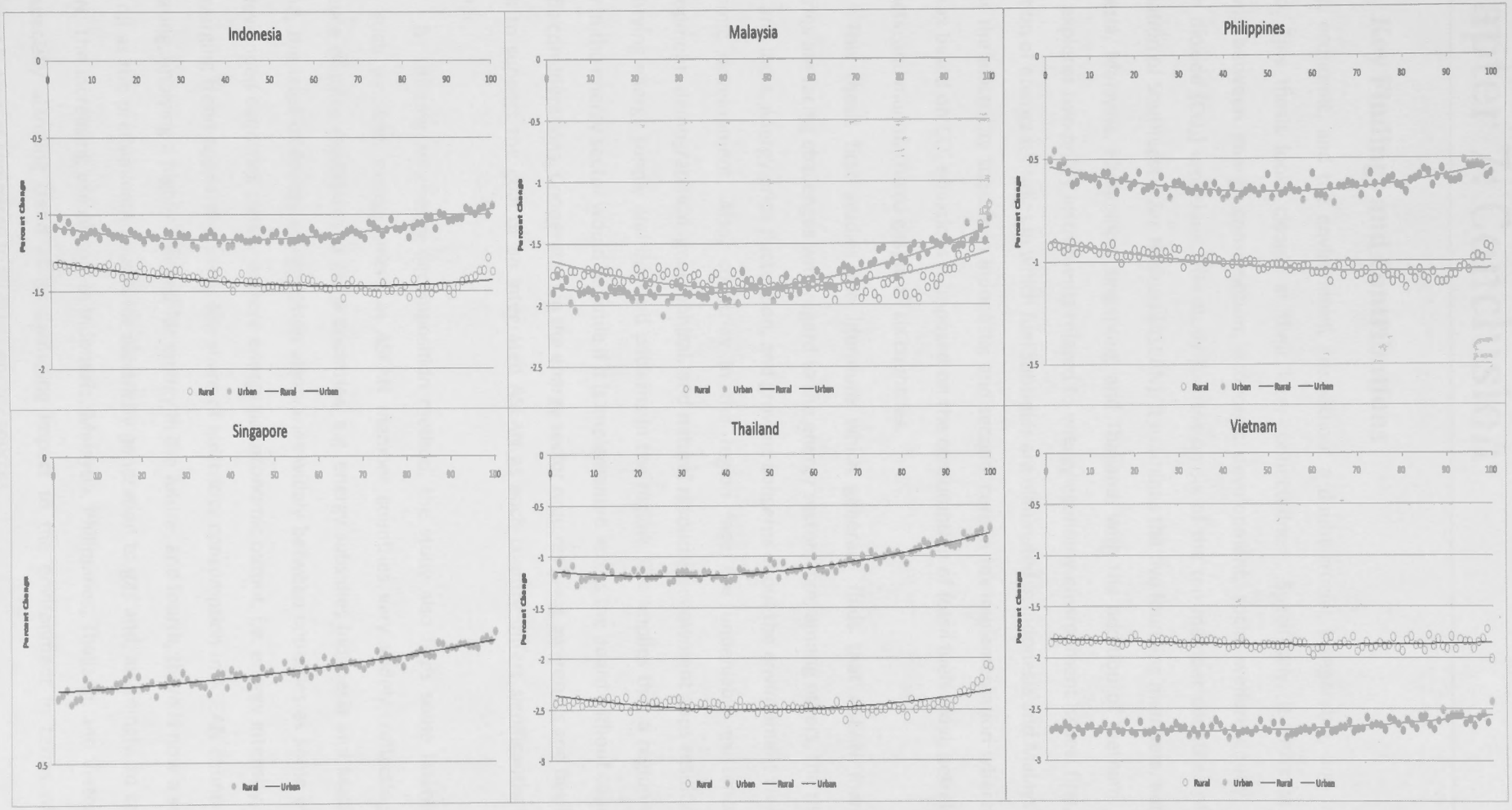
* - Negligible Value

** - Symmetric Carbon Tax at USD 10 per ton of CO_2 Emissions with 5% Energy Efficiency in Oil Use

Appendix 6.8. Real Household Expenditure Changes in Percentages with the Second Recycling Revenue Mechanism



Appendix 6.9. Real Household Expenditure Changes in Percentages with the Third Recycling Revenue Mechanism



Chapter 7: Conclusion

7.1. Key Findings and Contributions

Energy, economic, and the environment are without a doubt crucial, inseparable, and inter-related. This thesis looks closely at their inter-connectedness. Specifically, it looks at the relations between energy consumption, economic development, social welfare/equity, and carbon dioxide (CO_2) emissions. The study focuses on six of the ten member countries of the Association of Southeast Asian Nations (ASEAN). It examines the five founding members, namely Indonesia, Malaysia, Philippines, Singapore, and Thailand, with the addition of Vietnam. The thesis explores two policy instruments related to energy-economy-environment issues: first, the reduction of energy subsidies in which fuel subsidies are eliminated in Indonesia and Malaysia as well as the electricity subsidy in Indonesia; and second, carbon tax implementation whereby a sales tax based on CO_2 emissions is imposed on the consumption of fossil fuels (coal, petroleum products, and manufactured gas) in all six countries.

This thesis first studies the literature which generally finds that ASEAN member countries are facing challenges with regard to the energy sector from, among others, the rise of China and India, energy price fluctuation, and growing concerns about the environment *vis-à-vis* economic development. Also, countries in the region face the undeniable existence of development, demographical, geographical, and natural resource endowment gaps resulting in the varying energy supply and demand patterns in the region. This implies that a region-wide policy in the energy sector would be futile if it is implemented across the board without country-specific considerations. Cooperation in the energy sector requires great awareness and flexibility if it is to support the goal of an integrated ASEAN as each country differs significantly from another.

By utilizing an energy decomposition method, the study also finds some interesting facts, such as: first, energy prices in ASEAN member countries vary widely, reflecting the existence of price distortions in some countries, e.g. energy subsidies Indonesia and Malaysia; second, the level of energy consumption also varies widely between countries as some of the less developed countries consume more energy per economic output, i.e. energy intensity, with a converging trend appearing; third, the share of electricity consumption in ASEAN countries is increasing, implying a higher demand for energy in the future; and fourth, there is now a switch from oil as the predominant source for electricity generation to gas and, alarmingly, to coal in ASEAN. The increasing use of coal in Indonesia, Malaysia, Philippines, Thailand, and Vietnam is an especially alarming trend as its damaging impact to the environment in terms of CO_2 emissions is greater compared to all other energy sources.

In order to do a comprehensive analysis of energy and environmental policies, the thesis constructs a social accounting matrix for ASEAN (ASEAN-SAM) and develops a unique computable general equilibrium (CGE) model called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model. The model examines the relationship between production activities, household welfare, and pollution to capture the energy-economy-environment links. Two major highlights of the IRSA-ASEAN model are: first, it allows the exploration of the immediate impacts of a policy in one country on all other countries in the region; and second, it endogenizes various revenue recycling mechanisms, whether through increased government expenditure, lump sum cash transfer to households, and/or indirect tax reduction to industries. Another highlight of the IRSA-ASEAN model is its ability to be used as an analytical tool for international policy coordination. In other words, it is possible to use the model to understand the impact of coordinated and non-coordinated policies (energy subsidy reduction and carbon tax implementation) and to see how these affect the economy and environmental performance of all other countries in ASEAN.

In the first case study, the model eliminates existing energy subsidies, namely fuel subsidies in Indonesia and Malaysia as well as electricity subsidy in Indonesia. The thesis finds that the elimination of energy subsidies is an effective measure to reduce CO_2 emissions. Even with only a few countries implementing this policy, there appears to be little fear of either a carbon leakage or a rebound effect in those countries. Meanwhile, Indonesia and Malaysia stand to gain much by eliminating energy subsidies. This is because energy subsidies distort the economy and create an inefficient allocation of resources. These countries stand to gain regardless of the actions of other countries, such that only domestic concerns (e.g. distributional effect) should be considered.

As to the recycling method of the revenue, although it is of utmost importance in terms of policy feasibility and acceptability, it does not change the overall economic and environmental impacts by much. This is because the recycling mechanism affects only the distributional aspect of the policy; or in other words, it determines who gains and loses domestically, without affecting the net gain or loss. Welfare-wise, energy subsidy reduction appears to be progressive in nature, such that equity is not an issue. And lastly, efficiency gain as a response from the industrial sector could greatly benefit the country even more in terms of both economic gain and environmental improvement.

In the second case study, the thesis finds that implementing a USD 10 per ton of CO_2 emissions sales tax on coal, petroleum products, and manufactured gas is also an effective measure to improve the environment in terms of emissions reduction. However, this environmental improvement comes at a cost as gross domestic product (GDP) contracts in some countries if a carbon tax is enforced on all. Indonesia and Malaysia are the potential 'winners' as

they subsidize their respective energy sector such that a carbon tax actually acts as a compensating mechanism that will promote efficiency and a less distortionary tax system –in this case, one arising from energy subsidies. Vietnam is the likely 'loser' as the implementation of a carbon tax creates an additional distortionary tax with the only possible gain being an environmental improvement, which comes at a great cost in terms of relatively large economic reduction. Philippines, Singapore, and Thailand can still gain, depending on what each government does with the revenue. Although an economic reduction is unavoidable, the cost is not so great and of which also comes with great benefit in terms of environmental improvement and social equity. Also, whether this policy is enacted uniformly or not, this does not change the results by much, particularly with regard to who are the 'winners' and 'losers'; so much so that in fact Indonesia and Malaysia should really consider this policy as a possibility regardless of what their neighbors do.

Furthermore, another important result arises with regard to the distributional impact. In terms of impact to households, a carbon tax is strictly progressive in Vietnam and strictly regressive in Singapore, which is in line with the current theory that an energy or environmental tax is usually progressive in developing countries and regressive in developed countries. For Indonesia, Malaysia, Philippines, and Thailand, however, the nature of the tax is not as straightforward. It turns out that in these countries, a carbon tax is progressive for those up to the 70-90 percentile income group (depending on the country and areas) and regressive for those in the right-end tail, or higher, income group. This is neither contradictory to the current theory nor to other empirical evidence. In fact, this confirms the understanding that these countries are transitional economies, they are not entirely developing countries but neither are they yet developed.

7.2. Concluding Remarks and Policy Implications

A note of caution is required at this point in which an overarching direct comparison between energy subsidy reduction and a carbon tax implementation should be avoided; it would not be an 'apple to apple' comparison. Even with hindsight, 'forcing' the same amount of CO_2 emissions reduction would not be appropriate either because the amount of CO_2 emissions reduction depends very much on the magnitude of the energy subsidy reduction and the carbon tax implementation. Changing the magnitude would also change GDP and household expenditure. As such, one policy cannot be said to be 'better' than the other in which referring to a specific indicator. Furthermore, in both case studies, the most likely scenarios in terms of real-world possibility and feasibility have also been chosen such that 'forcing' the same value for one of the indicators would in the end be impractical. Fortunately, general comparisons between the two policies can still be conducted as long as they are based on a specific indicator and objective.

As such, the thesis finds that both an energy subsidy reduction and a carbon tax implementation are effective measures to improve the environment. However, in terms of economic development, a carbon tax implementation appears to be a second-best policy alternative to energy subsidy reduction, with the latter promoting a more efficient allocation of resources, as well as promoting economic expansion in countries where energy subsidies exist. Nevertheless, all countries still stand to gain, given an industrial response in which greater efficiency is achieved in the use of energy sources.

The thesis also finds that recycling mechanisms do not affect significantly the GDP and overall CO_2 reduction, but they affect greatly the distributional impact of these policies.

For Indonesia and Malaysia, their course of action is clear. The existence of energy subsidies creates a distortion to the economy. Both countries stand to gain by eliminating this distortion. This, above all else, should be a priority as there is so much gain at stakes in terms of economic, social, and environmental benefit.

The most important policy implication to arise from this thesis is that energy and environmental reforms do not necessarily conflict with development and equity objectives; however, any policies in these areas must be carefully designed to account for acceptability, feasibility, and utility. Also, as *clichéd* and overused as it may be, promoting energy efficiency should be a complementary policy. Energy efficiency does not appear to create a rebound effect and improves both the economy and environment.

7.3. Future Research

This thesis may still have some weaknesses both in terms of the results arising from the database and *caveats* arising from the model.

7.3.1. Improving the Database

One of these weaknesses in the database is due to the exclusion of carbon emissions from land use change and deforestation. For Indonesia in particular, carbon emissions from land use change and deforestation currently constitutes the largest source of emissions. It is important for future research to model explicitly the emissions from land use change and deforestation to obtain a better picture of the impact of energy and environmental policies.

Updating the reference year from 2004 should also be a priority in future research. Updating the data is not only a matter of relevance but also a reflection of underlying policy changes and structural adjustments that may have occurred in the intervening years. Estimating the parameters through rigorous econometric methods is also preferable. Admittedly, as with all

other research, the scarcity of data is a major hindrance but efforts should still be made to obtain it.

Moreover, efforts should also include the possibility of expanding the number of countries to cover all ten member countries of ASEAN so that it becomes a 'truer' representation of the region. However, the inclusion of further countries, e.g. China and India, might not be in the best interest of future research as it might cause technical difficulties to arise when too many countries with a large gap in terms of economic size are all integrated into one model, as well as an even more over-generalization of the results should this be forcefully attempted.

One possible improvement to the database is to include cross-country factors of production use. At present, the IRSA-ASEAN model has already included this feature; however, the lack of data prevents the full use of this feature in this thesis. Logically, capital would be the most mobile production factor to move between countries. One possible use of this would be to look at scenarios in which capital inflow/outflow occur quickly, as it did during the advent of the Asian Financial Crisis back in 1997.

One final note of caution deals with how the parameters are generated. Parameters utilized in this thesis do not come from rigorous estimation analysis due to their unavailability. For the case of Indonesia, many models have been developed for, some of which have produced reliable analysis, and so adopting parameters from those models is most likely to be appropriate. However, this is not true for other ASEAN countries. The GTAP dataset has proven itself to be a valuable source for obtaining parameter values. However, even this dataset can still be improved upon, as some countries appear to have the *exact* same set of parameter values (e.g. Armington and value-added elasticities); which is unlikely to occur if a separate estimation analysis has been conducted for each country. Lastly, another parameter that can be improved upon is the household consumption share (percentile-based) in order to provide a more accurate picture of the distributional impact in each country.

7.3.2. Improving the Model

A warning is needed with regards to the model and its use. This thesis only explores the most likely scenarios in terms of real-world development yet to occur. In this regard, the thesis does not explore all possibilities such as asymmetrical implementation of the policies by countries other than Indonesia and Malaysia, e.g. Vietnam or Thailand. Unlikely as these scenarios are to occur in real life, they might provide some further insights into cross-country inter-connectedness and relationships.

With regard to the model itself, the IRSA-ASEAN is a comparative static model. Extending the model to make it dynamic would provide a time path of how the impact of energy

and environmental policies would evolve over time. Another possible useful extension to the model would be to disaggregate further the energy sector and create a microsimulation to allow endogenous substitution between different energy sources. With this extension, numerous energy and environmental policies could be further explored; it would be a means of overcoming current computer program limitation when faced with a multi-sector, multi-household, and multi-country model.

Also, the IRSA-ASEAN model in this thesis uses a fixed share coefficient to determine the consumption bundle of households as well as the amount of new capital invested in each production sector. The marginal propensity to save is treated exogenously. For households, future research should consider developing a household model where households maximize their utility subject to their budget constraints, e.g. a linear expenditure system, which also endogenizes the amount of money that households save. As for the investment decision, future research should model a function of relative expected return of a sector compared to other sectors. With this addition, sectors that have high expected returns will be crowded with new capital. Hence, these sectors might grow more quickly than sectors with low expected returns.

Other potential extensions to the model would be to include other costs to portray the real-world more accurately. These costs could include, among others, export taxes and transportation costs. Even without an accurate database, it is still possible to include these costs into the model in which it will be assumed that a *change*, or a cost increase/decrease, has occurred. Not only will these create a better representation of the real-world but possible scenarios will increase as well, particularly those that focus more on the trade-aspect of the model. This, in fact, is another possible use of the model, as applications of the model in this thesis focus strongly on energy and environmental policies.

Bibliography

Abimanyu, A. 2000, "Impact of Agriculture Trade and Subsidy Policy on the Macroeconomy, Distribution, and Environment in Indonesia: A Strategy for Future Industrial Development", *Developing Economies*, vol. 38, no. 4, pp. 547-571.

Adriano, J. D. 2008, "Power Politics in the Philippines", *Asia Times*, 10 June 2008.

Aguaiar, A. H. and Dimaranan, B. V. 2008, "Chapter 6: Macroeconomic Data", in Narayanan G., B., and Walmsley, T. L. (eds.), *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

Albrecht, J., François, D., and Schoors, K. 2002, "A Shapley Decomposition of Carbon Emissions without Residuals", *Energy Policy*, vol. 30, pp. 727-736.

Alcott, B. 2005, "Jevons' Paradox", *Ecological Economics*, vol. 54, no. 1, pp. 9-21.

Allan, G., Gilmartin, M., McGregor, P., Swales, J. K., and Turner, K. 2009, "Economics of Energy Efficiency", in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 144-163.

Ang, B. W. 1994, "Decomposition of Industrial Energy Consumption: The Energy Intensity Approach", *Energy Economics*, vol. 16, no. 3, pp. 163-174.

Ang, B. W. and Liu, F. 2001, "A New Energy Decomposition Method: Perfect in Decomposition and Consistent in Aggregation", *Energy*, vol. 26, no. 6, pp. 537-548.

Ang, B. W. and Zhang, F. Q. 2000, "A Survey Index of Index Decomposition Analysis in Energy and Environmental Studies", *Energy*, vol. 25, pp. 1149-1176.

Ashton, R. 2010, "Climate Change and Indonesia's Role in Forging the Way Forward", *The Indonesian Quarterly*, vol. 38, no. 1, pp. 9-22.

Asia Pacific Energy Research Center (APERC) 2000, *Energy Efficiency Indicators: A Study for Energy Efficiency Indicators for Industry in APEC Economies*, Institute of Energy Economics, Tokyo.

Asia Pacific Energy Research Center (APERC) 2006, *APEC Energy Demand and Supply Outlook 2006: Energy at the Crossroads*, Institute of Energy Economics, Tokyo.

Asian Development Bank (ADB) 2009, *The Economics of Climate Change in Southeast Asia: A Regional Review*, Manila.

Asia-Pacific Economic Cooperation (APEC) 2007a, *APEC and Climate Change*, APEC Secretariat Singapore.

Asia-Pacific Economic Cooperation (APEC) 2007b, *APEC Leaders' Declaration on Climate Change, Energy Security, and Clean Development*, Sydney.

Association of Southeast Asian Nations (ASEAN) 2007, *Declaration on Climate Change, Energy, and the Environment*, Singapore.

Association of Southeast Asian Nations (ASEAN) 2008, *Overview: Energy*, <http://www.aseansec.org/6561.htm>.

Association of Southeast Asian Nations (ASEAN) 2009, *Fourth ASEAN State of the Environment Report 2009*, ASEAN Secretariat, Jakarta.

Association of Southeast Asian Nations (ASEAN) 2010, *ASEAN Plan of Action on Energy Cooperation (APAEC) 2010-2015*, <http://www.aseansec.org/22675.pdf>.

Azis, I. J. 2000, "Simulating Economy-Wide Models to Capture the Transition from Financial Crisis to Social Crisis", *The Annals of Regional Science*, vol. 34, no. 2, pp. 251-278.

Badan Pusat Statistik (BPS) 2008, *Sistem Neraca Sosial Ekonomi Indonesia 2005*, Jakarta.

Barker, T., Ekins, P., and Foxon, T. 2007, "Macroeconomic Effects of efficiency Policies for Energy-Intensive industries: The Case of the UK Climate Change Agreements, 2000-2010", *Energy Economics*, vol. 29, pp. 760-778.

Berkout, P. H. G., Muskens, J. C., and Velthuijsen, J. W. 2000, "Defining the Rebound Effect", *Energy Policy*, vol. 28, no. 6/7, pp. 425-432.

Bhattarai, R. and Okyere, E. 2005, *Welfare and Growth Impact of Taxes: Applied General Equilibrium Models of Ghana*, Research Memorandum No. 53, Centre for Economic Policy, University of Hull, Hull.

Böhringer, C. and Vogt, C. 2003, "Economic and Environmental Impacts of the Kyoto Protocol", *The Canadian Journal of Economics*, vol. 36, no. 2, pp. 475-494.

Bosseboeuf, D, Chateau, B., and Lapillonne, B. 1997, "Cross-country Comparison on Energy Efficiency Indicators: The On-going European Effort towards a Common Methodology", *Energy Policy*, vol. 5, no. 7-9, pp. 673-682.

Bovenberg, A. L. 1999, "Green Tax Reforms and the Double Dividend: an Updated Reader's Guide", *International Tax and Public Finance*, vol. 6, pp. 421–443.

Boyd, G. A. and Roop, J. M. 2004, "A Note on the Fisher Ideal Index Decomposition for Structural Change in Energy Intensity", *The Energy Journal*, vol. 25, no. 1, pp. 87-101.

Brännlund, R., Ghalwash, T., and Nordström, J. 2007, "Increased Energy Efficiency and the Rebound Effect: Effects on Consumption and Emissions", *Energy Economics*, vol. 29, pp. 1-17.

Breuss, F. and Tesche, J. 1991, "A CGE Model of Austria: Some Implications of Trade Liberalization", *Empirica*, vol. 18, no. 2, pp. 135-165.

Brookes, L. 2000, "Energy Efficiency Fallacies Revisited", *Energy Policy*, no. 28, vol. 6/7, pp. 355-366.

Burniaux, J. M., Chanteau, J., Dellink, R., Duval, R. and Jamet, S. 2009, *The Economics of Climate Change Mitigation: How to Build the Necessary Global Action in a Cost-Effective Manner*, Economics Department Working Papers No. 701.

Business Times 2008, "Manufacturers Asking for Lower Electricity, Gas Prices: Malaysia", 7 December 2008.

Chan, N. and Dung, T. K. 2001, *Further Development of CGE Model to Evaluate Tariff Policy in Vietnam*, paper presented at the MIMAP Modelers Conference on 23-28 April 2001, Singapore.

Chan, N. and Dung, T. K. 2001, *Further Development of CGE Model to Evaluate Tariff Policy in Vietnam*, paper presented at the MIMAP Modelers Conference on 23-28 April 2001, Singapore.

Chertow, M. R. 2001, "The IPAT Equation and Its Variants: Changing View of Technology and Environmental Impact", *Journal of Industrial Ecology*, vol. 4, no. 4, pp. 13-29.

Choi, K. and Ang, B. W. 2003, "Decomposition Aggregate Energy Intensity Changes in Two Measures: Ratio and Difference", *Energy Economics*, vol. 25, pp. 615-624.

Clarke, R. J. 2009, "Climate Change: No Cop Out", *Organization for Economic Cooperation and Development: The OECD Observer*, no. 276-277, pp. 11-12.

Coady, D., El-Said, M., Gillingham, R., Kpodar, K., Medas, P. and Newhouse, D. 2006, *The Magnitude and Distribution of Fuel Subsidies: Evidence from Bolivia, Ghana, Jordan, Mali and Sri Lanka,* International Monetary Fund (IMF) Working Paper WP/06/247.

Coalgossip 2008, "Malaysia - New Electricity Tariff Rates May Increase", 26 June 2008.

Corong, E. 2008, "Tariff Reductions, Carbon Emissions, and Poverty: An Economy-wide Assessment of the Philippines", *ASEAN Economic Bulletin*, vol. 25, no. 1, pp. 20-31.

Cororaton, C. and Corong, E. 2009, *Philippine Agricultural and Food Policies: Implications on Poverty and Income Distribution*, Research Report, International Food Policy Research Institute, Washington, D. C.

Cororaton, C. and Corong, E. 2006, *Agriculture-Sector Policies and Poverty in the Philippines: A Computable General Equilibrium (CGE) Analysis*, MPIA Working Paper 2006-09, Poverty and Economy Policy (PEP), Manila.

Deardorff, A. V., and Stern, R. M. 1986, *The Michigan Model of World Production and Trade*, Cambridge.

Defourney, J. and Thorbecke, E. 1984, "Structural Path Analysis and Multiplier Decomposition within a Social Accounting Matrix Framework", *Economic Journal*, vol. 94, no. 373, pp. 111-136.

Devarajan, S., Go, D. S., Robinson, S., and Thierfelder, K. 2009, *Tax Policy to Reduce Carbon Emissions in South Africa*, Policy Research Working Paper 4933, The World Bank, Washington, D. C.

Downes, P. 2007, *ASEAN Fiscal and Monetary Policy Responses to Rising Oil Prices*, Regional Economic Policy Support Policy (REPSF) Project 06/004: Final Report.

Duraman, H. I. and Asafu-Adjaye, J. 1999, "Short-Run Simulations with a CGE Model of Brunei Darussalam", in Obben, J. and Ee, T. S. (eds.), *Readings on the Economy of Brunei Darussalam*, Universiti Brunei Darussalam, pp. 72-99..

Ebert, S., Metschies, G. P., Schmid, D., and Wagner, A. 2009, *International Fuel Prices 2009: 6th Edition – More than 170 Countries*, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) as commissioned by Federal Ministry for Economic Cooperation and Development, Eschborn.

Elliott, L. 2003, "ASEAN and Environmental Cooperation: Norms, Interests and Identity", *The Pacific Review*, vol. 16, no. 1, pp. 29-52.

Ellis, J. 2010, "The Effects of Fossil Fuel-Subsidy Reform: A Review of Modeling and Empirical Studies", *Untold Billions: Fossil Fuel Subsidies, Their Impacts, and the Path to Reform*, Global Subsidies Initiative (GSI) and International Institute for Sustainable Development (IISD), Winnipeg.

Energy Information Agency (EIA) 2008a, *Country Analysis Briefs: Indonesia*, <http://www.eia.doe.gov/emeu/cabs/Indonesia/Oil.html>.

Energy Information Agency (EIA) 2008b, *Country Analysis Briefs: Philippines*, <http://www.eia.doe.gov/emeu/cabs/Philippines/Oil.html>.

Ernsberger, D. 2007, "The Strategic Challenges for the United States and China in Global Energy Supply" in *Energy Perspectives on Singapore and the Region*, Institute of Southeast Asian Studies, Singapore, pp. 197-219.

Findlay, C., Parsons, D., and Plunkett, H. 2007, "An Assessment of ASEAN's Priority Sectors for Integration", in Hew, D. (ed.), *Brick by Brick: The Building of an ASEAN Economic Community*, Institute of Southeast Asian Studies, Singapore, pp. 116-130.

Freeman, S. L., Niefer, M. J., and Roop, J. P. 1997, "Measuring Industrial Energy Intensity: Practical Issues and Problems", *Energy Economics*, vol. 25, pp. 703-714.

Food and Agricultural Organization (FAO) 2006, *Global Forest Resources Assessment 2005: Progress Toward Forest Maintenance*, Food and Agricultural Organization of the United Nations, Rome.

Frankhauser, S. 1992, *Global Warming Damage Costs: Some Monetary Estimates*, Centre for Social and Economic Research on the Global Environment, University College London and University of East Anglia, CSERGE GEC Working Paper 92-29.

Fujii, T. and Roland-Holst, D. 2005, *How Does Vietnam's Accession to the World Trade Organization Change the Spatial Incidence of Poverty and Inequality?*, paper presented at the JICA-UNU-WIDER Meeting on the Impact of Globalization on the Poor in Asia on 25-26 April 2005, Tokyo.

Glomma, G., Kawaguchi, D., and Sepulveda, F. 2007, "Green Taxes and Double Dividends in a Dynamic Economy", *Journal of Policy Modeling*, vol. 30, pp. 19-32.

Goldemberg, J. 1996, "A Note on the Energy Intensity of Developing Countries," *Energy Policy*, vol. 24, no. 8, pp. 759-761.

Goulder, L. H. 1995. "Environmental Taxation and the "Double Dividend": A Reader's Guide." *International Tax and Public Finance*, vol. 2, no. 2, pp. 157–183.

Grainger, C. A. and Kolstad, C. D. 2009, *Who Pays a Price on Carbon*?, National Bureau of Economic Research (NBER) Working Paper 15239, Cambridge.

Green, D. J. 2007, "Bridging the ASEAN Development Divide: A Regional Overview", *ASEAN Economic Bulletin*, vol. 24, no. 1, pp. 15-34.

Green, R. 2008, "Carbon Tax or Carbon Permits: The Impact on Generators' Risks", *The Energy Journal*, vol. 29, no. 3 pp. 67-88.

Greene, D. L., 1992, "Vehicle Use and Fuel Economy: How Big Is the Rebound Effect?", *Energy Journal*, vol. 13, no. 1, pp. 117–143.

Greene, D. L., Kahn, James R., and Gibson, R. C. 1999, "Fuel Economy Rebound Effect for U.S. Household Vehicles", *Energy Journal*, vol. 20, no. 3, pp. 1-32.

Greenhalgh, G. 1990, "Energy Conservation Policies", *Energy Policy*, vol. 18, no. 4, pp. 293-299.

Greening, L. A., Greene, D. L., and Difiglio, C., 2000, "Energy Efficiency and Consumption: The Rebound effect – A Survey", *Energy Policy*, vol. 28, no. 6/7, pp. 389-401.

Haaland, J. I. 1990, "Assessing the Effects of EC Integration of EFTA Countries: The Position of Norway and Sweden", *Journal of Common Market Studies*, vol. 28, no. 4, pp. 381-400.

Harrison, G. W., Rutherford, T. F., and Wooton, I. 1989, "The Economic Impact of the European Community", *American Economic Review*, vol. 79, no. 2, pp. 288-294.

Herald Tribune 2007, "Indonesia Tries to Shift from Kerosene to Natural Gas for Cooking", 10 September 2007.

Herald Tribune 2008, "Malaysia Sticks by Fuel Price Hikes, Assures No Further Increases in Near-Term", 6 June 2008.

Hertel, T. W. 1997, *Global Trade Analysis: Modeling and Applications*, Cambridge.

Hertel, T. W., Ianchovichina, E., and McDonald, B. J. 1997, "Multi-Region General Equilibrium Modeling", in Francois, J. F. and Reinert K. A. (eds.), *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press, pp. 94-121.

Hew, D. and Soesastro, H. 2003, "Realizing the ASEAN Economic Community by 2020: ISEAS and ASEAN-ISEAS Approaches", *ASEAN Economic Bulletin*, vol. 20, no. 3, pp. 292-296.

Ho, A. L. 2007, "Fuel Prices Up Again", *Inquirer.net*, 19 May 2007.

Holm, S. and Englund, G. 2009, "Increased Ecoefficiency and Gross Rebound Effect: Evidence from USA and Six European Countries 1960-2002", *Ecological Economics*, vol. 68, pp. 879-887.

Hulme, M. 2010, "Moving Beyond Climate Change", *Environment*, vol. 52, no. 3, pp. 15-19.

Intergovernmental Panel on Climate Change (IPCC), Organization for Economic Cooperation and Development (OECD), and International Energy Agency (IEA) 1997, *IPCC Guidelines for National Greenhouse Gas Inventories*, Paris.

Intergovernmental Panel on Climate Change (IPCC) 2007, *Fourth Assessment Report*, IPCC Secretariat, Geneva.

International Energy Agency (IEA) 1999, *World Energy Outlook 1999: Looking at Energy Subsidies -Getting the Prices Right,* Paris.

International Energy Agency (IEA) 2007a, *Energy Balances of Non-OECD Country: Documentation for Beyond 20/20 Files*, Head of Publications Service, Paris.

International Energy Agency (IEA) 2007b, *Energy Balances of OECD Country: Documentation for Beyond 20/20 Files*, Head of Publications Service, Paris.

International Energy Agency (IEA) 2008, *Energy Prices and Taxes*, Third Quarter 2008 Database, Paris.

International Energy Agency (IEA) 2009, *World Energy Outlook 2009*, Head of Publications Services, Paris.

International Energy Agency (IEA), Organization for Petroleum Exporting Country (OPEC), Organization for Economic Cooperation and Development (OECD), and World Bank 2010, *Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative*, Joint Report Prepared for Submission to the G-20 Summit Meeting, Toronto, 26-27 June 2010.

Jaafar, A. H., Al-Amin, A., and Siwar, C. 2008, *A CGE Analysis of the Economic Impact of Output-Specific Carbon Tax on the Malaysian Economy,* paper presented at the 3rd National Conference on Malaysia Economy on 20-22 August 2008, Port Dickson.

Jellema, T., Keuning, S., McAdam, P., and Mink, R. 2004, *Developing a Euro Area Accounting Matrix: Issues and Implications*, Working Paper Series no. 356, European Central Bank, Frankfurt.

Johansen, L. 1960, *A Multi-Sectoral Study of Economic Growth*, Amsterdam.

Jotzo, F. and Mazouz, S. 2010, "Indonesia's Climate Change Challenge: Economic Policy for Effective and Efficient Mitigation," *The Indonesian Quarterly*, vol. 38, no. 1, pp. 23-40.

Jotzo, F., Resosudarmo, I. A. P., Nurdianto, D. A., and Sari, A. P. 2009, "Climate Change and Development in Eastern Indonesia", in Resosudarmo, B. P. and Jotzo, F. (eds.), *Working with Nature against Poverty: Development, Resources and the Environment in Eastern Indonesia*, Institute for Southeast Asian Studies, Singapore, pp. 248-266.

Kaplow, L. and Shavell, S. 2002, "On the Superiority of Corrective Taxes to Quantity Regulation", *American Law and Economics Review*, vol. 4, no. 1, pp. 1-17.

Karki, S. K., Mann, M. D., and Salehfar, H. 2005, "Energy and Environment in the ASEAN: Challenges and Opportunities", *Energy Policy*, vol. 33, pp. 499-509.

Karunaratne, N. D. 1998, "Trade Liberalization in Thailand: A Computable General Equilibrium (CGE) Analysis", *The Journal of Developing Areas*, vol. 32, no. 4, pp. 515-540.

Kawase, R., Matsuoka, Y., and Fujino, J. 2006, "Decomposition Analysis of CO_2 Climate Stabilization Scenario", *Energy Economics*, vol. 34, pp. 2113-2122.

Kaya, Y. 1990, *Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios*, paper presented at the IPCC Energy and Industry Subgroup, Response Strategies Working Group, Paris.

Kemfert, C. and Truong, T. 2009, "Energy-Environment-Economy Modeling: A Survey", in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 367-382.

Khazzoom, J. D. 1980, "Economic Implications of Mandated Efficiency in Standards for Household Appliances', *Energy Journal*, vol. 1, no. 4, pp. 21-40.

Khazzoom, J. D. 1989, "Energy Saving Resulting from the Adoption of More Efficient Appliances: A Rejoinder", *Energy Journal*, vol. 10, no. 1, pp. 157–166.

Lai, Y. 2009, "Is a Double Dividend Better than a Single Dividend?", *Journal of Institutional and Theoretical Economics*, vol. 165, pp. 342-363.

Lee, H. 2008, *The Combustion-Based CO2 Emissions Data for GTAP Version 7 Data Base*, Center for Global Trade Analysis, Purdue University, Cambridge.

Lee, H. and Mensbrugghe, D. 2004, "EU Enlargement and Its Impacts on East Asia", *Journal of Asian Economics*, vol. 14, pp. 843-860.

Lee, H., Roland-Holst, D., and Mensbrugghe, D. 2004, "China's Emergence in East Asia under Alternative Trading Arrangements", *Journal of Asian Economics*, vol. 15, pp. 697-712.

Len, C. 2007, "Energy Security in Asia: An ASEAN-SCO Energy Partnership?" in *Energy Perspectives on Singapore and the Region*, Institute of Southeast Asian Studies, Singapore, pp. 156-175.

Leong, H. 2007, "China's Energy Security: Geo-politics versus Interdependence" in *Energy Perspectives on Singapore and the Region*, Institute of Southeast Asian Studies, Singapore, pp. 176-196.

Leverett, F. and Bader, J. 2005, "Managing China-U.S. Energy Competition in the Middle East", *The Washington Quarterly*, vol. 29, no. 1, pp. 187-201.

Lewis, J. D. 1991, *A Computable General Equilibrium (CGE) Model of Indonesia,* HIID Series of Development Discussion Papers No. 378, Cambridge.

Li, J. C. 2002, *A 1998 Social Accounting Matrix (SAM) for Thailand*, Trade and Macroeconomic Division Discussion Paper no. 95, International Food Policy Research Institute, Washington, D. C.

Liu, N. and Ang, B. W. 2007, "Factors Shaping Aggregate Energy Intensity Trend for Industry: Energy Intensity vs. Product Mix", *Energy Economics*, vol. 29, pp. 609-635.

Lloyd, P. J. 2005, "What Is a Single Market? An Application to the Case of ASEAN", *ASEAN Economic Bulletin*, vol. 22, no. 3, pp. 251-265.

Lovins, A. B. 1988, "Energy Saving from More Efficient Appliances: Another View", *Energy Journal*, vol. 9, pp. 155-162.

Lozano, S. and Gutiérrez, E. 2008, "Non-parametric Frontier Approach to Modeling Relationships among Population, GDP, Energy Consumption, and CO_2 Emissions", *Ecological Economics*, vol. 66, pp. 687-699.

Ma, C. and Stern, D. I. 2008, "Biomass and China's Carbon Emissions: A Missing Piece of Carbon Decomposition", *Energy Policy*, vol. 36, pp. 2517-2526.

Markandya, A., Pedroso-Galinato, S., and Streikmikiene D. 2006, "Energy Intensity in Transition Economies: Is there Convergence towards the EU Average?", *Energy Economics*, vol. 28, pp. 121-145.

Matete, M. E. 2004, *The Ecological Economics of Inter-Basin Water Transfers: the Case of the Lesotho Highlands Water Project*, Unpublished Ph.D. Thesis, University of Pretoria, Pretoria.

McDonald, S. and Sonmez, Y. 2004, *Augmenting the GTAP Database with Data on Inter-Regional Transactions*, Paper Prepared for the 7th Annual Conference on Global Economic Analysis, *Trade, Poverty, and the Environment*, World Bank, Washington, D. C., June 17-19, 2004.

McDonald, S. and Thierfelder, K. 2004, *Deriving a Global Social Accounting Matrix from GTAP Versions 5 and 6 Data*, GTAP Technical Paper no. 22, Center for Global Trade Analysis, Purdue University.

McDonald, S., Thierfelder, K., and Robinson, S. 2007, *Globe: A SAM Based Global CGE Model using GTAP Data*, Departmental Working Paper, United States Naval Academy Department of Economics, Annapolis.

McDougall, R. A. and Aguaiar, A. H. 2008, "Chapter 11: Energy Data", in Narayanan G., B., and Walmsley, T. L. (eds.), *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

McKibbin, W. J., Wilcoxen, P. J., and Woo, W. T. 2008, *China Can Grow and Still Help Prevent the Tragedy of CO_2 Commons*, Centre for Applied Macroeconomics Analysis (CAMA) Working Paper Series, The Australian National University, Canberra.

Medlock, K. B. 2009a, "The Economics of Energy Supply", " in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 50-72.

Medlock, K. B. 2009b, "Energy Demand Theory", " in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 89-111.

Mensbrugghe, D. 2005, *LINKAGE Technical Reference Document*, Development Prospects Group (DECPG), The World Bank, Washington, D. C.

Metcalf, G. E. 2009, *Cost Containment in Climate Change Policy: Alternative Approaches to Mitigating Price Volatility*, National Bureau of Economic Research (NBER) Working Paper 15125, Cambridge.

Metschies, G. P. 2005, *International Fuel Prices 2005: 4th Edition – 172 Countries*, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) commissioned by Federal Ministry for economic Cooperation and Development of Germany, Eschborn.

Ministry of Finance 2009, *Ministry of Finance Green Paper: Economic and Fiscal Policy Strategies for Climate Change Mitigation in Indonesia*, Ministry of Finance of the Republic of Indonesia and Australia Indonesia Partnership, Jakarta.

Ministry of Forestry 2008, *IFCA 2007 Consolidation Report: Reducing Emissions from Deforestation and Forest Degradation in Indonesia,* Forestry Research and Development Agency (FORDA), Ministry of Forestry of the Republic of Indonesia, Jakarta.

Mizobuchi, K. 2008, "An Empirical Study on the Rebound Effect Considering Capital Costs", *Energy Economics,* vol. 30, pp. 2486-2516.

Morgenstern, R. 1995, *Environmental Taxes: Dead or Alive*, Resources for the Future Discussion Paper 96-03, Washington, D. C.

Nakicenovic, N. 1997, "Decarbonization as a Long-term Energy Strategy", in Kaya, Y. and Yokobori, K. (eds.), *Environment, Energy, and Economy: Strategies for Sustainability*, United Nations University, New York.

Narayanan G., B. and Dimaranan, B. V. 2008, "Chapter 3: What's New in GTAP 7?", in Narayanan G., B., and Walmsley, T. L. (eds.), *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

Narayanan G., B., Dimaranan, B. V., and McDougall, R. A. 2008, "Chapter 2: Guide to the GTAP Data Base", in Narayanan G., B., and Walmsley, T. L. (eds.), *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

Narjoko, D. A. and Amri, P. D. 2007, "The Development Gap between the ASEAN Member Countries: The Perspectives of Indonesia", *ASEAN Economic Bulletin*, vol. 24, no. 1, pp. 45-71.

National Council on Climate Change (*Dewan Nasional Perubahan Iklim* or NCCC) and United Nations Framework Convention on Climate Change (UNFCC) 2009, *National Economic, Environment, and Development Study (NEEDS) for Climate Change: Indonesia Country Study*, Jakarta.

Naya, S. F. and Plummer, M. G. 1997, "Economic Co-operation after 30 Years of ASEAN", *ASEAN Economic Bulletin*, vol. 14, no. 2, pp. 117-125.

Nielsen, C. P. 2002, *Social Accounting Matrices for Vietnam 1996 and 1997*, Trade and Macroeconomic Division Discussion Paper no. 86, International Food Policy Research Institute (IFPRI), Washington, D. C.

Norman, V. 1989, "EFTA and the Internal European Market", *Economic Policy*, vol. 9, pp. 423-465.

Oktaviani, R., Hakim, D., Sahara, S., and Siregar H. 2007, *The Impact of a Lower Oil Subsidy on Indonesian Macroeconomic Performance, Agricultural Sector and Poverty Incidences: A Recursive Dynamic Computable General Equilibrium Analysis*, MPIA Working Paper 2007-28, Poverty and Economic Policy (PEP), Manila.

Organization for Economic Cooperation and Development (OECD) 2002, *Defining and Measuring Environmentally-Harmful Subsidies in the Energy Sector*, General Secretariat, Paris.

Organization of Petroleum Exporting Countries (OPEC) 2007, *World Oil Outlook 2007*, OPEC Secretariat, Vienna.

Otto, V. M., Löschel, A., and Reilly, J. 2008, "Directed Technical Change and Differentiation of Climate Policy", *Energy Economics*, vol. 30, pp. 2855-2878.

Oum, S. 2009, *Income Distribution and Poverty in a CGE Framework: A Proposed Methodology*, Economic Research Institute for ASEAN and East Asia (ERIA) Discussion Paper Series ERIA-DP-2009-18, Jakarta.

Paltsev, S. 2004, *Moving from Static to Dynamic General Equilibrium Economic Models (Notes for a Beginner in MPSGE)*, Technical Note No. 4, Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Cambridge.

Patuellia, R., Nijkampb, P., and Pelsb, E. 2005, "Environmental Tax Reform and the Double Dividend: A Meta-Analytical Performance Assessment", *Ecological Economics*, vol. 55, pp. 564-583.

Pearce, D. W. 1991, "The Role of Carbon Taxes in Adjusting to Global Warming", *Economic Journal*, vol. 101, pp. 938-948.

Peng, D. 2000, "The Changing Nature of East Asia as an Economic Region", *Pacific Affairs*, vol. 73, no. 2, pp. 171-191.

Percebois, J. 1979, "Is the Concept of Energy Intensity Meaningful?", *Energy Economics*, vol. 1, no. 3, pp. 148-155.

Phylipsen, G. J. M., Blok, K. and Worrell, E. 1998, *Handbook on International Comparisons of Energy Efficiency in the Manufacturing Industry*, Department of Science, Technology and Society, Utrecht University.

Piermartini, R. and Teh, R. 2005, *Demystifying Modelling Methods for Trade Policy*, Discussion Paper No. 10, World Trade Organization (WTO), Geneva.

Pizer, W. A. 2002, "Combining Price and Quantity Controls to Mitigate Global Climate Change", *Journal of Public Economics*, vol. 85, no. 3, pp. 409-434.

Pizer, W. A. 2006, "The Evolution of a Global Climate Change Agreement", *The American Economic Review*, vol. 96, no. 2, pp. 26-30.

Plassmann, F. 2005, "The Advantage of Avoiding the Armington Assumption in Multi-Region Models", *Regional Science and Urban Economics*, vol. 35, no. 6, pp. 777-794.

Pyatt, G. and Round, J. I. 1977, "Social Accounting Matrices for Development Planning", *Review of Income and Wealth*, vol. 23, no. 4, pp. 339-364.

Pyatt, G., Roe, A., Round, J., and Lindley, R. 1977, *Social Accounting for Development Planning with Special Reference to Sri Lanka*, Cambridge University Press, Cambridge.

Pyatt, G., Round, J. I., and Denes, J. 1984, *Improving the Macroeconomic Data Base: A SAM for Malaysia, 1970*, the International Bank for Reconstruction and Development, Washington, D. C.

Ratha, D. and Shaw, W. 2007, *South-South Migration and Remittances*, the International Bank for Reconstruction and Development, Washington, D. C.

Raupach, M. R., Marland, G., Ciais, P., Quéré, C., Canadell, J. G., Klepper, G., Field, C. B. 2007, "Global and Regional Drivers of Accelerating CO_2 Emissions", *Proceedings of the National Academy of Sciences*, vol. 104, no. 24, pp. 10288-10293.

Reinert, K. A. and Roland-Holst, D. W. 1997, "Social Accounting Matrices", in Francois, J. F. and Reinert K. A. (eds.), *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press, pp. 94-121.

Resosudarmo, B. P., Hartono, D., and Nurdianto, D. A. 2009, "Inter-Island Economic Linkages and Connections in Indonesia", *Economics and Finance in Indonesia*, vol. 56, no. 3, pp. 297-327.

Resosudarmo, B. P., Nurdianto, D. A., and Yusuf, A. A. 2009, "Greenhouse Gas Emission in Indonesia: The Significance of Fossil Fuel Combustion", in Robiani B., Resosudarmo B. P., Alisjahbana A. A., and Rosa A. (eds.), *Regional Development, Energy, and the Environment in Indonesia*, Indonesian Regional Science Association, Palembang, pp. 146-159.

Resosudarmo, B. P., Ramayandi, A., Yusuf, A. A., and Siyaranamual, M. D. 2008, *Technical Note and Manual for Inter Regional System of Analysis for Indonesia in Five Regions (IRSA-Indonesia5)*, available at http://ceds.fe.unpad.ac.id/ircge/.

Resosudarmo, B. P., Wuryanto, L. E., Hewings, J. D., and Saunders, L. 1999, "Decentralization and Income Distribution in the Inter-Regional Indonesian Economy", in Hewings, G. (ed.), *Understanding and Interpreting Economics Structure*, New York, Springer Publication, pp. 297-215.

Reuters India 2008, "Malaysia Revamps Energy Price System, Risks Backlash", 4 June 2008.

Round, J. I. 2003, "Constructing SAMs for Development Policy Analysis: Lessons Learned and Challenges Ahead", *Economic Systems Research*, vol. 15, no. 2, pp. 161-183.

Ryan, D. L. and Plourde, A. 2009, "Empirical Modeling of Energy Demand", in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 112-143.

Sadoulet, E. and de Janvry, A. 1995, *Quantitative Development Policy Analysis*, Baltimore, John Hopkins University Press.

Salazar, L. C. and Das, S. B. 2007, "Bridging the ASEAN Development Divide: Challenges and Prospects", *ASEAN Economic Bulletin*, vol. 24, no. 1, pp. 1-14.

Sanne, C., 2002, "Willing Consumers or Locked In? Policies for a Sustainable Consumption", *Ecological Economics*, vol. 42, pp. 273-287.

Sari, A. P., Maulidya, M., Butarbutar, R. N., Sari, R.E., and Rusmantoro W. 2007, *Indonesia and Climate Change: Current Status and Policies*, PT. Pelangi Energi Abadi Citra Enviro (PEACE) for World Bank and Department for International Development (DFID), Jakarta.

Saunders, H. D. 2000, "A View from the Macro Side: Rebound, Backfire and Khazzoom-Brookes", *Energy Policy*, vol. 28, no. 6/7, pp. 439-449.

Savard, L. 2010, "Scaling Up Infrastructure spending in the Philippines: A CGE Top-Down Bottom-Up Microsimulation Approach, *International Journal of Microsimulation*, vol. 3, no. 1, pp. 43-59.

Schipper, L. and Grubb, M. 2000, "On the Rebound? Feedbacks Between Energy Intensities and Energy Uses in IEA Countries", *Energy Policy*, vol. 28, no. 6/7, pp. 367-388.

Schob, R. 2005, "The Double-Dividend Hypothesis of Environmental Taxes: A Survey", in Folmer, H. and Tientenberg, T. (eds.), *The International Yearbook of Environmental and Resource Economics 2005/2006: A Survey of Current Issue*, Massachusetts, pp. 223-279.

Seng, K. C. 2007, "The Outlook for Energy: A View to 2030" in *Energy Perspectives on Singapore and the Region*, Institute of Southeast Asian Studies, Singapore, pp. 113-131.

Severino, R. C. 2007, "The ASEAN Development Divide and the Initiative for ASEAN Integration", *ASEAN Economic Bulletin*, vol. 24, no. 1, pp. 35-44.

Shoven, J. B. and Whalley, J. 1992, *Applying General Equilibrium,* New York.

Siriwardana, M. and Iddamalgoda, A. 2003, *"Effects of the Asian Economic Crisis on Singapore and Its Policy Responses: A General Equilibrium Analysis", Journal of the UNE Asia Centre,* no. 6, Armidale.

Sitompul, R. F. 2006, *Energy-Related CO_2 Emissions in the Indonesian Manufacturing Sector*, Unpublished Ph.D. Thesis, University of New South Wales, Sydney.

Situmeang, H. H. 2010, "Towards an Equitable Climate Change Regime", *The Indonesian Quarterly*, vol. 38, no. 1, pp. 41-53.

Smith, A., and Venables, A. J. 1988, "Completing the International Market in the European Community: Some Industry Simulations", *European Economic Review*, vol. 32, no. 7, pp. 1501-1525.

Sorrell, S. 2009, "The Rebound Effect: Definition and Estimation", in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 199-233.

Sorrell, S. and Dimitropoulos, J. 2008, "The Rebound Effect: Microeconomic Definitions, Limitations, and Extensions", *Ecological Economics*, vol. 65, pp. 636-649.

Stern, N. 2006, *Stern Review: The Economics of Climate Change*, H. M. Treasury, London.

Strand, J. 2010, *Taxes and caps as Climate Policy Instruments with Domestic and Imported Fuels*, Policy Research Working Paper 5171, The World Bank, Washington, D. C.

Sun, J. W. 1998, "Changes in Energy Consumption and Energy Intensity: A Complete Decomposition Model", *Energy Economics*, vol. 20, pp. 85-100.

Sun, J. W. 2003, "Three Types of Decline in Energy Intensity – An Explanation for the Decline of Energy Intensity in Some Developing Countries", *Energy Policy*, vol. 31, pp. 519-526.

Sundberg, M. 2005, *Spatial Computable General Equilibrium Modeling – Static and Dynamic Approaches*, Unpublished Ph.D. Thesis, Royal Institute of Technology, Stockholm.

Symon, A. 2005, "Energy and ASEAN Economic Integration", in Heng, R. H. and Sen, R. (eds.), *Regional Outlook: Southeast Asia 2005-2006*, Institute for Southeast Asian Studies, Singapore, pp. 80-83.

Thorbecke, E. 1985, "The Social Accounting Matrix and Consistency Type Planning Models", in Pyatt, G. and Round, J.I. (eds.), *The Social Accounting Matrices: A Basis for Planning*, the International Bank for Reconstruction and Development, Washington, D. C., pp. 207-256.

Thurlow, J. 2004, *A Dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI Model*, Working Paper No. 1, Trade and Industrial Policy Strategies (TIPS), Johannesburg.

United Nations (UN) 2010, *Millennium Development Goals Indicators: Carbon Dioxide Emissions (CO_2),* collected by Carbon Dioxide Information Analysis Center (CDIAC), available at < http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=>, accessed 24 August 2010.

United Nations Development Program (UNDP) 2004, *World Energy Demand: Overview 2004 Update*, Bureau for Development Policy, New York.

United Nations Framework Convention on Climate Change (UNFCCC) 2007, *Climate Change: Impact, Vulnerabilities, and Adaptation in Developing Countries*, Climate Change Secretariat, Geneva.

Verde, S. F. and Tol, R. S. J. 2009, "The Distributional Impact of a Carbon Tax in Ireland", *The Economic and Social Review*, vol. 40, no. 3, pp. 317-338.

Vincent, J. R., and Panayotou, T. 1997, "Consumption: Distraction to Sustainable Development," *Science*, vol. 276, pp. 53-57.

Warr, P. 2005, "Food Policy and Poverty in Indonesia: A General Equilibrium Analysis", *Australian Journal of Agricultural and Resource Economics*, vol. 49, no. 4, pp. 429-451.

Weitzman, M. L. 1974, "Prices vs. Quantity", *The Review of Economic Studies*, vol. 41, no. 4, pp. 477-491.

Welsch, H. 1996, "The Carbon Tax game: Differential tax Recycling in a Two-Region General Equilibrium Model of the European Community", *Weltwirtschaftliches Archiv*, vol. 132, no. 2, pp. 356-377.

Weyman-Jones, T. 2009, "The Theory of Energy Economics: An Overview" in Evans, J. and Hunt, L. C. (eds.), *International Handbook on the Economics of Energy*, Cheltenham, pp. 20-49.

Whalley, J. 1985, *Trade Liberalization among Major World Trading Areas*, Cambridge.

World Bank 2008, *World Development Indicators*, Washington, D. C.

Wu, K. and O'Kray, C. R. 2007, "The Implications and Impacts of China's Oil Demand on the Asia Pacific" in *Energy Perspectives on Singapore and the Region*, Institute of Southeast Asian Studies, Singapore, pp. 132-141.

Yudhoyono, S. B. 2009, *Intervention at the G20 Leaders' Summit*, Pittsburgh.

Yusuf, A. 2007, *The Impact of Environmental Policies on Poverty and Income Distribution: An Application of Micro-simulation CGE Model to Indonesia*, Unpublished Ph.D. Thesis, Australian National University, Canberra.

Yusuf, A. A. and Francisco, H. A. 2009, *Climate Change Vulnerability Mapping for Southeast Asia*, Economy and Environment Program for Southeast Asia (EEPSEA), Singapore.

Yusuf, A. A. and Resosudarmo, B. P. 2007, *On the Distributional Effect of Carbon Tax in Developing Countries: The Case of Indonesia*, Paper no. EEN0706, Economics and Environment Network, The Australian National University, Canberra.