Three Essays on General Equilibrium Analysis of Economic Policy in Thailand

by

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A thesis submitted to The Faculty of Graduate Studies and Research
In partial fulfillment of the requirements for the degree of

Doctor of Philosophy
Department of Economics

Carleton University
Ottawa, Ontario
May 2007

Your file Votre référence
ISBN: 978-0-494-33482-9
Our file Notre référence
ISBN: 978-0-494-33482-9

Abstract:

This thesis contains three chapters of general equilibrium analysis of economic policy in Thailand, which can be summarized as follows:

The first chapter is the static general equilibrium analysis of the impacts of oil prices shock and government subsidies. The results show that oil prices shock in 2004 lowers the GDP of the Thai economy by 0.14 percent and household welfare by ฿ 26.67 billion (0.57 percent of GDP). The negative impact of oil prices shock on GDP can be alleviated by government subsidies while the negative impact on household welfare can be mitigated only when the cost of subsidies is financed by (i) the contraction of government consumption and (ii) the contraction of government consumption together with uniform direct tax rates increase. Nevertheless, subsidies policy is a regressive measure for income distribution.

The second chapter extends the analysis of oil prices shock to cover its dynamic transition. The results show that oil prices shock lowers GDP of the Thai economy by an approximately 1 percent in 2006-2007. The contraction of GDP is led by the reduction of investment and private consumption. Consumption price increases by 0.24 percent in 2004 before steeply rising to 1.5 percent in 2006 -2007. The net real-export increases and contributes positively to GDP in 2004. However, as the shock persists and accelerates, the net real export decreases and reinforces the contraction of other GDP components. Household welfare decreases by 0.743 percent.

The third chapter is an analysis of the impact of trade liberalization in a revenue constrained economy. The results show that, without revenue compensation, the impacts of trade liberalization are consistent with the standard trade theory. In general, it raises GDP (0.036 percent) and household welfare by ฿ 6.469 billion (0.139 percent of GDP). Government revenue decreases by ฿ 20.829 billion (0.450 percent of GDP). In the context of a revenue constrained economy, the impacts of trade liberalization significantly differ from the case without revenue compensation. In all cases of revenue compensation, household welfare decreases and all tax measures are less efficient than tariffs.

Dedication

To Mr. Jaroon, Mrs. Juarattana, Mrs. Yupawade, Mr. Watcharawich and Mr. Pichayadul Boonchit.

Acknowledgement

I am grateful to my thesis supervisors Professor Marcel Mérette and Professor Yazid Dissou at University of Ottawa for valuable advice through all stage of this thesis and their expertise in CGE modeling that benefited me greatly from very beginning until it leads to this thesis. In addition, I am indebted to my thesis supervisor and PhD supervisor at Carleton University, Professor Christopher Worswick, for valuable advice and encouragements.

I am also grateful to Mr. Arkhom Termpittayapaisith, Dr. Porametee Vimolsiri and Dr. Pattama Teanravisitsagool at the National Economic & Social Development Board (NESDB) for inspiring me to joint PhD program and various supports. My academic years in abroad would not be possible if without financial support from the Energy Conservation Fund and the Joint Japan / World Bank Graduate Scholarship Program. I also would like to express my appreciation for various helps from my colleagues at Economic Modeling Section of NESDB, including Mrs. Mukda who passed away in July 2005.

I would like to thank to, Hans Lofgren and Delfin Sia Go, at the World Bank for patiently keep responding to my questions in various occasions. In this respect, I would like to extend my thanks to Professor Sergey Paltsev at MIT and Professor Rob Dellink at Wageningen University for responding to my questions as well as valuable suggestions when I first moved from static to dynamic model.

Special thanks also go to Cynthia Bail, for her excellent and quick editing. Thanks to Mr. Boonthom Panikorn for support and entertainment. Finally, thanks to the Santiwarangkools for continual moral support through this long and tedious PhD process.

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Chapter 1: The impacts of oil prices shock and government subsidies in Thailand: a static CGE analysis

Abstract:

This chapter analyzes the impacts of oil prices shock and government subsidies on the Thai economy in 2004. To satisfy the need for an analytical tool, I developed a static general equilibrium model that takes into account the roles of energy substitution. The results show that oil prices shock in 2004 lowers the GDP of the Thai economy by 0.14 percent. Consumption and investment decrease by 1.05 and 1.18 percent in response to the reduction of income. The net real-export increases by 2.57 percent. An increase in energy cost imposes a pressure on the cost of production and raises producer prices index by 0.79 percent. The real exchange rate slightly appreciates to restore external balance. Measured by compensating variation, an increase in oil prices reduces household welfare by ฿ 26.67 billion which is equivalent to 0.57 percent of GDP.

The impacts of subsidies policy in 2004 are investigated under the assumptions of three alternative financing scenarios, (i) the contraction of government consumption (ii) the contraction of government consumption together with uniform direct tax rates increase, and (iii) uniform direct tax rates increase. The results show that subsidies policy raises GDP by approximately 0.06 - 0.07 percent regardless of financing scenarios. However, the objective of welfare improvement for the poors can be met only in the first and second financing scenarios. Nevertheless, when the subsidies policy is justified in terms of GDP stimulation, it is a regressive measure for income distribution and reinforces the prevailing pressure on the cost of production that is generated by oil prices shock. Under the first and second financing scenarios, subsidies policy raises producer prices index by another 0.16 percent and causes domestic currency to depreciate by 0.39 to 0.51 percent.

1. Introduction and background

1.1 Introduction

An increase in oil prices during 2004 by nearly 40 percent raises new concerns about the detrimental effects for net oil-importing country such as Thailand. In particular, there are worries that it would lead to similar effects caused by the oil crisis in 1973-1974 and 1978-1985 when the Thai economy experienced an economic downturn, high inflation and continuous large current account deficit. The fears lead to the introduction of petroleum price subsidies package as a countervailing measure. However, it raises another concern for policy makers about the burden of subsidies. The debate is now on the ultimate consequence of subsidies, particularly whether it is the effective counteractive measure to minimize the negative impacts of oil prices shock.

The extent to which the oil prices shock generated economic slowdown and inflation is still a controversial issue. The recent literature on the advanced country cases tend to put less weight on oil prices shock as an explanation for the slowdown in output and the rise in inflation than the earlier literature. In addition, a number of studies in energy-producing countries suggest that energy subsidies resulted in the welfare losses and undesired pattern of income distribution. However, studies in net oil-importing developing countries seem to be lacking. This study provides a general equilibrium analysis of the impacts of oil prices shock in 2004 on the Thai economy and quantitatively assesses how subsidies affect welfare, GDP and income distribution.

1.2 Background

Thailand, located in the center of Southeast Asia, covers a total area of 513,115 square kilometers. It has a total population of 61 million. In the early 1950s Thailand was primarily an agricultural economy. Most of its population was living under absolute poverty while its national income was dependent on a narrow range of primary commodities. In 1961, the first economic development plan was introduced. The national development strategy has been revised according to external and internal socioeconomic conditions every five years, from basic infrastructure development strategy in an early stage of development plan to import substitution and outward oriented respectively.

The results of these development strategies have been quite encouraging. Overall, the Thai economy can be regarded as one of the fastest growing economies. The rapid economic expansion of an average 6.9 percent per year over the last 4 decades had resulted in a remarkable change of socioeconomic structure. Share of agricultural sector in GDP has continually declined from 33.0 in 1961 to 9.4 percent in 2002 while the same figure of manufacturing sector increases from 15.2 to 33.9 percent during the same period. The ratio of trade value to GDP increases from 30.8 percent in 1972 to 116.6 percent in 2004. Per capita income in nominal term increases from ฿ 2,000 in 1961 to ฿ 103,044 in 2004. Life expectancy increases from 56 years in 1950s to 69.2 years in 2002. Primary school enrollment increases to almost universal enrollment in 1985. According to the United Nation Development Program (UNDP), the Human Development Index (HDI) in Thailand rose steadily from 0.612 in 1975 to 0.768 in 2001 and belonged to the group of medium human development outcomes with a rank of 74th among 175 countries.

The success side of the Thai economy has masked two structural problems, income inequality and current account instability. Rapid economic expansion led to the satisfactory reduction of poverty incidence, but the income gap increasingly widened. At the same time, the problem of current account deficit repeatedly emerged. In some cases, it triggered the economy-wide crisis as in the mid of 1980s and 1990s. The current account crisis in the early 1980s was driven by the high oil prices and terms of trade deterioration. Since the 1990s however, current account instability was attributable to the extensive reliance on import and the high exposure of the domestic economy to the world market. In such situations, any economic policy must be evaluated carefully in terms of its effects on economic growth, current account and income distribution.

As in many other developing countries, energy demand in Thailand grows at a faster rate than income[1]. This is because the fast growing modern-manufacturing sector is the energy intensive industry and higher living standards have continually raised energy consumption per-capita. Because the domestic supply of petroleum insufficiently meets demand, the Thai economy is highly dependent on imported energy. According to the Energy Information Administration (EIA), Thailand is in the rank of high energy intensive economies. In 2002, total energy consumption accounted for 14 percent of GDP and the imported energy accounted for 52.4 percent of its requirement. The transportation sector is the largest energy consumption sector with 37 percent of total final energy consumption followed by the industrial sector with 36 percent and the residential sector with 26 percent.

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[1] According to the Energy Policy & Planning Office, one percent increase in GDP raises energy demand by 1.4 percent.

The vital role of imported energy together with structural problems raises concerns among policy makers and investors about the vulnerability of the Thai economy to the fluctuation of oil prices. In particular, the oil price increase in 2004 was feared to generate a similar outcome as in 1973-1974 and 1978-1985 when the Thai economy experienced an economic downturn, high inflation and a large current account deficit. Therefore, the increase of crude oil prices from an average US$ 28.84 per barrel in 2003 to US$ 61 per barrel in August 2005 made, in many investors' opinion, Thailand among the most vulnerable economy in Asia due to its high energy intensity, high import reliance, and high exposure to the global economy. As a result, think tanks downsized their GPD projections for the Thai economy by 0.5 – 2.5 percent[2].

The highlighted adverse effects are mostly centered at production cost, competitiveness of external sector and household income. The run-up of oil prices in 2004-2005 occurred in a situation of excess capacity in the global economy, low inflation, and oil price subsidies in export-competing countries. Under this situation, domestic firms are less able to pass higher energy-input cost to their export prices. As a result, higher energy cost erodes profit of domestic firms, slows down a recovery of investment and reduces factor income. Together with its direct effects, high oil prices can possibly have a serious impact on household income and cause poverty reduction policy to be delayed.

[2] For example, with the assumption of crude oil prices of US$ 35 per barrel, International Energy Agency and International Monetary Fund lower their projection of Thailand's GDP growth by 1.8 percent while Deutsche Bank currency strategists estimated that an increase in oil prices of 25 percent to US$ 50 a barrel could reduce GDP growth of the Thai economy by 2.1 percent.

To mitigate these adverse impacts, the Thai government introduced a counteractive measure by imposing a cap on domestic retail prices of gasoline and diesel in January 2004. Since then the burden of subsidies has grown continuously at an average of ฿ 5.1 billion per month (between January 2004 and June 2005) and reached a total of ฿ 91.1 billion, which is equivalent to 1.4 percent of the 2004 GDP[3].

The extent to which the oil prices shocks hurt developed economies in the 1970s has yet to be sorted out. Hooker (1996) and, Change and Wong (2003), for instance, put less weight on oil prices shock as an explanation for the slowdown in output and the rise in inflation than the earlier literature. In addition, the fiscal cost of subsidies can be significant. It can place a heavy burden on the government budget, weaken trade balance by stimulating importation of oil that tends to exacerbate current account instability. Therefore, the ultimate consequence of subsidies is debatable, particularly whether it is the effective countervailing measure to minimize the negative impacts of oil prices shock.

Energy market may not work properly. Therefore, it can be argued that there exists a justification for government to intervene the market in order to optimize social welfare. Subsidies can be justified only if overall welfare is increased. Clarke and Edwards (1997), however, show that GDP would be higher without subsidies. Some studies conclude that oil subsidy is not necessarily associated with less domestic prices volatility. Hope and Singh (1995), and Freund and Wallich (2000) indicate that subsidies benefit the rich more than the poors. All this implies that, in some cases, energy subsidies are not an effective countervailing measure to mitigate the impacts oil prices shock since

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[3] For details, see Table E-5 of an Appendix E.

it reduces aggregate GDP and can be justified neither on the ground of income distribution nor on the ground of economic stability.

Therefore, it is important to understand the economic adjustment to oil prices shock and subsidies that will provide a guideline for policy formulation and evaluation. Among the critical questions to answer are (i) what are the general equilibrium effects of oil prices shock on the Thai economy? and (ii) If it led to undesired impacts on economic growth, welfare of the poors, and economic stability, can these adverse effects be mitigated by subsidies policy that was introduced in 2004? With these questions in mind, in this chapter, I develop a Computable General Equilibrium (CGE) model of the Thai economy to trace the long-run energy-economy interaction and address the two questions stated above. This chapter is organized in 5 sections: section 1 is the introduction and background, section 2 provides a review of the literature, section 3 describes the model that is developed for the purpose of this study, section 4 presents the results of model simulations and section 5 is the conclusion.

2. A review of the literature

After the macroeconomic turbulences that followed the two major oil prices shocks in the 1970s, the role of oil prices on economic activity has been deeply investigated both from theoretical and empirical perspectives. The analysis of oil prices shock is now part of many standard textbooks. As the energy sector is subject to increasing returns to scale, fluctuations in this sector have the potential to generate economy-wide business cycles. Moreover, it has been recognized that the demand for energy goods from households is rather inelastic. Hence, an increase in the oil prices may significantly contract the budget of the poors.

As oil prices have important economic implications at both positive (economic performance) and normative (income distribution, welfare of the poors) levels, arguments exist for government intervention. In Thailand, intervention has taken the form of subsidies for domestic demand. To assess the impacts of oil prices shock and subsidies on the economy of Thailand, I review the literature. To better evaluate the overall impacts of oil prices shock and subsidies, I organize this literature review by first discussing the macroeconomic sensitivity to changes in oil prices. This will facilitate the discussion that will follow on the role of energy subsidies.

2.1 Energy prices and the macro-economy

Choucri and Lahiri (1984) use a macro general equilibrium model to analyze the short-run interaction between energy and economy in Egypt. The model comprises 10 productive sectors, a single representative consumer and two primary factors. The study shows that an increase in domestic petroleum prices of 54 percent raises inflation by 2.8

percent, reduces the share of wage income that lowers household consumption, and contracts output by 2.0 percent.

Hooker (1996) analyzes the relationship between oil prices and U.S macroeconomic variables, and examines the tentative explanations that have been used to explain, in many research papers, the weak relationship between oil prices and macroeconomic variables of the U.S economy after 1973. The main tentative explanations are as follows:

a) Many authors argue that 1973 is the breaking point for the structural change of the U.S economy. It is the beginning period of productivity slowdown, floating exchange rate regime, followed by several years of unusually low interest rates. This structural change potentially causes the problem of sample instability, weakening Granger causality between oil prices shock and macroeconomic variables.

b) Some authors suggest that oil prices are endogenously determined by other model variables. The Granger causality test is essentially for whether the unforeseeable component of oil prices helps predict macroeconomic variables. The more information about future oil prices is contained in model variables, the smaller is the unforeseeable component of oil prices. In such a case, it is difficult to identify a significant relationship between oil prices and macroeconomic variables in an unrestricted Vector Autoregressive (VAR) framework.

c) Several theorists argue that both energy prices increases and decreases have a contractionary component since energy prices changes lead to costly reallocation of labor and capital. Therefore, the actual impact of energy prices decrease is perhaps economic contraction rather than expansion.

Hooker (1996) shows that oil prices increase has had a significant impact on the U.S economy but impacts of oil prices decline in the 1980s are smaller and harder to characterize. However, the tentative explanations for the weak relationship between oil prices shock and aggregate economy are not supported by the data.

Hamilton (1996) responds to Hooker (1996) by reexamining the relationship between oil prices shock and macroeconomic variables of the U.S economy. Instead of using the percentage change of oil prices over previous quarter as in Hooker, Hamilton uses the percentage change over its previous year's maximum. He concludes that the recent U.S. data are consistent with the historical correlation between oil prices shock and economic recession. This implies that the weak Granger causality between oil prices shock and macroeconomic variables found in Hooker is attributable to the calculation of oil prices change.

Uri and Boyd (1997) evaluate the effects of energy prices increase in Mexico. Using a static CGE model of 13 production sectors, 4 representative households and 3 factors of production, the study shows that a 26.2 percent increase in gasoline and electricity prices result in a reduction of output by 0.05 percent, aggregate consumption by 0.99 percent, but in an increase of government revenue by 0.73 percent.

Adjaye (2000) estimates the causal relationship between energy consumption and income in four developing countries, including India, Indonesia, Philippines and Thailand. Using Vector Error Corrective Model (VECM), the estimation suggests a short-run unidirectional Granger causality runs from energy to income for India and Indonesia. For Thailand and Philippine, there are bidirectional Granger causality runs from energy to income. These findings are consistent with the expectation that an energy-dependent economy is relatively more vulnerable to oil prices shock.

Chang and Wong (2003) investigate the impact of oil prices fluctuation on the key macroeconomic variables of Singapore. Using quarterly data from 1978 to 2000 together with a Vector Error Corrective Model (VECM), the results show that the negative impacts of oil prices shock on GDP, inflation and employment are only marginal. This weak relationship between oil prices fluctuation and macroeconomic variables is possibly attributable to the decline of the share of oil consumption in GDP.

Cunado and Gracia (2003) analyze the impacts of oil prices fluctuations on inflation and industrial production during the period of 1960-1999 in 15 European countries. Using Vector Auto Regressive (VAR) model, the results show a permanent effect of oil prices increase on inflation and a short-run asymmetric impact on the growth rate of production. Moreover, the economic responses to the oil prices fluctuations are greatly different across countries.

Doroodian and Boyd (2003) use a dynamic CGE model of 8 production sectors and 3 representative households to examine whether an oil prices shock of the 1973-1974 magnitude is inflationary in the U.S economy. The model simulations are conducted under the two separate cases (regular economic growth and low economic growth). The study shows that an oil prices shock of the 1973-1974 magnitude has fairly severe impacts on the prices of gasoline and refining but, in aggregate, these price changes are largely dissipated over time. In addition, technology progress leads to a reduction of Consumer Price Index (CPI) and Producer Price Index (PPI) regardless of the growth cases.

Ayadi (2005) uses a VAR model to analyze the relationship between oil prices changes and economic development via industrial production in Nigeria[4]. Using data from 1980 to 2004, the study shows that oil prices changes affect real exchange rate, which in turn indirectly affect industrial production. However, this indirect effect is not statistically significant. Therefore, the study concludes that, in Nigeria, an increase in oil prices does not lead to an increase in industrial production.

Cunado and Gracia (2005) examine the relationship between oil prices, economic activity and inflation in six Asian countries including Japan, Singapore, South Korea, Malaysia, Thailand and Philippines. By applying co-integration technique and the Granger causality test on the data between 1975 and 2002, the study shows that the impact of oil prices shock on economic activity is limited only to the short-run. With respect to GDP, the study shows Granger causality between oil prices shock and economic growth rate in Japan, South Korea and Thailand. In terms of domestic price stability, the study shows a significant effect on inflation in every country and increasingly significant when the oil prices shock is defined in terms of local currency. However, the impacts of oil prices shock are asymmetric. In particular, the relationship between oil prices and the economy seem to be less significant for the case of Malaysia, which is the only net oil- exporting country in the sample.

Roeger (2005) investigates the impacts of oil prices change on the economic growth and inflation in EU/OECD countries. Using the GUES model, the study shows that a permanent increase in oil prices of 50 percent during 2004 results in an output loss of 0.5 percent in 2005 and 1 percent in the long run. However, the results contain a trade-

[4] Note that, Nigeria is an oil exporting country.

off between GDP growth and inflation. For example, a temporary increase in inflation by 0.25 percent reduces output loss by 0.02 percent.

From an empirical perspective, most researchers found causality between oil prices shock, output and inflation. In most cases, oil prices increase leads to GDP contractions and generates a pressure on inflation. However, these impacts are asymmetric across countries. Some studies report strong impacts (such as in Choucri and Lahiri (1984)) while some others report moderate impacts (such as in Uri and Boyd (1997), and Chang and Wong (2003)). In some studies, however, the impacts of oil prices shock are insignificant (as in Ayadi (2005)). The asymmetric effects of oil prices shock across countries are attributable to the fact that countries differ from each other in their economic setting. In general, oil importing countries are relatively more vulnerable to oil prices shock (as in Adjaye (2000) and Cunado and Gracia (2005)). Among these countries, the degree of vulnerability is likely to depend on the degree to which they are net importer and the oil intensities of their economy.

The literature does not provide a clear transmission mechanism on how oil prices increases affect the economy; some of them, however, report a strong reduction in consumption and wage income. From a theoretical perspective, oil prices increase causes income reduction in oil importing country, which eventually lowers household consumption and saving. On the supply side, rising oil prices signals the scarcity of energy, a basic production input. Consequently, it lowers productivity that depresses demand for other inputs and eventually reduces the real wage rate. This transmission mechanism is known as a classic supply-side shock[5]. With institutional rigidity, the resistances to a real decline in wage rate generate an upward pressure on nominal wage. Together with the reduction in demand for labor, oil prices increase typically leads to higher unemployment and further GDP reduction. In addition, a higher domestic prices level and higher import prices of energy are likely to deteriorate trade balance.

Oil prices shock draws the attention of policy makers as it raises concerns about its impacts on output, inflation, international competitiveness and welfare of the poors. These concerns may lead to government intervention in the form of energy subsidies that bring the domestic energy prices lower than the full costs. Obviously, subsidies are a burden on public budgets. However, the ultimate consequences of subsidies on the economy are less clear. In the following subsection, I explore the empirical implications of energy subsidies that have been investigated so far in the literature.

2.2 Energy subsidies

Burniaux, Martin and Martins (1992) use the OECD-GREEN model[6] to estimate the impacts of removing energy prices distortion on real GDP and carbon emissions in OECD and non-OECD countries. The result shows that removing energy subsidies in the non-OECD countries and energy taxes in OECD countries reduces oil prices in the world market. This raises the real income of OECD and non-OECD countries through two main channels: terms of trade changes and efficiency gains. Overall, it raises GDP of OECD countries and non-OECD countries over the period 1990-2050 by 0.1 and 1.6 percent respectively.

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5 For details, see Rasche and Tatom (1977 and 1981)

6 Multi regional dynamic general equilibrium model

Hope and Singh (1995) analyze the impacts of energy prices increase in 6 developing countries, including Columbia, Ghana, Indonesia, Malaysia and Zimbabwe. By analyzing the direct partial impact of energy prices increase on consumers, the study shows that the impacts of higher energy prices on equity depend on the share of energy in total household budgets in each income class and the price elasticity of demand. In aggregate, the budget share of commercial energy rises with income. Therefore, subsidies largely benefit non-poor people. With respect to the impacts of higher energy prices on producers and other aggregate macroeconomic variables, the study shows modest impacts on industry because energy costs account for only 0.5 to 3 percent of total cost and many industries are flexible to substitute when energy prices increase. Under the partial equilibrium framework, the authors suggest that it is hard to trace the impacts on inflation and national income. However, the effects on inflation would not be severe and inflation may even be reduced in the intermediate to long term. In addition, the growth rate of income is higher during the year of prices increase.

Bohringer (1996) applies a static CGE model of a small-open economy (of 25 production sectors and 2 primary factors) to analyze the economic cost of an alternative hard coal subsidy policy in Germany at different levels of CO2 reduction. The study shows that, for a target of 35 percent CO2 reduction, the hard coal subsidy as a measure for retaining jobs can be very costly with additional specific costs up to DM 70,000 annually.

Clarke and Edwards (1997) use a single-country static CGE model to analyze the economic and environmental impacts of hard coal subsidies in Western Germany. The result shows that removing all producer energy subsidies and the pfennig tax[7] leads to a dramatic fall in demand for hard coal. The output of hard coal decreases by 64.4 percent. However, the efficiency gain raises GDP by 0.35 percent.

IEA (1999) conducts a study on the impacts of energy subsidies in 8 countries (China, Russia, India, Indonesia, Iran, South Africa, Venezuela and Kazakhstan). The main question in this study is "what would happen to energy consumption, exports and imports, and CO2 emissions if all end-use subsidies were removed?" Within a partial equilibrium framework, the study shows a positive relationship between subsidies removal and income growth. In aggregate, it reduces primary energy consumption by 13 percent and raises GDP by almost 1 percent. The results for each individual country are shown in Table 2-1.

Table 2-1: Results from 1999 IEA study

Area	Subsidy (% of reference price)	Efficiency gains (% GDP)	Change in energy consumption (%)	Change in CO2 emissions (%)
China	10.89	0.37	9.41	13.44
Russia	32.52	1.54	18.03	17.10
India	14.17	0.34	7.18	14.15
Indonesia	27.51	0.24	7.09	10.97
Iran	80.42	2.22	47.54	49.45
South Africa	6.41	0.10	6.35	8.11
Venezuela	57.57	1.17	24.94	26.07
Total	21.12	0.73	12.80	15.96

***Source:** IEA (1999)*

Freund and Wallich (2000) analyze the welfare impact of energy subsidies reform in Poland. By estimating the change in consumer surplus with the assumed price elasticity of demand, the study shows that the higher the elasticity, the lower the welfare loss. By assuming a zero elasticity of demand and 80 percent increase in energy prices, the welfare of the lowest income-group and that of the highest income-group declines by

[7] A special consumption tax on electricity that is used to finance hard coal subsidies

5.9 and 8.2 percent respectively. That is, removing energy subsidies would lead to higher welfare losses for the non-poor people than for the poors.

Saboohi (2001) evaluates the impact of reducing energy subsidies on the living expenses of households in Iran. By using a quantitative model that comprises of input-output analysis and reduced form regression function, the study indicates that, as subsidies are phased out through raising energy prices by 50.6 percent, the cost of living of urban and rural households increases by 28.7 and 33.7 percent respectively. However, financial resources obtained from subsidies elimination could be reallocated to compensate loss in purchasing power of households.

Arocena, Contin and Huerta (2002) analyze the distribution of benefit of energy prices regulation in Spain during the period 1987-1997. By comparing the actual evolution of energy prices with some alternative benchmarks, the study shows that the regulation is a pro-industry biased policy. The consumers benefit very little from the partial protection of an excessive monopolistic abuse.

Gangopadhyay, Ramaswami and Wadhwa (2005) examine the impact of reducing energy subsidies on the welfare of the poors in India. Basically, Liquid Petroleum Gas (LPG) and kerosene are subsidized by the Indian government to reduce the pressure of deforestation and indoor air pollution associated with biomass use. Using household consumption expenditure data over 100,000 households, the study shows that the LPG subsidy is largely used by the higher expenditure group in the urban sector. Therefore, it is regressive and is unlikely to have significant effects on biomass use. Kerosene subsidy, on the other hand, is widely used and is more likely to displace biomass use. On a per-capita basis, however, the urban sector receives a larger subsidy. Therefore, the study concludes that LPG and Kerosene subsidies are very ineffective measures for improving the welfare of the poors or displacing biomass use.

In general, the empirical studies on the interaction between energy subsidies and the economy can be divided into two groups. The first group focuses extensively on the welfare impact of subsidies reform policy both in partial and general equilibrium frameworks. The results suggest that subsidies removal raises economic efficiency and GDP of the economy. By analogy, this implies energy subsidies result in a reduction of allocation efficiency and aggregate income.

The second group of studies focuses on the distribution effect of energy subsidies that are mostly conducted under the partial equilibrium framework and the analysis of consumption expenditure. The findings suggest that the benefit of subsidies is largely distributed to non-poor people. This is why the removal of subsidies hurt non-poor people more than the poors. According to the analysis of consumption expenditure, the regressive nature of energy subsidies is attributable to the structures of consumption bundle. From a theoretical perspective, however, the distribution impacts may also depend on how subsidies distort relative prices and how subsidies redistribute income in the economy.

2.3 Methodology

The methodologies used in the literature are broadly classified into three main approaches: statistical, partial equilibrium analysis and general equilibrium analysis. These three approaches are commonly found in the analysis of the impacts of oil prices shock on the economy while the studies focusing on the impacts of subsidies are limited to partial and general equilibrium analysis.

In principle, each approach has its own advantages and limitations. The statistical model (such as VAR) has its own advantage in forecasting, but usually is a system of few equations and considers the economy at aggregate level. The partial equilibrium model provides a realistic picture of the focusing sector, but it ignores the changes in the remaining economy and the consequent interactions. In contrast, the general equilibrium model is a representation of the economy that captures the complex interdependencies across agents and sectors. However, it is often poor in providing estimates of uncertainty around output fluctuation and relies on parameters that require statistical estimates.

Nevertheless, there are relevant reasons suggesting that oil prices shock and energy pricing policy can best be analyzed in the context of the general equilibrium framework. In this subsection, I briefly discuss two supporting reasons: the nature of the energy sector and the critical questions this study want to answer. Then I briefly discuss the model of interest.

By its nature, energy commodities are used in both consumption and production. Therefore, the general equilibrium effects of energy policy tend to be significant. From an empirical perspective, potentially important spillover effects are asserted in the literature. For example, Choucri and Lahiri (1984) noted that, "treating the energy sector in isolation of the rest of the economy could be counter productive and lead to the adoption of measures that may even have detrimental effects in the short run" (p.809).

Bohringer and Rutherford (2004) suggest that researchers can rely on partial equilibrium analysis as long as the spillover effects are insignificant. In the presence of spillover effects, however, if the policy is designed to achieve a change in target variable, it would affect other economic variables. In this situation, Thissen (1998) points out that the final outcome of policy instrument may well differ from the effects predicted by the partial equilibrium approach. Therefore, Bergman and Henrekson (2003) suggest that, if proposed policy measures or other exogenous changes are likely to have spillover effects then, the CGE model should be used.

Apart from the nature of energy sector, the questions I introduced earlier require an analytical tool that allows for an integrate assessment of the impacts of energy prices shock and subsidies covering welfare, production and distribution issues. In this regard, the partial equilibrium model may not be appropriate since it falls short of incorporating income flow and market interdependencies.

In contrast, general equilibrium models are capable of representing many sectors and agents in a coherent system as well as incorporating market interactions. Producers and consumers are linked through an interdependence of commodity and factor markets as well as the distribution of factor incomes across institutions. Bhattacharyya (1996) concludes that "since energy policy issues are related to various aspects of the economy such as price formation, output determination, income generation and distribution, consumption behavior, government operation, etc., a coherent and systematic mechanism is required for such analysis" (p.145).

Basically, a computable general equilibrium model is an analytical tool that is based on general equilibrium theory. The first CGE model was presented in the work of Johansen (1960). Since then, CGE models have been increasingly used as analytical tools for economic policy analysis in various areas. In connection with the energy sector, the CGE model that is particularly formulated for energy policy analysis dates back to the early 1970s when the first oil crisis provided an impetus for modelers to develop models for analyzing the impacts of energy policy. The first energy CGE model was an econometric CGE model of Hudson and Jorgenson (1975).

The second oil and economic crisis in the 1980s generated an additional demand from policy makers to develop models for analyzing exogenous shock. Since a CGE model is a powerful tool for comprehensive economic assessment, it gained popularity among the energy and macroeconomic modelers. After the second oil crisis, the global economy was on the path to recovery with the contribution of low and stable oil prices. However, since the early 1990s, the world community has been increasingly concerned about environmental problems. Together with the fact that the energy sector is a major source of pollution, the interest of policy makers shifted toward environmental problems that are related to the energy sector. In this regard, CGE models are widely applied to assess the economic and environmental consequences of different measures for controlling Green House Gas (GHG) emissions. The applications of CGE model in this area are, for example, Perroni and Wigle (1994), Abrego, Perroni, Whalley and Wigle (2001).

As with other quantitative models, the CGE model has its own limitations. With respect to the CGE model for energy policy analysis, Bergman and Henrekson (2003) summarize useful implications for environmental CGE modeling that can be applied to the energy-economic model of interest. Particularly they suggest that, "the model should have an elaborate treatment of the possibilities to substitute other forms of energy, or other factors of production, for fossil fuels" (p.8).

Over the last few years, CGE models that address the issues of the energy sector have increasingly paid attention to energy substitution, particularly in the studies where the linkage between energy, economy and the environment is the main focus. However, only a few models take into account the full implications of energy substitution, which are the infra-energy substitution, substitution between primary and non-primary energy, between energy and labor, and between energy and capital.

From an empirical perspective, a number of studies found the existence of substitution between different types of energy, and between non-primary and primary energy. Also, various empirical studies support the substitutability between labor and capital, and between labor and energy, both in the short run and long run. In the case of capital and energy, there is conflicting econometric evidence. Some studies found that capital and energy are substitutes (for example, Christensen and Greene (1976), Griffin and Gregory (1976), Pindyck (1979)), while some others concluded that capital and energy are complements (for example, Hudson and Jorgenson (1974), Berndt and Wood (1975)). In practice, most empirical analyses assume that capital and energy are substitutes at less or equal magnitude as between labor and energy.

The full implications of energy substitution are captured in large scale regional models such as the GTAP-E and the GREEN models. However, these models and their large scale data are not publicly accessible. Moreover, they are specifically designed for analyzing policy at the international focus and contain only one representative household for each country. These models cannot satisfy the need for an analytical tool in this chapter, where the within-country distribution effect is one of the main focuses. Given these limitations, I develop a CGE model for Thailand that captures the full implications of energy substitution that is suitable for analyzing energy policy at the national level.

2.4 Expected contributions of this study

Overall, the impacts of oil prices shock and subsidies have been extensively investigated by a large body of research. The review of the literature in previous subsections provides the areas where this study can make contributions.

First, it has been asserted that the impacts of oil prices shock and subsidies are asymmetric across countries. From a theoretical perspective, these asymmetric effects are asserted as the result of the fact that countries differ in their composition and their relative position. From an empirical perspective, asymmetric effects were found in the literature (for example, Cunado and Gracia (2003), Cunado and Gracia (2005)). This implies that the estimates of the impacts of oil prices shock and subsidies cannot be based on the results of previous studies in other countries. Therefore, the findings of this study will directly contribute to the work in the area of economic analysis and policy evaluation of the Thai economy.

Second, studies on the impacts of oil prices shock and subsidies are concentrated in developed economies and net-energy exporting developing countries while the studies on general equilibrium effects of oil prices shock and subsidies in net-oil importing developing countries seem to be lacking. Moreover, the conclusions regarding the distribution effects of subsidies are mostly drawn from partial equilibrium studies and the analysis of consumption expenditures. These results are, in some sense, suspicious[8] since

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[8] As pointed out by Sadoulet and Janvry (1995), the partial equilibrium approach often gives misleading results. An elaborate example of the limitation of partial equilibrium analysis in energy policy studies is the study by DRI, which is documented in UNEP (2002). According to the DRI study of 6 OECD countries, the effects of removing coal subsidies on demand for coal are small and the macroeconomic effects are insignificant. Anderson and McKibbin (1997) show that the effects have been largely underestimated because if the spillover effects on regional employment were taken into account, the impacts of removing coal subsidies would be significantly higher.

their analytical frameworks ignore the indirect impacts of subsidies. Therefore, the findings of this study will not only fill the research gap between energy-producing developed countries and energy-importing developing countries but also provide a better understanding about the impacts of subsidies from a general equilibrium perspective.

Third, the extensive reliance on partial equilibrium analysis by large research bodies in developing countries is, in many cases, attributable to the limited access to an analytical tool for general equilibrium analysis. Therefore, the model developed in this study is expected to be used in the future by Thai government representatives.

3. Model

For the purpose of the analysis in this chapter, I develop a Computable General Equilibrium (CGE) model of the Thai economy. The model is a static energy-economic CGE model for a small-open economy. It is developed from the neoclassical structuralism modeling tradition. The model pays particular attention to the energy sector and its linkages to the rest of the economy. It takes into account the substitutability between different types of energy inputs, and between energy inputs and non-energy primary factors.

The model is made up of 534 linear and nonlinear equations that govern the behaviors of agents, sectors and their interdependencies in the economy. These interdependencies are described by equilibrium conditions and macroeconomic closures. The model belongs to a family of small-open economy GGE models found in the literature, which is suitable for long-run static comparative analysis of public policy at national levels.

The model is able to disaggregate production, consumption and factors of production up to the level that is provided by the Social Accounting Matrix (SAM). In this study, however, I disaggregate production into 12 activities, consumption into 3 representative households, and primary factors into capital and labor. The model is homogenous of degree zero in prices. In this section, I describe in detail the equations within the model including the first order conditions. The lists of model variables and parameters are provided in Appendix A.

3.1 Production

Production is made up of 12 production activities: agricultural, manufacturing, coal & lignite, crude petroleum, diesel, gasoline, aviation fuel, fuel oil, electricity, gas, transportation, and services. The energy sector is composed of non-primary energy production, which is electricity, and primary energy production that includes coal & lignite, crude petroleum, diesel, gasoline, aviation fuel, fuel oil and gas. The primary energy sector is further divided into non-substitutable primary energy (crude petroleum, coal & lignite[9], aviation fuel and fuel oil) and substitutable primary energy (gasoline, diesel and gas).

Production block is particularly designed to capture stylize facts of energy sector, in particular, the substitution between different types of substitutable primary-energy inputs, between primary energy input and non-primary energy input, and between energy input and other primary factors (labor and capital).

As depicted in Figure 3-1, the model is made up of 9 production nests. Five of them are governed by the fixed–share Leontief production technology and the rest are governed by Constant Elasticity of Substitution (CES) production technology. With this production structure, I postulate the optimization problem at each production nest as a cost minimization problem as follows:

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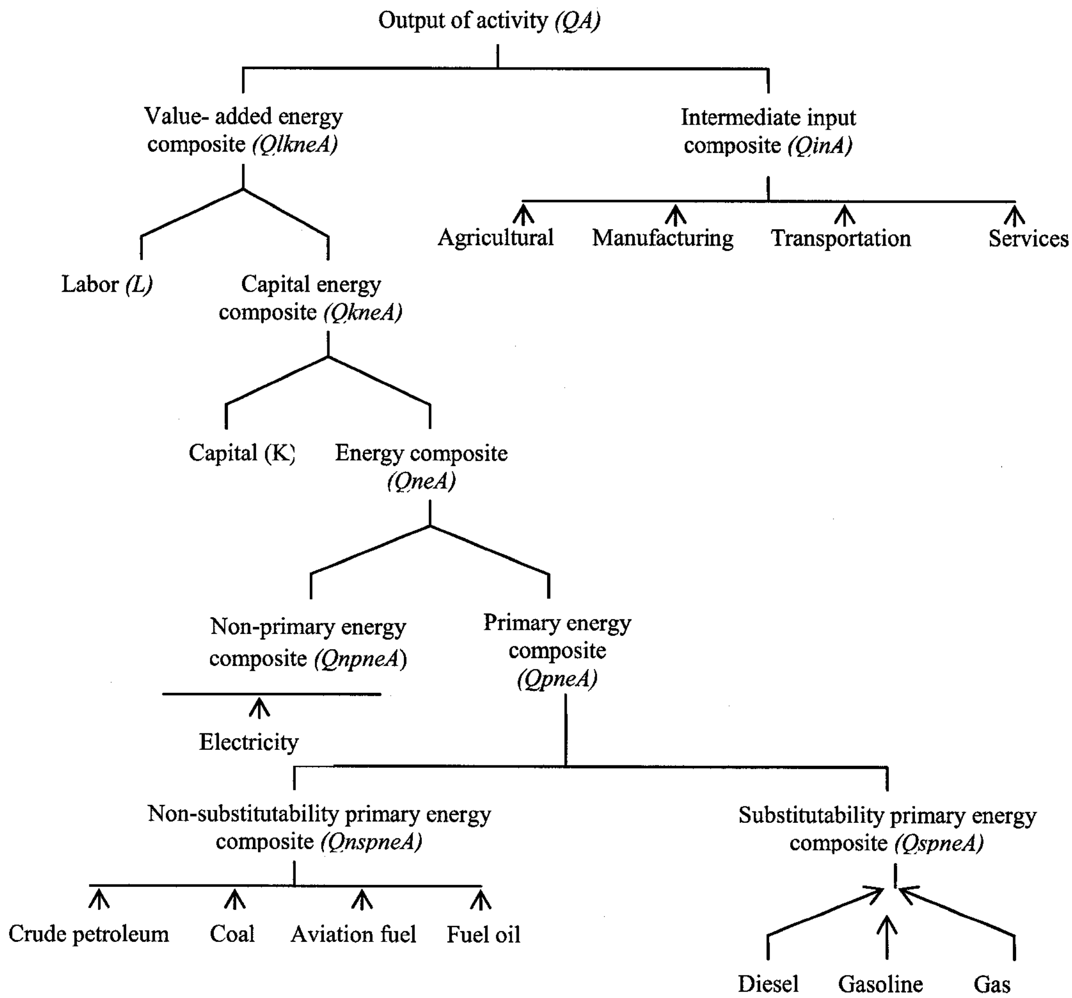
[9] It should be noted that I treat coal & lignite as non-substitutable primary-energy inputs. This is because, in Thailand, coal & lignite is mostly used in electricity production and is recently facing strong resistant from inhabitants surrounding electricity generation plant. Therefore, the possibility of substituting coal & lignite for other inputs is rather limited.

Figure 3-1: Production structure



3.1.1 Activity output (QA)

$$Min : PA_a(1 - tar_a)QA_a = PinA_aQinA_a + PlkneA_aQlkneA_a$$

$$+ tvr_a\left(L_aWdist_aW + K_aRdist_aR\right)$$

Subject to

$$QA_a = Min\left\{\frac{QinA_a}{in_a}, \frac{QlkneA_a}{inlkne_a}\right\}$$

The optimality conditions are:

$$QinA_a = in_a QA_a \tag{1}$$

$$QlkneA_a = inlkne_a QA_a \tag{2}$$

$$PA_a(1-tar_a)QA_a = PinA_a QinA_a + PlkneA_a QlkneA_a$$

$$+ tvr_a(L_a Wdist_a W + K_a Rdist_a R) \tag{3}$$

3.1.2 Intermediate input composite ($QinA$)

$$Min: PinA_a QinA_a = \sum_c ica_{c,a} Pq_c QinA_a$$

Subject to

$$QinA_a = \quad Min\left\{\frac{QCinA_{c,a}}{ica_{c,a}}\right\}$$

The optimality conditions are:

$$QCinA_{c,a} = ica_{c,a} QinA_a \tag{4}$$

$$PinA_a = \sum_c ica_{c,a} Pq_a \tag{5}$$

3.1.3 Value added-energy composite ($QlkneA$)

$$Min: PlkneA_a QlkneA_a \quad = \quad Wdist_a L_a W + PkneA_a QkneA_a$$

Subject to

$$QlkneA_a = \quad \alpha_a^{lkne}[\delta_a^{lkne} L_a^{-\theta_a^{lkne}} + (1-\delta_a^{lkne}) QkneA_a^{-\theta_a^{lkne}}]^{-\frac{1}{\theta_a^{lkne}}} \tag{6}$$

The optimality conditions are:

$$\frac{L_a}{QkneA_a} = \left[\frac{PkneA_a}{Wdist_a W}\frac{\delta_a^{lkne}}{(1-\delta_a^{lkne})}\right]^{\frac{1}{1+\theta_a^{lkne}}} \tag{7}$$

$$PlkneA_a QlkneA_a = Wdist_a L_a W + PkneA_a QkneA_a \tag{8}$$

3.1.4 Capital energy composite ($QkneA$)

$$Min: PkneA_a QkneA_a = Rdist_a K_a R + PneA_a QneA_a$$

Subject to

$$QkneA_a = \alpha_a^{kne}[\delta_a^{kne} K_a^{-\theta_a^{kne}} + (1-\delta_a^{kne}) QneA_a^{-\theta_a^{kne}}]^{-\frac{1}{\theta_a^{kne}}} \tag{9}$$

The optimality conditions are:

$$\frac{K_a}{QneA_a} = \left[\frac{PneA_a}{Rdist_a R}\frac{\delta_a^{kne}}{(1-\delta_a^{kne})}\right]^{\frac{1}{1+\theta_a^{kne}}} \tag{10}$$

$$PkneA_a QkneA_a = Rdist_a K_a R + PneA_a QneA_a \tag{11}$$

3.1.5 Energy composite ($QneA$)

$$Min: PneA_a QneA_a = PnpneA_a QnpneA_a + PpneA_a QpneA_a$$

Subject to

$$QneAD_a = \alpha_a^{ne}[\delta_a^{ne} QnpneA_a^{-\theta_a^{ne}} + (1-\delta_a^{ne}) QpneA_a^{-\theta_a^{ne}}]^{-\frac{1}{\theta_a^{ne}}} \tag{12}$$

The optimality conditions are:

$$\frac{QnpneA_a}{QpneA_a} = \left[\frac{PpneA_a}{PnpneA_a}\frac{\delta_a^{ne}}{(1-\delta_a^{ne})}\right]^{\frac{1}{1+\theta_a^{ne}}} \tag{13}$$

$$PneA_a QneA_a = PnpneA_a QnpneA_a + PpneA_a QpneA_a \tag{14}$$

3.1.6 Non-primary energy composite ($QnpneA$)

$$Min.: PnpneA_a QnpneA_a = \sum_c icnpne_{c,a} Pq_c QnpneA_a$$

Subject to

$$QnpneA_a = \quad Min\left\{\frac{QCnpneA_{c,a}}{icnpne_{c,a}}\right\}$$

The optimality conditions are:

$$QCnpneA_{c,a} = icnpne_{c,a}QnpneA_a \tag{15}$$

$$PnpneA_a = \sum_c icnpne_{c,a}Pq_c \tag{16}$$

3.1.7 Primary energy composite ($QpneA$)

$Min: PpneA_aQpneA_a$

$$= \quad PnspneA_aQnspneA_a + PspneA_aQspneA_a$$

Subject to

$$QpneA_a = \quad Min\left\{\frac{QnspneA_a}{inspne_a}, \frac{QspneA_a}{ispne_a}\right\}$$

The optimality conditions are:

$$QnspneA_a = \quad inspne_aQpneA_a \tag{17}$$

$$QspneA_a = \quad ispne_aQpneA_a \tag{18}$$

$$PpneA_a = inspne_aPnspneA_a + ispne_aPspneA_a \tag{19}$$

3.1.8 Non-substitutable primary energy composite ($QnspneA$)

$$Min: PnspneA_aQnspneA_a = \sum_c icnspne_{c,a}Pq_cQnspneA_a$$

Subject to

$$QnspneA_a = \quad Min \left\{ \frac{QCnspneA_{c,a}}{icnspne_{c,a}} \right\}$$

The optimality conditions are:

$$QCnspneA_{c,a} = icnspne_{c,a} QnspneA_a \tag{20}$$

$$PnspneA_a = \sum_c icnspne_{c,a} Pq_c \tag{21}$$

3.1.9 Substitutable primary energy composite ($QspneA$)

$$Min : PspneA_a QspneA_a = \sum_c Pq_c \; QCspneA_{c,a}$$

Subject to

$$QspneA_a = \quad \alpha_a^{spne} \left[\sum_c \delta_{c,a}^{spne} QCspneA_{c,a}^{-\theta_a^{spne}} \right]^{-\frac{1}{\theta_a^{spne}}} \tag{22}$$

The optimality conditions are:

$$Pq_c$$

$$= PspneA_a QspneA_a \left(\sum_c \delta_{c,a}^{spne} QCspneA_{c,a}^{-\theta_a^{spne}} \right)^{-1} \delta_{c,a}^{spne} QCspneA_{c,a}^{-\theta_a^{spne}-1} \tag{23}$$

$$PspneA_a QspneA_a = \sum_c Pq_c QCspneA_{c,a}$$

3.2 Domestic output and trade

3.2.1 Commodity output

Activity output is linked to commodity output through the fixed coefficient[10].

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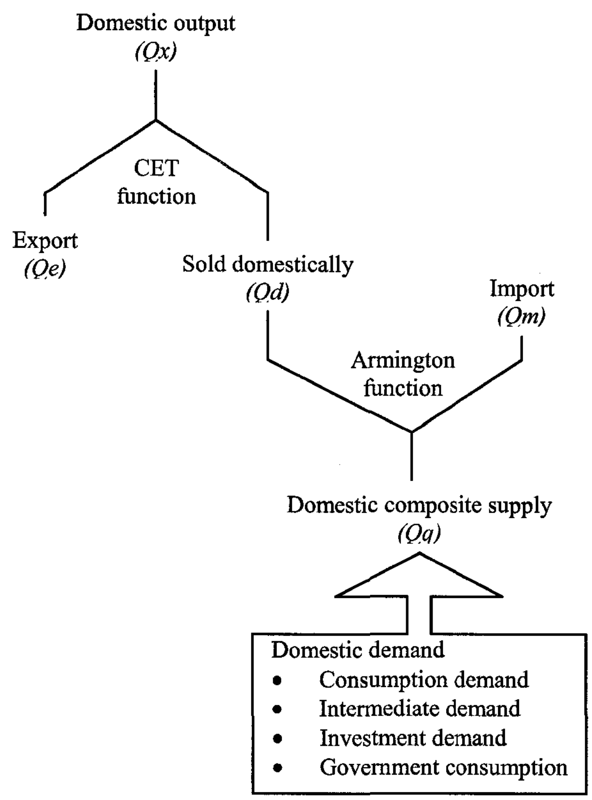
10 Since each commodity in SAM is produced only by a single activity, the quantity of domestic output of each commodity is equal to the output of that activity. That is $\theta_{a,c} = 1$.

$$Qx_c = \sum_a \theta_{a,c} QA_a \tag{24}$$

$$PA_a = \sum_c \theta_{a,c} Px_c \tag{25}$$

Figure 3-2: Flow of commodity



Domestic economy is linked to the world economy through trade as depicted in figure 3-2. The allocation of each domestic output to the domestic sale and export is described by CET function, which implies the assumption of imperfect transformability between these two destinations. The final ratio of domestic sales to exports of each commodity is determined by the endogenous ratio of export price to domestic supply price.

The relationship between domestic output and import of each commodity is described by the Armigton equation. Similar to the CET specification, the Armington equation implies the assumption of imperfect substitution between two sources of commodities. The final ratio of domestic output to import is determined by the endogenous ratio of import price to domestic supply price.

3.2.2 Allocation of domestic output

The behavior of domestic producers to allocate their output between domestic sales and exports is postulated as a revenue maximization problem.

$$Max: Px_c Qx_c = Pds_c Qd_c + Pe_c Qe_c$$

Subject to

$$Qx_c = \alpha_c^t \left[\delta_c^t Qe_c^{\theta_c^t} + (1-\delta_c^t) Qd_c^{\theta_c^t} \right]^{\frac{1}{\theta_c^t}} \tag{26}$$

The optimality conditions are:

$$\frac{Qe_c}{Qd_c} = \left[\frac{Pe_c (1-\delta_c^t)}{Pds_c \delta_c^t} \right]^{\frac{1}{(\theta_c^t - 1)}} \tag{27}$$

$$Px_c Qx_c = Pds_c Qd_c + Pe_c Qe_c \tag{28}$$

3.2.3 Combination of domestic composite goods

The behavior of domestic agents in choosing an optimal bundle of foreign and domestic commodities is depicted as a cost minimization problem.

$$Min: Pq_c (1 - tcr_c) Qq_c = Pds_c Qd_c + Pm_c Qm_c$$

Subject to

$$Qq_c = \alpha_c^q \left[\delta_c^q Qm_c^{-\theta_c^q} + (1-\delta_c^q) Qd_c^{-\theta_c^q} \right]^{-\frac{1}{\theta_c^q}} \tag{29}$$

The optimality conditions are:

$$\frac{Qm_c}{Qd_c} = \left[\frac{Pds_c\delta_c^q)}{Pm_c(1-\delta_c^q)}\right]^{\frac{1}{(1+\theta_c^q)}} \tag{30}$$

$$Pq_c(1-tcr_c)Qq_c = Pds_cQd_c + Pm_cQm_c \tag{31}$$

3.2.4 Export and import prices

Using the assumption of a small-open economy, the domestic economy faces a perfectly elastic world supply and demand at given import and export prices. Therefore, I define the import and export prices in local currency units as:

$$Pm_c = (1+tm_c)pwm_cExr \tag{32}$$

$$Pe_c = pwe_cExr \tag{33}$$

3.3 Institutions and Incomes

Institutions in the model are made up of households, state enterprise, private enterprise, government and the rest of the world. Gross income of domestic non-government institutions is made up of 4 components: factor income, domestic infra-institutional transfer, government transfer, and remittances to the rest of the world. Factor income is distributed to institutions proportionately to an institution's share in total factor supply.

3.3.1 Gross income of institutions

$$Yi_i = Yif_i + \sum_{i'} Trii_{i.i'} + trnsfr_{i,gov}cpi + trnsfr_{i,row}Exr \tag{34}$$

3.3.2 Infra-institutional transfer

$$Trii_{i,i'} = shii_{i,i'}(1-mpsbar_i)(1-Tins_i)Yi_i \tag{35}$$

3.3.3 Factor income

$$Yif_i = shil_i \sum_{a'} Wdist_a L_a W + shik_k \sum_a Rdist_a K_a R_a \tag{36}$$

3.4 Households and consumption

Households are grouped according to their occupational category into agricultural households, nonagricultural households, and government-employed households. With this level of disaggregation, the model is able to investigate the impacts of oil prices shock and subsidies on the welfare of each representative household.

3.4.1 Household disposable income

The disposable income of households is equal to their factor income net out of direct tax, and infra-institutional transfer.

$$Dy_h = (1 - Tins_h)\left(1 - \sum_i shii_{i,h}\right)Yi_h$$

3.4.2 Household consumption expenditure

$$Eh_h = (1 - mpsbar_h)(1 - Tins_h)\left(1 - \sum_i shii_{i,h}\right)Yi_h \tag{37}$$

3.4.3 Household consumption

Consumer preferences are described by a Stone-Geary utility function. Therefore, the consumer optimization problem can be postulated as a utility maximization problem as follows:

$$Max : U_h = \prod_c \left(Qh_{c,h} - \gamma^m_{c,h}\right)^{\beta^m_{c,h}}$$

Subject to

$$Eh_h = \sum_c Pq_c Qh_{c,h}$$

The optimality conditions are:

$$Qh_{c,h}Pq_c = Pq_c\gamma^m_{c,h} + \beta^m_{c,h}\left(Eh_h - \sum_c Pq_c\gamma^m_{c,h}\right) \tag{38}$$

$$Eh_h = \sum_c Pq_cQh_{c,h}$$

3.4.4 Consumer price index

In the model, consumer price index is the numeraire.

$$cpi = \sum_c cwts_cPq_c \tag{39}$$

3.5 Government

Government revenue is made up of direct taxes from non-government institutions, indirect taxes from activities and commodities, import tariffs, factor income, and transfers from the rest of the world. Government expenditure is composed of government consumption and transfers to households. In this model, government consumption is distributed across commodities according to the exogenous base year fixed share.

3.5.1 Government revenue

$$Yg = \sum_i Tins_iYi_i + \sum_a tvr_a(L_aWdist_aW + K_aRdist_aR)$$

$$+ \sum_a tar_aPa_aQa_a + \sum_c tm_cpwm_cQm_cExr_c + \sum_i tcr_cPq_cQq_c$$

$$+ Yi_{gov} + trnsfr_{gov,row}Exr \tag{40}$$

3.5.2 Government demand for consumption

$$Qg_c = qbag_cGadj \tag{41}$$

3.5.3 Direct tax rate

$$Tins_i = tinsbar_i + tinsdumy_iDtins \tag{42}$$

3.5.4 Government expenditure

$$Eg = \sum_c Pq_c Qg_c + \sum_i trnsfr_{i,row} cpi \tag{43}$$

3.6 System constraints

Factor and commodity balances are the equilibrium conditions for factor and commodity markets. Current account balance is specified in terms of foreign currency and the gap between spending and earning of foreign currency is foreign saving. Government saving indicates the difference between government revenue and its expenditure. Household savings is a fraction of its income after tax. Saving-investment balance requires that the sum of these savings be equal to total investment of the economy.

3.6.1 Commodity market equilibrium

$$\begin{aligned} Qq_c = & \sum_a QCinA_{c,a} + \sum_a QCnpneA_{c,a} + \sum_a QCnspneA_{c,a} + \sum_a QCspneA_{c,a} \\ & + \sum_h Qh_{c,h} + Qinv_c + qdst_c + Qg_c \end{aligned} \tag{44}$$

3.6.2 Labor market equilibrium

$$\sum_a L_a = \overline{ls} \tag{45}$$

3.6.3 Capital market equilibrium

$$\sum_a K_a = \overline{ks} \tag{46}$$

3.6.4 Government balance

$$Yg = Eg + Gsav \tag{47}$$

3.6.5 External balance

$$\sum_{c} pwm_c Qm_c = \sum_{i} pwe_c Qe_c + \sum_{i} trnsfr_{i,row} + Fsav \qquad (48)$$

3.6.6 Saving-investment balance

$$Pq_c Qinv_c = \psi_c Tsav \qquad (49)$$

$$Tsav = \sum_{i} mpsbar_i (1 - Tins_i) Yi_i + Gsav + ExrFsav - \sum_{c} Pq_c qdst_c \qquad (50)$$

3.7 Macroeconomic closures

In the model, I assume that both labor and capital are fully employed factors. However, capital is an activity-specific factor while labor mobile across production activities. With these assumptions, economy-wide wage rate is a labor market clearing variable and activity-specific rates are capital markets clearing variables.

For current account balance, given the managed-float exchange rate system, foreign saving is fixed and the exchange rate adjusts to maintain external balance. For government balance, in the base model, government savings and all tax rates are fixed. Therefore, government real consumption adjusts to maintain government balance.

3.8 Model calibration

The model is calibrated to the 1998 Social Accounting Matrix (SAM) of the Thai economy in Appendix B and a set of elasticity parameters in Appendix D. Note that in this study, I apply elasticity parameters found in relevant literature.

4 Simulation

To investigate the impacts of oil prices shock and subsidies policy on the Thai economy in 2004, a set of simulations is undertaken. This section reports the results of four simulations: (i) the impacts of oil prices shock, (ii) the impacts of a subsidies policy when its cost is financed by a contraction of government consumption, (iii) the impacts of a subsidies policy when its cost is financed by a contraction of government consumption and direct tax rates increase, and (iv) the impacts of a subsidies policy when its total cost is financed by direct tax rates increase.

4.1 The impacts of oil prices shock

The main interest in the first simulation is to investigate the impacts of oil prices shock in 2004 on the Thai economy. In this simulation, I shock the model by the actual percentage change of energy commodity prices as shown in Table 4-1[11]. The percentage change of crude oil price is calculated from crude oil prices in the major oil markets. The percentage changes of gasoline, diesel and fuel oil prices are calculated using a Thailand energy prices dataset, which is available from the Energy Policy and Planning Office (EPPO) of Thailand.

In simulation, I assume that both the import and export prices of each energy commodity increase by the same magnitude. In addition, the percentage changes of export and import prices of aviation fuel are approximated by the change in export and

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[11] See Table E-3 in Appendix E for calculation.

import prices of gasoline[12]. In order to isolate the impacts of oil prices shock from other factors, the world market prices of other commodities are assumed to be constant. Taking into account that the run-up of oil prices in 2004 occurred in a situation of excess capacity in the global market, this assumption should not be far from reality.

Table 4-1: Shock to the model variables (%Δ)

	Crude petroleum	Gasoline		Diesel	Aviation fuel	Fuel oil	Gas
		ULG 95[13]	URG 91[14]				
Actual change in import price	34.00	43.9	42.5	38.2	42.5	15.4	25.0
Shock to model's export & import prices	34.00	42.5		38.2	42.5	15.4	25.0

Table 4-2 shows the impacts of oil prices shock on the domestic market prices of energy commodities. In general, it raises the domestic market prices of energy commodities but at a smaller magnitude than the shock. In addition, simulation results are very close to the changes of shadow prices of energy commodities, which make the next section's analysis relevant.

Table 4-2: Energy prices (%Δ)

	Crude petroleum	Gasoline	Diesel	Aviation fuel	Fuel oil	Electricity	Gas
Model results							
- Domestic supply prices	31.75	21.94	24.05	20.53	7.63	1.18	23.95
- Domestic market prices	33.22	21.97	24.41	22.40	8.61	1.17	24.07
Actual market prices + subsidies (shadow prices)	-	23.40	25.60	23.40	8.50	-	-

[12] This is because import price data of aviation fuel is not available, but it's historical data reveals a close movement with gasoline price

[13] Unleaded premium gasoline (Octane = 95)

[14] Unleaded regular gasoline (Octane = 91)

4.1.1 Impacts on the aggregate economy

Table 4-3 reports the impacts of oil prices shock on the economy at aggregate level. Overall, it results in a contraction of real GDP by 0.14 percent. The reduction of aggregate income reduces private consumption and investment by 1.05 and 1.18 percent respectively. Government consumption increases by 2.75 percent as a result of higher indirect tax revenues.

Table 4-3: Impacts of oil prices shock on the aggregate economy

	Base case (฿ billion)	% Δ (except for CV)
Absorption	3,914.51	-0.64
- Private consumption	2,529.28	-1.05
- Fixed investment	1,027.92	-1.18
- Government consumption	500.70	2.75
Export	2,723.72	-0.25
Import	2,002.30	-1.26
- Net export	721.41	2.57
GDP	4,635.92	-0.14
Producer price index	-	0.79
Exchange rate	-	-0.003
Compensating variation (฿ billion)		-26.67

An increase in energy cost of production raises the producer price index by 0.79 percent. With the assumption of fixed foreign saving, the real exchange rate slightly appreciates to restore external balance. A change in relative prices reduces real export but as import decreases at a faster rate, the net real export increases by 2.57 percent. Measured by compensating variation, oil prices shock reduces the aggregate welfare by ฿ 26.67 billion, which is equivalent to 0.57 percent of GDP[15].

[15] According to the model specification, the increase in government consumption does not contribute to household welfare. Therefore, in some senses, the negative impact of oil prices shock on household welfare is seen to be overestimated. For analytical purposes, I run a separate simulation by fixing the government consumption and used addition government revenues (that are generate by oil prices shock) to reduce the income tax burden on households. The results show that, the aggregate welfare decreases by ฿ 12.02 billion (0.26 percent of GDP).

4.1.2 Sectoral impacts

4.1.2.1 Costs and Prices

Table 4-4 summarizes the impacts of oil prices shock on per-unit costs and prices across production sectors. On average, except for electricity, oil prices shock raises the per-unit energy cost of energy productions by approximately 20 to 33 percent.

Table 4-4: Impacts of oil prices shock on sectoral costs and prices (%Δ)

	Cost per-unit of input				Price per-unit of output		
	Energy	Intermediate	Capital	Labor	Activity	Domestic supply	Domestic market
Agricultural	21.10	-0.25	-2.48	-1.22	-0.30	-0.38	-0.36
Manufacturing	7.11	-0.29	-2.55	-1.22	-0.44	-0.66	-0.47
Coal & lignite	22.68	1.92	-22.59	-1.22	-13.82	-13.82	-11.95
Crude petroleum	24.45	-0.30	67.99	-1.22	31.87	31.75	33.22
Gasoline	32.91	-0.26	-9.99	-1.22	23.54	21.94	21.97
Diesel	32.90	-0.26	-11.71	-1.22	25.06	24.05	24.41
Aviation fuel	32.91	-0.27	50.94	-1.22	30.23	20.53	22.40
Fuel oil	19.46	-0.02	-17.69	-1.22	7.92	7.63	8.61
Electricity	6.46	-0.01	-1.01	-1.22	1.18	1.18	1.17
Gas	32.77	-0.39	-9.37	-1.22	24.33	23.95	24.07
Transportation	21.28	0.74	-5.33	-1.22	2.62	3.24	2.89
Services	7.69	-0.21	-0.53	-1.22	-0.40	-0.46	-0.42

For the non-energy sector, the strong increases in per-unit energy cost are observed in agricultural and transportation productions. This is because energy inputs of these two sectors are mostly primary energy commodities, in particular, diesel and gasoline, which are directly affected by the shock. In contrast, energy inputs of manufacturing and services productions are mostly electricity. Therefore, the impacts of oil prices shock on their per-unit energy cost are less severe than in other non-energy productions.

Oil prices shock reduces the per-unit labor cost of every production sector by 1.22 percent. Since capital is activity-specific, the variation in each sectoral rental rate is driven by the fluctuation in its corresponding production activity. Entrepreneurs in crude petroleum and aviation fuel productions are better off as the rate of return on their capital stock increase by 67.99 and 50.94 percent respectively, while the entrepreneurs in other sectors are worse off.

An increase in energy cost generates an upward pressure on the prices of high energy-content commodities. On average, the domestic market prices of energy commodities increase by 8 to 33 percent, except for coal & lignite. Electricity is a special case, its market price increases by only 1.17 percent because it has a lower energy content than other energy commodities. For non-energy commodities, the domestic market prices of agricultural, manufacturing, coal & lignite and services decline. Manufacturing is an intermediate-input intensive production while agricultural, services and coal & lignite are value-added intensive productions. Therefore, the effect of higher energy cost is offset by the reduction in non-energy cost and a contraction in the demand for their products. In contrast, the domestic market price of transportation increases by 2.89 percent.

4.1.2.2 Households

The impacts of oil prices shock on households are summarized in Table 4-5. Government-employed households experience the largest drop in real consumption and nominal income, followed by nonagricultural and agricultural households respectively. The extent to which the household income is affected by oil prices shock depends on the structure of the household endowment, how the shock reallocates factor incomes in the economy and the change in relative prices. In aggregate, oil prices shock reduces wage income by more than rental income. The strongest income reduction is observed in government-employed households, which are those with the largest share of labor income.

Table 4-5: Impacts of oil prices shock on households

	Agricultural Households	Nonagricultural Households	Government – employed households
Real consumption (%Δ)	-0.92	-1.06	-1.19
Total nominal income (%Δ)	-1.01	-1.04	-1.17
Compensating variation (฿ billion)	-5.53	-16.41	-4.73
- Per-capita C.V (฿)	-218.75	-549.56	-780.53
Sources of household income			
Wage income (%Δ)	38.08	38.99	85.58
Rental income (%Δ)	56.04	58.14	13.05
Government transfer (%Δ)	2.15	1.21	0.59
Transfer from ROW (%Δ)	3.73	1.65	0.77
Change in aggregate income			
Wage income (%Δ)		-1.22	
Rental income (%Δ)		-0.98	

Although agricultural households have the largest share of energy consumption[16], Table 4-5 shows that the largest per-capita welfare loss occurred with government-employed households, followed by nonagricultural and agricultural households respectively. This implies that agricultural households, who are the lowest income group[17], suffer the least from oil prices shock.

4.1.2.3 Demand for sectoral commodities

Table 4-6 shows the impacts of oil prices shock on the demand for sectoral commodities. Based on the assumption of fixed government savings, the change in domestic demand for each commodity is determined by variations in demand for private consumption, intermediate input, investment, and government consumption. The results

[16] See Table C-9 of Appendix C for the structure of consumption bundle

[17] For per-capita income, see Table C-6 of Appendix C.

show that, an increase in oil prices reduces real domestic demand for every commodity while its impact on real export varies across sectors.

Table 4-6: Impacts of oil prices shock on demand for sectoral commodities (%Δ)

	Household consumption	Intermediate demand	Government consumption	Investment Demand	Domestic demand	Export
Agricultural	-0.82	-0.33	2.75	-1.26	-0.44	-0.28
Manufacturing	-1.01	-0.40	2.75	-1.15	-0.66	-0.20
Coal & lignite	-	-2.17	-	-	-2.03	3.70
Crude petroleum	-	-3.41	-	-	-3.34	3.95
Gasoline	-4.39	-4.29	-	-	-4.30	6.78
Diesel	-4.72	-4.67	-	-	-4.65	2.18
Aviation fuel	-	-4.92	-	-	-4.82	7.70
Fuel oil	-	-3.67	2.75	-	-3.58	1.09
Electricity	-1.05	-0.18	2.75	-	-0.18	-0.77
Gas	-5.58	-3.34	2.75	-	-3.69	-3.22
Transportation	-2.14	-0.69	2.75	-4.37	-1.20	-3.31
Services	-0.80	-0.38	2.75	-1.20	-0.02	0.13

4.1.2.4 Sectoral trades

Relative price changes affect the competitiveness of domestic products. Based on the assumption of imperfect substitution between domestic and foreign commodities both in production and consumption, Table 4-7 summarizes the impacts of oil prices shock on foreign trade of sectoral commodities.

Table 4-7: Impacts of oil prices shock on sectoral trades (%Δ)

	Domestic supply price	Domestic market price	World market price (FCU)	Real export	Real import	Net export (import)
Agricultural	-0.38	-0.36	-	-0.28	-0.58	-0.18
Manufacturing	-0.66	-0.47	-	-0.20	-1.00	3.18
Coal & lignite	-13.82	-11.95	-	3.70	-8.07	(-8.08)
Crude petroleum	31.75	33.22	34.50	3.95	-7.42	(-7.85)
Gasoline	21.94	21.97	42.50	6.78	-24.22	7.51
Diesel	24.05	24.41	38.20	2.18	-18.56	15.11
Aviation fuel	20.53	22.40	42.50	7.70	-24.23	12.91
Fuel oil	7.63	8.61	15.40	1.09	-7.03	(-9.79)
Electricity	1.18	1.17	-	-0.77	0.40	(0.69)
Gas	23.95	24.07	25.00	-3.22	-4.19	-2.93
Transportation	3.24	2.89	-	-3.31	0.78	-7.54
Services	-0.46	-0.42	-	0.13	-0.19	0.72

For non-primary energy commodities[18], oil prices shock raises domestic supply prices of electricity and transportation. While the world market prices of these commodities remains unchanged, the increase in their domestic supply prices leads to a reduction of the net real-export of transportation and an increase in the net real-import of electricity. Conversely, the reduction in domestic supply prices raises the net real-export of manufacturing and services commodities. For primary energy commodities, domestic supply prices of crude petroleum, diesel, gasoline, aviation fuel, and fuel oil increased by a smaller magnitude than the increase in their world market prices. This is why improvements are observed in the trade balance of these sectoral commodities.

The negative impacts of oil prices shock on trade balance occur mostly through the deterioration in the trade balance of agricultural and transportation commodities. However, these negative impacts are outweighed by an increase in the net real-export of manufacturing and services, which account for approximately 80 percent of total imports and exports. As a result, the aggregate net export increases by 2.57 percent in real terms.

4.1.2.5 Sectoral supplies

Table 4-8 summarizes the impacts of oil prices shock on supply across production sectors. Oil prices shock contributes to the expansion of production activity of crude petroleum, aviation fuel and services but it depresses the production activity of other sectors. The expansion of economic activity in crude petroleum production is driven by the decrease of its net real-import. As its domestic supply price increases by a smaller magnitude than its world market price, domestic demand for crude petroleum shifts

[18] As defined in previous sections, primary energy commodities are coal & lignite, crude petroleum, gasoline, diesel, aviation fuel, fuel oil and gas.

towards domestic product. The expansion in economic activity of both aviation fuel and services production is driven by the increase in their net real-export.

Table 4-8: Impacts of oil prices shock on sectoral supplies (%Δ)

	Level of activity	Domestic supply	Net export (import)
Agricultural	.-0.40	-0.43	-0.18
Manufacturing	-0.43	-0.53	3.18
Coal & lignite	-0.97	-0.97	(-8.08)
Crude petroleum	1.71	1.61	(-7.85)
Gasoline	-3.38	-4.26	7.51
Diesel	-3.76	-4.23	15.11
Aviation fuel	2.03	-2.60	12.91
Fuel oil	-2.90	-3.05	(-9.79)
Electricity	-0.19	-0.18	(0.69)
Gas	-3.48	-3.63	-2.93
Transportation	-1.80	-1.44	-7.54
Services	0.008	-0.009	0.72

4.1.2.6 Savings

Investment in the model is saving-driven. As foreign and government savings are fixed at their base year levels, a reduction of aggregate investment implies the decrease of household and enterprise savings. Table 4-9 shows that savings of every household and enterprise decreases and results in a reduction of aggregate savings of 1.61 percent in nominal terms.

Table 4-9: Impacts of oil prices shock on savings

	Households			Enterprises		Total
	Agricultural	Non agricultural	Government - employed	State	Private	
Base case (฿ billion)	-68.39	478.96	45.97	90.30	632.62	1027.92
% Δ	-1.01	-1.17	-1.04	-1.35	-1.28	-1.61

4.1.2.7 Government balance

The impacts of oil prices shock on government balance are summarized in Table 4-10. Overall, it raises aggregate government revenue by 1.53 percent as a result of higher price and the expansion of economic activity in energy productions. Since government savings is fixed at a base year level, an increase in aggregate government revenue raises government consumption by 2.37 percent in nominal terms.

Table 4-10: Impacts of oil prices shock on government balance (฿ billion)

Revenues	Base Case	% Δ	Expenditures	Base case	% Δ
Capital income	79.40	-0.97	Consumption	500.70	2.42
Indirect taxes	475.62	3.25	Agricultural	0.83	2.41
Value added	139.64	0.28	Manufacturing	23.88	2.26
Indirect taxes on activity	185.46	7.32	Fuel oil	0.45	13.33
Indirect taxes on commodity	88.49	2.26	Electricity	4.79	3.97
Import taxes	62.03	-0.82	Gas	0.41	26.83
Direct taxes	219.28	-1.17	Transportation	7.92	5.68
Net transfer from ROW	19.81	0.00	Services	462.42	2.32
Total income	794.11	1.53	Net transfer to institutions	11.97	0.00
			Total expenditure	512.67	2.37
			Savings	281.45	0.00

4.2 The impacts subsidies policy when its cost is financed by government consumption contraction

The main interest of this simulation is to evaluate the role of a subsidies policy in 2004. To finance the cost of subsidies, I assume that the government contracts its consumption sufficiently to write off the cost. Based on this assumption, the total cost of subsidies is a burden on the government budget. In this simulation, I first run the oil prices shock as a base case scenario. A subsidies policy is then introduced to the model as negative indirect tax rates on gasoline and diesel commodities (see Table 4-11). To analyze the impacts of subsidies, I compare the results of the base case scenario (oil prices shock without subsidies in 4.1) with the results of the model with oil prices shock and subsidies.

The direct impact of subsidies is the reduction of domestic market prices of gasoline and diesel of 5.5 and 16.3 percent respectively.

Table 4-11: Per-unit subsidies and indirect tax rates of gasoline and diesel

	Gasoline		Diesel
	ULG 95	URG 91	
Actual per-unit subsidy (% base year price)	5.7	6.6	23.9
Shock to the model through indirect tax rate	-6.1		-23.9
% Δ in market prices implied by the model	- 5.5		-16.3
Gap between shadow and actual market retail prices (%)	- 5.4	- 6.1	- 16.6

4.2.1 Impacts on the aggregate economy

Table 4-12 summarizes the impacts of a subsidies policy in 2004 on the economy at aggregate level. Overall, it raises GDP by 0.07 percent. Given that the total cost of subsidies is a burden on the government budget, government consumption decreases by 4.35 percent. The expansion of aggregate income stimulates private consumption and investment by 0.82 and 0.39 percent respectively. Measured by compensating variation (CV), subsidies raise aggregate welfare by ฿ 20.60 billion. Producer price index increases by 0.16 percent while domestic currency significantly depreciates.

Table 4-12: Impacts of subsidies on the aggregate economy

	Base case (฿ billion)	%Δ (except for CV)
Absorption	3889.56	0.05
- Private consumption	2502.7	0.82
- Fixed investment	1015.78	0.39
- Government consumption	514.47	-4.35
Export	2716.96	0.33
Import	1977.02	0.39
GDP	4629.51	0.07
Producer price index	-	0.16
Exchange rate	-	0.51
Compensating variation (฿ billion)		20.60

The increase of CV does not imply that subsidies raise the allocation efficiency. To replicate the general situation of the Thai economy, without subsidies in simulation 4.1, I fixed government savings and therefore the real government consumption is a market clearing variable for government balance. As oil prices shock raises government income from indirect taxes, government consumption increases. To finance the cost of subsidies in this simulation, government consumption has to be lowered than in the case of oil prices shock without subsidies in 4.1. Therefore, private consumption increases but on the contraction of government real consumption. Thus, the increase of CV in Table 4.12 is simply a result of consumption transfer from government to households.

While the alteration of CV cannot reflect the impact of subsidies on the allocation efficiency, a likely surprise is that subsidies raise GDP in the model of this study. This contradicts the findings in some previous studies. For example, Clark and Edwards (1997) show that removing hard coal subsidies in Germany eliminates distortion and results in a higher GDP, which implies subsidies reduce aggregate welfare. However, the second best theory suggests that the welfare impact of introducing subsidies into a distorted market could be affected by the existing distortions. In the work of Clark and Edwards (1997), the coal market distortion in the base run is totally eliminated in the counterfactual analysis. Therefore, removing subsidies in their study results in a net efficiency gain which should be reflected in a higher GDP. In this study, however, gasoline and diesel markets in the base run are distorted by high indirect tax rates on activities. Therefore introducing final demand subsidies in counterfactual analysis potentially reduces the existing distortion. If this is the case, GDP can increase.

4.2.2 Sectoral impacts

4.2.2.1 Costs and prices

The impacts of subsidies on sectoral costs and product prices are summarized in Table 4-13. The results show that subsidies reduce the per-unit energy cost of every non-energy production sector. The strong contributions of energy cost reduction are observed in agricultural and transportation productions.

The larger reductions of per-unit energy cost in agricultural and transportation productions than manufacturing and services productions are attributable to the structure of energy inputs. Since energy inputs of agricultural and transportation productions are mainly made up of diesel and gasoline, these two sectors directly benefit from subsidies. In contrast, the main energy inputs of manufacturing and services productions are electricity. Therefore, these two sectors benefit less from subsidies than other non-energy productions.

Within energy sector, the reduction of per-unit energy cost is observed in coal & lignite and crude petroleum productions. However, subsidies raise the domestic market price of crude petroleum by 0.77 percent and result in higher per-unit energy cost in other energy productions, with the exception of coal & lignite.

Table 4-13: Impacts of subsidies on sectoral costs and prices (% Δ)

	Cost per-unit of input				Price per-unit of output		
	Energy	Intermediate	Capital	Labor	Activity	Domestic supply	Domestic market
Agricultural	-12.62	0.08	2.28	0.85	0.32	0.28	0.29
Manufacturing	-1.48	0.25	2.90	0.85	0.58	0.61	0.58
Coal & lignite	-15.20	-0.32	6.08	0.85	3.10	3.10	2.71
Crude petroleum	-4.78	-0.18	3.30	0.85	1.05	1.07	0.77
Gasoline	0.73	-0.16	-2.72	0.85	0.41	0.39	-5.46
Diesel	0.72	-0.17	55.25	0.85	4.34	4.68	-16.27
Aviation fuel	0.73	-0.16	6.98	0.85	2.39	4.21	3.88
Fuel oil	1.25	-0.24	14.08	0.85	2.94	3.04	2.71
Electricity	0.81	-0.06	0.67	0.85	0.63	0.63	0.63
Gas	0.72	-0.15	-13.99	0.85	-0.26	-0.69	-0.56
Transportation	-6.61	-0.32	3.50	0.85	-0.52	-0.75	-0.62
Services	-1.93	-0.08	-1.67	0.85	-0.62	-0.79	-0.68

4.2.2.2 Households

Table 4-14 shows the impacts of a subsidies policy on households. When the total cost of subsidies is a burden on the government budget, subsidies raise real consumption and nominal income of every household. In terms of nominal income, government-employed households are better off the most, followed by nonagricultural and agricultural households. Therefore, a subsidies policy is a regressive measure for income distribution.

Subsidies raise real consumption and nominal income of nonagricultural and government-employed households by almost the same magnitude. Welfare per-capita, however, shows that the benefit of subsidies is largely distributed to government-employed households, followed by nonagricultural and agricultural households.

Table 4-14: Impacts of subsidies on households

	Agricultural Household	Nonagricultural Household	Government – employed household
Real consumption (%Δ)	0.62	0.88	0.90
Total nominal income (%Δ)	0.81	0.82	0.84
Disposable income (%Δ)	0.81	0.82	0.84
Compensation variation (฿ billion)	3.70	13.39	3.51
- Per-capita C.V (฿)	146.36	448.43	579.21
Source of household income			
Wage income (%)	38.08	38.99	85.58
Rental income (%)	56.04	58.14	13.05
Government transfer (%)	2.15	1.21	0.59
Transfer from ROW (%)	3.73	1.65	0.77
Change in aggregate income			
Wage income (%Δ)		0.85	
Rental income (%Δ)		0.83	

According to household consumption structure, agricultural households have the largest share of consumption spending on gasoline and diesel as compared to those of other households[19]. With this consumption structure, the usual consumption bundle analysis tends to predict that subsidies policy in 2004 would benefit agricultural households the most. However, this study shows that this prediction does not necessarily hold true when the general equilibrium effects are taken into account. The impacts of subsidies on income and welfare distribution also depend on how subsidies redistribute

[19] See Table C-9 of Appendix C for the structure of consumption bundle

factor income in the economy, the structure of household incomes and the change in relative prices.

4.2.2.3 Domestic demand for sectoral commodities

Table 4-15 shows the impacts of subsidies on domestic demand for sectoral commodities. Energy subsidies contribute to the expansion of domestic demand for almost every commodity. However, domestic demand for gas, gasoline and services decreases. The contraction of domestic demand for services is attributable to the reduction of government consumption while the contraction of domestic demand for gas and gasoline is attributable to the role of energy substitution in production.

Table 4-15: Impacts of subsidies on demand for sectoral commodities (%Δ)

	Household consumption	Intermediate demand	Government consumption	Investment Demand	Domestic demand	Export
Agricultural	0.64	0.22	-4.35	0.58	0.31	0.41
Manufacturing	0.71	0.28	-4.35	0.29	0.37	0.29
Coal & lignite	-	0.51	-	-	0.47	-0.50
Crude petroleum	-	1.62	-	-	1.59	-0.38
Gasoline	1.48	-0.55	-	-	-0.36	-0.28
Diesel	3.91	4.92	-	-	4.88	2.19
Aviation fuel	-	2.11	-	-	2.07	-0.61
Fuel oil	-	1.45	-4.35	-	1.40	-0.30
Electricity	0.44	0.08	-4.35	-	-0.01	-0.07
Gas	0.63	-2.48	-4.35	-	-1.93	-1.25
Transportation	1.11	0.36	-4.35	1.50	0.57	1.43
Services	0.95	0.21	-4.35	1.56	-0.29	0.14

4.2.2.4 Sectoral supplies

Table 4-16 summarizes the impacts of subsidies on sectoral supplies. Energy subsidies contribute to the expansion of production activity in almost every production sector. The strong positive impact observed in the production of diesel is attributable to the increase in the demand for its product. The contraction of production activity of services is attributable to the decrease in government demand.

Table 4-16: Impacts of subsidies on sectoral supplies (%Δ)

	Level of activity	Domestic supply	Real export
Agricultural	0.34	0.32	0.41
Manufacturing	0.33	0.35	0.29
Coal & lignite	0.28	0.28	-0.50
Crude petroleum	0.21	0.24	-0.38
Gasoline	-0.35	-0.36	-0.28
Diesel	4.51	4.71	2.19
Aviation fuel	0.50	1.58	-0.61
Fuel oil	1.14	1.20	-0.30
Electricity	-0.01	-0.01	-0.07
Gas	-1.62	-1.84	-1.25
Transportation	0.81	0.67	1.43
Services	-0.20	-0.25	0.14

4.2.2.5 Savings

An expansion of aggregate investment is driven by an increase in aggregate savings. Since foreign and government savings are fixed in the model, it implies an increase in the savings of households and enterprises. Table 4-17, shows that subsidies raise savings of every household and enterprise, and result in an increase in aggregate savings of 0.87 percent in nominal terms.

Table 4-17: Impacts of subsidies on savings

	Household			Enterprises		Total
	Agricultural	Non Agricultural	Government - employed	State	Private	
Base case (฿ billion)	-67.70	473.96	45.44	89.07	624.50	1011.34
% Δ	0.81	0.82	0.84	1.15	0.92	0.87

4.2.2.6 Government balance

Subsidies reduce aggregate government revenue by 3.13 percent, mainly through the reduction of indirect tax income. This is expected since the total cost of subsidies is a burden on the government budget, and it enters the model as negative indirect tax rates on gasoline and diesel commodities. As shown in Table 4-18, based on the assumption of fixed government savings, the government has to contract its consumption spending by 4.93 percent to finance the total cost of subsidies.

Table 4-18: Impacts of subsidies on government balance (฿ billion)

Revenues	Base case	% Δ	Expenditures	Base case	% Δ
Capital income	78.63	0.83	Consumption	512.81	-4.93
Indirect taxes	491.08	-5.68	Agricultural	0.85	-3.53
Value added	140.03	1.07	Manufacturing	24.42	-3.81
Indirect taxes on activity	199.04	2.22	Fuel oil	0.51	-1.96
Indirect taxes on commodity	90.49	-37.95	Electricity	4.98	-3.82
Import taxes	61.52	0.88	Gas	0.52	-5.77
Direct taxes	216.72	0.87	Transportation	8.37	-4.90
Net transfer from ROW	19.81	0.50	Services	473.16	-5.00
Total income	806.24	-3.13	Net transfer to institutions	11.98	0.00
			Total expenditure	524.79	-4.93
			Savings	281.45	0.00

4.3 The impacts of subsidies policy when its cost is financed by government consumption contraction and income tax

In this experimental simulation, I assume that the government finances the cost of subsidies in part by contracting its real consumption to the level before oil prices shock. The remaining cost of subsidies is then financed by raising household income tax rates. Based on this assumption, the cost of subsidies is partially a burden on household budgets.

Similarly, to 4.2, in this simulation, subsidies enter the model, as they did in 4.2, as negative indirect tax rates on gasoline and diesel commodities (see Table 4-11). However, the real government consumption is fixed at the level before oil prices shock. To analyze the impacts of subsidies, I compare the results of the base case scenario (oil prices shock without subsidies in 4.1) with the results of this simulation. In addition, to analyze the implications of different financing scenarios, I compare the results of this simulation (cost of subsidies is partially a burden on household budgets) to the results in 4.2 (total cost of subsidies is a burden on government budget).

Table 4-19: Per-unit subsidy and indirect tax rates of gasoline and diesel

	Gasoline		Diesel
	ULG 95	URG 91	
Actual per-unit subsidy (% base year price)	5.7	6.6	23.9
Shock to the model through indirect tax rate	-6.1		-23.9
% Δ in market prices implied by the model	- 5.6		-16.4
Gap between shadow and actual market retail prices (%)	- 5.4	- 6.1	- 16.6

The direct impact of subsidies is the reduction of domestic market prices for gasoline and diesel of 5.6 and 16.4 percent respectively.

4.3.1 Impacts on the aggregate economy

The impacts of a subsidies policy on the aggregate economy are summarized in Table 4-20. Overall, it raises GDP by 0.07 percent. Private consumption increases by 0.46 percent while government consumption decreases by 2.68 percent. Producer price index increases by 0.16 percent and domestic currency depreciates by 0.39 percent.

Table 4-20: Impacts of subsidies on the aggregate economy

	Base case (฿ billion)	%Δ (except for CV)
Absorption	3889.56	0.05
- Private consumption	2502.7	0.46
- Fixed investment	1015.78	0.42
- Government consumption	514.47	-2.68
Export	2716.96	0.27
Import	1977.02	0.32
GDP	4629.51	0.07
Producer price index	-	0.16
Exchange rate	-	0.39
Compensating variation (฿ billion)	-	11.48

Overall, the simulation results show that, when the cost of subsidies is partially financed by direct tax increase, the impacts of a subsidies policy on the aggregate economy are similar to its impacts when the total cost of subsidies is financed by a contraction of government consumption as described in 4.2. However, domestic demand is increasingly determined by government consumption, and the pressure on domestic currency depreciation is less severe. Moreover, since the cost of subsidies is partially a burden on household budgets, household welfare increases by a smaller magnitude than when the total cost of subsidies is financed by a contraction of government consumption[20].

4.3.2 Sectoral impacts

The simulation results show that the impacts of a subsidies policy on sectoral demands and sectoral supplies are very similar to its impacts when the total cost of subsidies is financed by the contraction of government consumption. Therefore, in this subsection, I limited the discussion to the impacts of subsidies on households and government budget.

4.3.2.1 Households

Table 4-21 shows the impacts of subsidies on households. Since the cost of subsidies is partially a burden on household budgets, the real consumption of every household increases by a smaller magnitude than when the total cost of subsidies is financed by the contraction of government consumption. In addition, with the assumption of a uniform direct tax rates increase, the income tax burden on agricultural households increases by a larger magnitude than those of nonagricultural and government-employed households.

In terms of income, subsidies reduce income-gaps between agricultural households and government-employed households, and between nonagricultural

[20] As described in 4.2.1, the increase in CV indicates consumption transfer from government to household.

households and government-employed households. However, income gap between agricultural and nonagricultural households is increasingly widened.

Table 4-21: Impacts of subsidies on households

	Agricultural Households	Nonagricultural Households	Government – employed households
Real consumption (%Δ)	0.35	0.50	0.46
Total nominal income (%Δ)	0.81	0.82	0.80
Disposable income (%Δ)	0.46	0.47	0.42
Direct tax burden (%Δ)	71.58	9.51	4.94
Compensating variation (฿ billion)	2.06	7.62	1.80
- Per-capita C.V (฿)	81.49	255.19	297.03
Change in aggregate income			
Wage income (%Δ)		0.80	
Rental income (%Δ)		0.87	

In terms of per-capita welfare, the largest benefits occurred for government-employed households, followed by nonagricultural and agricultural households respectively. Therefore, the impacts of subsidies on welfare distribution are indifferent between these two alternative financing scenarios.

4.3.2.2 Government balance

Table 4-22: Impacts of subsidies on government balance (฿ billion)

Revenues	Base case	% Δ	Expenditures	Base case	% Δ
Capital income	78.63	0.86	Consumption	512.81	-2.91
Indirect taxes	491.08	-5.77	Agricultural	0.85	-2.35
Value added	140.03	1.11	Manufacturing	24.42	-2.25
Indirect taxes on activity	199.04	2.07	Fuel oil	0.51	-1.96
Indirect taxes on commodity	90.49	-38.06	Electricity	4.98	-2.21
Import taxes	61.52	0.67	Gas	0.52	-3.85
Direct taxes	216.72	5.83	Transportation	8.37	-3.46
Net transfer from ROW	19.81	0.40	Services	473.16	-2.95
Total income	806.24	-1.85	Net transfer to institutions	11.98	0.00
			Total expenditure	524.79	-2.85
			Savings	281.45	0.00

Table 4-22 shows the impacts of subsidies on government budget when the cost of subsidies is partially a burden on household budgets. In order to finance the cost of subsidies, the government contracts its real consumption to the level before oil prices shock, which results in the reduction of total government expenditure by 2.85 percent. To finance the remaining cost, the government raises household income tax rates by 0.003 percent, which results in a direct tax income increase of 5.83 percent.

4.4 The impacts of subsidies policy when its cost is financed by income tax

As an alternative financing scenario, in this simulation, I assume that the total cost of subsidies is financed by a uniform household income tax rates increase. The government is assumed to use up its additional income that is generated by oil prices shock on its consumption. In order to finance the cost of subsidies, however, the government raises income tax rates on households. Based on this assumption, the total cost of subsidies is a burden on household budget.

In this simulation, subsidies enter the model, as they did in 4.2 and 4.3, as negative indirect tax rates on gasoline and diesel commodities (see Table 4-11). However, the real government consumption is fixed at its level in the base case scenario (oil prices shock without subsidies). To analyze the impacts of subsidies, I compare the results of the base case scenario (oil prices shock without subsidies in 4.1) with the results of this simulation. In addition, to analyze the implications of different financing scenarios, I compare the results of this simulation (total cost of subsidies is a burden on household budget) to the results in 4.2 (total cost of subsidies is a burden on government budget).

4.4.1 Impacts on the aggregate economy

The impacts of subsidies policy on the aggregate economy when the total cost of subsidies is financed by the uniform household income tax rates increase are summarized in Table 4-23. Overall, GDP increases by 0.6 percent, slightly lower than when the total cost of subsidies is financed by a contraction of government consumption (in 4.2). In contrast, private consumption decreases by 0.13 percent as a result of a higher income tax burden. Measured by compensating variation, aggregate welfare decreases by ฿ 3.18 billion.

Table 4-23: Impacts of subsidies on the aggregate economy

	Base case (฿ billion)	%Δ (except for CV)
Absorption	3889.56	0.04
- Private consumption	2502.7	-0.13
- Fixed investment	1015.78	0.48
- Government consumption	514.47	0.00
Export	2716.96	0.19
Import	1977.02	0.21
GDP	4629.51	0.06
Producer price index	-	0.16
Exchange rate	-	0.20
Compensating variation (฿ billion)	-	-3.18

The producer price index increases by 1.6 percent. However, the pressure on domestic currency is significantly less severe as it depreciates by 0.20 percent, compared to 0.51 percent when the total cost of subsidies is a burden on government budget. This can be explained by the fact that the import demand for energy commodities increases by a smaller magnitude.

4.4.2 Sectoral impacts

4.4.2.1 Costs and prices

Changes in the component of domestic demand affect the direction and magnitude of the change in sectoral per-unit costs and product prices. In particular, the services commodity price increases by 0.36 percent compared to a decrease when the total cost of subsidies is a burden on government budget (in 4.2), and there is a decrease in agricultural commodity price compared to an increase in 4.2. This is because the expansion of domestic demand is increasingly driven by government consumption, where the spending on services has its largest contribution.

Table 4-24: Impacts of subsidies on sectoral costs and prices (% Δ)

	Cost per-unit of input				Price per-unit of output		
	Energy	Intermediate	Capital	Labor	Activity	Domestic supply	Domestic market
Agricultural	-13.07	0.01	0.47	0.71	-0.39	-0.55	-0.51
Manufacturing	-1.90	0.08	1.00	0.71	0.19	0.18	0.19
Coal & lignite	-15.62	-0.94	4.75	0.71	2.13	2.13	1.85
Crude petroleum	-5.18	0.22	2.53	0.71	0.68	0.70	0.44
Gasoline	0.40	0.20	-4.60	0.71	-0.03	-0.06	-5.89
Diesel	0.40	0.20	51.52	0.71	3.82	4.13	-16.70
Aviation fuel	0.40	0.20	5.65	0.71	1.83	3.14	3.12
Fuel oil	0.79	0.08	11.87	0.71	2.34	2.42	2.13
Electricity	0.30	0.05	0.04	0.71	0.27	0.27	0.27
Gas	0.39	0.26	-15.16	0.71	-0.59	-1.04	-0.89
Transportation	-7.11	-0.32	1.48	0.71	-1.24	-1.57	-1.38
Services	-2.13	0.07	0.55	0.71	0.36	0.38	0.36

4.4.2.2 Households

Table 4-25 shows that when the total cost of subsidies is a burden on household budgets, subsidies policy aggravates the negative impacts of oil prices shock on the household welfare. With the assumption of a uniform income tax rates increase, simulation results show that every household is worse off. Therefore, subsidies policy cannot be used to alleviate the excess burden of the poors although it raises the aggregate GDP. In terms of welfare per-capita, government-employed households suffer the most, followed by agricultural and nonagricultural households respectively.

Table 4-25: Impacts of subsidies on households

	Agricultural Households	Nonagricultural Households	Government – employed households
Real consumption (%Δ)	-0.10	-0.11	-0.25
Total nominal income (%Δ)	0.80	0.83	0.73
Disposable income	-0.10	-0.11	-0.24
Compensating variation (฿ billion)	-0.57	-1.64	-0.97
- Per-capita C.V (฿)	-22.50	-54.92	-160.07
Change in aggregate income			
Wage income (%Δ)		0.709	
Rental income (%Δ)		0.938	

In terms of nominal income, subsidies raise the nominal income of every household. However, an increase in income tax burden reduces household disposable income and real consumption. In terms of nominal income, government-employed households benefit the least since a subsidies policy raises wage income by a smaller magnitude than rental income.

4.4.2.3 Domestic demand for sectoral products

Table 4-26 shows the impacts of a subsidies policy on domestic demand for sectoral commodities. Overall, it contributes to an increase in the domestic demand for almost every commodity, but at a smaller magnitude than when the total cost of subsidies is a burden on government budget (in 4.2). In addition, the domestic demand for services increases compared to its decrease in 4.2. This is because government consumption is the largest contributor to domestic demand for services.

Table 4-26: Impacts of subsidies on demand for sectoral commodities

	Domestic demand (%Δ)
Agricultural	0.09
Manufacturing	0.11
Coal & lignite	0.39
Crude petroleum	1.42
Gasoline	-0.54
Diesel	4.64
Aviation fuel	1.78
Fuel oil	1.22
Electricity	-0.04
Gas	-2.05
Transportation	0.31
Services	0.02

4.4.2.4 Sectoral supplies

Table 4-27 summarizes the impacts of subsidies on sectoral supplies. Subsidies policy contributes to the expansion of production activity in almost every sector, but at a slower pace than when the total cost of subsidies is a burden on government budget (in

4.2). In addition, economic activity of services production slightly increases due to the expansion of domestic demand for its product. The contractions of production activities in gas, gasoline and electricity are attributable to the role of energy substitution.

Table 4-27: Impacts of subsidies on sectoral supplies (%Δ)

	Level of activity	Domestic supply
Agricultural	0.17	0.11
Manufacturing	0.12	0.12
Coal & lignite	0.24	0.24
Crude petroleum	0.19	0.22
Gasoline	-0.52	-0.54
Diesel	4.29	4.48
Aviation fuel	0.42	1.35
Fuel oil	0.99	1.05
Electricity	-0.04	-0.04
Gas	-1.73	-1.95
Transportation	0.64	0.44
Services	0.004	0.01

4.4.2.5 Savings

Since household savings is a fixed proportion to household disposable income, an increase in income tax burden contracts a household savings. Table 4-28 shows that when the cost of subsidies is financed by a uniform direct tax rates increase, the subsidies policy reduces savings of every household. Nevertheless, enterprise savings increases. Overall, aggregate saving increases by 0.66 percent compare to 0.87 percent when the total cost of subsidies is a burden on government budget.

Table 4-28: Impacts of subsidies on savings

	Household			Enterprises		Total
	Agricultural	Non agricultural	Government - employed	State	Private	
Base case (฿ billion)	-67.70	473.96	45.44	89.07	624.50	1011.34
% Δ	-0.10	-0.11	-0.24	1.30	1.09	0.66

4.4.2.6 Government balance

Although the government real consumption is fixed at its level in the base case scenario (oil prices shock without subsidies in 4.1), government expenditure increases by 0.32 percent due to the relative price changes. In order to finance the cost of subsidies, the government raises the household income tax rates by 0.009 percent, which eventually raises government income from direct tax by 13.82 percent.

Table 4-29: Impacts of subsidies on government balance (฿ billion)

Revenues	Base case	% Δ	Expenditures	Base case	% Δ
Capital income	78.63	0.93	Consumption	512.81	0.33
Indirect taxes	491.08	-5.92	Agricultural	0.85	0.00
Value added	140.03	1.18	Manufacturing	24.42	0.20
Indirect tax on activities	199.04	1.85	Fuel oil	0.51	1.96
Indirect tax on commodities	90.49	-38.23	Electricity	4.98	0.20
Import tax	61.52	0.33	Gas	0.52	0.00
Direct tax	216.72	13.82	Transportation	8.37	-1.31
Net transfer from ROW	19.81	0.20	Services	473.16	0.36
Total income	806.24	0.21	Net transfer to institutions	11.97	0.00
			Total expenditure	524.79	0.32
			Savings	281.45	0.00

5. Conclusion

The purpose of this chapter is to analyze the likely long-run impacts of oil prices shock in 2004 on the Thai economy and to investigate economic implications of a subsidies policy that is introduced by the Thai government to offset the negative impacts of oil prices shock. For this purpose, I develop a single country static General Equilibrium Model of the Thai economy. The results of this chapter can be summarized as follows:

Oil prices shock in 2004 had negative effects on the Thai economy in terms of GDP contraction, lower household welfare, and a higher pressure on production prices. In aggregate, oil prices shock contracts the GDP by 0.14 percent. The reduction of household incomes reduces private consumption by 1.05 percent and investment by 1.18 percent. The contraction of domestic demand together with relative price changes contributes to the expansion of the net real-export of 2.57 percent. Driven by higher indirect tax income, government consumption increases by 2.75 percent. On the production side, oil prices shock has asymmetric effects across production sectors. It contributes to the expansion of production activity of crude petroleum, aviation fuel and services, while other production sectors are negatively affected.

Oil prices shock generates pressures on production prices and domestic currency. Producer price index increases by 0.79 percent[21]. Real exchange rate appreciates slightly to restore external balance. At a disaggregate level, relative price changes contribute to an increase in the net real-export of primary energy commodities as their domestic output

[21] Note that CPI in the model is the numeraire.

prices increase by a smaller magnitude than the increase in their world market prices. The net real-exports of manufacturing and services increase as energy prices shock reduces their domestic output prices. Since theses sectors are the key determinants of trade balance, it raises the net real-export of the aggregate economy.

Households are negatively affected by oil prices shock. In aggregate, oil prices shock reduces household welfare by ฿ 26.67 billion (0.57 percent of GDP). However, the largest welfare loss occurred with government-employed households (the highest income group) followed by nonagricultural households (the middle income group). Agricultural households (the lowest income group) suffered the least even though it has a larger share of energy consumption than those of other households. Nevertheless, since the lowest income group is a net borrower, the reduction of its income provides some justifications for intervention policy to alleviate its excess burden caused by oil prices shock.

The impacts of subsidies policy are investigated based on the assumptions of three alternative financing scenarios: (i) the government contracts its consumption sufficiently to finance subsidies, (ii) the government contracts its real consumption to the level before oil prices shock together with a uniform household income tax increase and (iii) the government spends its extra income that is generated by oil prices shock on its consumption but it raises household income tax to finance subsidies.

With these three alternative financing scenarios, simulation results show that a subsidies policy raises GDP by approximately 0.06 - 0.07 percent. Therefore, a subsidies policy is justified on the basis of GDP stimulation. With the third financing scenario, a subsidies policy reduces welfare of every household. Therefore, a subsidies policy cannot be justified in terms of excess burden alleviation when its cost is totally financed by a uniform income tax rates increase, as it aggravates the negative effects of oil prices shock on household welfare.

Subsidies reinforce the prevailing pressure on the cost of production that is generated by oil prices shock. Results from simulations show that, with the first and second scenarios, a subsidies policy raises producer price index by another 0.16 percent and causes domestic currency to depreciate by 0.51 percent and 0.39 percent (with the first and the second financing scenarios respectively).

With respect to income distribution, simulation results show that while a subsidies policy is justified in terms of excess burden alleviation (with the first and second financing scenarios) it raises income gaps in the economy. With the first financing scenario, nominal and disposable incomes of government-employed households (the highest income group) increase by a larger magnitude than those of nonagricultural households (the middle-income group) and agricultural households (the lowest income group). With the second financing scenario, the income gap between agricultural and nonagricultural households increases. In terms of welfare, the benefit of subsidies is largely distributed to government-employed households (the highest income group) even though they have the smallest share of energy consumption among the three household groups. Measured in terms of welfare per-capita, the government-employed households benefit the most from a subsidies policy, followed by nonagricultural and agricultural households respectively. Therefore, a subsidies policy is a regressive measure for income distribution.

It follows that the usual partial equilibrium analysis and consumption bundle analysis of the impacts of subsidies on income and welfare distribution can be misleading. Since agricultural households has the largest share of consumption spending on gasoline and diesel, the usual partial equilibrium analysis and consumption bundle analysis tends to predict that a subsidies policy would benefit mostly agricultural households. However, simulation results show that this prediction does not necessary hold true when the general equilibrium effects of oil prices shock and subsidies are taken into account. The impacts of a subsidies policy on income and welfare distribution depend on how subsidies reallocate factor income in the economy and the structure of household incomes as well as the relative price changes.

Overall, this chapter provides a full range of analysis on the impacts of oil prices shock and subsidies on the Thai economy at both micro and macroeconomic levels. However, static analysis in this chapter faces limitations. First, the impacts of oil prices shock may differ if the dynamic properties of the economic system are taken into account (i.e. (i) if investment contraction in the wake of oil prices shock lower output in subsequent periods and (ii) if consumers can substitute their current period consumption for next period consumption). Second, as in most static CGE models, savings is a fixed proportion to income and it is distributed to sectoral investments according to its base year proportion. In other words, investment behavior in the model is not the result of an optimal decision. Third, the impacts of oil prices shock may depend on the timing and horizon of the shock. Fourth, the short-run impacts of oil prices shock may differ from its intermediate and long run impacts and may be potentially important for policy decisions. These limitations provide room for future research in this area to improve an understanding of oil prices shock on the Thai economy.

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Appendix A: List of parameters and variables in the model

A-1 List of parameters

α_a^{kne}	Shift parameter of capital-energy production function
α_a^{lkne}	Shift parameter of value added- energy production function
α_a^{ne}	Shift parameter of energy production function
α_c^{q}	Shift parameter of Armington function
α_a^{spne}	Shift parameter of substitutable primary-energy production function
α_c^{t}	Shift parameter of CET function
$\beta_{c,h}^{m}$	Marginal share of consumption spending
δ_a^{kne}	Share parameter of capital-energy production function
δ_a^{lkne}	Share parameter of value added- energy production function
δ_a^{ne}	Share parameter of energy production function
$\delta_{c,a}^{spne}$	Share parameter of substitutable primary energy production function
δ_c^{q}	Share parameter of Armington function
δ_c^{t}	Share parameter of CET function
$\gamma_{c,h}^{m}$	Quantity of subsistence consumption
$\theta_{a,c}$	Output yield parameter
θ_a^{kne}	Exponential parameter of capital-energy production function
θ_a^{lkne}	Exponential parameter of value added energy production function
θ_a^{ne}	Exponential parameter of energy production function
θ_a^{spne}	Exponential parameter of substitutable primary energy production function
θ_c^{q}	Exponential parameter of Armington function
θ_c^{t}	Exponential parameter of CET function
ψ_c	Share of real investment in total saving
$cwts_c$	Weight of consumption commodity in consumption basket
cpi	Consumer price index
$ica_{c,a}$	Intermediate input commodity per unit of aggregate intermediate input
$icapkne_a$	Capital input per unit of aggregate capital-energy input
$icnpne_{c,a}$	Non-primary energy commodity per unit of aggregate non-primary energy input
$icnspne_{c,a}$	Non-substitutable primary energy commodity per unit of aggregate non-substitutable primary energy input
$icspne_{c,a}$	Substitutable-primary energy commodity per unit of aggregate substitutable primary energy input

$iknelkne_a$	Aggregate capital-energy input per unit of aggregate energy-value added input
$ilablkne_a$	Labor input per unit of aggregate energy-value added input
$inekne_a$	Aggregate energy input per unit of aggregate capital-energy input
$inlkne_a$	Aggregate energy value-added input per unit of activity
$inpne_a$	Aggregate non-primary energy input per unit of aggregate energy input
$inspne_a$	Aggregate non-substitutable primary energy input per unit of aggregate primary energy input
$ipne_a$	Aggregate primary energy input per unit of aggregate energy input
ina_a	Aggregate intermediate input per activity unit
$ispne_a$	Aggregate substitutable primary energy input per unit of aggregate primary energy input
$\overline{ks}$	Supply of capital
$\overline{ls}$	Supply of labor
$mpsbar_i$	Base year propensity to save
pwe_c	Export price in foreign currency unit
pwm_c	Import price foreign currency unit
$qb\arg_c$	Base year quantity demand for government consumption
$qbarinv_c$	Base year quantity demand for fixed investment
$qdst_c$	Quantity demand for stock investment
$shik_i$	Share of institution i in total capital income
$shil_i$	Share of institution i in total labor income
$shii_{i,i^*}$	Share of institution i in net income of institution i^*
tar_a	Rate of indirect tax on activity
tcr_c	Rate of indirect tax on commodity
$tinsbar_i$	Base year direct tax rate of institution
$tinsdummy_i$	Dummy variable
tm_c	Tariff rate
$trnsfr_{i,ac}$	Transfer between institution i and other institutions
tvr_a	Value added tax rate

A-2 List of variables[22]

$Dtins$	Direct tax rate adjusting factor

[22] Note that $Dtins$, $Gsav$, $Fsav$, R, and $Wdist_a$ are fixed in the base model

Eg	Government expenditure
Eh_h	Household disposable income
Exr	Exchange rate (local currency unit per foreign currency unit)
$Fsav$	Foreign saving in foreign currency unit
$Gadj$	Government scaling factor
$Gsav$	Government saving
K_a	Capital input
L_a	Labor input
PA_a	Activity price
Pds_c	Supply price of commodity produced and sold domestically
Pe_c	Export price in local currency unit
$PinA_a$	Price of aggregate intermediate input
$PkneA_a$	Price of aggregate capital-energy input
$PlkneA_a$	Price of aggregate energy-value added input
Pm_c	Import price in local currency unit
$PneA_a$	Price of aggregate energy input
$PnpneA_a$	Price of aggregate non-primary energy input
$PnspneA_a$	Price of aggregate non-substitutable primary energy input
$PpneA_a$	Price of aggregate primary energy input
Pq_c	Price of composite supply
$PspneA_a$	Price of aggregate substitutable primary energy input
Px_c	Price of domestic output
QA_a	Level of activity
$QCnpneA_{c,a}$	Quantity demand for non-primary energy commodity
$QCnspneA_{c,a}$	Quantity demand for non-substitutable primary energy commodity
$QCspneA_{c,a}$	Quantity demand for substitutable primary energy commodity
Qd_c	Quantity of commodity produced and sold domestically
Qe_c	Quantity of export
Qg_c	Quantity of government demand
$Qh_{c,h}$	Quantity of consumption of goods
$QCinA_{c,a}$	Quantity demand for intermediate commodity
$QinA_a$	Quantity of aggregate intermediate input
$Qinv_c$	Quantity of investment demand
$QkneA_a$	Quantity of aggregate capital-energy input
$QlkneA_a$	Quantity of aggregate energy-value added input

Qm_c	Quantity of import
$QneA_a$	Quantity of aggregate energy input
$QnpneA_a$	Quantity of aggregate non-primary energy input
$QnspneA_a$	Quantity of aggregate non-substitutable primary energy input
$QpneA_a$	Quantity of aggregate primary energy input
Qq_c	Quantity of composite supply
$QspneA_a$	Quantity of aggregate substitutable primary energy input
Qx_c	Quantity of domestic output
R	Rental rate
$Rdist_a$	Rental rate distortion factor
$Tins_i$	Direct tax rate
$Trii_{i,i^*}$	Infra institutional transfer
$Tsav$	Total saving
W	Wage rate
$Walrassrq$	Square of saving-investment gap
$Walras$	Saving-investment gap
$Wdist_a$	Wage distortion factor
Yg	Government revenue
Yi_i	Total gross income of domestic non-government institution
Yif_i	Factor income of domestic institution

A-3 Set

A = Set of production activity

$a \in A$ = {Agricultural, Manufacturing, Coal & lignite, Crude petroleum, Diesel, Gasoline, Aviation fuel, Fuel oil, Electricity, Gas, Transportation, Services}

C = Set of commodities

$c \in C$ = {Agricultural, Manufacturing, Coal & lignite, Crude petroleum, Diesel, Gasoline, Aviation fuel, Fuel oil, Electricity, Gas, Transportation, Services}

I = Set of institutions

$i \in I$ = {Agricultural household, Nonagricultural household, Government-employed household, State enterprise, Private enterprise, Government, Rest of the world}

H = Set of households

$h \in H$ = {Agricultural household, Nonagricultural household, Government-employed household}

Appendix B: 1998 Social Accounting Matrix (฿ billion)

	A-AGR	A-IND	A-COALIG	A-PMPETR	A-GASLNE	A-DEISEL
C-AGR	87.28	397.85				
C-IND	186.37	2891.41	0.54	11.52	1.09	1.33
C-COALIG		3.09				
C-PMPETR		1.09		5.03	54.22	65.93
C-GASLNE	3.09	9.63		1.34	0.11	0.13
C-DEISEL	34.35	18.83	0.20	3.65	0.11	0.14
C-AVIFUL		1.000000E-3				
C-FULOIL	6.06	36.68	1.000000E-3	1.54	0.25	0.30
C-ELCITY	1.99	95.87	0.01	0.68	0.24	0.29
C-GAS	0.08	5.13			0.10	0.13
C-TRAN	22.96	210.23	1.53	1.18	0.14	0.17
C-SERV	127.56	844.31	0.08	16.48	1.45	1.76
LABOR	181.67	527.57	1.06	5.38	5.71	5.01
CAP	369.32	693.40	6.17	31.18	7.88	6.91
VATa	0.16	56.01	0.05	4.03	1.38	1.68
TA	-0.14	87.45		8.20	23.86	32.19
TOTAL	1020.77	5878.55	9.65	90.22	96.56	115.99

	A-AVIFUL	A-FULOIL	A-ELCITY	A-GAS	A-TRAN	A-SERV
C-AGR					0.34	129.30
C-IND	0.46	2.86	14.25	1.01	76.06	391.87
C-COALIG			7.50			
C-PMPETR	23.09	23.67		21.21		
C-GASLNE	0.05	0.35		1.000000E-3	53.02	14.12
C-DEISEL	0.05	1.38	1.83		47.01	3.14
C-AVIFUL					25.61	
C-FULOIL	0.11	30.32	20.30		13.29	0.66
C-ELCITY	0.10	0.26	11.64	0.07	2.43	41.52
C-GAS	0.04	0.05	7.02	0.85	2.21	1.44
C-TRAN	0.06	1.05	3.86	0.04	100.69	69.36
C-SERV	0.62	4.42	11.51	1.36	107.14	456.02
LABOR	6.79	12.33	38.29	1.70	66.79	605.67
CAP	9.36	17.00	52.78	2.35	227.51	1278.44
VATa	0.59	1.31	5.62	0.06	3.26	65.49
TA	0.09	5.22		1.06	-1.92	29.45
TOTAL	41.41	100.23	174.61	29.71	723.42	3086.48

	C-AGR	C-IND	C-COALIG	C-PMPETR	C-GASLNE	C-DEISEL
A-AGR	1020.77					
A-IND		5878.55				
A-COALIG			9.65			
A-PMPETR				90.22		
A-GASLNE					96.56	
A-DEISEL						115.99
TC	0.79	71.65	0.12	7.78	0.72	2.27
IMPTAX	1.69	55.77	9.000000E-3	2.000000E-3	1.000000E-3	0.03
ROW	48.64	1504.39	1.56	104.01	0.16	3.05
TOTAL	1071.89	7510.37	11.34	202.01	97.45	121.34

	C-AVIFUL	C-FULOIL	C-ELCITY	C-GAS	C-TRAN	C-SERV
A-AVIFUL	41.41					
A-FULOIL		100.23				
A-ELCITY			174.61			
A-GAS				29.71		
A-TRAN					723.42	
A-SERV						3086.48
TC	3.000000E-3	1.06		0.09		4.00
IMPTAX	0.02	0.65		6.000000E-3		3.85
ROW	2.48	13.59	1.29	2.46	71.08	249.58
TOTAL	43.90	115.54	175.90	32.27	794.50	3343.92

	LABOR	CAP	HH_AGR	HH_GOV	HH_NAG	GOV
C-AGR			70.61	27.67	113.86	0.83
C-IND			367.16	179.55	691.86	23.88
C-GASLNE			2.53	1.24	4.77	
C-DEISEL			0.60	0.29	1.14	
C-FULOIL						0.45
C-ELCITY			4.67	2.28	8.79	4.79
C-GAS			1.27	0.62	2.39	0.41
C-TRAN			32.14	39.61	153.33	7.92
C-SERV			117.50	144.82	560.58	462.42
HH_AGR	202.48	297.92				11.44
HH_GOV	425.46	64.89				2.94
HH_NAG	830.05	1237.66				25.70
GOV		79.40				
ENT_G		124.50				-34.20

ENT_P		897.92	1.01	13.90	28.85	6.09
DIRTAX			2.58	41.17	84.07	
S_I			-68.39	45.97	478.96	281.45
TOTAL	1457.99	2702.30	531.66	497.13	2128.61	794.13

	ENT_G	ENT_P	VATa	TA	TC	IMPTAX
GOV			139.64	185.46	88.49	62.03
DIRTAX		91.46				
S_I	90.30	632.62				
TOTAL	90.30	724.08	139.64	185.46	88.49	62.03

	DIRTAX	S_I	DSTK	ROW	TOTAL
A-AGR					1020.77
A-IND					5878.55
A-COALIG					9.65
A-PMPETR					90.22
A-GASLNE					96.56
A-DEISEL					115.99
A-AVIFUL					41.41
A-FULOIL					100.23
A-ELCITY					174.61
A-GAS					29.71
A-TRAN					723.42
A-SERV					3086.48
C-AGR		0.28	28.67	215.20	1071.89
C-IND		946.14	-202.71	1925.70	7510.37
C-COALIG			0.74	1.000000E-3	11.34
C-PMPETR			3.96	3.79	202.01
C-GASLNE			-0.10	7.17	97.45
C-DEISEL			0.58	8.03	121.34
C-AVIFUL			0.53	17.76	43.90
C-FULOIL			1.97	3.62	115.54
C-ELCITY				0.25	175.90
C-GAS			-0.14	10.68	32.27
C-TRAN		10.18	0.26	139.77	794.50
C-SERV		71.32	22.84	391.73	3343.92
LABOR					1457.99
CAP					2702.30
HH_AGR				19.82	531.66
HH_GOV				3.83	497.13

HH_NAG				35.20	2128.61
GOV	219.28			19.81	794.13
ENT_G					90.30
ENT_P				-223.69	724.08
VATa					139.64
TA					185.46
TC					88.49
IMPTAX					62.03
DIRTAX					219.28
S_I				-576.38	884.53
DSTK		-143.39			-143.39
ROW					2002.30
TOTAL	219.28	884.53	-143.39	2002.30	

Source: *Thailand Development Research Institute*

Definition

I. Production activities

A-AGR	Agriculture
A-IND	Non-energy industry
A-COALIG	Coal and lignite
A-PMPETR	Crude petroleum
A-GASLNE	Gasoline
A-DEISEL	Diesel
A-AVIFUL	Aviation fuel
A-FULOIL	Fuel oil
A-ELCITY	Electricity
A-GAS	Gas
A-TRAN	Transport services
A-SERV	Other services

II. Commodities

C-AGR	Agriculture
C-IND	Non-energy industry
C-COALIG	Coal and lignite
C-PMPETR	Crude petroleum
C-GASLNE	Gasoline
C-DEISEL	Diesel
C-AVIFUL	Aviation fuel
C-FULOIL	Fuel oil
C-ELCITY	Electricity
C-GAS	Gas
C-TRAN	Transport services

C-SERV	Other services

III. Factors of production

LABOR	Labour
CAP	Capital

IV. Domestic institutions

HH_AGR	Agricultural household
HH_GOV	Government services household
HH_NAG	Non-agricultural household
GOV	Government
ENT_G	Private enterprise
ENT_P	Public enterprise

V. Taxes

VATa	Value added taxes
TA	Indirect taxes on activity
TC	Indirect taxes on commodity
IMPTAX	Import duty
DIRTAX	Direct taxes

VI. Miscellaneous

S_I	Saving-investment
DSTK	Investment in stock
ROW	Rest of the world
TOTAL	Total/

Appendix C: Structure of the Thai economy as displayed by SAM

Table C-1: GDP balance sheet

	Expenditure			Income	
	฿ billion	(%)		฿ billion	(%)
Government consumption	500.70	10.80	GDP at factor cost	4,160.29	89.74
Private consumption	2,529.28	54.56	Indirect taxes	475.63	10.26
Investment	884.53	19.08			
Net export	721.41	15.56			
- Export	2,723.71	58.75			
- Import	-2,002.30	-43.19			
GDP (market prices)	4,635.92	100.00	GDP (market prices)	4,635.92	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-2: Production structure (%)

	Output	Value added	Intermediate Input	Energy input
Agriculture	9.00	13.20	6.87	6.47
Industry	51.70	29.30	70.32	24.17
Energy	5.78	5.10	1.26	40.35
- Coal & lignite	0.08	0.20	0.03	0.03
- Crude petroleum	0.80	0.90	0.47	1.74
- Gasoline	0.80	0.30	0.04	7.81
- Diesel	1.00	0.30	0.05	9.50
- Aviation Fuel	0.40	0.40	0.02	3.33
- Fuel oil	0.90	0.70	0.13	7.95
- Electricity	1.50	2.20	0.48	6.85
- Gas	0.30	0.10	0.04	3.14
Transportation	6.40	7.10	4.60	20.37
Services	27.20	45.30	16.94	8.64
Total	100.00	100.00	100.0	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-3: Share of inputs in the value of output (%)

	Value added			Intermediate Input	Energy input	Total
	Capital	Labor	Total			
Agriculture	36.18	17.80	53.98	41.55	4.47	100.00
Industry	12.09	9.20	21.29	75.74	2.97	100.00
Energy	23.32	13.31	36.63	13.75	49.62	100.00
- Coal & lignite	64.27	11.09	75.36	22.39	2.25	100.00
- Crude petroleum	39.98	6.90	46.88	37.43	15.69	100.00
- Gasoline	11.05	8.01	19.06	3.76	77.18	100.00
- Diesel	8.42	6.10	14.52	3.97	81.51	100.00
- Aviation Fuel	22.98	16.67	39.65	2.80	57.55	100.00
- Fuel oil	18.15	13.16	31.31	8.89	59.80	100.00
- Electricity	31.23	22.66	53.89	17.53	28.58	100.00
- Gas	8.21	5.95	14.16	8.42	77.42	100.00
Transportation	31.51	9.25	40.76	39.36	19.88	100.00
Services	42.74	20.25	62.99	34.98	2.03	100.00

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-4: Capital account balance sheet (฿ billion)

	Expenditure		Income
Imports of goods and services	2,002.30	Exports of goods and services	2,723.71
		Net factor income payment from ROW	-145.01
		Net current transfer from ROW	-576.40
Total	2,002.30	Total	2,002.30

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-5: Structure of trade by output

	Export (%)	Import (%)	Net export (฿billion)	Export / Output (%)	Import / Final demand (%)
Agriculture	7.90	2.43	164.87	21.08	5.88
Industry	70.70	75.13	365.53	32.76	28.30
Energy	1.87	6.41	-78.02	7.79	17.46
- Coal & lignite	0.00	0.08	-1.57	0.01	13.97
- Crude petroleum	0.14	5.19	-100.22	4.21	54.62
- Gasoline	0.26	0.01	7.00	7.43	0.19
- Diesel	0.29	0.15	4.95	6.92	2.78
- Aviation Fuel	0.65	0.12	15.27	42.89	9.53
- Fuel oil	0.13	0.68	-10.63	3.61	12.85
- Electricity	0.01	0.06	-1.03	0.14	0.73
- Gas	0.39	0.12	8.21	35.94	11.48
Transportation	5.13	3.55	68.69	19.32	10.86
Services	14.38	12.46	138.30	12.69	8.60
Total	100.00	100.00	659.37	23.96	19.28

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-6: Population by household and income per-capita

	Population		Income	
	Person (Million person)	(%)	Total (฿ billion)	Income per-capita (฿)
Agriculture household	25.28	41.3	534.328	21,135.7
Non-agriculture household	29.86	48.8	2,138.979	71,640.6
Government-employed household	6.06	9.9	497.127	81,990.8
Total	61.20	100.0	3,170.434	-

Source: *Thailand 1998 Social Accounting Matrix*

Table C-7: Source of household income (%)

	Wage income	Rental Income	Government Transfer	Transfer from ROW	Total
Agriculture household	38.08	56.04	2.15	3.73	100
Non-agriculture household	38.99	58.14	1.21	1.65	100
Government-employed household	85.58	13.05	0.59	0.77	100
Total	38.08	56.04	2.15	3.73	100

Source: *Thailand 1998 Social Accounting Matrix*

Table C-8: Distribution of household spending (%)

	Agriculture Household	Non-agriculture Household	Government-employed Household
Consumption spending	112.19	72.18	79.68
Transfer payment	0.19	1.36	2.8
Income tax	0.48	3.95	8.28
Saving (borrowing)	-12.86	22.50	9.25
Total	100.00	100.00	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-9: Distribution of household consumption spending (%)

	Agriculture Household	Non-agriculture Household	Government-employed Household
Non energy commodity	98.48	98.89	98.88
- Agricultural	11.84	7.41	6.99
- Manufacturing	61.55	45.02	45.33
- Transportation	5.39	9.98	10.00
- Services	19.7	36.48	36.56
Energy commodity	1.51	1.11	1.12
- Gasoline	0.42	0.31	0.31
- Diesel	0.10	0.07	0.07
- Electricity	0.78	0.57	0.58
- Gas	0.21	0.16	0.16
Total	100.00	100.00	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-10: Structure of government balance

	Spending		Income	Revenue	
	฿ billion	%		฿ billion	%
Consumption	500.70	63.05	Taxes income	694.9	87.51
- Non energy commodity	495.05	62.34	- Value added	139.64	17.58
- Energy commodity	5.65	0.71	- Tax on activity	185.46	23.35
Transfer	11.97	1.51	- Tax on commodity	88.49	11.14
- Agriculture household	11.44	1.44	- Import tax	62.03	7.81
- Non-agriculture household	25.70	3.24	- Direct tax	219.28	27.61
- Government-employed household	2.94	0.37	Capital income	79.40	10.00
- Enterprise	-28.11	-3.54	Transfer from ROW	19.81	2.49
Savings	281.45	35.44			
Total	794.12	100.00	Total	794.12	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-11: Saving-investment balance (฿ billion)

	Saving		Investment
Household	456.54	Gross fixed capital formation	1027.92
- Agricultural household	-68.39	- Agriculture	0.28
- Non-agricultural household	478.96	- Manufacturing	946.14
- Government-employed household	45.97	- Transportation	10.18
Enterprises saving	722.92	- Services	71.32
Government saving	281.45	Investment in stock	-143.39
Foreign saving	-576.38		
Total	884.53	Total	884.53

Source: *Thailand 1998 Social Accounting Matrix*

Appendix D: Parameters in the model

Table D-1: Trade elasticity

	Armington elasticity	CET elasticity
Agriculture	0.7	0.9
Industry	0.9	1.2
Energy		
- Coal & lignite	0.5	0.3
- Crude petroleum	4.5	1.1
- Gasoline	1.5	0.7
- Diesel	1.5	0.6
- Aviation Fuel	1.5	0.6
- Fuel oil	0.6	0.6
- Electricity	0.5	0.5
- Gas	0.7	0.5
Transportation	0.7	0.7
Services	0.4	0.4

Table D-2: Elasticity of input substitution

	K-EN[a]	L-KEN[b]	ELEC-NELEC[c]	SPNE[d]
Agriculture	0.30	0.60	0.50	0.60
Industry	0.30	0.40	0.50	0.60
Energy				
- Coal & lignite	0.20	0.30	0.50	0.60
- Crude petroleum	0.20	0.20	0.50	0.60
- Gasoline	0.20	0.20	0.50	0.60
- Diesel	0.20	0.20	0.50	0.60
- Aviation Fuel	0.20	0.20	0.50	0.60
- Fuel oil	0.20	0.20	0.50	0.60
- Electricity	0.20	0.20	0.50	0.60
- Gas	0.20	0.20	0.50	0.60
Transportation	0.30	0.30	0.50	0.60
Services	0.30	0.40	0.50	0.60

[a] *Between capital (K) and energy composite (EN)*
[b] *Between labor(L) and capital-energy composite (KNE)*
[c] *Between electric (ELEC) and non-electricity (NELEC)*
[d] *Between primary energy*

Table D-3: Income elasticity of demand

	Agricultural household	Nonagricultural Household	Govt-employed household
Agriculture	0.95	0.90	0.90
Industry	1.50	1.40	1.30
Energy			
- Gasoline	0.90	0.70	0.70
- Diesel	0.90	0.70	0.70
- Aviation Fuel			
- Fuel oil			
- Electricity	0.90	0.90	0.90
- Gas	0.90	0.90	0.90
Transportation	1.50	1.30	1.10
Services	1.05	1.05	1.05

Frisch parameter = -2.8

Appendix E: Oil prices and subsidies

Table E-1: Domestic retail price, subsidy and shadow price of petroleum products

	ULG95[23] (฿/Liter)			UGR91[24] (฿/Liter)			Diesel (฿/ Liter)		
	Retail Price	Shadow Price	Subsidy	Retail price	Shadow Price	Subsidy	Retail Price	Shadow price	Subsidy
2003 Jan	16.8	16.8	0.0	15.8	15.8	0.0	14.7	14.7	0.0
Feb	17.1	17.1	0.0	16.1	16.1	0.0	14.9	14.9	0.0
Mar	17.0	17.0	0.0	16.0	16.0	0.0	14.8	14.8	0.0
Apr	16.9	16.9	0.0	15.9	15.9	0.0	14.7	14.7	0.0
May	16.3	16.3	0.0	15.3	15.3	0.0	14.0	14.0	0.0
Jun	15.4	15.4	0.0	14.4	14.4	0.0	12.8	12.8	0.0
Jul	16.3	16.3	0.0	15.3	15.3	0.0	13.0	13.0	0.0
Aug	17.2	17.2	0.0	16.2	16.2	0.0	13.6	13.6	0.0
Sep	16.4	16.4	0.0	15.4	15.4	0.0	13.6	13.6	0.0
Oct	16.3	16.3	0.0	15.4	15.4	0.0	13.8	13.8	0.0
Nov	16.6	16.6	0.0	15.8	15.8	0.0	14.1	14.1	0.0
Dec	17.1	17.1	0.0	16.3	16.3	0.0	14.4	14.4	0.0
Average	16.6	16.6	0.0	15.7	15.7	0.0	13.8	13.8	0.0
2004 Jan	17.0	18.6	-1.6	16.2	17.9	-1.7	14.6	15.5	-0.9
Feb	17.0	17.7	-0.7	16.2	17.0	-0.8	14.6	15.1	-0.5
Mar	17.0	18.8	-1.8	16.2	18.1	-2.0	14.6	15.2	-0.6
Apr	17.0	18.8	-1.8	16.2	18.1	-1.9	14.6	15.5	-0.9
May	17.5	20.6	-3.1	16.7	19.9	-3.2	14.6	16.8	-2.2
Jun	18.3	19.6	-1.3	17.5	18.9	-1.4	14.6	16.5	-1.9
Jul	18.8	19.9	-1.1	18.0	19.2	-1.2	14.6	17.7	-3.1
Aug	20.7	21.5	-0.7	19.9	20.8	-0.8	14.6	19.2	-4.6
Sep	21.8	20.8	1.0	21.0	20.1	0.9	14.6	19.9	-5.3
Oct	22.0	22.3	-0.3	21.2	21.6	-0.4	14.6	20.9	-6.3
Nov	21.7	21.7	0.0	20.9	20.9	0.0	14.6	20.1	-5.5
Dec	19.9	19.9	0.0	19.1	19.1	0.0	14.6	18.1	-3.5
Average	19.0	20.1	-1.0	18.3	19.3	-1.0	14.6	17.5	-3.3
% of subsidy	-5.0	-4.8	-	-5.7	-5.4	-	-20.2	-16.8	
The impacts of subsidy on the gap between shadow and actual retail prices ULG95 = 100*(19.0/20.1 -1) = - 5.4 % URG91 = 100*(18.2/19.3 -1) = - 6.1% Diesel = 100*(14.6/17.5 -1) = - 16.6 %									

Source: Energy Policy & Planning Office, Ministry of Energy

23 Unleaded premium gasoline (Octane = 95)

24 Unleaded regular gasoline (Octane = 91)

Table E-2: Change in domestic retail and shadow prices

		ULG95		UGR91		Diesel	
		Retail Price	Shadow Price	Retail Price	Shadow price	Retail Price	Shadow price
2004	Jan	1.1	10.5	2.5	13.2	-0.4	5.9
	Feb	-0.5	3.4	0.7	5.6	-1.9	1.6
	Mar	0.0	10.8	1.3	13.5	-1.4	2.8
	Apr	0.8	11.5	2.1	14.2	-0.5	5.5
	May	7.5	26.9	9.3	30.6	4.1	20.0
	Jun	18.8	27.0	21.5	30.9	13.6	28.4
	Jul	15.3	22.0	17.7	25.3	12.0	35.5
	Aug	20.7	24.9	23.2	28.3	7.0	40.9
	Sep	33.2	27.1	35.9	30.0	7.0	46.0
	Oct	34.9	36.8	37.6	39.9	6.0	52.0
	Nov	30.6	30.6	32.2	32.2	3.6	42.8
	Dec	16.5	16.5	17.2	17.2	1.4	25.7
Average		14.9	20.7	16.8	23.4	4.2	25.6

Source: Energy Policy & Planning Office, Ministry of Energy

Table E-3: Change in import price of petroleum products

		ULG95	UGR91	Kerosene	Diesel	Fuel oil
2004	Jan	32.6	33.7	15.7	1.5	-2.5
	Feb	37.5	37.0	20.9	7.5	-5.8
	Mar	17.4	15.8	-0.3	-0.3	-1.9
	Apr	50.4	48.7	31.0	25.3	18.6
	May	71.5	70.5	53.7	43.4	22.9
	Jun	60.4	58.9	51.2	46.9	24.9
	Jul	35.6	33.8	52.7	46.7	12.0
	Aug	38.5	37.0	48.4	51.0	16.5
	Sep	43.2	41.7	57.9	55.4	20.5
	Oct	53.6	52.0	75.1	65.8	26.6
	Nov	49.4	47.5	60.2	62.8	30.8
	Dec	36.1	33.9	43.1	52.6	21.8
Average		43.9	42.5	42.5	38.2	15.4

Source: Energy Policy & Planning Office, Ministry of Energy

Table E-4: Ratio of subsidy to base year shadow price

		ULG95 (฿/Liter)			UGR91 (฿/Liter)			Diesel (฿/Liter)		
		Base year shadow price*	Subsidy	% of Subsidy	Base year shadow price*	Subsidy	% of Subsidy	Base year shadow price*	Subsidy	% of Subsidy
2004	Jan	16.8	-1.6	-9.4	15.8	-1.7	-10.8	14.7	-0.9	-6.3
	Feb	17.1	-0.7	-3.9	16.1	-0.8	-4.8	14.9	-0.5	-3.5
	Mar	17.0	-1.8	-10.8	16.0	-2.0	-12.2	14.8	-0.6	-4.1
	Apr	16.9	-1.8	-10.7	15.9	-1.9	-12.1	14.7	-0.9	-6.0
	May	16.3	-3.1	-19.4	15.3	-3.2	-21.3	14.0	-2.2	-15.9
	Jun	15.4	-1.3	-8.2	14.4	-1.4	-9.4	12.8	-1.9	-14.8
	Jul	16.3	-1.1	-6.6	15.3	-1.2	-7.7	13.0	-3.1	-23.6
	Aug	17.2	-0.7	-4.3	16.2	-0.8	-5.1	13.6	-4.6	-33.9
	Sep	16.4	1.0	6.1	15.4	0.9	5.9	13.6	-5.3	-38.9
	Oct	16.3	-0.3	-1.9	15.4	-0.4	-2.3	13.8	-6.3	-46.0
	Nov	16.6	0.0	0.0	15.8	0.0	0.0	14.1	-5.5	-39.2
	Dec	17.1	0.0	0.0	16.3	0.0	0.0	14.4	-3.5	-24.3
Average		16.6	-1.0	-5.7	15.7	-1.0	-6.6	13.8	-3.3	-23.9

*Note: *Price in 2003 is the base year shadow price in 2004.*
Source: Energy Policy & Planning Office, Ministry of Energy

Table E-5: Cost of subsidies policy

		Cost of subsidies (฿ billion)				
		ULG95	UGR91	Diesel	Total	Accumulated subsidy
2004	Jan	0.3	0.4	0.9	1.6	1.6
	Feb	0.2	0.3	0.7	1.1	2.7
	Mar	0.5	0.7	0.9	2.0	4.7
	Apr	0.4	0.7	1.2	2.3	7.0
	May	0.8	1.2	3.1	5.1	12.1
	Jun	0.3	0.5	2.6	3.3	15.4
	Jul	0.3	0.4	4.6	5.3	20.7
	Aug	0.2	0.3	7.2	7.7	28.4
	Sep	-0.3	-0.3	8.0	7.4	35.8
	Oct	0.1	0.1	9.8	10.1	45.9
	Nov	0.0	0.0	8.3	8.3	54.1
	Dec	0.0	0.0	5.4	5.4	59.6

GDP 2004 = 6,577 Billion Baht
- Accumulated subsidy at the end of December 2004 = 0.9 percent of GDP 2004
- Accumulated subsidy at the end of June 2005 = 1.4 percent of GDP 2004

Source: Energy Policy & Planning Office, Ministry of Energy
National Economic & Social Development Board

Chapter 2: The dynamic impacts of transitory oil prices shock on the Thai economy: a dynamic CGE assessment

Abstract:

In this chapter, I pursue the analysis of the impacts of transitory oil prices shock. To overcome the limitations of the long-run static analysis, I develop a dynamic CGE model along the lines of the neoclassical growth theory of the Ramsey type with the inclusion of investment *Q* theory. The results can be summarized as follows:

At an aggregate level, oil prices shock lowers GDP of the Thai economy by 0.16 percent in 2004, close to the result from static analysis, and approximately 1 percent in 2006-2007. The contraction of GDP is led by the reduction of real investment (2.58 percent in 2004 and approximately 4.4 percent in 2006-2007) and real private consumption (0.44 percent in 2004 and approximately 2.4 percent in 2006-2007). Consumption price increases by 0.24 percent in 2004 before steeply rising to approximately 1.5 percent in 2006 -2007. The net real-export increases and contributes positively to GDP in 2004, consistent with the result from a long-run static analysis. However, as oil prices shock persists and accelerates, the net real export decreases and reinforces the contraction of other GDP components. Measured by compensating variation, household welfare decreases by 0.743 percent. In addition, the results suggest that oil prices shock has a strong negative impact on terms of trade of the Thai economy.

Taking into account the accumulated effect, the dynamic model shows a smaller negative impact of the shock on real consumption but a greater negative impact on real investment than the static model. At a more microeconomic level, oil prices shock raises prices of almost every commodity. It contributes to capital accumulation in almost every energy sector but hurts non-energy investment. Demands for every commodity decline but the increases of net real exports contribute to the expansion of crude oil and aviation fuel productions.

1. Introduction

One of the important and more perplexing aspects of oil prices shock is its dynamic interaction with the economy. This is because, the impacts of oil prices shock depend on the size and horizon of the shock. Therefore, permanent and transitory shocks have different implications. Taking into account the dynamic properties of the economy, the short and medium run impacts of oil prices shock potentially differ from the results of the long run static analysis. Therefore, the implications of the transitional adjustment process of the economy are potentially important for policy recommendations. Consequently, policy decision requires the analysis of oil prices shock in two dimensions, the long run analysis and the investigation of its dynamic interaction with economic variables.

With regards to this thesis, the model I developed in the previous chapter is formulated along the lines of a static CGE model. With sectoral and structural details, it provides a very good framework for analyzing the long run impacts of oil prices shock on income distribution and intersectoral resources allocation, which are the focuses of the analysis in the previous chapter. However, the model measures the change in the economy by comparing the initial equilibrium before the shock to the new equilibrium at some points of time in the future. It follows that the results from the static model are limited to the long-run likely impacts and cannot cover the dynamic aspect of oil prices shock where the dynamic setting in the model is necessary. This limitation is found in most of the CGE literature since the dynamic CGE models have been developed relatively recently and their applications are not very common.

Given that the dynamic aspect of oil prices shock is of particular interest, in this chapter, I pursue an analysis of the dynamic interactions between oil prices shock and economic variables. Since access to dynamic models in the literature is rather limited, I develop a multi-sector perfect-foresight dynamic CGE model along the lines of the neoclassical growth theory. To take into account the economic dynamic properties, I explicitly model investment behavior at disaggregate level and take into account the role of intertemporal substitution in consumption.

The remainder of this chapter is organized as follows: Section 2 provides a review of the literature. Section 3 provides a brief description of the model. Section 4 outlines the results of the model simulation and section 5 provides the conclusion.

2. A review of the literature

Analytical CGE modeling has evolved from its first generation[1] that is characterized by perfect market competition, to incorporate some stylize facts of imperfect market competition[2]. The emergence of the neoclassical growth theory stimulates the development of CGE modeling further by attempting to incorporate dynamic features of the economy. The recent development of multi-sector dynamic general equilibrium models of the third generation provides a consistent framework for analyzing the transitional path of the economy that cannot be inferred in the framework of static analysis.

For the purpose of the study I briefly review in this section, the evolution of theoretical perspectives that underline the formulation of dynamic CGE models and we distinguish two new strands of third generation CGE models. At the end of this section, I review the findings of previous studies that have applied the perfect foresight dynamic CGE model to investigate the dynamic impacts of oil prices shock.

2.1 Underlying theoretical perspectives

The introduction of the dynamic properties of the economy into the CGE model has been motivated by an attempt to analyze the dynamic nature of economic shock and the adjustment process of the economy over time. Most dynamic CGE models of the third generation are inspired by the neoclassical growth theory.

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[1] According to Lloyd and Maclaren (2004), the "first generation" of CGE models generally assumed that all markets are perfectly competitive, while a "second generation" of models has been able to include increasing returns to scale and imperfect competition. In the "third generation", CGE models sought to endogenize some dynamic effects, including allowing for investment and productivity growth

[2] See, for example, Nguyen and Wigle (1992), and Wigle (1998).

According to the literature, there are two main neoclassical approaches to the growth theory that significantly influence the development of third generation CGE modeling. In the first approach, as described in Solow (1956) and Swan (1956), there is no specific presumption about consumer expectations. Production function is required to increase at the decreasing rate with capital input. Saving rate is exogenously given.

For every hypothetical economy, there exists a long term steady-state level of capital-labor ratio such that per-capita saving is offset by the capital depreciation and population growth. The evolution of the economy is described by an adjustment along the trajectory path to the long run steady-state in which no additional (net) investment and the per-capita income growth must eventually halt. In the short run, economic shock can cause the level of capital-labor ratio to deviate from its long run steady-state level and therefore growth or contraction of income per-capita can be observed in a transitional process to steady-state equilibrium.

The second approach of neoclassical growth theory refers to the works of Ramsey (1928), Cass (1965) and Koopmans (1965) in which saving is endogenously determined. In this approach, economic agents are assumed to have a perfect foresight and operate in a perfect competitive market. The economy optimizes its intertemporal utility such that the optimal intertemporal consumption and saving paths are endogenously determined. As a consequence, Ramsey-Cass-Koopmans models rely heavily on mathematic optimization and implicitly embodied a rational expectation notion of dynamic equilibrium.

As in the first approach, the Ramsey-Cass-Koopmans growth model is governed by the long run steady-state equilibrium such that there is a steady-state level of capital to satisfy some versions of the golden rule. In the analytical model, however, there is a tendency for the capital stock to adjust instantaneously to this steady-state level. This "bang bang" behavior of investment makes the results empirically implausible. To solve this problem, structuralism modelers incorporate the convex cost of adjustment as has been proposed by Eisner and Strotz (1964), Gould (1967) and Lucas (1967). This finally leads to the inclusion of Q theory of investment[3] into the model with the contributions of Abel (1979) and Hayashi (1982)[4]. The extension of the theoretical growth model of the Ramsey-Cass-Koopmans type to incorporate adjustment costs of investment is described in Blanchard and Fisher (1989).

2.2 The recursive CGE and the Ramsey-Cass-Koopmans CGE

Recursive dynamic CGE models are formulated along the lines of the Solow-Swan exogenous saving model with some modifications. Economic agents are usually assumed to be myopic such that the consumer's expectation can be either static or adaptive. With static expectations, there is no change in decision parameters over time, while adaptive expectations are backward looking. The model produces a sequence of static equilibriums, connected to each other through adjustment in stock variables. In other words, the model solves for equilibrium one period at a time.

Single country models of this type were developed by Li, Huang, Lin, and Hsu (2002) on China, and by Thurlow and Seventer (2002) on South Africa. Some large scale

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[3] According to Tobin (1969), investment is an increasing function of the ratio of the market value of the firm to the replacement cost of its capital.

[4] Abel (1979) and Hayashi (1982) show that if the firm operates in perfect competitive market and with constant return to scale production technology, the model with standard adjustment cost leads to a Tobin's Q theory of investment. In such a model, Hayashi explicitly show that the marginal Q is equal to average Q.

multi-country recursive dynamic CGE models were also developed. For example, the Dynamic Applied Regional Trade (DART) general equilibrium model described in Springer (1998), the GREEN model described in Burniaux, Martin, Nicoletti and Martins (1992), and the APEC model described in Coyle and Wang (1998).

Dynamic CGE models with perfect foresight endogenize saving decisions through intertemporal optimization. They are formulated along the lines of the Ramsey-Cass-Koopmans endogenous saving model. Economic agents are usually assumed to have a rational expectation, which means that current and future information are taken into account in the decision process. As the decisions of economic agents are time-inseparable, the model has to be solved simultaneously for all periods. Consequently, these CGE models are more complex and have to incorporate less sectoral details to be manageable.

Single country dynamic models with perfect foresight include Goulder and Summers (1990), Keuschnigg and Kohler (1995), Devarajan and Go (1998), Annabi and Rajhi (2001), Dissou (2002), Diao, Rattso and Stokke (2005). Multi-country dynamic models of this type include the RICE model described in Nordhaus and Yang (1996), the DGETM model described in Mercenier, Merette, Beausejour and Hsueh (2001) and the GCUBE model described in McKibbin and Wilcoxen (1998).

2.3 The dynamic CGE model with perfect foresight and oil prices shock

According to the literature, Srinivasan (1982), and Ballard and Goulder (1985), the empirical estimates suggest that consumers do look ahead to some extent. In addition, it is hard to imagine that none of the economic agents in the economy take a long term view for their decisions. Most dynamic CGE models with perfect foresight in literature were applied to trade issues (for example, Nordhaus and Yang (1996), Mercenier, Merette, Beausejour and Hsueh (2001), Keuschnigg and Kohler (1995), Devarajan and Go (1998), Annabi and Rajhi (2001), Dissou (2002), and Diao, Rattso and Stokke (2005)). The applications of the dynamic CGE model with perfect foresight to the study of the dynamic impact of oil prices shock were constructed in Adachi, Boyd, Jung and Lacombe (2004) and in Dissou (2006).

Adachi, Boyd, Jung and Lacombe (2004) analyze the effect of oil prices shock on the Japanese economy and show that, an increase in oil prices could seriously deteriorate the Japanese economy in the long run. Simulation results show that the Japanese economy permanently diverges from the long-run steady-state growth path after the shock. However, positive technological change can counter the adverse impacts of oil prices shock and drive the Japanese economy to a higher growth rate than the original benchmark steady-state level.

Dissou (2006) analyzes the potential aggregate and sectoral impacts of a sustained increase in the prices of oil and other resource-based commodities on the Canadian economy. The author concludes that the increase in the prices of these commodities would be beneficial to the Canadian economy at an aggregate level. Regarding to the impact of oil prices, the 20 percent permanent increase of oil prices reduces the GDP at factor cost by 0.3 percent in the first year but raises GDP later on. In the long run, GDP stabilizes at 0.4 percent higher than its reference run. However, the impact on real GDP at market prices is at a smaller magnitude, which is attributable to the role of intertemporal substitution in consumption. At a disaggregate level, oil industries benefit from oil prices increase but it hurts non-oil producing industries.

3. Model

In this section, I describe the model developed for the analysis of this chapter. The model belongs to the family of dynamic CGE models with perfect foresight of a small-open economy with an extension to incorporate the adjustment costs of investment. The model draws upon the Ramsey theoretical model, as described in Blanchard and Fischer (1989). Its core dynamic is taken from Devarajan & Go (1998) with modifications to take into account multi investment sectors and multi consumption goods. Its dynamic module is characterized by intertemporal decisions and forward looking behavior of domestic agents. Investment and consumption are the result of separate but simultaneous optimal decisions. At any point in time, investment is an increasing function of the ratio of the present value of profit stream to the replacement costs of capital (Tobin's Q) and is subject to convex adjustment costs of capital as in Hayashi (1982). Consumption is an increasing function of wealth. Overall, its dynamic module features the neoclassical growth theory of the Ramsey-Cass-Koopmans type with the inclusion of investment Q theory.

Its core static module is similar to the model developed in the previous chapter. However, since welfare and income distribution are not of particular interest, I assume a single representative consumer and close the saving-investment gap by foreign borrowing which is supplied at a given world interest rate. In addition, since the model solves simultaneously for intra and intertemporal equilibrium, the number of unknown variables increases with the size of the horizon. Therefore, I reduced the production structure to three production nests. Overall, the model identifies 12 production and investment sectors with a single representative household. This provides a relevant degree of detail for production and investment diversity. The model can be divided into six blocks, consumption, investment and production, foreign sector, government, equilibrium condition, and terminal condition.

3.1 Households and consumption

As in the standard economic theory, households are the owners of factors of production and maximize their utility by choosing the optimal consumption. In the model, the representative household is faced with two levels of optimal decision: intertemporal decision to locate their time path of optimal aggregate consumption and saving; and intratemporal decision to allocate the aggregate consumption in each period across different consumption goods. In addition, for the purpose of model implementation, I define the households' budget constraint at a national scope such that it is consistent with the national income identity.

3.1.1 Intertemporal optimization problem

Households in the model are represented by a single infinite-lived and forward-looking representative agent. The representative household is endowed with one unit of labor, and is the owner of the stock of capital. The representative household chooses its intertemporal consumption by maximizing its lifetime utility subject to its lifetime budget constraint. Its intertemporal optimization problem is postulated as follows:

$$Max : U_0 = \sum_{t=0}^{\infty} \left(\frac{1}{1+p} \right)^{t+1} \frac{1}{1-v} Cf_t^{1-v} \tag{1}$$

Subject to

$$\sum_{t=0}^{\infty} u(t)Y_t \geq \sum_{t=0}^{\infty} u(t)Pf_t Cf_t \qquad (a1)$$

Where;

$$u(t) = \Pi_{s=0}^{t}(1+r_s)^{-1}$$

$$r_t = rwi_t + \frac{ER_{t+1}}{ER_t} - 1 \qquad (2)$$

$$Y_t = (1-ty)\left[YH_t - \sum_i^N Pk_t^i J_t^i - \sum_i^N Pc_t^i Qstk_t^i + ER_t FS_t + GS_t\right] \text{ and} \qquad (3)$$

$$YH_t = \sum_i^N W_t L_t^i + \sum_i^N Rk_t^i K_t^i + ER_t trowh_t + Pf_t trgh_t - rwi_t ER_t Debt_t \qquad (4)$$

Unless otherwise noted, the subscripts t,u,s denote time period, subscript i denotes sector of production which is identical to goods variety j[5]. The objective function U_0 in equation *(1)* is a familiar additive separable homogeneous utility function with constant elasticity of intertemporal substitution ν. This formulation assumes that the household utility at time $t = 0$ is the sum of all future discounted aggregate consumption (Cf_t). The rate of time preference ρ indicates the consumption is valued less in the future.

Let's denote price of aggregate consumption by Pf_t and household disposable income by Y_t, the intertemporal budget constraint in equation *(a1)* implies that the sum of the net present value of consumption expenditure cannot exceed the sum of the net present value of disposable income. The intertemporal discount rate r_t is the domestic

[5] See also Appendix A for notation

interest rate, which is linked to the world market interest rate (rwi_t) and exchange rate (ER_t) by the well-known uncovered interest rate parity in equation *(2)*.

Disposable income for consumption (Y_t) in equation *(3)* is defined as a function of household income (YH_t), investment expenditure $\left(\sum_i Pk_t^i J_t^i\right)$, inventory investment $\left(\sum_i Pc_t^i Qstk_t^i\right)$, government saving (GS_t) and foreign saving in terms of domestic currency unit $(ER_t FS_t)$. Since $YH_t - Pf_t Cf_t$ is private saving, the intertemporal budget constraint in equation *(a1)* is well defined at the national scope such that the national income identity holds.

Equation *(4)* is the definition of household income YH_t which turned out as the sum of total labor income $\left(\sum_i W_t^i L_t^i\right)$, total capital income $\left(\sum_i Rk_t^i K_t^i\right)$, remittances from the rest of the world $(ER_t trowh_t)$ and government transfer $(Pf_t trgh_t)$ net of interest rate payment on foreign borrowing $(rwi_t ER_t Debt_t)$.

The optimality conditions to the intertemporal optimization problem are:

$$\frac{Cf_{t+1}}{Cf_t} = \left[\frac{(1+p)(Pf_{t+1})}{(1+r)(Pf_t)}\right]^{\frac{-1}{v}} \tag{5}$$

$$Y_t = Pf_t Cf_t \tag{a2}$$

Equation *(5)* is the first necessary optimality condition. It is the well-known Euler equation that defines the growth rate of aggregate consumption between two adjacent periods as a function of the growth rate of aggregate consumption prices (Pf), rate of time preference (ρ) and the market rate of interest (r). Combining the first order condition in equation *(5)* into the intertemporal budget constraint gives the time path of consumption as

$$C_t = \frac{W_t(1+r_t)}{\left[Pf_t\left(1+\sum_{s=t+1}^{\infty}\Omega(t,s)\right)\right]} \tag{a3}$$

Where;

$$\Omega(t,s) = \left[\left(\frac{Pf_t}{Pf_s}\right)^{1-\upsilon}\frac{\prod_{u=t+1}^{s}(1+r)^{1-\nu}}{(1+\rho)^{s-t}}\right]^{1/\upsilon} \quad \text{and} \tag{a4}$$

$$W_t = \sum_{s=t}^{\infty} u(t)Y_t \tag{a5}$$

3.1.2 Intratemporal optimization problem

Within period, the representative household allocates the optimal aggregate consumption (Cf_t) across different consumption commodities (Cc_t^i). Equation *(a7)* indicates that the aggregate consumption expenditure in each period $(Pf_tCf_t^i)$ equals the sum of consumption spending across different commodities $\left(\sum_i Pc_t^i Cc_t^i\right)$. To avoid excessive complexity, in equation *(a6)* I specify the aggregate consumption as a Cobb-Douglas aggregation of different consumption commodities. This specification is a simplified version of a Linear Expenditure System (LES) I employed in the previous chapter, and implies unitary income and price elasticity of demand. I postulate the intratemporal consumption allocation problem as follows:

$$Max: Cf_t = \alpha_c \prod_{i=1}^{N} Cc_t^{i\,\rho^i} \qquad (a6)$$

Subject to

$$Pf_t Cf_t = \sum_{i=1}^{n} Pc_t^i Cc_t^i \qquad (a7)$$

Note that α_c and ρ^i are the shift and share parameters in the Cobb-Douglas aggregation function respectively. The first necessary order conditions are:

$$\rho^i Cc_t^{i\,\rho^i - 1} \alpha_c \prod_{j \neq i}^{N} Cc_t^{j\,\rho^j} = \varphi Pc_t^i \qquad (a8)$$

$$Pf_t Cf_t = \sum_{i=1}^{n} Pc_t^i Cc_t^i \qquad (a9)$$

Equations *(a8)* and *(a9)* are manipulated further to finally get the intratemporal consumption demand for each consumption commodity (Cc_t^i) and the aggregate consumption price level (Pf_t) as

$$Cc_t^i = \rho^i \frac{Pf_t Cf_t}{Pc_t^i} \qquad (6)$$

$$Pf_t = \frac{1}{\alpha_c} \prod_{i=1}^{N} \left[\frac{Pc_t^i}{\rho^i} \right]^{\rho^i} \qquad (7)$$

3.2 Firms, investment and production

The model identifies 12 production sectors. Each sector is assumed to behave as a single representative firm, producing a single homogenous commodity. Over the model horizon, each firm makes an intertemporal investment decision that determines the availability of capital stock in each period. Within period, each firm allocates aggregate investment across different investment commodities, and employs a combination of capital, labor and intermediate inputs in its production process that is governed by production technology.

3.2.1 Intertemporal investment optimization problem

For the purpose of a clearer description, I formulate the investment decision problem in continuous time. Each firm is a forward-looking agent. In equation *(a10)*, it chooses optimal investment by maximizing the net present value of a stream of cash flow subject to the standard law of motion of the stock of capital in equation *(a11)*.

$$Max : V_0^i = \int_0^{\alpha} e^{rt} RN_t^i dt \qquad (a10)$$

Subject to

$$\dot{K}^i = Inv_t^i - \delta^i K_t^i \qquad (a11)$$

Where;

$$RN_t^i = Rk_t^i K_t^i - Pk_t^i J_t^i \qquad and$$

$$J_t^i = \left[1 + \frac{\beta}{2} \frac{\left[(Inv_t^i / K_t^i) - \alpha\right]^2}{(Inv_t^i / K_t^i)}\right] Inv_t^i \qquad (8)$$

Investment cash flow (RN_t^i) of each firm is defined as the return on capital $(Rk_t^i K_t^i)$ net of investment expenditure $(Pk_t^i J_t^i)$[6]. Note that Pk_t^i is per-unit acquisition cost or purchased price of capital. J_t^i is the quantity of gross investment by destination sector, which is a function of net investment (Inv_t^i), capital stock (K_t^i) and adjustment cost parameters (β, α). Let subscripts *inv* and *k* on *J* denote derivative with respect to

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[6] With this specification, an investment decision can be made by a firm, its subsidiary unit, or the corresponding independent investment firm.

its arguments, by its definition, $J_{inv} > 0$, $J_{inv,inv} > 0$, $J_k < 0$ and $J_{k,k} < 0$. There are two implications here. First, the marginal cost of investing is positive and increasing which implies the faster the rate at which the firm adjusts its capital, the higher the cost will be. Second, the larger the capital stock that the firms start with, the lower the cost of adjustment will be. Also note that the investment definition in equation *(8)* is a linear homogenous function. The Hamiltonian equation and its three necessary first order conditions to the investment optimization problem are as follows:

$$H = e^{-rt}\left[Rk_t^i K_t^i - Pk_t^i\left[1 + \frac{\beta}{2}\frac{\left[(Inv_t^i / K_t^i) - \alpha\right]^2}{(Inv_t^i / K_t^i)}\right]Inv_t^i\right] + \gamma_t^i\left[Inv_t^i - \delta^i K_t^i\right]$$

$$\frac{\partial H^i}{\partial Inv_t^i} \Rightarrow e^{-rt}\left[Pk_t^i + Pk_t^i \beta\left(\frac{Inv_t^i}{K_t^i} - \alpha\right)\right] = \gamma_t^i \qquad (a12)$$

$$\dot{K}^i = \frac{\partial H}{\partial \gamma_t} = Inv_t^i - \delta^i K_t^i \qquad (9)$$

$$\dot{\gamma}^i = -\frac{\partial H}{\partial K_t^i} = -\left[e^{-rt}\left(Rk_t^i - Pk_t^i \frac{\beta}{2}\left(\alpha^2 - \left(\frac{Inv_t^i}{K_t^i}\right)^2\right)\right) - \delta^i \gamma_t^i\right] \qquad (a13)$$

Let λ_t denote the shadow value of capital delivered at time t, $\lambda_t^i = e^{rt}\gamma_t^i$, the first order conditions in equation *(a12), (9)* and *(a13)* are solved to finally get

$$\lambda_t^i = \left[Pk_t^i + Pk_t^i \beta\left(\frac{Inv_t^i}{K_t^i} - \alpha\right)\right] \qquad (a14)$$

$$r\lambda_t^i = \left[Rk_t^i - Pk_t^i \frac{\beta}{2}\left(\alpha^2 - \left(\frac{Inv_t^i}{K_t^i}\right)^2\right)\right] + \dot{\lambda}^i - \delta^i \lambda_t^i \qquad (10)$$

Equation *(a14)* indicates that, in optimal decision, firms invest such that the marginal cost of investment is equal to the shadow value of capital (λ_t^i) and equation *(10)* implies that the required return on capital $(r\lambda_t^i)$ is equal to the marginal revenue product of addition unit of capital plus capital gain $(\dot{\lambda}^i)$ net of depreciation loss $(\delta\lambda_t^i)$.

Imposing Transversality condition $(lim_{t->\infty} e^{-rt}\lambda_t^i K_t^i = 0)$, equation *(a13)* is solved to finally get

$$\lambda_t^i = \int_{s=t}^{\infty} e^{-(r+\delta)s}\left[Rk_t^i - Pk_t^i \frac{\beta}{2}\left(\alpha^2 - \left(\frac{Inv_t^i}{K_t^i}\right)^2\right)\right]dt \qquad (a15)$$

Equation *(a15)* is the shadow value of capital (λ_t^i) which is the present value of the stream capital earnings that will contribute to an increase in the value of the firm and the adjustment cost that can be saved in the future due to an increase in that unit of capital. However, since capital stock depreciates through time, the marginal benefit is discounted by the rate of capital depreciation.

Equation *(a16)* is the discrete time equivalent of the continuous time solution in equation *(a15)*.

$$\lambda_t^i = \sum_{s=t}^{\infty} u(s)\left\{\left[Rk_t^i - Pk_t^i \frac{\beta}{2}\left(\alpha^2 - \left(\frac{Inv_t^i}{K_t^i}\right)^2\right)\right](1-\delta)^{s-t}\right\} \qquad (a16)$$

Investment-capital ratio is an increasing function of Tobin Q as indicated in equation *(11)*. Equation *(12)* is the well-known Hayashi's identity. According to Tobin (1969), investment is an increasing function of the ratio of value of the firm (V_t^i) to its replacement cost of capital $(Pk_t^i K_t^i)$. This ratio is known as the average Q (Q_t^{iA}).

However, Hayashi (1982) shows that, if the firm operates in perfect competitive environments and its investment function is linear homogenous, average Q is identical to marginal Q (Q_t^{iM}). The latter is a ratio of shadow value of capital stock (λ_t^i) to its per-unit cost of capital (Pk_t^i).

$$\frac{Inv_t^i}{K_t^i} = \alpha + \frac{1}{\beta}\left(Q_t^{iM} - 1\right) = \alpha + \frac{1}{\beta}\left(Q_t^{iA} - 1\right) \qquad (11)$$

Where;

$$Q_t^{iM} = \frac{\lambda_t}{Pk_t^i} = Q_t^{iA} = \frac{V_t^i}{Pk_t^i K_t^i} \qquad \text{and} \qquad (12)$$

$$\lambda_t^i = \frac{V_t^i}{K_t^i} \qquad (a17)$$

3.2.2 Intratemporal investment allocation problem

In each period, in equation *(a18)*, total investment expenditure $(Pk_t^i J_t^i)$ equals the sum of spending on different investment commodities $\left(\sum_j Pc_t^j Dinv_t^{i,j}\right)$. In equation *(a19)*, investment by destination sector (J_t^i) is specified as a Leontief aggregation of different investment commodities $(Dinv_t^{i,j})$. With this specification, I postulate the investment allocation problem as

$$Min: Pk_t^i J_t^i = \sum_j imat^{i,j} Pc_t^j J_t^i \qquad (a18)$$

Subject to

$$J_t^i = \quad Min\left\{\frac{Dinv_t^{i,j}}{imat^{i,j}}\right\} \qquad (a19)$$

The optimality conditions are:

$$Dinv_t^{i,j} = imat_t^{i,j} J_t^i \tag{13}$$

$$Pk_t^i = \sum_j imat^{i,j} Pc_t^j \tag{14}$$

Note, $imat_t^{i,j}$ denotes the coefficient in the Leontief function. The optimality conditions in equation *(13)* and *(14)* indicate that the demand for each investment commodity $(Dinv_t^i)$ is a fixed proportion to investment by destination (J_t^i), and that the purchased price of capital stock (Pk_t^i) is the weighted average prices of investment commodities.

3.2.3 Intratemporal production optimization problem

To avoid the excessive number of model variables, production is disaggregated into 3 production nests[7]. Two of them are governed by Constant Elasticity of Substitution (CES) production technology. At the top production nest, in equation *(15)*, output of each production sector (QA_t^i) is a CES aggregation of aggregate value added (Qv_t^i) and aggregate intermediate input $(QinAD_t^i)$. By zero profit condition, in equation *(a20)*, after tax revenue $(PA_t^i(1-txa^i)QA_t^i)$ equals the sum of value added cost $(Pv_t^i Qv_t^i)$ and intermediate input cost $(PinAD_t^i QinAD_t^i)$. Therefore, I postulate a cost minimization problem at the top production nest as

$$Min: PA_t^i(1-txa^i)QA_t^i = PinAD_t^i QinAD_t^i + Pv_t^i Qv_t^i \tag{a20}$$

Subject to

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7 With 12 production sectors, the model identifies 36,988 unknown variables.

$$QA_t^i = \alpha_a^i \left[\beta_a^i Qv_t^{i^{-\theta_a^i}} + (1-\beta_a^i) QinAD_t^{i^{-\theta_a^i}} \right]^{\frac{-1}{\theta_a^i}} \quad (15)$$

The optimality conditions are:

$$\frac{Qv_t^i}{QinAD_t^i} = \left[\frac{PinAD_t^i \beta_a^i}{Pv_t^i (1-\beta_a^i)} \right]^{\frac{1}{(1+\theta_a^i)}} \quad (16)$$

$$PA_t^i (1 - txa^i) QA_t^i = PinAD_t^i QinAD_t^i + Pv_t^i Qv_t^i \quad (17)$$

Equation (16) implies that the optimal input ratio of value added and aggregate intermediate input is a function of relative input prices and parameters in CES production function.

Similarly for the bottom nest, as indicated by equation *(18)*, aggregate value added (Qv_t^i) is a CES aggregation of labor (L_t^i) and capital (K_t^i). In equation *(a21)*, by zero profit condition, after tax revenue $(Pv_t^i(1-txva^i)Qv_t^i)$ equals total production cost, the sum of labor cost $(W_t L_t^i)$ and capital cost $(Rk_t^i K_t^i)$. I postulate this cost minimization problem as

$$Min: Pv_t^i (1 - txva^i) Qv_t^i = Rk_t^i K_t^i + W_t \, L_t^i \quad (a21)$$

Subject to

$$Qv_t^i = \alpha_{va}^i \left[\beta_{va}^i L_t^{i^{-\theta_{va}^i}} + (1-\beta_{va}^i) K_t^{i^{-\theta_{va}^i}} \right]^{\frac{-1}{\theta_{va}^i}} \quad (18)$$

The optimality conditions are:

$$\frac{L_t^i}{K_t^i} = \left[\frac{Rk_t^i \beta_{va}^i}{W_t (1-\beta_{va}^i)} \right]^{\frac{1}{(1+\theta_{va}^i)}} \quad (19)$$

$$Pv_t^i (1 - txva^i) Qv_t^i = Rk_t^i K_t^i + W_t \, L_t^i \quad (20)$$

Equation *(19)* indicates that the optimal labor-capital input ratio is the function of the ratio of the return on capital stock to wage rate and the parameters in CES production function.

In equation *(a23)*, aggregate intermediate input ($QinAD_t^i$) is specified as a Leontief aggregation of different intermediate input commodities ($QCinD_t^{i,j}$). Budget constraint in equation *(a22)* requires that the value of aggregate intermediate input ($PinAD_t^i QinAD_t^i$) be equal to its cost, the sum of spending across different intermediate input commodities $\left(\sum_j icin^{i,j} Pc_t^j QinAD_t^i\right)$. Therefore, I postulate a cost minimization problem as

$$Min: PinAD_t^i QinAD_t^i = \sum_j icin_t^{i,j} Pc_t^j QinAD_t^{i'} \qquad (a22)$$

Subject to

$$QinAD_t^i = \quad Min \left\{ \frac{QCinD_t^{i,j}}{icin_t^{i,j}} \right\} \qquad (a23)$$

The optimality conditions are:

$$QCinD_t^{i,j} = icin_t^{i,j} QinAD_t^i \qquad (21)$$

$$PinAD_t^i = \sum_j icin_t^{i,j} Pc_t^j \qquad (22)$$

Equation (21) and (22) indicate that, in optimal decision, demand for each intermediate input commodity ($QCinD_t^{i,j}$) is a fixed proportion to aggregate intermediate input and that the per-unit price of aggregate intermediate input ($PinAD_t^i$) is the weighted average prices of intermediate commodities.

3.3 Foreign trade

Domestic economy is linked to the world economy through trade and capital markets. By the assumption of a small-open economy, a domestic market faces perfect elastic world supply and demand curves. On the demand side, for any given commodity, domestic agents (firms, households and government) face a composite of locally produced and imported goods. On the supply side, for any given domestic output, each firm can either sell its output domestically or export it to foreign markets. Therefore, there are two optimization problems, the optimal combination of composite goods and the optimal allocation of domestic output. For capital market, the small-open economy balances its saving-investment gap (or external balance) through external borrowing at a given world rate of interest.

3.3.1 Allocation of domestic output.

Domestic output (QA_t^i) is allocated between domestic sale (QSc_t^i) and export (EXc_t^i). The allocation behavior of each firm is governed by the Constant Elastic Transformation function (CET) as in equation *(23)*. Imposing the CET specification implies the imperfect transformability between these two destinations. In equation *(a24)*, total revenue $(PA_t^i QA_t^i)$ is composed of the value of domestic sales $(PDc_t^i QSc_t^i)$ and the value of exports $(PXc_t^i EXc_t^i)$. Therefore I postulate the optimal allocation behavior as a revenue maximization problem as

$$Max: PA_t^i QA_t^i = PDc_t^i QSc_t^i + PXc_t^i EXc_t^i \qquad (a24)$$

Subject to

$$QA_t^i = \alpha_T^i \left[\beta_T^i EXc_t^{i\theta_T^i} + (1-\beta_T^i) QSc_t^{i\theta_T^i} \right]^{\frac{1}{\theta_T^i}} \tag{23}$$

The optimality conditions are:

$$\frac{EXc_t^i}{QSc_t^i} = \left[\frac{PXc_t^i (1-\beta_T^i)}{PDc_t^i \beta_T^i} \right]^{\frac{1}{(1+\theta_T^i)}-1} \tag{24}$$

$$PA_t^i QA_t^i = PDc_t^i QSc_t^i + PXc_t^i EXc_t^i \tag{25}$$

Equation *(24)* implies that the optimal ratio of export to domestic sale is a function of the ratio of export price to domestic market price and the parameters in CET function. In addition, since domestic firms are price takers, export price of each commodity in local currency unit (PXc_t^i) is the product of exchange rate (ER_t^i) and its world market price in foreign currency unit $(pcwx_t^i)$. That is

$$PXc_t^i = pcwx^i ER_t \tag{26}$$

3.3.2 The optimal combination of composite goods

For any goods i that are available in the domestic market, the composite goods (ABS_t^i) is the combination of locally produced (QDc_t^i) quantity and imported (Mc_t^i) quantity. The behavior of domestic agents (firms, households and government) in choosing their optimal combinations is governed by the Armington equation as shown in equation *(27)*, which implies imperfect substitution between imported and local goods.

Let Pc_t^i denote price of composite goods, PMc_t^i denote price of imported quantity in local currency unit and PDc_t^i denote price of locally produced quantity. The budget constraint in equation *(a25)* requires the total expenditure of domestic agents on composite goods (net of sale tax) be equal to the sum of spending on locally produced quantity and spending on imported quantity. The optimization problem of domestic agents can be depicted as an expenditure minimization problem as

$$Min: Pc_t^i(1-txc^i)ABST_t^i = PDc_t^i QDc_t^i + PMc_t^i Mc_t^i \qquad (a25)$$

Subject to

$$ABST_t^i = \alpha_q^i\left[\beta_q^i Mc_t^{i^{-\theta_q^i}} + (1-\beta_q^i)QDc_t^{i^{-\theta_q^i}}\right]^{-\frac{1}{\theta_q^i}} \qquad (27)$$

The optimality conditions are:

$$\frac{Mc_t^i}{QDc_t^i} = \left[\frac{PDc_t^i\beta_q^i)}{PMc_t^i(1-\beta_q^i)}\right]^{\frac{1}{(1+\theta_q^i)}} \qquad (28)$$

$$Pc_t^i(1-txc^i)ABST_t^i = PDc_t^i QDc_t^i + PMc_t^i Mc_t^i \qquad (29)$$

Equation *(28)* implies that the optimal ratio of imported to locally produced quantities is a function of the ratio of their relative price. In addition, since import tariff is imposed on the value of import, the import price in local currency unit is defined gross of tax as

$$PMc_t^i = pcwm^i(1+txm^i)ER_t \qquad (30)$$

3.3.3 Capital market

Current account position (FS_t) is defined in terms of foreign currency unit. It is the sum of spending on import $\left(\sum_i pcwm_t^i Mc_t^i\right)$ and interest rate payment on external debt $(rwi_t Debt_t)$ minus the sum of export income $\left(\sum_i pcwx_t^i EXc_t^i\right)$ and foreign remittances to household $(trowg_t)$ and to government $(trowh_t)$. With this specification, a positive value of FS_t implies current account deficit or, in other words, domestic saving insufficiently met the required optimal investment.

$$Fs_t = \sum_i^N pcwm_t^i Mc_t^i + rwi_t Debt_t - \sum_i^N pcwx_t^i EXc_t^i - trowh_t - trowg_t \qquad (a26)$$

$$Debt_t = Debt_{t-1} + Fs_t \qquad (31)$$

Domestic economy balances its current account (FS_t) through borrowing or lending to the world capital market at a given world rate of interest (rwi_t). The current account position affects the external debt accumulation process in equation *(31)*. This specification implied that domestic economy can access the world capital market without any constraint, and external borrowing is a capital market clearing variable.

3.4 Government

Government has no utility. It earns revenues from two main sources, tax income and foreign transfer, and spends its income on government consumption and transfers to households. Equation *(32)* identifies the components of tax revenue (TAX_t), direct tax, value-added tax, indirect tax on activities, import tax and sales tax. Tax and tariff rates are assumed to be exogenous and fixed throughout the model horizon. Equation *(33)* defines government saving as the sum of tax income and transfer from the rest of the world minus the sum of government consumption expenditure and government transfers to households.

$$TAX_t = ty\left[YH_t - \sum_i^N Pk_t^i J_t^i + ER_t FS_t + GS \right] + \sum_i^N txva^i Pv_t^i Qv_t^i$$

$$+ \sum_i^N txa^i Pa_t^i Qa_t^i + \sum_i^N txm^i ER_t Mc_t^i pcwm_t^i + \sum_i^N txc^i Pc_t^i ABST_t^i \qquad (32)$$

$$GS_t^i = \left(TAX_t + trowg_t ER_t\right) - \left(\sum_i^N Pc_t^i Qg_t^i + trgh_t Pf_t\right) \tag{33}$$

3.5 Within period equilibrium conditions

For the economy to reach equilibrium, in each period, the following equilibrium conditions must be satisfied:

3.5.1 Commodity market equilibrium

In each period, aggregate demand for each commodity is composed of intermediate inputs demand $\left(\sum_i QCinD_t^{i,j}\right)$, consumption demand (Cc_t^j), investment demand $\left(\sum_i Dinv_t^{i,j}\right)$, government consumption demand (Qg_t^j) and demand for stock investment $(Qstk_t^j)$. Commodity market equilibrium condition in equation *(34)* requires the aggregate demand for each commodity be equal to its composite supply. Note that, in equation *(35)*, inventory demand for each commodity $(Qstk_t^j)$ is a base year fixed proportion to output level (QA_t^j).

$$ABS_t^j = \sum_i^N QCinD_t^{i,j} + Cc_t^j + Dinv_t^j + Qstk_t^j + Qg_t^j \tag{34}$$

Where

$$Qstk_t^i = stk^i QA_t^i \tag{35}$$

$$QDc_t^i = QSc_t^i \tag{36}$$

Equation *(36)* also requires that, in equilibrium, demand for locally produced commodity (QDc_t^j) be equal to the quantity of domestic output supplied to the domestic market (QSc_t^j).

3.5.2 Labor market equilibrium

Labor market equilibrium condition requires that the sum of labor demand across production sectors in each period be equal to the labor supply.

$$\sum_{i}^{N} L_t^i = \overline{LS}_t \tag{37}$$

3.5.3 External balance

In each period, the domestic economy spends foreign currencies on imports $\left(\sum_i pcwm_t^i Mc_t^i\right)$ and interest rate payment on external debt $(rwi_t Debt_t)$ but earns foreign currencies from exports $\left(\sum_i pcwx_t^i EXc_t^i\right)$ and foreign remittances to government $(trowg_t)$ and households $(trowh_t)$. External balance requires that the current account position in each period (FS_t) be equal to the difference between spending and earning of foreign currencies.

$$Fs_t = \sum_{i}^{N} pcwm_t^i Mc_t^i + rwi_t Debt_t - \sum_{i}^{N} pcwx_t^i EXc_t^i - trowh_t - trowg_t \tag{38}$$

3.6 Steady-state conditions

The model is calibrated to the base year data from the 1998 Social Accounting Matrix of the Thai economy and parameter values shown in Appendix B. In calibration, the Thai economy is assumed to be in steady-state equilibrium with zero balance growth path, and then the model is solved for the consistent steady-state variables $\delta_{ss}^i, K_{ss}^i, Inv_{ss}^i, \lambda_{ss}^i$ and Q_{ss}^i.

Steady-state conditions are also imposed in terminal period $(t = ss)$. This is consistent with economic theory and ensures that the model will generate a steady-state equilibrium solution with values that are consistent with the benchmark data.

3.6.1 Steady-state budget constraint

$$\sum_{t=tss}^{\infty} \frac{1}{(1+r_{ss})^{t-1}} Y_{ss} = \sum_{t=tss}^{\infty} \frac{1}{(1+r_{ss})^{t-1}} Pf_{ss} Cf_{ss} \qquad (a27)$$

$$\frac{1}{r_{ss}} Y_{ss} = \frac{1}{r_{ss}} Pf_{ss} Cf_{ss}$$

$$Y_{ss} = Pf_{ss} Cf_{ss} \qquad (39)$$

Equation *(a27)* is the budget constraint from $t = ss$ and onward. In steady-state, exchange rate is constant. Therefore, domestic interest rate is fixed and equal to world market interest rate. It follows that, in equation *(39),* the steady-state value of consumption equals the steady-state disposable income.

3.6.2 Steady-state investment

$$Inv_{ss} = \delta^i_{ss} K^i_{ss} \qquad (40)$$

Equation (40) implies that steady-state investment of each sector just covers the depreciation of capital stock. Therefore, in steady-state, the value of capital stock of each production sector remains constant.

3.6.3 Steady-state shadow value of capital

$$(r_{ss} + \delta^i_{ss})\lambda^i_{ss} = \left[Rk^i_{ss} - Pki^i_{ss} \frac{\beta}{2}\left(\alpha^2 - \left(\frac{Inv^i_{ss}}{K^i_{ss}} \right)^2 \right) \right] \qquad (41)$$

In steady state, shadow value of capital stops changing. Therefore, the steady-state condition in equation (41) is the asset market equilibrium condition that requires the return on investment be equal to the market rate of interest plus the rate of capital depreciation.

With steady-state terminal conditions and the consistent steady-state values of variables $\delta^i_{ss}, K^i_{ss}, Inv^i_{ss}, \lambda^i_{ss}, Q^i_{ss}$, I solve the model as a social planner problem for intra and intertemporal solutions in a reference run over a horizon of 100 periods. Since the solution in a reference run represents the steady-state equilibrium of the Thai economy, an advent of oil prices shock traces an alternative time path that deviates from the steady-state equilibrium of the reference run.

4. Simulation

In this section, I first discuss the assumptions behind the simulation scenario. Then I present the simulation results. Unless otherwise specified, data in tables and figures presented in this section are expressed in terms of percentage deviations from their equilibrium values in the reference run.

4.1 Simulation scenario

The simulation scenario is based on 3 main assumptions. First, the reference case projection of International Energy Outlook (2005) and the low oil prices case of IEO (2006)[8] are assumed to be taken into consideration by agents in the model. There are two main conclusions that agents derive from these projections; (i) the long-run equilibrium oil prices lies somewhere between their average prices of 2003 and 2004, and (ii) oil prices reach their peak level at some point in time between 2006 and 2007, and gradually decrease to the long-run equilibrium before 2015. Second, while there are uncertainties about the duration of the shock, agents in the model take into account the pattern of the second oil crisis. In other words, the shock is assumed to be transitory and it takes about 8 years before returning to the pre-crisis level. Third, oil prices shock in the first period (2004) is assumed to be fully unanticipated.

Given these assumptions, I set import prices of oil in 2003 at long-run equilibrium and assume that oil prices shock is transitory with 8 years duration. Therefore, as shown in table 4-1, I simulate the model by using the actual percentage change of oil prices

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[8] Note that, over the last few years, most analytical and research paper as well as economics news base their analysis on IEO projections. Therefore, to some extend, it should influence the economic decision of agents.

during 2004-2006. In 2007, oil prices are set at the same level as in 2006, before proportionately decreasing over 2008-2012. To isolate the impacts of oil prices shock from other factors, the world market prices of other commodities are assumed to be constant.

Table 4-1: Shock to the import and export prices

	Crude petroleum	Gasoline	Diesel	Aviation fuel	Fuel oil	Gas
2004	34.50	42.50	38.20	42.50	15.40	24.00
2005	84.50	75.00	85.00	75.00	52.40	53.00
2006	137.00	108.60	114.00	108.60	84.00	80.00
2007	137.00	108.60	114.00	108.60	84.00	80.00
2008	109.60	86.70	91.00	86.70	66.30	63.90
2009	82.20	64.90	68.00	64.90	48.60	47.90
2010	54.80	43.10	45.00	43.10	30.80	31.90
2011	27.40	21.20	22.00	21.20	13.10	15.80
2012	0.00	0.00	0.00	0.00	0.00	0.00

4.2 The results from the model and the actual data

Table 4-2 shows the impact of oil prices shock on domestic market prices of gasoline, and diesel. Although the results from the model are not for forecasting purposes[9], they show that the model reasonably replicates the actual behavior of economic variables that should be directly affected by oil price increases in the world market.

Table 4-2: The impacts of oil prices shock on domestic market prices of gasoline and diesel

	Gasoline		Diesel	
	Result from model	Shadow price[10]	Result from model	Shadow price[11]
2004	21.77	23.24	24.25	25.02
2005	50.62	47.53	54.86	55.62
2006	77.24	76.95	84.10	87.08

[9] While the actual data is the market outcome of the interaction between various factors, the simulation results should be considered only as the likely impacts of oil prices shock given other things being equal.

[10] Average of January – July 2006

[11] Average of January – July 2006

4.3 The dynamic impacts of oil prices shock on the aggregate economy

Table 4-3 presents the impacts of oil prices shock on the aggregate economy during the period of the shock (2004-2011). In aggregate, oil prices shock reduces GDP in 2004 by 0.16 percent, which is very close to the result from long run static analysis in the previous chapter (0.14 percent). However, as oil prices accelerate further to their peak level in 2006-2007, it reduces GDP further to approximately 1 percent. The contraction of GDP coincides with an upward pressure on domestic prices. Aggregate consumption price increases by 0.24 percent in 2004 before steeply rising to approximately 1.50 percent in 2006 and 2007. Measured by compensating variation, oil prices shock reduces aggregate welfare by 0.743 percent.

Table 4-3: Impacts of oil prices shock on the aggregate economy

	GDP	C	I	G	X	M	CPI
2004	-0.16	-0.44	-2.58	3.34	-1.07	-2.01	0.24
2005	-0.54	-1.44	-3.71	7.59	-2.74	-4.03	0.85
2006	-0.99	-2.39	-4.59	11.44	-4.29	-5.63	1.44
2007	-1.07	-2.56	-4.19	11.29	-4.40	-5.63	1.54
2008	-0.93	-2.30	-3.13	9.09	-3.80	-4.87	1.38
2009	-0.78	-1.98	-2.10	6.83	-3.13	-4.01	1.18
2010	-0.63	-1.59	-1.11	4.50	-2.40	-3.03	0.95
2011	-0.48	-1.12	-0.21	2.07	-1.57	-1.87	0.66
C.V.			-0.743				

The contraction of GDP is led by the reduction of real investment and real consumption, which are the main components of GDP. In 2004, the net real export increases and contributes positively to real GDP as found in long-run static analysis. However, as oil prices accelerate, the net real export decreases and reinforces the contraction of other GDP components throughout the remaining periods of the shock (2005-2011).

Although oil prices shock lowers the aggregate economic activity, the increase in commodity prices and the expansion of energy production raise government income from indirect taxes. With the assumption of fixed government saving[12], government consumption increases throughout the period of the shock[13]. With its small contribution, the increase in government consumption is completely offset by the contractions of other GDP components. In addition, notice that the largest contraction of GDP occurs in 2007 due to the accumulated effects embodied in the dynamic properties of the model.

Also notice that, the contraction of the real consumption in the dynamic model is less than in the static analysis, but the contraction of real investment is greater. The possible explanation is the forward looking behaviors of agents in a dynamic setting. Since consumption price is expected to increase further, households consume more in the current period and less in the future. Similarly, firms cut their investment spending by taking into consideration the reduction of future stream of marginal product revenue of capital.

Figure 4-1 shows the dynamic transition path of aggregate economic variables. Since oil prices shock is assumed to be transitory, aggregate economic variables gradually converge to their balance growth paths in reference run. Nevertheless, the figure indicates the strong reductions of real investment, real consumption, real export and real import during the peak period of the shock.

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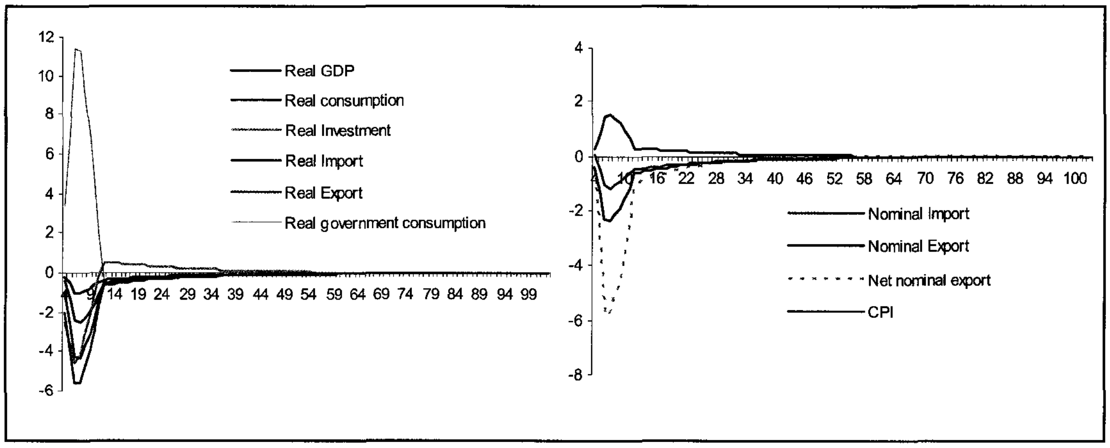
[12] This assumption is chosen to reflect the real situation in 2003-2006 and to make our results form dynamic analysis comparable to the results from static analysis.

[13] Note that, in 2003 and 2004 many analysts refer to the increase of tax revenues as a positive indication for aggregate economic activity. Our simulation shows that, in the presence of oil prices shock, tax revenues can increase concurrently with GDP contraction.

Figure 4-1: Transition path of aggregate variables



According to model specifications, the strong contraction of real consumption during the peak period of oil prices shock is attributable to the reduction of real lifetime income and the intertemporal substitution behavior of households. At any point in time, the increase in consumption price reduces the purchasing power of existing lifetime income[14]. In addition, since the increase of consumption price is transitory, households substitute their current period consumption by consumption in other periods, when the prices have eased.

The contraction of aggregate real investment is attributable to the reduction of investment in non-energy sectors. Although the higher prices of non-energy commodities provide a better prospect for firms, the sharp reduction in the demand for their products together with the higher cost of energy input makes their existing installed capital over-employed, and reduces the stream of marginal product revenue of capital. Combined with

[14] For details, see equation *(a3)* in previous section

the increase of purchased price of capital, the Q_t^i measurement decreases and firms adjust capital stock downward[15].

The increase of domestic price affects the price competitiveness of domestic output in the world market. Together with the reduction of domestic demand, it results in the contraction of both aggregate real export and real import throughout the period of the shock. The right panel of figure 4-1 shows that the aggregate nominal import decreases by a smaller magnitude than aggregate nominal export throughout the remaining periods of the shock. In contrast to their nominal value, the aggregate real import decreases by a larger magnitude than the decrease of aggregate real export as shown in the left panel of figure 4-1. This implies a strong deterioration effect of oil prices shock in terms of trade, which is consistent with the observed sharp reduction of the actual current account position in 2004 and 2005.

4.4 Sectoral impacts

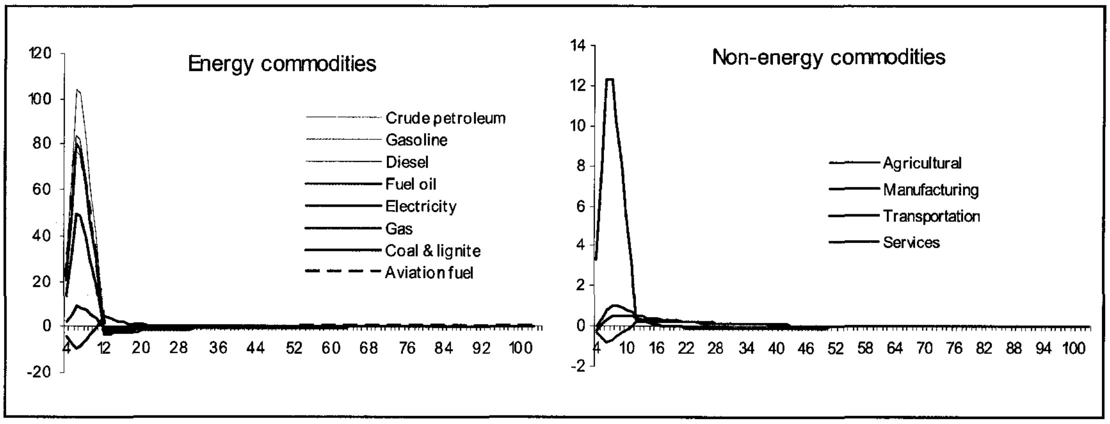
4.4.1 Prices

Simulation results show that oil prices shock raises the aggregate consumption price level by 0.24 percent in 2004 and approximately 1.5 percent in 2006 and 2007 when oil prices accelerate to their peak level. As the increase of aggregate price coincides with the contraction of aggregate demand, it is the stylized cost-push effect.

Figure 4-2 shows the transition path of commodity prices and Table 4-4 presents the impacts of oil prices shock on the prices of selected commodities. Except for services and coal & lignite, the size of impact of oil prices shock on each commodity price largely depends on the share and the structure of energy input.

[15] For details, see equation *(a15), (11) and (12)* in previous section

Figure 4-2: Transition path of commodity prices



With respect to energy commodities, domestic prices of crude oil, gasoline, diesel and aviation fuel strongly increase, but at a smaller magnitude than the increase in their world market prices. This is due to cheaper domestic cost embodied in their production processes[16]. In addition, simulation results show that domestic prices of gasoline and diesel in the model reasonably replicate their shadow price. Since crude oil accounts for approximately 70 percent of the total cost of gasoline, diesel and aviation fuel production, domestic market prices of these commodities strongly respond to the shock. However, the price of coal & lignite decreases as the pressure of higher energy cost is offset by a strong reduction of demand for its product.

Table 4-4: Impacts of oil prices shock on the prices of selected commodities

	Agri-cultural	Manu-facturing	Trans-portation	Services	Crude Petroleum	Gasoline	Diesel	Electricity
2004	0.05	-0.16	3.32	-0.33	29.56	21.77	24.25	2.32
2005	0.43	0.08	8.02	-0.59	67.95	50.62	54.86	5.71
2006	0.86	0.35	12.31	-0.75	104.46	77.24	84.10	8.71
2007	1.01	0.50	12.26	-0.64	102.33	75.40	82.14	8.55
2008	0.98	0.53	10.15	-0.47	81.48	60.23	65.50	6.86
2009	0.91	0.54	7.96	-0.31	61.00	45.24	49.10	5.16
2010	0.82	0.52	5.62	-0.14	40.41	30.02	32.50	3.40
2011	0.68	0.47	3.09	0.02	19.32	14.17	15.31	1.53

[16] Also, this implies the price advantage of refined petroleum products in international trade. This implication is consistent with the base year data, which indicates that Thailand is the net importer of crude oil but the net exporter of gasoline, diesel and aviation fuel.

The increase in energy price put an upward pressure on the domestic market prices of other commodities through the cost-push mechanism. Among non-energy productions, transportation is the highest energy intensive commodity and its energy input is mostly made up of gasoline and diesel. Therefore, price of transportation strongly responds to the shock, with an increase of 3.32 percent in 2004 and a steep rise of 12.31 percent in 2006. Agricultural price increases by more than manufacturing price as its energy input has a larger share of gasoline and diesel than manufacturing[17]. The cost-push pressure on the domestic market price of services is minimal and is totally offset by the reduction of demand. This is because the energy input of services production is mostly electricity. Therefore, it is indirectly affected by oil prices shock through the increase in electricity price. However, it is worth noting that, since the early 2000s, electricity production in Thailand has increasingly relied on gas generators as compared to 1998 (the base year data). Therefore, the impact of oil prices shock on electricity price is possibly underestimated. Nevertheless, considering the actual increases in electricity prices of 4.2 and 7.9 percent in 2004 and 2005, which is the market outcome of many factors, the results from the model reasonably replicate the direction of the actual data.

4.4.2 Sectoral investments

Investment behavior at disaggregate level cannot be analyzed in the framework of a static model presented in the previous chapter[18]. Therefore, it is of particular interest for the analysis in this subsection. Although the extension of the analytical model to take

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[17] The main energy input of manufacturing production is electricity. Therefore, it is indirectly affected through the increase in electricity price.

[18] In a static model, savings is a base year fixed proportion to income and is allocated across investment commodities according to the base year proportion.

into account dynamic investment is more commonly noted recently, most studies rely on the strong assumption of capital stock homogeneity. In addition, the traditional partial equilibrium analysis of investment Q theory tends to ignore the role of purchased price of capital stock.

Figure 4-3: Transition path of investment indicators of non-energy sectors

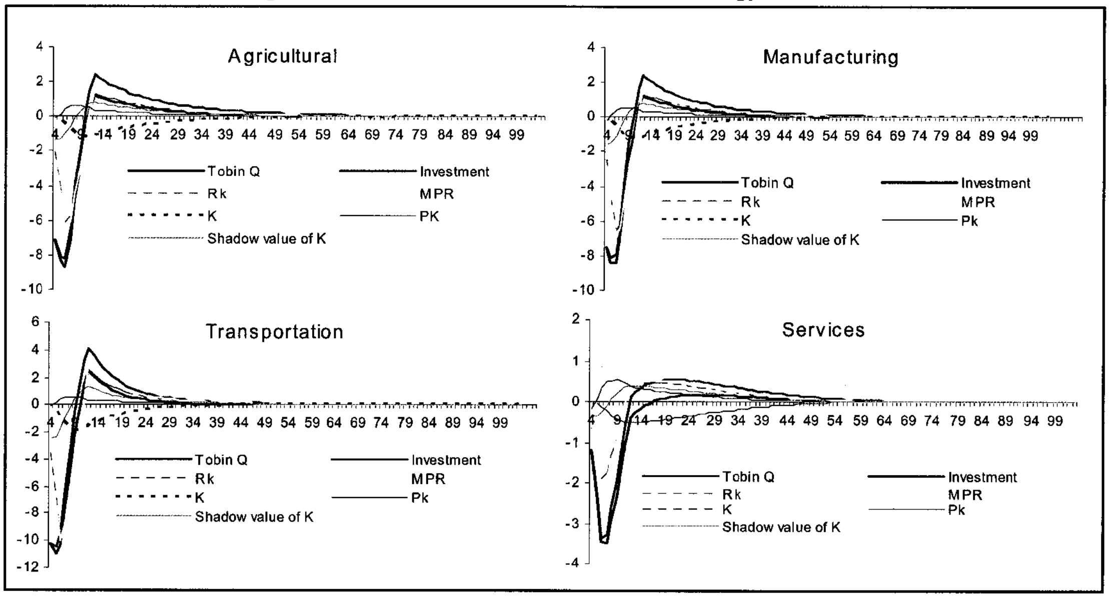

Figure 4-3 presents the transition path of investment indicators of non-energy production sectors, the key determinant of aggregate investment of the Thai economy. In general, except for services, oil prices shock affects investment indicators of non-energy sectors in a similar fashion. The fully unanticipated shock in 2004 instantaneously reduces the rate of return on capital. At the existing level of capital stock of the reference run, the shadow value of capital and Q_t^i of these sectors jump downward[19]. This

19 On the supply side, oil price increases imply scarcity of energy input and reduces the productivity of other inputs including capital input. On the demand side, the sharp reduction of demand for their products makes their installed capital over- employed. This situation reduces the rate of return on capital, value of firms and hence their shadow value of capital (λ_t^i). Together with the increase in purchased price of capital, at existing steady state level of capital stock, Q_t^i jumps downward.

situation creates a wedge between the rate of return on investment and the market rate of interest. Firms adjust their capital stock downward while the shadow value of capital increases. However, since oil prices shock persists and raises the purchased price of capital further, Q_t^i continually decreases and coincides with the reduction of capital stock until 2006-2007[20].

After 2007, oil prices gradually decline from their peak level. The economic environment improves and the purchased price of capital decreases (from its value in 2007). Therefore, in 2008, Q_t^i bottoms out. However, since the value of Q_t^i remains below its steady-state level, firms continue to adjust their capital stock downward and results in an increase of rate of return and shadow value of capital. This adjustment process continues until the capital stock, oil prices and purchased price of capital stock are sufficiently low and raise Q_t^i and investment across their steady-state levels at some point in time between 2010 and 2011. At this point, the level of capital stock reaches its lowest level.

In 2012 and onward, oil prices return to their steady-state equilibrium values in reference run. Without adjustment costs, the optimal level of capital stock required by profit maximizing firms would instantaneously set back to its steady-state level before the shock. With the investment adjustment costs, however, the delay in capital adjustment process raises the gap between the optimal and the existing level of capital stock. This situation raises the rate of return on capital stock and therefore Q_t^i further to their peak

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[20] If the shock was not persistent and did not raise purchased price of capital stock further, we would observe a decrease of the capital stock but an increase of Q_t^i after 2004.

level in 2012. Investment increases and capital stock gradually adjusts to its long run steady-state level. The higher level of capital stock reduces the rate of return on investment to finally equal the market rate of interest plus the rate of capital depreciation where the asset market equilibrium condition is met in the long run.

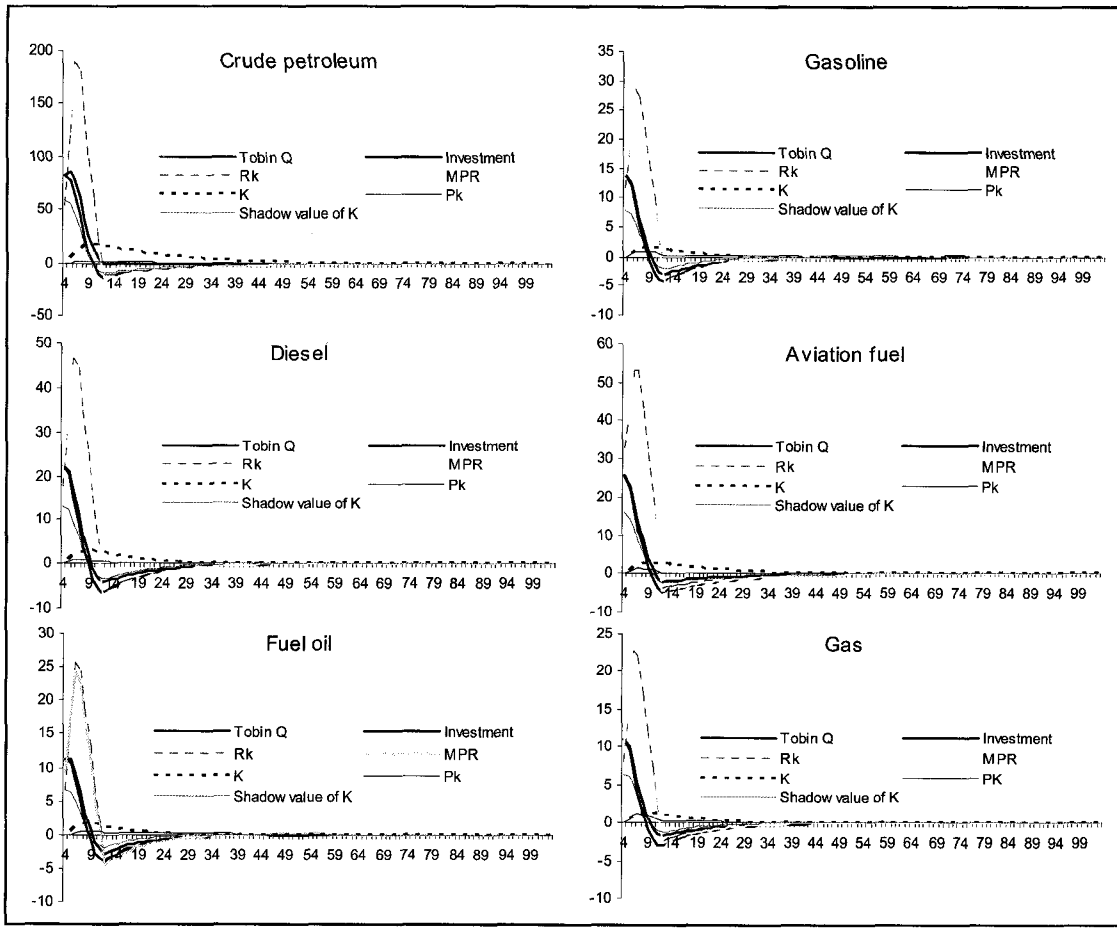
Table 4-5: Impacts of oil prices shock on the investment of non-energy sectors

	Agricultural	Manufacturing	Transportation	Services
2004	-7.11	-7.52	-10.28	-1.19
2005	-8.34	-8.38	-10.96	-2.38
2006	-8.71	-8.41	-10.37	-3.47
2007	-7.12	-6.71	-7.84	-3.49
2008	-4.84	-4.43	-4.81	-2.93
2009	-2.84	-2.48	-2.22	-2.33
2010	-1.15	-0.86	-0.10	-1.70
2011	0.23	0.41	1.51	-1.05

Although investment transition path of non-energy production sectors displays a similar pattern, the sizes of the impact of oil prices shock differ across production sectors. Table 4-5 shows that the impact of oil prices shock on the investment is strongest in the transportation sector, which is attributable to the strong reduction of demand and the strong increase of energy cost of production. The impacts on the investment in the agricultural and manufacturing sectors are almost at the same magnitude. The contraction of investment in the services sector is less than in other sectors and is mainly attributable to the increase in purchased price of capital stock.

Figure 4-4 presents the transition path of investment indicators of energy sectors. Except for coal & lignite and electricity, oil prices shock stimulates capital formation of energy production sectors. Since the behavior of investment indicators of coal & lignite and electricity as well as their underlined fundamental factors resemble those of non-energy sectors, the analysis in this subsection focuses on the sectors that benefit from oil prices shock.

Figure 4-4: Transition path of investment indicators of energy sectors



Although oil prices shock reduces demand for every energy commodity, the rate of return on capital stock increases. This implies that the negative effects of oil prices shock through the reduction of demand and the higher energy cost of production are fully offset by the increase in their output prices. Therefore, the shadow value of capital increases. In contrast to the non-energy sector, at their initial steady-state level of capital stock in 2004, Q_t^i jumps upward. The gap between the rate of return on investment and the market rate of interest stimulates investment in energy sectors. Firms gradually adjust their capital stock upward that, together with the increase of purchased price of capital stock, brings their Q_t^i downward. This process continues until Q_t^i measurement and investment fall to their steady-state levels at some point in time between 2010 and 2011, when capital stock of each sector reaches its peak level. Since oil prices shock is transitory, in 2012, the optimal level of capital stock required by profit maximizing firms is set back to its initial steady-state level. However, firms are subjected to convex adjustment costs. The delay in capital formation process reduces the rate of return on capital stock and pushes Q_t^i further downward below its steady-state level. Therefore, firms adjust their capital stock downward until the asset market equilibrium condition is met in the longer run.

Table 4-6: Impacts of oil prices shock on the investment of energy sectors

	Crude Petroleum	Gasoline	Diesel	Aviation fuel	Fuel oil	Gas	Coal & lignite	Electricity
2004	82.13	13.83	22.37	25.55	11.37	11.00	-25.57	-0.61
2005	85.20	12.67	21.20	22.80	11.17	10.03	-26.87	-1.21
2006	78.64	10.00	17.37	18.60	9.25	7.80	-24.69	-1.84
2007	61.35	6.61	12.01	13.55	6.21	5.13	-16.92	-2.02
2008	42.01	3.41	6.75	8.43	3.18	2.65	-7.99	-1.91
2009	25.71	0.76	2.36	4.16	0.70	0.67	-0.71	-1.73
2010	12.94	-1.27	-1.05	0.88	-1.17	-0.75	4.98	-1.50
2011	4.15	-2.58	-3.31	-1.27	-2.34	-1.55	8.97	-1.22

Table 4-6 presents the impacts of oil prices shock on the investment of energy sectors. Overall, it contributes to the expansion of investment in almost every energy sector, except for coal & lignite and electricity that suffer from higher energy cost of production and reduction of demand for their product.

4.4.3 Demand for sectoral commodities

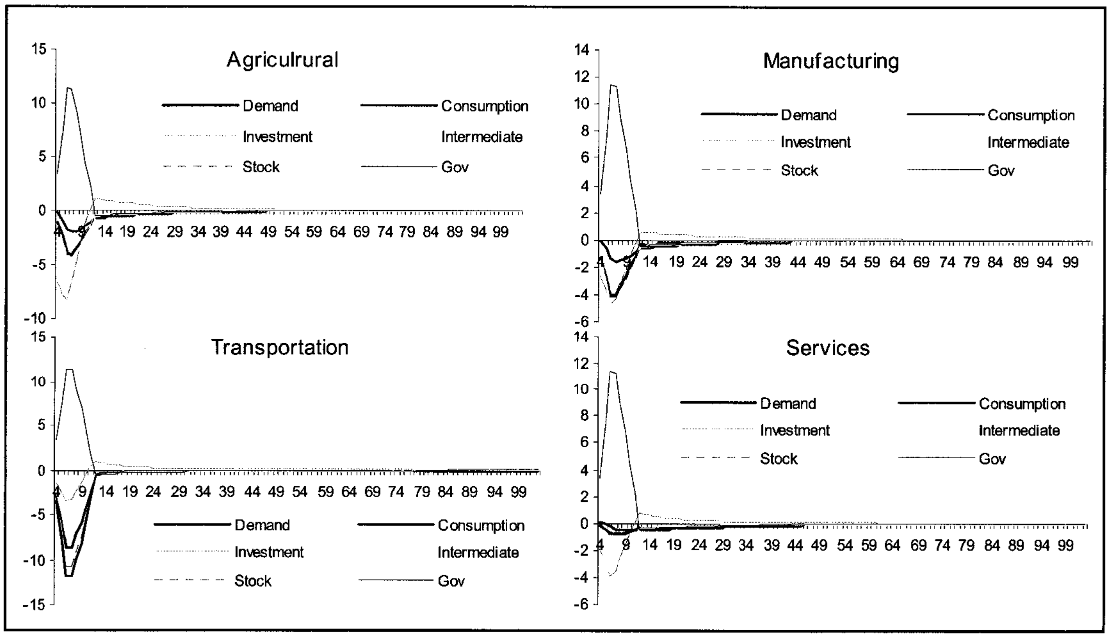
According to model formulation, the demand for each commodity comes from consumption, investment, intermediate inputs, government consumption and inventory. In general, simulation results show that oil prices shock results in a contraction of demand for every commodity.

Table 4-7: Impacts of oil prices shock on the demand for non-energy commodities

	Agricultural	Manufacturing	Transportation	Services
2004	-1.06	-1.30	-2.86	-0.17
2005	-2.56	-2.69	-5.81	-0.46
2006	-3.95	-3.96	-8.56	-0.73
2007	-4.04	-3.95	-8.54	-0.79
2008	-3.46	-3.30	-7.23	-0.75
2009	-2.83	-2.62	-5.80	-0.69
2010	-2.15	-1.89	-4.22	-0.60
2011	-1.38	-1.12	-2.43	-0.49

In terms of transmission mechanism, oil prices shock lowers household's wealth and the value of firms in major production sectors. In addition, its indirect effect in terms of higher price level lowers purchasing power of existing wealth and squeezes the budget of non-energy production firms. In this regard, households reduce their consumption and non-energy production firms reduce their intermediate and investment demands. Although the increase in price level gives rise to an increase of indirect tax income and raises government consumption, its contribution is fully offset by the contraction of other demand components.

Figure 4-5: Transition path of demand for non-energy commodities



Among non-energy commodities, Table 4-7 indicates that the largest reduction of demand is for transportation followed by agricultural and manufacturing, while the services sector suffers the least. According to the transition path of demand components in Figure 4-5, the reductions of demand for agricultural, manufacturing and transportation commodities are attributable to the contraction of intermediate inputs demand, while the reduction of demand for the services commodity is attributable to the decrease in consumption demand. This movement reflects the structure of demand of each non-energy commodity where the consumption demand has its highest share in the services commodity.

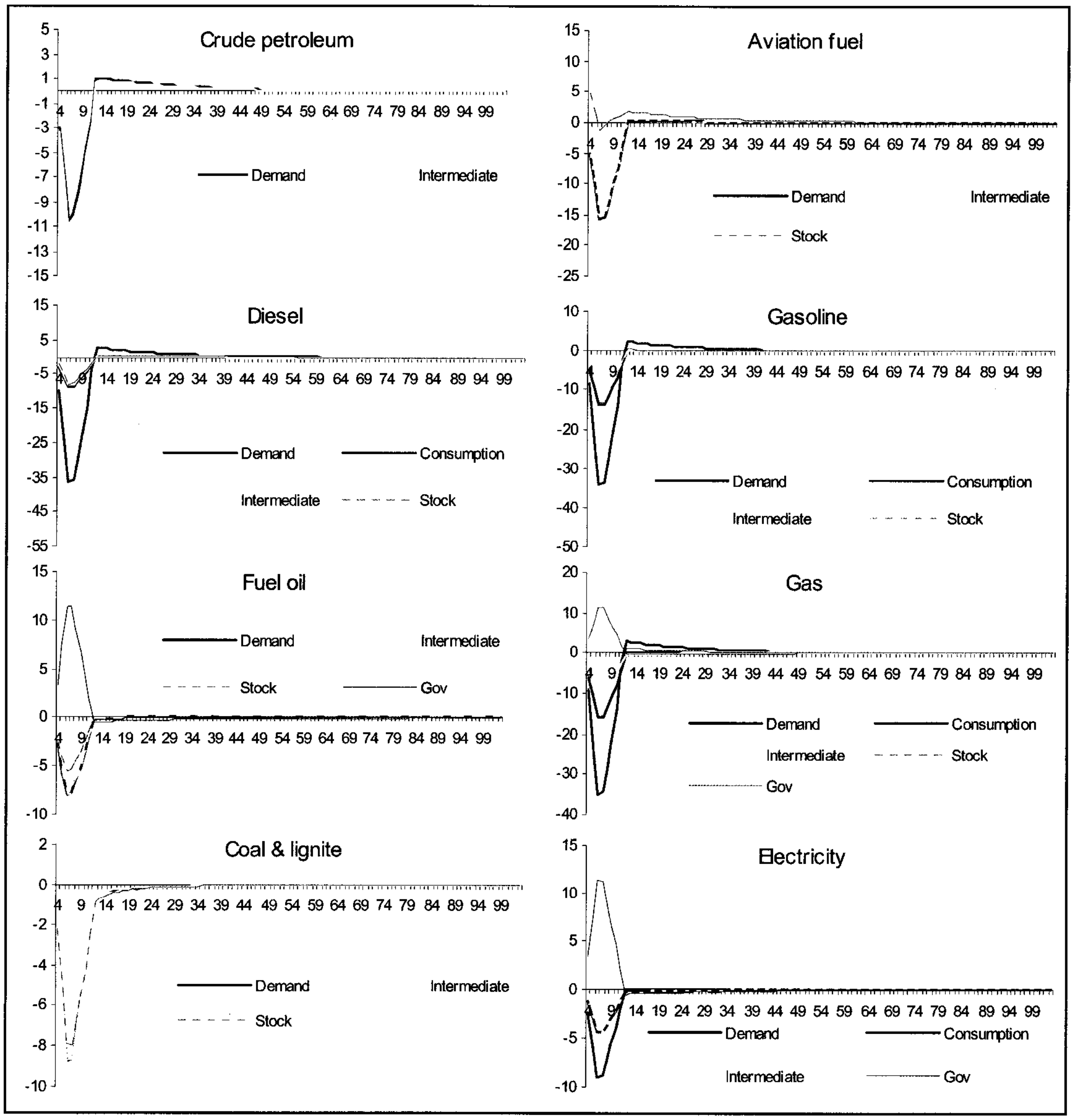
Table 4-8: Impact of oil prices shock on the demand for selected energy commodities

	Electricity	Crude petroleum	Gasoline	Diesel	Aviation fuel	Fuel oil	Gas
2004	-1.29	-2.99	-4.79	-2.87	-5.00	-2.77	-5.92
2005	-2.99	-7.27	-9.96	-6.19	-11.05	-5.53	-11.65
2006	-4.49	-10.48	-13.86	-8.88	-15.87	-7.95	-15.87
2007	-4.51	-9.98	-13.65	-8.68	-15.66	-7.82	-15.70
2008	-3.80	-8.28	-11.59	-7.20	-13.18	-6.54	-13.54
2009	-3.05	-6.53	-9.32	-5.65	-10.49	-5.21	-11.08
2010	-2.23	-4.58	-6.72	-3.98	-7.48	-3.76	-8.15
2011	-1.33	-2.21	-3.61	-2.08	-4.00	-2.12	-4.49

Table 4-8 presents the impacts of oil prices shock on the demand for selected energy commodities. The contraction of the aggregate economy and the increase in oil prices lead to a reduction of demand for every energy commodity. However, simulation results show that demands for crude oil, diesel, gasoline, and aviation fuel are rather inelastic. As their market prices in 2006 are about 1.2-1.4 times higher than in 2003, their demand only decreases by approximately 12 percent.

Although the sizes of the impact of oil prices shock on the demand are asymmetric across energy commodities, Figure 4-6 shows that their transition path share a similar pattern. Except for gas, they are largely determined by the movement of intermediate demands. This is because the intermediate use of energy accounts for approximately 70 percent of the total energy demand in Thailand. Together with the fact that the price elasticity of demand for energy is rather inelastic, any effective energy saving measure must take place in production rather than in consumption and the non-price measures are privileged.

Figure 4-6: Transition path of demand for energy commodities



4.4.4 Production and trade

Similar to the findings from long-run static analysis, the results from the dynamic model show that oil prices shock leads to the contraction of production output in almost every sector, except for crude petroleum and aviation fuel. Among non-energy productions, Table 4-9 shows that transportation experiences the largest contraction as its product price increases the most. The contractions of agricultural and manufacturing productions are almost at the same magnitude while the production of services decreases slightly.

Table 4-9: The impacts of oil prices shock on the production of non-energy sectors

	Agricultural	Manufacturing	Transportation	Services
2004	-1.07	-1.20	-3.27	-0.14
2005	-2.60	-2.74	-7.39	-0.40
2006	-4.04	-4.16	-10.82	-0.66
2007	-4.15	-4.23	-10.80	-0.73
2008	-3.57	-3.60	-9.16	-0.70
2009	-2.94	-2.93	-7.37	-0.66
2010	-2.24	-2.19	-5.38	-0.59
2011	-1.46	-1.39	-3.09	-0.50

In Figure 4-7, I plot the transition path of production, domestic demand and the net real export of non-energy sectors. The figure indicates that the contractions of production of agricultural, manufacturing, and transportation are the result of the reductions of both domestic demand and the net real export. According to model specifications, the increase in oil prices raises the relative price of domestic output to foreign market price. A relative price change of this kind reduces the net real export of non-energy commodities, in particular those of agricultural and manufacturing, which are the key determinants of current account balance of the Thai economy.

The transition path of the net real export of services shows a distinctive feature. The contraction of demand for services reduces its domestic price and raises the net real export during the first few periods of oil price shock. As oil prices gradually decrease after 2007, demand for services increases. This pushes its domestic price gradually upward and results in the deterioration of price competitiveness. After the shock in 2012, production of services cannot catch up with demand and bid up its domestic price further. This leads to the contraction of its net real export after the shock.

Figure 4-7: Transition path of production of non-energy sectors

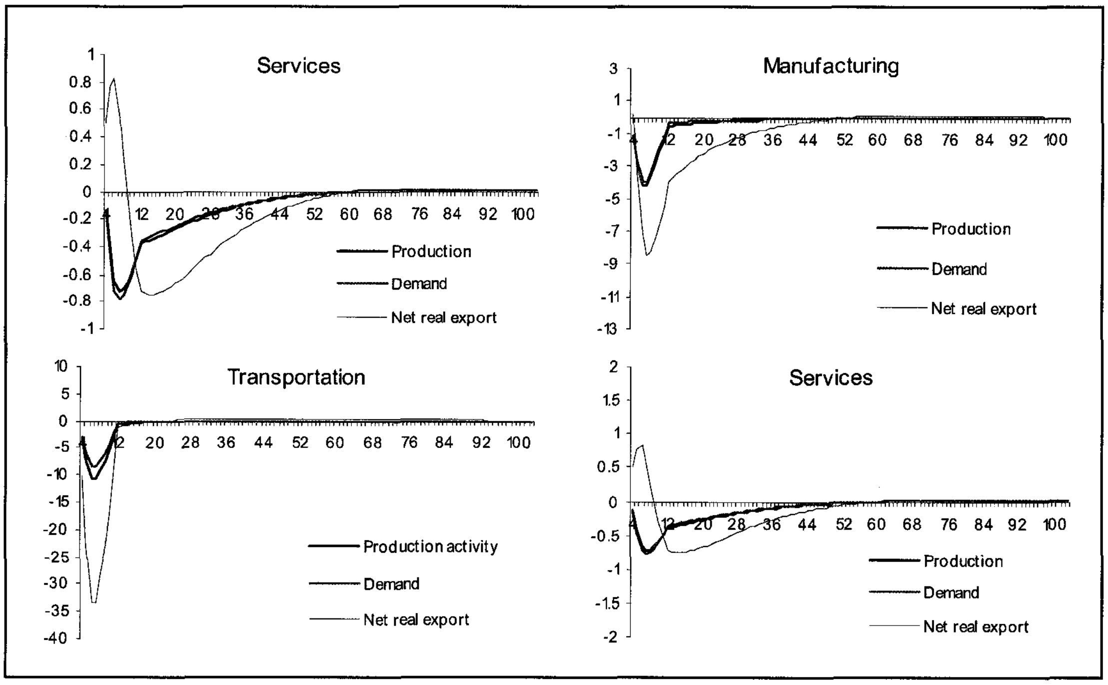


Table 4-10 shows the impacts of oil prices shock on the production of energy sectors. Except for crude oil and aviation fuel, the impact of oil prices shock on energy sectors is similar to its impact on non-energy production sectors. The increase in their commodity price reduces demand. Although the change in relative prices contributes to the expansion of the net real export in some production sectors, it is completely offset by a reduction in domestic demand. Therefore, we observe the contraction of production in almost every energy sector.

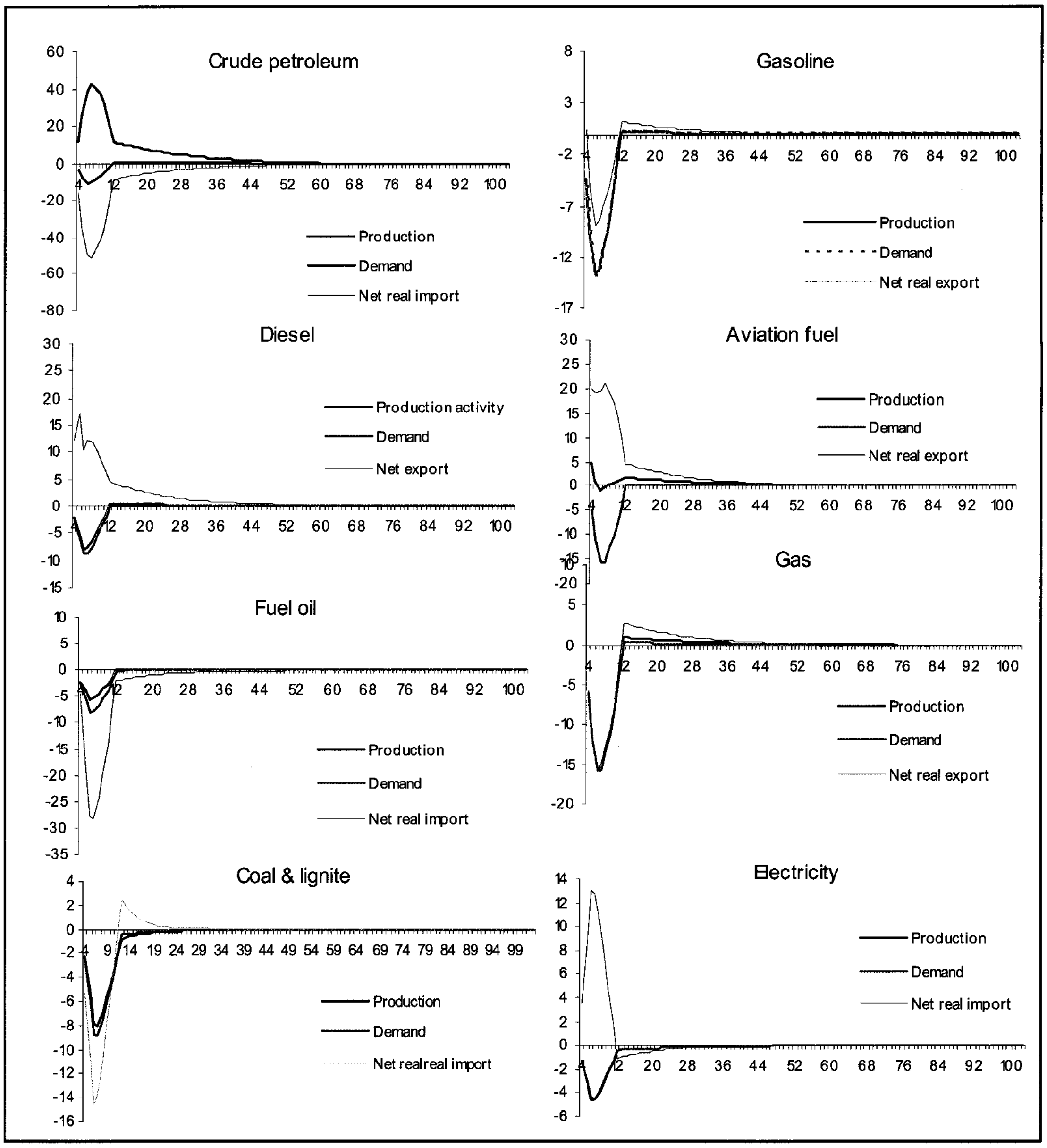
Table 4-10: Impacts of oil price shock on the production of energy sectors

	Electricity	Crude petroleum	Gasoline	Diesel	Aviation fuel	Fuel oil	Gas
2004	-1.32	11.55	-4.38	-2.20	4.92	-2.56	-5.87
2005	-3.05	26.31	-9.59	-5.10	1.08	-3.97	-11.55
2006	-4.59	38.45	-13.47	-7.99	-1.17	-5.59	-15.86
2007	-4.61	42.28	-13.24	-7.73	-0.34	-5.38	-15.47
2008	-3.88	40.75	-11.22	-6.33	0.26	-4.46	-13.30
2009	-3.11	37.05	-9.01	-4.92	0.64	-3.55	-10.88
2010	-2.27	31.19	-6.48	-3.41	0.93	-2.60	-7.97
2011	-1.35	22.98	-3.45	-1.70	1.24	-1.54	-4.21
2012	-0.37	11.81	0.36	0.33	1.78	0.10	1.04

Crude petroleum and aviation fuel are special cases. Domestic demand falls as product price rises, but their production increases. For crude petroleum, since its domestic price increases by a smaller magnitude than its world market price, domestic demand increasingly relies on domestic output. This results in the decrease of its net real import and therefore we observe the contraction of domestic demand but the expansion of its production. For aviation fuel, while domestic demand decreases, change in the relative prices contributes to the expansion of its export. With the high ratio of export to domestic output, we observe the expansion of its production.

The impacts of oil prices shock on the production of gasoline, diesel, fuel oil and gas are similar to the implications found in the static analysis of the previous chapter. The contractions of their productions are attributable to the reduction of domestic demand. However, while the results from both static and dynamic models indicate the increase in the net real export of gasoline in 2004, figure 4-8 shows that its net real export decreases in the longer run.

Figure 4-8: Transition path of production of energy sectors



5. Conclusion

In this chapter, I analyze the macro and microeconomic impacts of transitory oil prices shock on the Thai economy. For the purpose of this study, I develop a dynamic CGE model along the lines of the neoclassical growth theory of the Ramsey type. With the inclusion of the investment Q theory, it becomes possible for the analysis to investigate the dynamic investment behavior at a disaggregate level as well as to analyze the dynamic transitional path of the economy over a relevant time horizon.

The results indicate that oil prices shock reduces the GDP in 2004 by 0.16 percent, close to the result from static analysis. However, as the oil prices accelerate further, it reduces GDP by approximately 1 percent in 2006-2007. The contraction of GDP is led by a reduction of real investment (of 2.58 percent in 2004 and approximately 4.4 percent in 2006-2007) and the contraction of real private consumption (of 0.44 percent in 2004 and approximately 2.4 percent in 2006-2007). Aggregate consumption price increases by 0.24 percent in 2004 before steeply rising to approximately 1.5 percent in 2006 and 2007 when the shock reaches its peak. The net real export increases and contributes to GDP in 2004, which is consistent with the findings from the long run static analysis. However, as oil prices shock persists and accelerates further, the net real export decreases and reinforces the contraction of other GDP components. Considering the changes in real export and import relative to their nominal values, the results suggest that oil prices shock has a large and significant negative impact on terms of trade, and therefore on the current account position of the Thai economy.

In a dynamic setting, economic decisions in each period depend on expectation about future economic conditions. Consequently, when compared to static analysis, the results from dynamic model show a smaller negative impact of oil prices shock on real consumption, but a greater negative impact on real investment. In addition, this accumulated effect tends to increase with the size of the shock. In simulation, this adds another 0.08 percent of GDP contraction during the peak period of the shock in 2007.

At a more disaggregate level, oil prices shock puts upward pressure on production cost and raises the price of almost every commodity, except for coal & lignite and services. Among energy commodities, prices of gasoline, diesel, aviation fuel and crude oil increase sharply but at a smaller magnitude than the increases in their world market prices. This induces the expansion of the net real export of energy commodities. For non-energy commodities, price of transportation increases the most (3.32 percent in 2004 and approximately 12.3 percent in 2006-2007) followed by agricultural and manufacturing. Given that the world market price is constant, this situation reduces competitiveness and leads to a contraction of the net real export of non-energy commodities (except for services), which are the key determinants of aggregate export of the Thai economy.

The increase of commodity price and the negative effect of oil price shock on household incomes and budgets of firms lead to a contraction of demand for every commodity. For non-energy commodities, the largest contraction of demand is for transportation followed by agricultural and manufacturing respectively. The impact on services is minimal as it benefits from the expansion of government spending. With respect to energy commodities, except for coal & lignite and fuel oil, results suggest that the demand is inelastic. As their price in 2006-2007 is almost 1.4 times higher than in

2003, the demand for these energy commodities only decreases by approximately 12 percent on average.

Although energy production sectors experience a reduction of demand and higher energy cost of production, in most cases, these negative impacts are offset by the increase in their commodity price. Except for coal & lignite and electricity, oil prices shock raises marginal product revenue of capital and therefore stimulates capital accumulation in energy sectors. In contrast, investment in non-energy sectors is negatively affected. This is because the contraction of demand and increase in energy cost reduces the shadow value of capital. Reinforced by the increase in the purchased price of capital, it leads to the contraction of investment of every non-energy sector, which is the key determinant of the aggregate investment of the Thai economy.

On the production side, oil prices shock stimulates the productions of crude oil and aviation fuel. However, it reduces production in all other sectors. The increases of crude oil and aviation fuel productions are driven by the increases of their net real exports while their domestic demands show a contraction. The contraction of production in all other production sectors is attributable to the reduction of domestic demand, in particular the demands for intermediate inputs and consumption.

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Appendix A: List of parameters and variables in the model

I. List of parameters

α	Adjustment cost parameter
α_a^i	Shift parameter in domestic output CES production function
α_c	Shift parameter in Cobb-Douglas consumption function
α_q^i	Shift parameter in Armington function
α_t^i	Shift parameter in CET function
α_{va}^i	Shift parameter in value-added CES production function
β	Parameter in adjustment cost function
β_a^i	Share parameter in domestic output CES production function
β_q^i	Share parameter in Armington function
β_t^i	Share parameter in CET function
β_{va}^i	Share parameter in value-added CES production function
ρ^i	Share parameter in Cobb-Douglas consumption function
δ^i	Depreciation rate of capital stock
θ_a^i	Exponential parameter in domestic output CES production function
θ_q^i	Exponential parameter in Armington function
θ_t^i	Exponential parameter in CET function
θ_{va}^i	Exponential parameter in value-added CES production function
$icin_t^{i,j}$	Intermediate goods j per unit of aggregate intermediate input
$imat^{i,j}$	Share parameter in investment matrix
p	Rate of time preference
$pcwm_t^i$	Import price in foreign currency unit
$pcwx_t^i$	Export price in foreign currency unit
rwi_t	World market interest rate
stk^i	Ratio of inventory investment to output
$trgh_t$	Transfer between government and household
$trowg_t$	Transfer between ROW and government
$trowh_t$	Transfer between ROW and household
txa^i	Indirect tax rate on activity
txc^i	Indirect tax rate on commodity
txm^i	Import duty
$txva^i$	Value added tax rate
ty	Direct tax rate
v	Elasticity of marginal intertemporal utility

II. List of variables[21]

λ_t^i	Shadow value of capital
ABS_t^i	Quantity of domestic composite
Cc_t^i	Quantity of consumption demand for goods i
Cf_t	Quantity of full consumption
$Debt_t$	Foreign debt
$Dinv_t^{i,j}$	Quantity demand for investment goods by origin
ER_t	Nominal exchange rate (fixed as numeraire)
EXc_t^i	Quantity of export
FS_t	Capital flow
GS_t	Government saving
Inv_t^i	Quantity of investment by destination sector
J_t^i	Total investment by destination sector (including adjustment portion)
K_t^i	Capital stock
L_t^i	Demand for labor
$\overline{LS}_t$	Labor supply
Mc_t^i	Quantity of import
PA_t^i	Price of domestic output
Pc_t^i	Price of composite good
PDc_t^i	Price of domestic output sold domestically
Pf_t	Price of full consumption
$PinAD_t^i$	Price of aggregate intermediate input
Pk_t^i	Replacement cost of capital stock
PMc_t^i	Import price in local currency unit
PXc_t^i	Export price in local currency unit
Pv_t^i	Price of value added
Q_t^i	Q measurement
QA_t^i	Quantity of domestic output
$QCinD_t^{i,j}$	Quantity of intermediate demand for goods j
QDc_t^i	Quantity of domestic demand for domestic output

[21] Note that in the base model ER_t, GS_t, and $\overline{LS}_t$ are fixed

Qg_t^i	Quantity of government demand for goods i
$QinAD_t^i$	Quantity of aggregate intermediate input
QSc_t^i	Quantity of domestic output sold domestically
$Qstk_t^i$	Quantity of demand for stock investment
Qv_t^i	Quantity of value added
r_t	Domestic interest rate
Rk_t^i	Rental rate
TAX_t	Government revenue from taxes
U	Utility function
W_t	Wage rate
Y_t	Consumer's budget
YH_t	Household income

Appendix B: Parameters in the model

Table B-1: Trade elasticity

	Armington elasticity	CET elasticity
Agriculture	0.8	0.9
Industry	0.9	1.5
Energy		
- Coal & lignite	0.5	0.3
- Crude petroleum	4.5	1.1
- Gasoline	1.5	0.7
- Diesel	1.5	0.6
- Aviation Fuel	1.5	0.6
- Fuel oil	0.6	0.6
- Electricity	0.5	0.5
- Gas	0.7	0.5
Transportation	0.7	0.6
Services	0.5	0.5

Table B-2: Elasticity of input substitution and adjustment cost parameter

	K-L[a]	Qv-QintAD[b]	Adjustment cost parameter
Agriculture	0.5	0.3	3.33
Industry	0.5	0.3	3.33
Energy			
- Coal & lignite	0.5	0.3	13.00
- Crude petroleum	0.5	0.2	20.00
- Gasoline	0.5	0.2	16.00
- Diesel	0.5	0.2	16.00
- Aviation Fuel	0.5	0.2	20.00
- Fuel oil	0.5	0.2	10.00
- Electricity	0.5	0.2	16.00
- Gas	0.5	0.2	16.00
Transportation	0.5	0.3	3.33
Services	0.5	0.3	3.33

[a] *Between capital (K) and labor (L)*
[b] *Between value added composite (Qv) and intermediate composite (QintAD)*

Chapter 3: The impact of trade liberalization in a revenue constrained economy: the case of Thailand

Abstract:

This chapter analyzes the impact of trade liberalization in the context of a revenue constrained economy. In the framework of the CGE model for tax policy analysis, the results show that, tariff reductions of 41.9 percent for agricultural and 37.7 percent for manufacturing reduce government revenues by ฿ 20.829 billion which is equivalent to 0.450 percent of GDP. Aggregate production increases and raises the aggregate real income. GDP increases by 0.036 percent led by the expansions of investment and consumption. Government consumption decreases by 2.297 percent. Overall, without revenue constraint, tariff reductions raise the aggregate welfare by ฿ 6.469 billion which is equivalent to 0.139 percent of GDP.

In the context of a revenue constrained economy, the reduction in tariff revenue is neutralized by the incomes from Value Added Tax (VAT), Excise Tax (ET), Special Business Tax (SBT) and Household Income Tax (HIT). The results show that the impacts of trade liberalization significantly differ from the case without revenue compensation. In all cases, the aggregate welfare decreases and implies all tax measures are less efficient than tariffs. With VAT, SBT and HIT, GDP increases by significantly less than in the case without revenue compensation. With ET, it leads to GDP contraction. At a disaggregate level, simulation results show that ET has an economy-wide distortion effect on production. SBT directly distorts against services production. HIT reduces the aggregate production through its impact on labor force reallocation that raises wage rate. VAT directly distorts against informal agricultural production sectors. The distortion effect of VAT, which can be captured when the model explicitly takes into account the invoices rebate system, has an important implication for VAT policy analysis.

1. Introduction

Trade theory asserts that free trade is optimal for a small open-economy. Tariff revenue can even increase in the early stage of trade liberalization but may eventually decline. Consequently, a government may want to replace tariff revenue by another source. A recent study by Khattry (2003) shows that trade liberalization can pose an adverse effect on government revenue and induces developing countries to employ some sorts of tax compensation. It turns out that the removal of trade distortion is offset by other distortionary tax measures. Thailand is now likely to be in this situation.

In this respect, the ultimate goal of a free trade regime may not be fully met in a revenue-constrained economy. Since the recent literature, for example Baunsgaard and Keen (2005), indicates that the revenue effect of tariff reduction tends to be stronger in the later stages of trade liberalization, the revenue impact of proactive tariff reduction and the distortionary effect of revenue compensation measures in Thailand are of particular interest. Therefore, this chapter analyzes the impacts of trade liberalization in the context of a revenue-constrained economy.

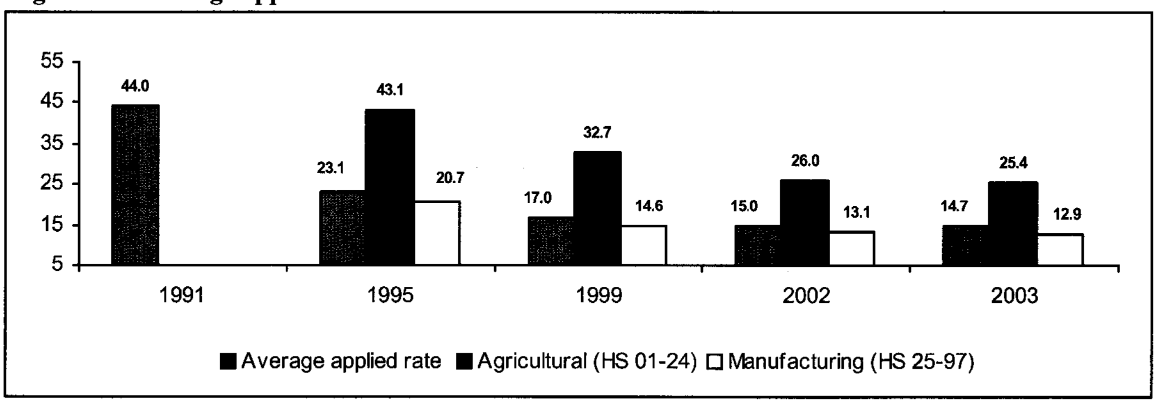
1.1 Background

1.1.1 Trade liberalization and tariff reform in Thailand

In the early stage of economic development, tariffs in Thailand were used as a means to increase government revenue and to protect domestic infant-industries along the line with an import-substitution industrial development strategy. The turning point was in the mid 1970s when the development strategy shifted from import-substitution to export promotion. However, the political uncertainty in the region of Southeast Asian and the prolonged world economic recession in the late 1970s and early 1980s delayed the process of industrial development.

The big-push for an outward-oriented policy took a major step in the mid 1980s when the government launched a spatial infrastructure development project to support the manufacturing sector and moved further to establish a sound fundamental for the free market regime. Trade barriers were significantly reduced. Together with the favorable external economic and political environments, these policies effectively hasten the transformation process of the Thai economy from predominantly agricultural to an industrial-based economy in 1992. The export sector has been successfully used as a growth-engine and drove the growth rate of the Thai economy to an average 10.9 percent per year during the last four years of the 1980s.

Figure 1-1: Average applied tariff rates in Thailand



Source: WTO

Under the extensive liberalization plan, trade and investment barriers were gradually abolished. The major tariff reductions were initiated in 1988, starting with the reduction of tariffs on electric and electronic appliances as well as the tariffs on their inputs. In 1995 and 1997 a comprehensive tariff reform was implemented, aimed at the reduction of both the nominal tariff rates and their dispersion. The maximum rate decreased from 100 percent to 30 percent in most cases and covered 4,000 commodity items. The complicate rates were simplified and brought down to the six tariff rates system. Two top rates of 20 and 30 percent were levied on finished products. Two middle rates of 5 and 10 percent were levied on intermediate goods. Two low rates of 0 and 1 percent rates were applied for raw materials. This resulted in the reduction of applied average tariff rates from 44 percent in 1991 to 23 percent in 1995.

In 1998, economic crisis resulted in the shortfall of government revenues. The Ministry of Finance raised tariff rates on some commodity items[1] and imposed a temporary surcharge of 10 percent on all imports with customs duty of over 5 percent. This measure slightly raised the average applied tariff rate but none of these tariff increases or surcharges violates Thailand's tariff binding commitments.

In 1999, the temporary surcharge was eliminated and the government announced an additional tariff restructuring plan to strengthen industrial competitiveness and to meet its international commitments. Tariff rates for 1,190 commodity items were reduced to between 0 and 5 percent in January 2000. About 153 commodity items are exempted from customs duties. In order to strengthen industrial competitiveness, the tariff rates on capital goods[2] and raw materials[3] of more than more than 630 commodity items were reduced or exempted on a permanent basis.

In 2002, the tariff system was restructured and further simplified to only 3 rates. The top rate of 10 percent is applied to finished products, products requiring extra

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[1] e.g., the rates on tobacco and clothing were raised from 30 to 60 percent, and the rates on some cosmetics and leather goods were raised from 10 to 40 percent

[2] Machinery, mechanical appliances and parts, electrical machinery equipment and parts

[3] Inputs of pharmaceutical, food, chemical, plastic and textile industries

protection, and luxury goods. The middle rate of 5 percent is levied on semi-finished products and the lower rate of 1 percent is applied on raw materials and inputs not produced in the domestic economy. As of January 2005, approximately 73 percent of total tariff lines are aligned with the 3 rates system. The proactive tariffs reform after the financial crisis reduced the average applied tariff rate further from 17.00 percent in 1999 to 15.00 percent in 2002, 14.7 percent in 2003 and approximately 10.71 percent in 2004[4].

1.1.2 Tariff reduction and government revenue compensation

Apart from tariffs, the alternative sources of government tax revenues are household Income Tax (HIT), Corporate Income Tax (CIT), Value Added Tax (VAT) and Excise Tax (ET), Special Business Tax (SBT). VAT is imposed on the purchase of both locally produced and imported goods. ET is a selective production tax that has been used for a revenue purpose and as a means to correct market failures. SBT is the semi corporate income tax. It is levied on the activities where it is difficult to measure value added.

The proactive tariff reform continually reduces the government revenue from tariffs. As indicated in Table 1-1, the share of tariffs in the total tax revenues significantly decreases from 16.0 percent in 1996 to only 9.0 percent in 2004, while the ratio of tariff revenue to GDP decreases from 2.8 percent to 1.6 percent over the same period. The reduction of tariff revenue is however offset by a raise of VAT and ET revenues with respect to total tax revenue and GDP.

[4] It is noteworthy that since only 73 percent of total tariff lines are aligned with the 3 rates system, the average applied tariff rate are higher than the top rate of 3 rates system.

Table 1-1: Structure of tax revenues (%)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
VAT									
- % total tax revenue	22.90	24.40	32.20	29.60	27.10	28.00	26.90	26.60	27.50
- %GDP	4.10	4.20	5.00	4.40	4.00	4.20	4.30	4.50	4.90
Excise tax									
- % total tax revenue	20.80	22.50	21.50	24.00	23.20	23.10	24.50	25.00	23.90
- %GDP	3.80	3.80	3.50	3.40	3.40	3.50	3.90	4.30	4.40
Tariff									
- % total tax revenue	16.00	12.80	9.30	9.80	12.00	11.90	11.40	11.20	9.00
- %GDP	2.80	2.20	1.40	1.50	1.80	1.80	1.80	1.90	1.60

1.1.3 Trends

According to the tariff restructuring plan, there will be further tariff reductions in 2007 and 2008. It is expected that by 2008, over 73 percent of commodity items will be covered by the current 3 rates system. In addition, economic policy after the period of economic crisis indicates that Thailand has continually pursued a proactive trade liberalization strategy. These trends indicate that the government revenue from custom duties will decrease further and some sorts of revenue compensation measure may be implemented.

Therefore, the implications of trade liberalization on public finance in Thailand are similar to other developing countries that have been involved in free trade regime. Trade liberalization leads to a reduction of tariff revenue, which is neutralized by income from other taxations. This trend features a process of trade liberalization in a second-best tax revenue constrained economy. Although this trend is increasingly recognized by international economic and trade organizations, few attempts have been devoted to investigating its implications.

1.2 Objective of the study

According to trade theory, free trade is optimal for a small open-economy. But custom duties are an important source of government revenue in a revenue constrained economy. If the tariff revenue cannot be easily compensated, trade liberalization implies a fiscal issue. In such a situation, IMF (2005) suggests that, unless the government wishes to reduce the tax burden of the economy, economic management requires some compensating measures to neutralize the fiscal effect of trade liberalization.

According to the research of Ebrill, Stotsky and Gropp (1999), tariff revenue potentially increases in the early stage of trade liberalization. However, Baunsgaard and Keen (2005) argue that there must be some points at which further trade liberalization leads to tariff revenue reductions, since a move towards a more liberalized economy is a move towards no trade tax. Recent empirical study by Devarajan, Go, and Li (1999) on sixty countries shows that trade liberalization generates a significant loss of government revenue.

In principle, trade liberalization induces economic expansion and raises other tax revenues. Baunsgaard and Keen (2005), however, show that the recovery rate of tariff reduction in developing countries is rather low. IMF (2005) suggests that, it would be unwise to count on long-run second-round revenue effects of trade liberalization. Therefore, as the reduction of tariff revenue cannot be self-financing and the negative revenue impact is often stronger in the latter stage of liberalization, revenue-constrained economies search for some sort of compensation and increasingly rely on other taxation measures.

Konan and Maskus (2000) show that interactions between the existing distortion and tax-compensation measures can significantly reduce welfare gains from trade. In such a situation, the devise revenue neutralize strategy is to secure and maximize the efficiency gain from trade.

Thailand has performed trade liberalization policy since 1980s. The fiscal indicators trends indicate that tariff reductions cannot be self-financing. In addition, the progress in privatization policies made the reduction of tariffs revenue difficult to replace by the incomes from non-taxation. Therefore, some sorts of tax compensation measure evidently have been employed and seemingly are being used increasingly. This paper aims to analyze the impacts of trade liberalization and tax-compensation measures in Thailand in the context of a revenue constrained economy.

The remainder of this paper is organized as follows: Section 2 provides a review of the literature. Section 3 provides a description of the model in this study. Section 4 presents the results of model simulations and section 5 provides the conclusion.

2. A review of the literature

Edwards (1993) and many others found a strong correlation between trade liberalization and economic growth. The effect of trade liberalization on government revenue is ambiguous because it is dependent on the economic structure of each country, the stage of liberalization as well as the relative mix of intervention measures and the elasticity of tax revenues with respect to tariff rates. In some cases, trade liberalization has an important negative impact on government revenue. Therefore, it is often important to consider a comprehensive tax reform to mitigate the undesired revenue consequences of trade liberalization and to preserve the gains from trade liberalization.

The impacts of trade liberalization on government revenue as well as the implications of its associated revenue compensation measures have been debated in the literature. Some attempts have been devoted to analyzing their empirical implications. Across countries, the results vary greatly. In this section, I first review the empirical evidences of the impacts of trade liberalization on government revenue and the empirical implications of revenue compensation measures that have been found in the literature.

2.1 Trade liberalization and government revenue

Baunsgaard and Keen (2005) examine the degree to which countries can recover the revenues they have lost from a past episode of trade liberalization. Using panel data of 111 countries over 25 years together with the GMM estimator, they conclude that the recovery rate is rather weak in low-income countries- at best they can recover not more than 30 cents for each lost dollar. Within this group, the presence of VAT insignificantly affects the rate of recovery. For the middle-income countries, the recovery rate is between 40-60 percent. For high-income countries, the recovery rate is high in fact it is in excess of a dollar per dollar. Within this group, recovery is also higher for those countries with VAT.

Khattry (2003) uses panel data of 80 countries during 1970-1998 to examine the presumption that trade leads to a fiscal squeeze because of declining tax revenues and rising debt interest expenditure. Under the fixed effect regression framework, the results indicate that trade liberalization adversely affects trade tax revenues of low and upper middle-income countries. That is, trade liberalization leads to the reduction of government revenues and higher interest payments. This situation contributes to the observed decline in infrastructure spending.

Ebrill, Stotsky and Gropp (1999) show that the revenue implications of trade liberalization depend significantly on the episode of liberalization. In the early stage, the impact on tax revenue tends to be smaller and, in some cases, tax revenue can be increased provided that (a) the initial protection is highly restrictive, (b) trade liberalization involves tariffication of the existing quantitative restrictions, (c) in moving to the uniform system, the reduction in tariff dispersion raises some existing low rates and eliminates some existing exemptions, and (d) custom and trade administration reforms reduce the incentive for tax evasion. However, the negative relationship between trade liberalization and trade tax revenue is more prominent in the longer run.

Devarajan, Go, and Li (1999) estimate the fiscal effect of trade reform in 60 countries. In a general equilibrium framework, they found that, with the current account constraint, for the domestic commodity to be substituted by imported goods, the transformation elasticity has to be high. With the higher substitutability between domestic and foreign goods, both in consumption and production, tariff reform has a larger impact on the external sector and can theoretically be self-financing. If the elasticities are not large, tariff reduction leads to a decrease in tax revenues. In this case, a fiscal adjustment policy is necessary. However, since the study shows that the estimated elasticities are in the range of 0-3 in most cases, the self-financing tariff reform is unlikely.

IMF (2005) summarizes the channels through which trade tax reforms affect the government revenue. In the short-run, the direct effect is the reduction of tariff revenue. For indirect effects, since the consumption taxes are imposed gross of tariff rate, tariff reduction indirectly affects other tax revenues. In the longer run, trade liberalization affects the growth rate of the economy, which potentially raises government revenues. Therefore, the full implications of trade liberalization on government revenues depend on a range of considerations. However, since the second round effects are subjected to uncertainty, it is not prudent to presume that the second round effects will automatically compensate for the revenue loss caused by trade liberalization. The IMF paper suggests that some policy responses are needed to deal with revenue loss unless the government wishes to reduce the overall tax burden on the economy. By examining sample data of 8 countries with different magnitudes of tariff rate reduction and different rates of revenue recovery[5], the paper concludes that countries with a high rate of recovery also raise their domestic consumption tax. The income tax revenues are also stronger in the countries with a high rate of tariff revenue recovery. In addition, countries which fail to recover

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[5] The less than full recovery countries are composed of Kenya, Sri Lanka, Egypt and Cote d'Ivoire. The full recovery countries are Malawi, Uganda, Senegal and Jordan.

tariff revenue appear to have fairly large fiscal deficits over the period, which indicates budget pressure.

2.2 Trade liberalization and tax reform

Many attempts have been devoted to explaining why fiscal reform (tax reform) and trade liberalization are often observed together. Kubota (2005), for example, proposes that fiscal constraint is the driving force for trade liberalization. According to this view, tariff reduction and trade liberalization are the logical consequences of the demand to increase government revenues. In contrast, the trade liberalization literature (WTO, IMF) suggests that the causality tends to run in the opposite direction. Trade liberalization ultimately leads to a tax revenue reduction. Consequently fiscal reform (tax reform) can be considered as an integral part of trade liberalization.

Since each country requires a certain level of government revenue to sustain development, the reduction of tariffs revenue imposes a fiscal constraint on developing countries. This is a potential driving force for fiscal reforms in developing countries. The tendency by developing countries to move away from tariffs toward other forms of taxation is also stimulated by the fact that customs duties are not an efficient source of revenues. In principle, tariffs have a narrower base than income tax and VAT and its distortionary feature interferes with both production and consumption decisions. Therefore, the recent policy advice by the IMF and WTO recommends the use of other taxation measures to neutralize the revenue effect of tariff reduction. This policy advice seems to be a standard premise for trade liberalization in a revenue constrained economy.

Among non-trade taxes, indirect taxes on consumption are generally preferred to direct taxes. According to public finance theory, indirect taxes that shift the burden from factor of production to consumption are generally believed to be associated with better conditions for saving, employment and investment. In addition, they are perceived as an effective measure for market failure correction and have merit in terms of tax administration. However, a uniform consumption tax increase tends to be regressive and discriminates against the poors.

Since the modifications of tax structure have both positive and normative implications, in this subsection, I briefly review the consequences of revenue compensation measures that have been found in the literature[6].

Clarete and Whalley (1987) use a CGE model to examine the distortion effect of trade and commodity taxes in the Philippines. By comparing the marginal welfare costs of trade and commodity taxes, the result shows that the marginal welfare costs of the former are substantially larger than the latter. That is, moving from trade tax to commodity tax raises welfare.

Erbil (2001) investigates the welfare impact of trade reform when trade tax revenue is replaced by an increase in other indirect taxes. By using the concept of marginal cost of fund, he shows that trade tax is a cheaper distortion than other indirect taxes for 11 countries. Therefore, replacing the trade tax by other indirect taxes will lead to welfare reduction. For 4 other countries, trade tax is a more expensive distortion than other indirect taxes; therefore replacing trade tax by other indirect taxes improves welfare.

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[6] It is noteworthy that, in principle, tax bases broadening and improving tax administration as suggested in policy advice can compensate the trade tax loss. However, it is difficult to measure the value of such contributions. In addition, given the limited capabilities of developing countries to achieve tax base broadening and tax administration strengthening in the short-run, this study is limited only to compensation measures using increased rates of alternative taxes.

Go, Kearney, Robinson and Thierfelder (2005) analyze the impacts of replacing the Goods and Services Tax (GST) system by a VAT in South Africa and then evaluate the impacts of an alternative revenue neutral tax system by replacing the VAT by income taxation. In the framework of a static CGE model with fixed labor and capital supplies, the study indicates that VAT is mildly regressive but it is an effective source of government revenue compared to other tax instruments. Replacing the GST system by VAT leads to welfare improvement. For the alternative revenue neutral tax system, the result shows that, replacing VAT by income taxes can benefit the low-income group without imposing an excess burden on the high-income group.

Konan and Maskus (2000) use the CGE model to analyze the impacts of various tax reform schemes, various trade reform schemes, and tax reform in conjunction with trade reform schemes in Egypt. In the framework of a revenue constrained economy, the real government revenue is fixed and the reduction of one or more tax revenues is compensated by the increase of some others. The result shows that welfare effects depend critically on the type of replacement scheme. In the presence of the domestic distortion taxes and revenue constraint, the welfare gains from trade liberalization can be significant smaller than what predicted by standard trade theory. With some specific compensation measures, it is possible that unilateral tariff reduction can reduce Egyptian welfare.

3. Model

In this chapter, I develop a static CGE model for tax policy analysis. The model departs from the static CGE model for energy policy analysis in the first chapter by taking into account details of the tax system of the Thai economy. The production structure is scaled down to 3 production nests. All tax rates are endogenized in the model in order to analyze the impacts of different revenue compensation measures.

The model belongs to the small-open economy CGE literature[7]. It is composed of 3,254 linear and nonlinear equations that govern the behavior of agents, sectors and their interdependencies in the economy. Production is composed of 54 sectors. In order to analyze the distribution effects of trade liberalization and revenue compensation measures, households are represented by 3 occupational categories. Factor of production is composed of labor, capital and intermediate goods. In this section, I describe in detail the equations of the model including the first order conditions. The lists of model variables and parameters are provided in Appendix A.

3.1 Production

Production is made up of 54 sectors. Each of them is assumed to behave as a single representative firm, producing a single homogenous commodity. As depicted in Figure 3-1, the production structure of each sector is composed of 3 production nests. The production of output and aggregate intermediate input are governed by the fixed-

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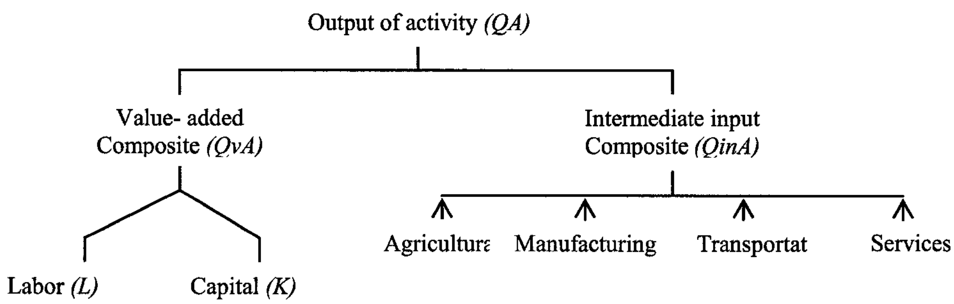
[7] Modeling style is largely influenced by the standard CGE modeling tradition described in Lofgren, Harris and Robinson (2001).

coefficient Leontief production technology. The production of aggregate value-added input is governed by the Constant Elasticity of Substitution (CES) production function.

Figure 3-1: Production structure



3.1.1 Production output.

In each production sector, activity output (QA_a) is a Leontief aggregation of aggregate value-added (QvA_a) and aggregate intermediate input $(QinsA_a)$ as indicated in equation *(a2)*. According to the zero profit condition, in equation *(a1)*, after tax revenue $(PA_a(1 - TexcR_a - TspbR_a - TsubR_a)\ QA_a)$ of each sector is equal to its total cost, which is the sum of aggregate value-added input cost $(PvA_a QvA_a)$ and aggregate intermediate input cost $(PinsA_a QinsA_a)$ Therefore, a cost minimization problem at this production nest is postulated as

$$Min : PA_a(1 - TexcR_a - TspbR_a - TsubR_a)QA_a = PvA_a QvA_a + PinsA_a QinsA_a \quad (a1)$$

Subject to

$$QA_a = Min\left\{\frac{QvA_a}{iv_a}, \frac{QinsA_a}{ins_a}\right\} \quad (a2)$$

The optimality conditions are:

$$QinsA_a = ins_a QA_a \quad (1)$$

$$QvA_a = iv_a QA_a \tag{2}$$

$$PA_a(1 - TexcR_a - TspbR_a - TsubR_a)QA_a = PvA_a QvA_a + PinsA_a QinsA_a \tag{3}$$

The variables *TexcR, TspbR and TsubR* denote the effective rates of excise tax, special business tax and subsidy respectively. Equations *(1)* and *(2)* show that the optimal level of aggregate intermediate input $(QinsA_a)$ and aggregate value-added input (QvA_a) are the fixed proportion to output (QA_a) level.

3.1.2 Aggregate value-added

At the second production nest, as indicated by equation *(19)*, aggregate value added (QvA_a) is a CES aggregation of primary inputs $(QF_{f,a})$ which are labor and capital. By zero profit condition in equation *(a3),* total revenue $(PvA_a QvA_a)$ equals the sum of return on factors of production $(\sum_f WF_f WFdist_{f,a} QF_{f,a})$. A cost minimization problem at this production nest is postulated as:

$$Min: PvA_a QvA_a = \sum_f WF_f WFdist_{f,a} QF_{f,a} \tag{a3}$$

Subject to

$$QvA_a = \alpha_a^{va} \left[\sum_f \delta_{f,a}^{va} QF_{f,a}^{-\theta_a^{va}} \right]^{-\frac{1}{\theta_a^{va}}} \tag{4}$$

The optimality conditions are:

$$WF_f WFdist_{f,a} = PvA_a QvA_a \left(\sum_f \delta_{f,a}^{va} QF_{f,a}^{-\theta_a^{va}} \right)^{-1} \delta_{f,a}^{va} QF_{f,a}^{-\theta_a^{va}-1} \tag{5}$$

$$PvA_a QvA_a = \sum_f WF_f WFdist_{f,a} QF_{f,a} \tag{a4}$$

3.1.3 Aggregate intermediate input

Aggregate intermediate input $(QinA_a)$ is the Leontief aggregation of different intermediate input commodities as shown in equation *(a6)*. Zero profit condition in equation *(a5)* requires that total revenue $(PinsA_a QinsA_a)$ be equal to the sum of spending on different intermediate input commodities $(\sum_c Pq_c QCinA_{c,a})$ net out of VAT rebate $(REBATE_a)$. With this specification, the production decision at the third production nest is postulated as a cost minimization problem as

$$Min: PinsA_a QinsA_a = \sum_c Pq_c QCinA_{c,a} - REBATE_a \qquad (a5)$$

Subject to

$$QinsA_a = \quad Min \left\{ \frac{QCinA_{c,a}}{ica_{c,a}} \right\} \qquad (a6)$$

The optimality conditions are:

$$QCinA_{c,a} = ica_{c,a} QinsA_a \qquad (6)$$

$$PinsA_a = \sum_c ica_{c,a} Pq_c - \left(\frac{REBATE_a}{QinsA_a} \right) \qquad (7)$$

Equation *(6)* and *(7)* indicate that the optimal level of each intermediate input commodity $(QCinA_{c,a})$ is the fixed proportion to aggregate intermediate input $(QinsA_a)$ and the price of intermediate aggregate input $(PinsA_a)$ is a weighted average price of different intermediate commodities $(\sum_c ica_{c,a} Pq_c)$ net of VAT rebate per-unit of aggregate intermediate input.

3.2 Domestic output and trade

3.2.1 Commodity output

Activity output (QA_a) is linked to its corresponding commodity output (Qx_c) through the fixed coefficient $(\theta_{a,c})$[8].

$$Qx_c = \sum_a \theta_{a,c} QA_a \tag{8}$$

$$PA_a = \sum_c \theta_{a,c} Px_c \tag{9}$$

3.2.2 Allocation of domestic output

Domestic output of each commodity (Qx_c) is allocated between domestic sales (Qd_c) and export (Qe_c). With the assumption of imperfect transformability between these two destinations, the allocation behavior of each firm is governed by the Constant Elastic Transformation function (CET) as described in equation *(11)*. In equation *(a7)*, total value of domestic output of each sector $(Px_c Qx_c)$ equals the value of domestic output sold domestically $(Pd_c Qd_c)$ and the value of export $(Pe_c Qe_c)$. Therefore, the optimal allocation behavior is postulated as a revenue maximization problem:

$$Max: Px_c Qx_c = Pds_c Qd_c + Pe_c Qe_c \tag{a7}$$

Subject to

$$Qx_c = \alpha_c^t \left[\delta_c^t Qe_c^{\theta_c^t} + (1-\delta_c^t) Qd_c^{i\theta_c^t} \right]^{\frac{1}{\theta_c^t}} \tag{10}$$

8 Since each representative production sector produces a single homogenous commodity output (Qx_c), the transformation coefficient $(\theta_{a,c})$ equals 1. Therefore $QA_a = Qx_c$ and $PA_a = Px_c$.

The optimality conditions are:

$$\frac{Qe_c}{Qd_c} = \left[\frac{Pe_c(1-\delta_c^t)}{Pd_c \delta_c^t} \right]^{\frac{1}{(\theta_c^t - 1)}} \qquad (11)$$

$$Px_c Qx_c = Pd_c Qd_c + Pe_c Qe_c \qquad (12)$$

Equation *(11)* implies that the optimal ratio of export to domestic sales is a function of the ratio of export price to domestic output price and the parameters in CET function. In addition, with the assumption of a small-open economy, domestic firms are price takers. Therefore, export price of each commodity in local currency unit (Pe_c) is the product of exchange rate (Exr) and its world market price in foreign currency units (pwe_c). That is

$$Pe_c = pwe_c^{\ i} Exr \qquad (13)$$

3.2.3 Optimal combination of composite goods

The composite goods (Qq_c) of each commodity available in domestic market are the combination of domestic output sold domestically (Qd_c) and imported (Qm_c). With the assumption of imperfect substitution between imported and domestic goods, the behavior of domestic agents (firms, households and government) in choosing their optimal combinations is governed by the Armington equation as shown in equation *(14)*.

Let Pq_c denote price of composite goods, Pm_c denote price of imported goods in local currency unit and Pd_c denote price of domestic output sold domestically. The budget constraint in equation *(a8)* requires that the total expenditure of domestic agents on composite goods net out of VAT be equal to the sum of spending on domestic output and spending on imported. The optimization problem of domestic agents can be depicted as an expenditure minimization problem:

$$Min: Pq_c(1 - TvatR_c)Qq_c = Pd_cQd_c + Pm_cQm_c \tag{a8}$$

Subject to

$$Qq_c = \alpha_c^q\left[\delta_c^q Qm_c^{-\theta_c^q} + (1-\delta_c^q)Qd_c^{-\theta_c^q}\right]^{-\frac{1}{\theta_c^q}} \tag{14}$$

The optimality conditions are:

$$\frac{Qm_c}{Qd_c} = \left[\frac{Pd_c\delta_c^q)}{Pm_c(1-\delta_c^q)}\right]^{\frac{1}{(1+\theta_c^q)}} \tag{15}$$

$$Pq_c(1 - TvaR_c)Qq_c = Pd_cQd_c + Pm_cQm_c \tag{16}$$

$TvatR_c$ in equation *(16)* is the VAT rate on each commodity that is imposed on both locally produced and imported goods. With the assumption of a small-open economy, domestic agents are faced with a perfectly elastic supply of foreign goods. Therefore, the import price in local currency units is defined as gross of tariff as

$$Pm_c = (1 + tm_c)pwm_cExr \tag{17}$$

3.3 Institutions and incomes

Institutions in the model are households, state enterprise, private enterprise, government and the rest of the world. Households, state and private enterprises are domestic non-government institutions.

3.3.1 Gross income of institutions

Gross income of domestic non-government institutions *(Y_i)* is made up of 4 components: factor income $(\sum_f Yif_{i,f})$, domestic infra-institutional transfer $(\sum_i Trii_{i,i^*})$, transfers from government $(trnsfr_{i,gov}CPI)$, and remittances from the rest of the world $(trnsfr_{i,row}Exr)$.

$$Yi_i = \sum_f Yif_{i,f} + \sum_{i'} Trii_{i,i*} + trnsfr_{i,gov}CPI + trnsfr_{i,row}Exr \qquad (18)$$

3.3.2 Infra-institutional transfer

Infra-institutional transfer between domestic non-government institutions is a fixed proportion $(shii_{i,i'})$ to gross income (Y_i) net out of income tax and saving. Note that, $Tins_i$ and $mpsbar_i$ are the rate of income tax and the average saving rate respectively.

$$Trii_{i,i'} = shii_{i,i'}(1 - mpsbar_i)(1 - Tins_i)Yi_i \qquad (19)$$

3.3.3 Factor income

Total income from primary factors (Yf_f), is the sum of returns on labor and capital across production sectors $(\sum_a WF_f WFdis_{f,a} QF_{f,a})$. In equation *(21)*, total factor income is allocated across domestic institutions $(Yif_{i,f})$ according to the base year share of each instruction in the aggregate endowment of each factor $(shif_{i,f})$.

$$Yf_f = \sum_a WF_f WFdist_{f,a} QF_{f,a} \qquad (20)$$

$$Yif_{i,f} = shif_{i,f} Yf_f \qquad (21)$$

3.4 Households and consumption

Households are represented by the 3 occupational representative households, agricultural, nonagricultural, and government-employed households. With this level of disaggregation, the model can be used to investigate the impacts of trade liberalization and different revenue compensation measures on income and welfare distribution.

3.4.1 Consumption expenditure

Consumption expenditure (Eh_h) of each household is the gross household income (Yi_h) net out of saving, income tax payment and transfer to other domestic non-government institutions.

$$Eh_h = (1 - mpsbar_h)(1 - Tins_h)\left(1 - \sum_i shii_{i,h}\right)Yi_h \tag{22}$$

3.4.2 Consumption

Consumer preferences are described by the Stone-Geary utility function as shown in equation *(a9)*. Budget constraint in equation *(a10)* requires that the consumption expenditure of each household *(Eh_h)* be equal to the sum of its spending on different consumption commodities *($\sum_c Pq_c Qh_{c,h}$)*. Therefore, the consumption problem of each representative household can be postulated as a utility maximization problem:

$$Max : U_h = \prod_c \left(Qh_{c,h} - \gamma^m_{c,h}\right)^{\beta^m_{c,h}} \tag{a9}$$

Subject to

$$Eh_h = \sum_c Pq_c Qh_{c,h} \tag{a10}$$

The optimality conditions are:

$$Qh_{c,h} Pq_c = Pq_c \gamma^m_{c,h} + \beta^m_{c,h}\left(Eh_h - \sum_c Pq_c \gamma^m_{c,h}\right) \tag{23}$$

$$Eh_h = \sum_c Pq_c Qh_{c,h} \tag{a11}$$

3.4.3 Consumer price index

Consumer price index is the weighted average price of different consumption commodities. In the model, consumer price index is the fixed numeraire.

$$CPI = \sum_{c} cwts_c Pq_c \tag{24}$$

3.5 Government

Government is a separate institution without preference. The role of government in the model is to collect revenues from different sources, and spend its income on government consumption and transfers to other non-governmental institutions.

3.5.1 Government revenue

Government revenue is made up of income tax revenue from non-governmental institutions $(\sum_{i} Tins_i Y_i)$, VAT revenue from the purchased of domestic composite goods $(\sum_{c} TvatR_c Pq_c Qq_c)$, net out of VAT rebate for the purchased of intermediate input $(\sum_{a} REBATE_a)$, excise tax revenue $(\sum_{a} TexcR_a PA_a QA_a)$, special business tax revenue $(\sum_{a} TspbR_a PA_a QA_a)$, tariff revenue $(\sum_{c} tm_c pwm_c Qm_c Exr)$, factor income (Yi_{gov}) and transfer from the rest of the world $(trnsfr_{gov,row} Exr)$.

$$\begin{aligned} Yg = {} & \sum_{i} Tins_i Yi_i + \sum_{c} TvatR_c Pq_c Qq_c - \sum_{a} REBATE_a \\ & + \sum_{a} TexcR_a PA_a QA_a + \sum_{a} TspbR_a PA_a QA_a \\ & + \sum_{c} tm_c pwm_c Qm_c Exr_c + Yi_{gov} + trnsfr_{gov,row} Exr \end{aligned} \tag{25}$$

3.5.2 Government expenditure

Government expenditure (Eg) is composed of government consumption spending $(\sum_c Pq_c Qg_c)$, subsidies to domestic production sector $(\sum_a TsubR_a PA_a QA_a)$, and government transfers to domestic non-government institutions $(\sum_i Trnsfr_{i,gov})$.

$$Eg = \sum_c Pq_c Qg_c + \sum_a TsubR_a PA_a QA_a + \sum_i trnsfr_{i,gov} CPI \tag{26}$$

3.5.3 Government demand for consumption

Government consumption demand for each commodity (Eg_c) is a function of its base year value $(qbag_c)$ and the scaling $(Gadj)$ factor. With this specification, government consumption demand can be either fixed at its base year level by setting scaling factor at unity, or endogenized to the model by allowing scaling factor to adjust.

$$Qg_c = qbag_c Gadj \tag{27}$$

3.5.4 Tax rates

For the purpose of tax policy analysis, the income tax rate $(Tins_i)$, VAT rate $(TvatR_c)$, excise tax rate $(TexcR_a)$, special business tax rate $(TspbR_a)$, and the rate of production subsidy $(TsubR_a)$, can be selectively endogenized to the model according to the following specifications:

$$Tins_i = tinsbar_i(1 + tinszo_i TinsADJ) \tag{28}$$

$$TvatR_c = tv_c(1 + vatzo_c VatADJ) \tag{29}$$

$$TexcR_a = texc_a(1 + exczo_a ExcADJ) \tag{30}$$

$$TspbR_a = tspb_a(1 + spbzo_a SpbADJ) \tag{31}$$

$$TsubR_a = sub_a(1 + subzo_a SubADJ) \tag{32}$$

Note that, $TinsADJ$, $VatADJ$, $ExcADJ$, $SpbADJ$, *and* $SubADJ$ are adjustment variables for the proportional scaling endogenous change of their corresponding tax rates. If one of these tax rates is chosen as the endogenous model variable, its corresponding adjustment variable must be endogenous. Alternatively, these rates are fixed by setting their corresponding adjustment variable to zero.

3.5.5 VAT rebate

The VAT system in Thailand is of European-style; all purchased transactions are taxed at a fixed proportional rate regardless of whether they are purchased for final demand or purchased for intermediate demand. This means that both domestic goods sold domestically and imported goods are subjected to VAT but the exportation of domestic output is not. However, firms can deduct VAT paid on the purchase of their intermediate inputs. Therefore, to prevent the cascading effects of the change in VAT rate on intermediate input use, I model the VAT rebate as found in the work of Delfin S. Go, Marna Kearney, Sherman Robinson and Karen Thierfelder (2005) as

$$REBATE_a = \sum_c TvatR_c Pq_c QCinA_{c,a} \tag{33}$$

3.6 System constraints

For the economy to reach equilibrium, the following equilibrium conditions must be satisfied;

3.6.1 Commodity market equilibrium

The aggregate demand for each composite commodity is composed of intermediate input demand ($\sum_a QCinA_{c,a}$), household consumption demand ($\sum_h Qh_{c,h}$), investment demand $(Qinv_c)$, government consumption demand (Qg_c) and demand for stock investment $(qdst_c)$. The commodity market equilibrium condition in equation *(34)* requires that the aggregate demand for each commodity be equal to its composite supply (Qq_c).

$$Qq_c = \sum_a QCinA_{c,a} + \sum_h Qh_{c,h} + Qinv_c + Qg_c + qdst_c \tag{34}$$

3.6.2 Factor market equilibrium

Factor market equilibrium condition requires that the sum of each primary input (labor and capital) employed across production sectors $(\sum_a QF_{f,a})$, be equal to total endowment (QF_f).

$$\sum_a QF_{f,a} = QFS_f \tag{35}$$

3.6.3 Government balance

Government balance requires that government income (Yg) be equal to the sum of government spending (Eg) and government saving $(Gsav)$.

$$Yg = Eg + Gsav \tag{36}$$

3.6.4 External balance

Current account balance in equation *(37)* is defined in terms of foreign currency. The gap between spending $(\sum_c pwe_c Qe_c + \sum_i trnsfr_{row,i})$, and earnings of foreign currency $(\sum_c pwm_c Qm_c)$ is foreign savings $(Fsav)$.

$$\sum_c pwm_c Qm_c = \sum_i pwe_c Qe_c + \sum_i trnsfr_{row,i} + Fsav \tag{37}$$

3.6.5 Saving-investment balance

Total savings *(Tsav)* is composed of private savings of domestic non-government institutions $(\sum_i mpsbar_i (1 - Tins_i)\ Yi_i)$, government savings *(Gsav)*, and foreign savings in terms of domestic currency *(ExrFsav)* net out of inventory investment $(\sum_c Pq_c qdst_c)$. Savings is distributed across different investment commodities according to their base year shares (ψ_c). Since the sum of ψ_c is unity, equation *(39)* is the Walras saving-investment identity.

$$Tsav = \sum_i mpsbar_i (1 - Tins_i) Yi_i + Gsav + ExrFsav - \sum_c Pq_c qdstbar_c \tag{38}$$

$$Pq_c Qinv_c = \psi_c Tsav \tag{39}$$

3.7 Model closures

In order to analyze the impacts of trade liberalization (without revenue compensation measures) on the fiscal balance and other macroeconomic variables, government savings in equation *(36)* is fixed at its base year level. All tax rates in equations *(28-32)* are fixed and the real government consumption adjusts to maintain government balance. With this closure rule, the direction and magnitude of the change in government consumption indicates the impact of tariff reduction on government real revenue.

To analyze the impact of trade liberalization in conjunction with revenue compensation measures, the real government consumption and government saving are fixed. The reduction of tariff revenue is offset by the increase in other tax revenues. Therefore, one of the tax rates in equation *(28-32)* is endogenized to the model depending on the hypothetical compensation measure.

In all simulations, labor is assumed to be fully employed factor and mobile across production activities. Therefore, supply of labor is fixed and the economy-wide wage rate is a labor market clearing variable. Capital is fully employed but activity specific factor. Therefore, specific wage rates are the capital market clearing variable. In order to prevent the domestic economy from financing the shortfall of tariff revenue by foreign borrowing, the foreign savings $(Fsav)$ is fixed at its base year level. In addition, the exchange rate (Exr) is the fixed numeraire.

3.8 Model calibration

The model is calibrated to the 1998 Social Accounting Matrix (SAM) of the Thai economy and a set of elasticity parameters in Appendix B. Note that in this study, I apply elasticity parameters found in the relevant literature. The structure of the Thai economy and tax system as displayed by SAM are provided in Appendix C.

3.9 Taxes in the model

The model incorporates all major taxes of the Thai economy[9] which are the direct income tax on households (HIT) and enterprises, Value Added Tax (VAT), Excise Tax (ET), Special Business Tax (SBT) and tariffs. VAT is imposed on the purchase of both locally produced and imported goods. The suppliers of certain goods and services are subjected to a zero VAT rate. According to the 1998 SAM, the effective VAT rates on

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[9] Note first that the tax system in Thailand can be divided into major taxes that are administered by the central government and the local taxes that are administered by the local government. However, our brief review is limited to the former which is directly relevant to our analysis and is covered by SAM.

manufacturing and services are almost at the same rate of approximately 2.3 percent[10] but the effective rates on agricultural and transportation are lower. This is because various agricultural and transportation commodities are subjected to a zero VAT rate.

ET is a selective production tax. In addition to revenue purpose, excise tax has been used as a means to correct market failures and some other specific purposes. According to SAM, the base of ET covers agricultural, manufacturing and services productions. However, the effective rate on services production is very low and the effective rate on agricultural production is negligible. Therefore, excise tax revenue is mainly derived from manufacturing production in particular energy production.

SBT is the semi corporate income tax. It is levied on the activities where it is difficult to measure value added. To avoid the excess burden of value added calculation, some certain businesses are subjected to a special business tax such as financial services and real estates. Tariffs are levied on either a specific or ad-valorem basis. The ad-valorem rate is based on CIF prices and import classification is based on the Harmonized Commodity. The effective tariff rates in SAM vary across production sectors.

3.10 Informal sectors

In calibration, some productions are treated as informal production sectors and are unable to rebate their VAT burden on the purchased of intermediate inputs. This is because the VAT in Thailand is implemented through the invoices rebate system. In principle, suppliers are required to collect VAT at a statutory rate of 7 percent of the sale value on their invoices. This is called the output tax. However, the net VAT liability of

[10] Note that all tax rates in the model are the effective rates that are differ to their statutory rates due to sector aggregation, the treatment of the informal sector and measurement error.

each supplier is calculated by deducting the output tax by the VAT payment shown on the invoices of their intermediate purchased (which is called the input tax). With this system, sectors without invoices and a standard accounting system are unable to rebate their VAT burden on their intermediate purchased. By considering the facts of the production structure of the Thai economy, in calibration, the productions of paddy, fruits & vegetable, other crops, livestock, fishing and other agricultural productions are treated as informal sectors. Overall, these sectors account for 9.05 percent of the total value of production and 13.13 percent of the total value added of the Thai economy.

4. Simulation

To analyze the impact of trade liberalization both with and without revenue compensation measures, I first simulate the model by using a tariff reduction of a similar magnitude as its actual reduction during 1996-2002. Then different revenue compensation measures are introduced to the model in conjunction with tariff reduction to neutralize the effect of tariff reduction on government revenue. This section, reports the results of the following 5 simulation scenarios:

(a) Trade liberalization without revenue compensation. In this simulation, I introduce unilateral tariff rate reductions of 41.900 percent for agricultural imports and 37.700 percent for manufacturing imports. The purpose of this simulation is to investigate the impacts of trade liberalization on government revenue and other economic indicators.

(b) Value Added Tax (VAT) compensation measure. In this simulation, the impact of trade liberalization on government revenue is offset by an increase in income from VAT. Therefore, the tariff reductions in (a) are introduced to the model in conjunction with an endogenous percentage change in effective VAT rates.

(c) Excise Tax (ET) compensation measure. In this simulation, the government revenue effect of trade liberalization is compensated by an increase in income from excise tax. That is, the tariff reductions in (a) are introduced to the model in conjunction with an endogenous percentage change in effective excise tax rates.

(d) Special Business Tax (SBT) compensation measure. In this case, the effect of trade liberalization on government revenue is neutralized by an increase in income from SBT. Therefore, the tariff reductions in (a) are introduced to the model in conjunction with an endogenous percentage change in effective SBT rates.

(e) Household Income Tax (HIT) compensation measure. Instead of indirect tax compensation, in this simulation, the impact of trade liberalization on government revenue is neutralized by an increase in income from HIT. Tariff reductions in (a) are introduced to the model in conjunction with an endogenous percentage change in effective HIT rates.

It is noteworthy that the purpose of the analysis in this chapter is not to investigate the implications of optimal tax literature[11]. This is because to investigate such implications, the burden of revenue compensation measures must be imposed on the commodities that their tariff rates have been reduced. Instead, in this study, tax burden of revenue compensation measures is imposed at convenience on the commodities or sectors that are already subjected to tax instrument. In addition, the increases of tax rates of each revenue compensation measure are assumed to be a uniform percentage change, not a uniform point change that involves a higher cost of tax administration. These assumptions are not far from reality where the government seeks to offset its revenue loss while minimizing the costs of tax administration.

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[11] While the implication from optimal tax literature is sound theoretically, in practice, it involves the cost of tax administration. In addition, VAT is not a pure consumption tax (as it is required by optimal tax literature) but, in the presence of informal sectors, it implies a production distortion.

4.1 The impacts on the aggregate economy

Table 4-1 presents the impacts of trade liberalization with and without revenue compensation measures on the aggregate economy. Without revenue compensation, tariff reduction reduces the producer cost and consumption price. The reduction in producer cost stimulates aggregate production activity and raises factor income by ฿ 1.766 billion. Together with the reduction in domestic market price, the real consumption and real investment increase by 0.257 percent and 0.649 percent respectively. With respect to fiscal balance, government revenue decreases by ฿ 20.829 billion which is equivalent to government revenue loss of 0.450 percent of GDP. As a result, real government consumption decreases by 2.297 percent. However, with its small contribution, the contraction of government consumption is outweighed by the expansion of private consumption and investment. In aggregate, tariff reduction raises the real GDP by 0.036 percent.

Through its impacts on income and consumption price, tariff reduction improves household well-being. Measured by compensation variation, aggregate household welfare increases by ฿ 6.469 billion which is equivalent to 0.139 percent of GDP. On external balance, both real export and real import increase. Therefore, the domestic economy increasingly relies on the world market. With respect to import, tariff reduction reduces import price relative to domestic producer price, in particular those of agricultural and manufacturing products, which are the main consumption and intermediate input commodities. This situation shifts domestic demand towards import goods and raises real import by 0.889 percent. The reduction of domestic demand for domestic goods and the lower cost of intermediate input reduces domestic producer price. The ratio of export price to domestic producer price increases and raises the aggregate real export by 0.653 percent.

Table 4-1: The impacts on the aggregate economy

	(a)	(b)	(c)	(d)	(e)
Real GDP (% Δ)	0.036	0.012	-0.016	0.015	0.017
- Private consumption	0.257	-0.014	-0.162	-0.024	-0.114
- Investment	0.649	0.089	0.327	0.127	0.358
- Government consumption	-2.297	0.000	0.000	0.000	0.000
- Export	0.653	0.460	0.488	0.468	0.487
- Import	0.889	0.626	0.664	0.637	0.662
Real absorption	0.043	0.015	-0.019	0.018	0.020
Production output (% Δ)	0.184	0.058	0.034	0.056	0.061
Producer price index (% Δ)	-0.199	-0.081	0.048	0.052	-0.137
CPI (% Δ)	-0.345	0.273	0.086	-0.224	-0.345
Factor income (Δ : ฿ billion)	1.766	11.053	-3.081	-10.482	10.943
Welfare (C.V: ฿ billion)	6.469	-0.359	-4.120	-0.631	-2.890
Per-capita C.V (฿)	105.696	-5.857	-67.313	-10.317	-47.222
Effective VAT rate (%)	2.625	3.520	2.625	2.625	2.625
Effective excise tax rate (ET: %)	10.735	10.735	11.733	10.735	10.735
Effective SBT tax rate (%)	5.979	5.979	5.979	9.517	5.979
Effective income tax rate (HIT: %)	3.179	3.179	3.179	3.179	3.725

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

Columns (b), (c), (d) and (e) present the impacts of trade liberalization in conjunction with revenue compensation measures. In order to sufficiently compensate the government revenue loss, VAT rates must be increased by 34.075 percent. Alternatively, the rates of ET, SBT or HIT must be raised by 9.291 percent, 59.181 percent and 17.177 percent respectively. Although each of these compensation measures generates the same real government revenue, they differ in their economic implications and their impacts on the economy. Simulation results show that VAT directly distorts against agricultural production. ET distorts against economy-wide production through its indirect effect on energy price[12]. SBT directly distorts against services production[13]. The degree of distortion is reflected in the alteration of aggregate economic variables from the standard case without revenue compensation in (a).

Overall, with the revenue compensation measures, the impacts of tariff reduction on the aggregate economic variables significantly differ from the case without revenue compensation. In the cases of VAT, SBT and HIT, the aggregate GDP increases by 0.012, 0.015, and 0.017 percent respectively, significantly lower than without revenue compensation. In the case of ET, it results in the contraction of the aggregate economy by 0.016 percent.

In all cases of revenue compensation, the aggregate production output is lower than without revenue compensation. This is attributable to two main reasons: first, the production resources are allocated to the value-added intensive services production more than in the case without revenue compensation and, second, indirect tax measures distort against production. Without the direct distortion effect on production, the slower rate of production output of 0.061 percent in the case of HIT is attributable to its indirect effect on resources reallocation that raises the economy-wide wage rate. This reallocation effect is reinforced by the direct effect on production distortion in the case of indirect tax measures. Therefore, it results in the slower expansions of production output of 0.058, 0.034 and 0.056 percent in the cases of VAT, ET and SBT respectively, significantly lower than in the case without revenue compensation.

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[12] Excise tax is imposed on production of luxury commodities but also covers gasoline, diesel and crude oil. The base year effective rate for energy commodities is reasonably high.

[13] SBT is imposed on the production sectors for which it is difficult to calculate value added. In the base year data, only banking and real estate productions are subjected to SBT.

Aggregate factor income increases by ฿ 11.053 billion and ฿ 10.943 billion in the cases of VAT and HIT respectively, significantly higher than in the case without revenue compensation. This is because the domestic production structure after the increase of VAT or HIT relies more on the value-added intensive production. However, with ET and SBT the aggregate factor income decreases by ฿ 3.081 billion and ฿ 10.482 billion as the former leads to economy-wide production distortion and the latter directly distorts against the value-added intensive services production.

Producer price index and consumer price index are higher than in the case without revenue compensation. With VAT, CPI increases the highest of all cases while the PPI is higher than in the case without revenue compensation. This is because the domestic market price is gross of VAT and therefore the consumption price strongly reflects the increase in VAT burden. In addition, since VAT on the intermediate purchased of agricultural production is not deductible, it raises the PPI higher than in the case without revenue compensation. With ET, both CPI and PPI increase as it is imposed on production and its burden is partially shifted to consumers. With SBT, PPI suffers its highest increase as it is imposed on value-added intensive production. Nevertheless, its burden is partially shifted to consumers as reflected in its slightly higher CPI when compared to the case without revenue compensation. The increase in wage rate, in the case of HIT, raises PPI to a level slightly higher than in the case without revenue compensation.

With revenue compensation measures, aggregate real investment increases at a slower pace. In the case of VAT, it is attributable to the increase in domestic market prices of investment commodities while, in the case of HIT, it is attributable to the reduction of disposable income caused by a higher income tax burden. In the case of ET, it is attributable to both the reduction of aggregate factor income and the increase in the price of investment commodities. In the case of SBT, it is solely attributable to the reduction of aggregate factor income.

Aggregate real consumption declines in all cases of revenue compensation. Although the aggregate factor income is higher in the cases of VAT and HIT than in the case without revenue compensation, the real consumption decreases. In the case of VAT, the price effect works in the opposite direction and outweighs the income effect. With HIT, both price effect and income effect contribute to the expansion of aggregate real consumption but insufficiently cover the increase in income tax burden. In the cases of ET and SBT, the aggregate factor income decreases. With ET, the income effect is reinforced by the prices effect and result in the strongest contraction of real consumption. With SBT the aggregate factor income decreases more than in the case of ET. However, the income effect is partially offset by the price effect. Overall, the aggregate real consumption decreases and results in household welfare contraction in all cases of revenue compensation. In this regard, the static welfare implications of trade liberalization in a revenue constrained economy significantly differ from the standard case without revenue compensation.

The contraction of aggregate household welfare in all cases of revenue compensation implies that all tax measures in simulations are less efficient than tariffs. This potentially raises questions about the results as it is generally believed that VAT is a cheaper distortion than tariffs which is contradictory to the results of this study. However, this contradiction arises because of the presence of informal production sectors in the model. In order to test this implication I run a separate simulation scenario by assuming that there are no informal sectors in the Thai economy and therefore VAT burden on intermediate purchased of every production sector is deductible.

Simulation results in Table 4-2 show that, in the absence of informal sectors, VAT is more efficient than tariffs. Therefore, the contradiction is entirely attributable to the presence of informal sectors. This implies that, in the presence of informal sectors, invoices VAT rebate system creates a production distortion, which is the important implication for tax policy analysis in developing countries. In addition, it implies that the real consumption tax, as it is required by optimal tax literature, hardly exists in second-best developing countries. Therefore, the standard premise of trade liberalization for a revenue constrained economy should be carefully evaluated.

Table 4-2: The impacts on the aggregate economy in the absence of informal sectors

	(a)	(b)	(c)	(d)	(e)
Real GDP (% Δ)	0.036	0.011	-0.016	0.015	0.017
- Private consumption	0.257	0.011	-0.162	-0.025	-0.114
- Investment	0.649	0.024	0.327	0.127	0.358
- Government consumption	-2.297	0.000	0.000	0.000	0.000
- Export	0.653	0.449	0.488	0.468	0.487
- Import	0.889	0.611	0.664	0.637	0.662
Real absorption	0.043	0.013	-0.019	0.018	0.020
Production output (% Δ)	0.184	0.056	0.034	0.056	0.061
Producer price index (% Δ)	-0.199	-0.089	0.048	0.052	-0.137
CPI (% Δ)	-0.345	0.357	0.086	-0.224	-0.345
Factor income (Δ : ฿ billion)	1.765	14.660	-3.072	-10.481	10.937
Welfare (C.V: ฿ billion)	6.471	0.252	-4.121	-0.633	-2.890
Per-capita C.V (฿)	105.733	4.118	-67.342	-10.336	-47.225

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

4.2 Sectoral impacts

This subsection reports the impacts of trade liberalization and different revenue compensation measures at a disaggregate level. To summarize the results, I aggregate the 54 production sectors of the model into 4 major sectors, agricultural, manufacturing, transportation and services.

4.2.1 Sectoral price indexes

Column (a) of Table 4-3 presents the impacts of tariff reduction on sectoral price indexes. Tariff reduction reduces import prices of agricultural and manufacturing commodities, which are the main intermediate-input of domestic production. Therefore, every sectoral production sector benefits from tariff reduction in terms of lower intermediate-input prices.

Economy-wide wage rate decreases by 0.587 percent as the tariff reduction leads to the contraction of labor-intensive production. However, the sector-specific rate of return on capital of every sector increases which indicates the expansion of production in other sectors. Since labor accounts for 35.045 percent of total value added, the reduction in the economy-wide wage rate is offset by the increase in the aggregate rate of return on capital. Therefore, the aggregate value-added price index increases by 0.040 percent. At a disaggregate level, however, the value-added price indexes of labor-intensive agricultural and services productions decrease as a result of the reduction of economy-wide wage rate while the value-added price index of intermediate-input intensive manufacturing production increases which reflect a strong expansion in its production activity.

The effect on the domestic output price of each sector depends on the structure of its input as well as the elasticity of substitution between labor and capital. In general, the output price index of every sector decreases, except for transportation. The reduction of output price indexes in agricultural and service productions is attributable to the reduction of both intermediate-input price and value-added price while the reduction of the output price index of manufacturing is attributable to the reduction of intermediate input price. The increase in the output price index of transportation is attributable to the increase in value-added price and reflects the expansion in its production activity.

Table 4-3: The impacts on sectoral prices

	(a)	(b)	(c)	(d)	(e)
(1) Import price index (% Δ)	**-1.066**	**-1.066**	**-1.066**	**-1.066**	**-1.066**
- Agricultural	-1.408	-1.408	-1.408	-1.408	-1.408
- Manufacturing	-1.261	-1.261	-1.261	-1.261	-1.261
- Transportation	0.000	0.000	0.000	0.000	0.000
- Service	0.000	0.000	0.000	0.000	0.000
(2) Intermediate input price index (% Δ)	**-0.237**	**-0.151**	**-0.151**	**0.009**	**-0.255**
- Agricultural	-0.226	0.302	-0.115	0.135	-0.305
- Manufacturing	-0.264	-0.287	-0.264	-0.153	-0.303
- Transportation	-0.066	-0.061	0.811	0.079	-0.120
- Service	-0.197	-0.089	0.003	0.280	-0.140
(3) Economy-wide wage rate	**-0.584**	**0.357**	**-0.041**	**-0.207**	**0.287**
(4) Rate of return of capital	**0.313**	**-0.072**	**-0.279**	**-0.373**	**0.049**
- Agricultural	0.220	-0.469	-0.536	-0.506	-0.228
- Manufacturing	0.925	0.670	0.143	0.139	0.644
- Transportation	0.654	0.321	-1.104	-0.262	-0.125
- Service	0.026	0.103	0.065	-0.481	0.199
(5) Value added price index	**0.040**	**0.265**	**-0.075**	**-0.252**	**0.263**
- Agricultural	-0.045	-0.197	-0.373	-0.407	-0.058
- Manufacturing	0.286	0.537	0.064	-0.008	0.493
- Transportation	0.372	0.329	-0.864	-0.250	-0.032
- Service	-0.175	0.184	0.031	-0.393	0.228
(6) Domestic output price index (% Δ)	**-0.151**	**-0.062**	**0.036**	**0.040**	**-0.104**
- Agricultural	-0.093	0.124	-0.196	-0.109	-0.152
- Manufacturing	-0.191	-0.178	0.067	-0.211	-0.185
- Transportation	0.114	0.100	0.122	-0.056	-0.084
- Service	-0.148	0.087	0.028	0.650	0.082
(7) Composite price index (% Δ)	**-0.345**	**0.273**	**0.086**	**-0.224**	**-0.345**
- Agricultural	-0.068	0.070	-0.416	-0.193	-0.419
- Manufacturing	-0.536	0.112	0.247	-0.494	-0.516
- Transportation	0.126	0.281	0.134	-0.062	-0.093
- Service	-0.248	0.573	-0.048	0.142	-0.132

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

Assuming imperfect substitution between domestic and foreign goods, the price of each commodity available in the domestic market or composite price is the outcome of the interactions between export, import and domestic output prices that are governed by CET and Armington equations. Overall, it results in the reduction of the composite price and the producer price indexes for agricultural manufacturing and services but the increase in domestic producer price and composite price indexes for transportation. At an aggregate level, the composite price index and domestic producer price index decrease by 0.345 and 0.199 percent respectively.

Columns (b), (c), (d) and (e) present the impacts of tariff reduction in conjunction with revenue compensation measures on the sectoral price indexes. Since the exchange rate is the numeraire, aggregate and sectoral import price indexes are equal to the case without revenue compensation. Therefore, the change of intermediate input price index from the case without revenue compensation reflects the change in the structure of production, the demand condition as well as the distortion effect of each revenue compensation measure.

In general, with revenue compensation measures, production resources are increasingly diverted from intermediate-input intensive manufacturing production. Therefore, without distortion effect on production, the aggregate intermediate-input price index tends to be lower than in the case without revenue compensation as in the case of HIT. In all cases of indirect tax compensation measures, however, the aggregate intermediate price indexes are higher than in the case without revenue compensation. This is attributable to the distortion effect of indirect tax measures on production. VAT directly raises the intermediate-input price index of agricultural production while ET and

SBT directly raise the intermediate-input price indexes of transportation and services productions respectively.

In all cases of revenue compensation measures, labor-intensive services production decrease by a smaller magnitude than in the case without revenue compensation. Therefore, the economy-wide wage rate is higher than in the case without revenue compensation. Among the revenue compensation measures, the economy-wide wage rate is the highest in the case of VAT followed by HIT, ET and SBT respectively. Although the HIT is without production distortion and the aggregate production increases more than in the case of VAT, the economy-wide wage rate increases by a smaller magnitude. This is because, with HIT, the expansion of production activity is induced by the expansion of intermediate-intensive manufacturing production by more than in the case of VAT.

In contrast, the aggregate rate of return on capital is lower than in the case without revenue compensation. This is because, with revenue compensation measures, the aggregate production activity increases at a slower pace. In the cases of indirect tax compensation measures, the aggregate rate of return on capital decreases in contrast to the case without revenue compensation and to the case of HIT. At a disaggregate level, the sectoral specific rates of return on capital reflect the strong distortion effect of VAT on agricultural production, the distortion effect of ET on transportation production and the distortion effect of SBT on the services production.

Each revenue compensation measure affects the sectoral valued-added price indexes through its impact on the economy-wide wage rate and the sectoral specific rates of return on capital. With VAT and HIT, the aggregate value-added price index is higher than in the case without revenue compensation. In contrast, with the ET and SBT, the aggregate value added price index decreases against its increase in the case without revenue compensation. Ceteris paribus, this results imply the higher aggregate factor income in the cases of VAT and HIT than in the case without revenue compensation and vice versa in the cases of ET and SBT.

Output price is the Leontief aggregation of intermediate and value added prices, and is defined gross of indirect taxes on production. The change in the output price index reflects the supply side condition. In general, the aggregate output price index tends to be higher in the cases of revenue compensation than in the case without revenue compensation. With VAT and HIT, aggregate output price index decreases at a slower pace than in the case without revenue compensation, which is attributable to the increase in the aggregate value-added price index discussed earlier. In addition, with VAT, the VAT burden on the intermediate purchased of agricultural production reinforces the increase in value-added price. With ET and SBT, aggregate domestic output price index increases compared to its decrease in the case without revenue compensation. The increase of aggregate output price index in the case of ET is solely attributable to the higher tax burden, while the case of SBT is attributable to both the increase of intermediate-input price and the higher tax burden.

Similarly, composite price reflects the demand condition and is defined gross of VAT. Without revenue compensation, tariff reduction reduces the price of imported commodities in terms of domestic currency unit and therefore the aggregate composite price. With revenue compensation measures, the aggregate composite price index tends to be higher than in the case without revenue compensation. Among the indirect tax measures, composite price index is the highest in the case of VAT. This is because the composite price is VAT inclusive. With ET and SBT, the aggregate composite price index is higher than in the case without revenue compensation but lower than in the case of VAT. This is because ET and SBT are levied on production but their tax burdens are partially shifted to consumers and therefore the higher aggregate composite price is observed.

4.2.2 Sectoral productions

Table 4-4 shows the impacts of tariff reduction with and without revenue compensation measures on the sectoral production activities. Column (a) shows that, without revenue compensation, except for services, tariff reduction raises the production activity of every sector and results in the increase of aggregate production by 0.184 percent. The strongest expansion is for manufacturing production followed by transportation and agricultural productions respectively. This is because, as shown in Table 4-3, the first-round direct effect of tariff reduction is the reduction of import price of intermediate inputs. Therefore, without revenue compensation, tariff reduction benefits the intermediate input intensive manufacturing production more than the value-added intensive agricultural and transportation productions. However, the value-added intensive services production decreases as tariff reduction results in the contraction of government demand.

The expansion of aggregate production activity raises the demand for aggregate intermediate input. However, the demand for aggregate value-added decreases because the contraction of services production. In terms of demand by origins, the expansion of aggregate production is driven by the increase in both aggregate domestic demand and the aggregate demand for export. Nevertheless, the expansion of aggregate demand for export is significantly stronger than domestic demand. In addition, the strong increase in export at an aggregate level is attributable to the strong increase in manufacturing exports. Therefore, the expansions of manufacturing and the aggregate production activity[14] are mainly driven by export demand.

Table 4-4: The impacts on sectoral productions

	(a)	(b)	(c)	(d)	(e)
(1) Production output (% Δ)	**0.184**	**0.058**	**0.034**	**0.056**	**0.061**
- Agricultural	0.107	-0.096	-0.045	-0.040	-0.067
- Manufacturing	0.374	0.124	0.090	0.119	0.138
- Transportation	0.140	-0.004	-0.122	-0.006	-0.047
- Service	-0.188	-0.016	-0.023	-0.033	-0.035
(2) Intermediate-input composite (% Δ)	**0.297**	**0.098**	**0.077**	**0.094**	**0.101**
- Agricultural	0.097	-0.083	-0.047	-0.036	-0.061
- Manufacturing	0.401	0.150	0.133	0.142	0.164
- Transportation	0.140	-0.004	-0.122	-0.006	-0.047
- Service	-0.012	-0.017	-0.040	-0.022	-0.048
(3) Value-added composite (% Δ)	**-0.003**	**0.000**	**-0.001**	**0.000**	**0.000**
- Agricultural	0.116	-0.107	-0.043	-0.043	-0.072
- Manufacturing	0.314	0.061	0.054	0.064	0.073
- Transportation	0.140	-0.004	-0.122	-0.006	-0.047
- Service	-0.301	-0.015	-0.011	-0.036	-0.028
(4) Domestic demand for local goods (% Δ)	**0.033**	**-0.070**	**-0.112**	**-0.076**	**-0.075**
- Agricultural	0.091	-0.101	-0.080	-0.076	-0.107
- Manufacturing	0.158	-0.111	-0.174	-0.111	-0.097
- Transportation	0.157	0.010	-0.104	-0.015	-0.059
- Service	-0.224	-0.010	-0.019	-0.030	-0.033
(5) Export (% Δ)	**0.653**	**0.460**	**0.488**	**0.468**	**0.487**
- Agricultural	0.169	-0.075	0.088	0.097	0.082
- Manufacturing	0.866	0.658	0.686	0.642	0.672
- Transportation	0.072	-0.064	-0.194	0.028	0.003
- Service	0.053	-0.057	-0.047	-0.047	-0.050

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

In this respect, the main channel through which trade liberalization induces the economic expansion is its indirect stimulation effect on manufacturing exports. This is

[14] Note that manufacturing output accounts for 57.62 percent of total production. Therefore changes in manufacturing production strongly influence the aggregate output production.

because tariff reduction reduces producer price of manufacturing product by a smaller magnitude than its import price, but by a larger magnitude than export price. Change in the relative prices of this manner shifts domestic demand for manufacturing towards import goods and boosts its exportation. However, while tariff reduction raises the aggregate value-added price index by 0.040 percent, it reduces the demand for aggregate value-added by 0.003 percent. Therefore, the positive effect of trade liberalization in terms of factor income stimulation is not strong.

Columns (b), (c), (d), and (e) indicate that, in all cases of revenue compensation, the aggregate production increases at a slower rate than in the case without revenue compensation. This indicates direct and indirect distortion effects on production. Among the revenue compensation measures, the aggregate production output is highest in the case of HIT but significantly lower than in the case without revenue compensation. Since HIT has no direct distortion effect on production, the slower expansion in aggregate production is attributable to its indirect effect on the production resources reallocation that raises the aggregate value-added cost higher than without revenue compensation. In the case of indirect tax measures, this reallocation effect is reinforced by the direct distortion effect on production. Therefore, the aggregate production activity is lower in the cases of VAT, ET and SBT than in the case of HIT.

At a disaggregate level, in all cases of revenue compensation, manufacturing production increases but the production activities of all others sectors decrease. However, the production activity of manufacturing increases at a slower pace than in the case without revenue compensation while the production activity of services decreases at a slower pace. Therefore, the demand for aggregate intermediate inputs is lower than in the case without revenue compensation and vice-versa for the demand for aggregate value-added input.

The changes in sectoral production activities indicate the location of the distortion effect for each indirect tax measure. VAT shows a strong negative impact on agricultural production while ET and SBT show a strong bias against transportation and services productions respectively. These results are consistent with the structure of the tax system of the Thai economy and the way they distort the relative prices discussed in the previous subsection. That is, VAT is levied on the purchased of both domestic and imported commodities. In general, the VAT burden on the purchased of intermediate goods is deductible through the invoices rebate system. In the absence of standard accounting and invoices system, the VAT burden on the intermediate purchased is on the producer. Therefore, VAT distorts against the agricultural sector by raising its intermediate input price. ET is imposed mainly on luxury productions but covers gasoline, diesel and crude petroleum. Therefore, ET has a strong and economy-wide distortion effect in terms of higher energy input price. SBT is imposed specifically on the productions of real estate and banking. Therefore, it directly distorts against services production.

The slower expansion of aggregate production activity is consistent with the changes in demands. In all cases of revenue compensation, domestic demand decreases and export demand increases at a slower pace than without revenue compensation. The reduction of domestic demand is attributable to the slower expansion of the real income at an aggregate level and the change in relative price that favors import goods. The slower pace of the increase in export demand is attributable to the higher domestic producer price index which is caused by the increase in tax rates. Since the domestic demand decreases in all cases of revenue compensation, the expansion of production activity and the aggregate domestic economy rely totally on the exportation.

4.2.3 Sectoral demands

Table 4-5 shows the impacts of trade liberalization with and without revenue compensation measures on sectoral demands. At an aggregate level, without revenue compensation, trade liberalization raises the aggregate domestic demand by 0.206 percent. The expansion of domestic demand is driven by increases in the demand for consumption, intermediate input and investment demand, but government consumption demand decreases. This result is expected as tariff reduction depletes government revenue and reduces the real government consumption. At a disaggregate level, it contributes to the expansion of domestic demand for agricultural, manufacturing and transportation, but domestic demand for services decreases. The strongest increase in the composite demand is for manufacturing.

Nevertheless, the aggregate import demand increases at a faster rate than the aggregate demand for domestic output. Tariff reduction reduces the aggregate import price in terms of domestic currency by a larger magnitude than the reduction in the aggregate domestic producer price. Changes in the relative price create a bias against domestic goods in favor of import goods and therefore the aggregate domestic demand increasingly relies on the world market. At a disaggregate level, the strong increase in sectoral import demands is observed in agricultural and manufacturing commodities, which is consistent with the pattern of tariff reductions.

Table 4-5: The impacts on sectoral demands

	(a)	(b)	(c)	(d)	(e)
(1) Domestic composite demand(% Δ)	**0.206**	**0.068**	**0.043**	**0.066**	**0.073**
- Agricultural	0.129	-0.060	-0.045	-0.041	-0.068
- Manufacturing	0.412	0.131	0.101	0.135	0.160
- Transportation	0.168	0.020	-0.093	-0.020	-0.067
- Service	-0.207	-0.019	-0.026	-0.030	-0.043
(2) Consumption demand (% Δ)	**0.257**	**-0.014**	**-0.162**	**-0.025**	**-0.114**
- Agricultural	0.113	0.008	-0.071	-0.040	-0.036
- Manufacturing	0.354	0.028	-0.165	0.066	-0.029
- Transportation	0.102	-0.013	-0.270	-0.102	-0.273
- Service	0.186	-0.084	-0.152	-0.138	-0.223
(3) Intermediate input demand (% Δ)	**0.298**	**0.099**	**0.078**	**0.094**	**0.102**
- Agricultural	0.143	-0.087	-0.038	-0.043	-0.083
- Manufacturing	0.354	0.147	0.114	0.139	0.155
- Transportation	0.248	0.033	0.004	0.031	0.040
- Service	0.218	0.057	0.043	0.043	0.049
(4) Investment demand (% Δ)	**0.649**	**0.090**	**0.327**	**0.127**	**0.358**
- Agricultural	0.616	0.037	0.198	-0.174	0.111
- Manufacturing	0.749	0.174	0.377	0.186	0.410
- Transportation	0.282	0.224	-0.151	-0.252	0.133
- Service	-0.621	-1.055	-0.273	-0.596	-0.292
(5) Government demand (% Δ)	**-2.297**	**2.187**	**2.205**	**2.189**	**2.194**
- Agricultural	-2.297	2.187	2.205	2.189	2.194
- Manufacturing	-2.297	2.187	2.205	2.189	2.194
- Transportation	-2.297	2.187	2.205	2.189	2.194
- Service	-2.297	2.187	2.205	2.189	2.194
(6) Demand for domestic goods (% Δ)	**0.033**	**-0.070**	**-0.112**	**-0.076**	**-0.075**
- Agricultural	0.091	-0.101	-0.080	-0.076	-0.107
- Manufacturing	0.158	-0.111	-0.174	-0.111	-0.097
- Transportation	0.157	0.010	-0.104	-0.015	-0.059
- Service	-0.224	-0.010	-0.019	-0.030	-0.033
(7) Demand for imported goods (% Δ)	**0.889**	**0.626**	**0.664**	**0.637**	**0.662**
- Agricultural	0.733	0.587	0.503	0.513	0.533
- Manufacturing	1.073	0.761	0.815	0.774	0.826
- Transportation	0.256	0.097	0.001	-0.063	-0.132
- Service	-0.105	-0.097	-0.100	-0.034	-0.154

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

Columns (b), (c), (d) and (e) show the impact of tariff reductions in conjunction with revenue compensation measures. In all cases, the aggregate domestic demand increases at a slower pace than in the case without revenue compensation. At a disaggregate level, the impact of every revenue compensation measure on the structure of domestic demand shares a similar feature. It leads to the expansion of domestic demand for manufacturing but it results in the contraction of the domestic demand for other commodities. In addition, the domestic demand for services decreases by a smaller magnitude than in the case without revenue compensation. These results reflect the change in the structure of the aggregate GDP where the real investment increases on the contraction of consumption and the reduction of government consumption is less than in the case without revenue compensation. In addition, it is consistent with the composition of domestic demand where the aggregate demand for intermediate input, investment and government consumption increase but the aggregate demand for consumption decreases in all cases of revenue compensation.

In terms of demand by the origin of the goods, Table 4-5 shows that, in all cases of revenue compensation, the aggregate demand for domestic output decreases and is replaced by the increase in the import demand. Among the indirect tax measures, while the increase in the domestic demand is strongest in the case of VAT follow by SBT and ET, the strongest increase in import demand is for ET followed by SBT and VAT respectively. Therefore, VAT provides the lowest incentive to domestic economy for importation, followed by SBT and ET respectively. This is consistent with the nature of each tax instrument. VAT is levied on both domestic and imported commodities. Therefore, it has a neutrality effect on commodities from different origins. ET and SBT bias against domestic goods due to the fact that they raise domestic price relative to import price. The import stimulation effect is particularly high in the case of ET since its base covers the energy commodity.

4.2.4 Sectoral trades

Table 4-6, presents the impacts of tariff reduction with and without revenue compensation measures on sectoral trades. At an aggregate level, without revenue compensation, trade liberalization results in a reduction of aggregate domestic producer price index. Since exchange rate is the numeraire, the ratio of aggregate export price to aggregate domestic price increases and raises aggregate real export by 0.653 percent. At a disaggregate level, the real export of every commodity increases. The strong expansions are observed in the exportation of agricultural and manufacturing commodities that are directly benefit from tariff reduction.

Without revenue compensation measures, tariff reduction reduces the import price index at a faster rate than producer price. The aggregate real import increases by 0.889 percent. At a disaggregate level, except for services, the import of every sectoral commodity increases. Together with the change in the sectoral exports, tariff reduction raises the net real export of services and agricultural commodities.

Columns (b), (c), (d) and (e) show the impacts of trade liberalization in conjunction with revenue compensation measures. At an aggregate level, in all cases of revenue compensation, both aggregate real import and aggregate real export increase less than without revenue compensation. Among the indirect tax measures, the smallest increase in aggregate domestic demand is in the case of ET. However, the aggregate real import shows the highest increase in the same case. This implies that ET has the strongest stimulation effect on importation since it puts an economy-wide upward pressure on production cost. Similarly, in the case of SBT, while aggregate domestic demand is lower than in the case of VAT, aggregate import increases by a larger magnitude.

Table 4-6: The impacts on sectoral trades

	(a)	(b)	(c)	(d)	(e)
(1) Import price index (% Δ)	**-1.066**	**-1.066**	**-1.066**	**-1.066**	**-1.066**
- Agricultural	-1.408	-1.408	-1.408	-1.408	-1.408
- Manufacturing	-1.261	-1.261	-1.261	-1.261	-1.261
- Transportation	0.000	0.000	0.000	0.000	0.000
- Service	0.000	0.000	0.000	0.000	0.000
(2) Domestic producer price index (% Δ)	**-0.199**	**-0.081**	**0.048**	**0.052**	**-0.137**
- Agricultural	-0.049	0.141	-0.274	-0.129	-0.254
- Manufacturing	-0.275	-0.257	0.096	-0.305	-0.267
- Transportation	0.142	0.124	0.151	-0.070	-0.104
- Service	-0.171	0.100	0.033	0.746	0.094
(3) Export/ Domestic prices (% Δ)	**0.200**	**0.082**	**-0.048**	**-0.052**	**0.138**
- Agricultural	0.049	-0.141	0.274	0.129	0.255
- Manufacturing	0.276	0.257	-0.096	0.306	0.268
- Transportation	-0.141	-0.124	-0.151	0.070	0.104
- Service	0.171	-0.100	-0.033	-0.741	-0.094
(4) Import / Domestic price (% Δ)	**-0.869**	**-0.985**	**-1.113**	**-1.117**	**-0.930**
- Agricultural	-1.360	-1.548	-1.138	-1.281	-1.157
- Manufacturing	-0.989	-1.006	-1.355	-0.959	-0.996
- Transportation	-0.141	-0.124	-0.151	0.070	0.104
- Service	0.171	-0.100	-0.033	-0.741	-0.094
(5) Real export (% Δ)	**0.653**	**0.460**	**0.488**	**0.468**	**0.487**
- Agricultural	0.169	-0.075	0.088	0.097	0.082
- Manufacturing	0.866	0.658	0.686	0.642	0.672
- Transportation	0.072	-0.064	-0.194	0.028	0.003
- Service	0.053	-0.057	-0.047	-0.047	-0.050
(6) Real Import (% Δ)	**0.889**	**0.626**	**0.664**	**0.637**	**0.662**
- Agricultural	0.733	0.587	0.503	0.513	0.533
- Manufacturing	1.073	0.761	0.815	0.774	0.826
- Transportation	0.256	0.097	0.001	-0.063	-0.132
- Service	-0.105	-0.097	-0.100	-0.034	-0.154
(7) Ratio of real export to local goods (% Δ)	**0.620**	**0.531**	**0.601**	**0.545**	**0.563**
- Agricultural	0.078	0.027	0.168	0.174	0.189
- Manufacturing	0.707	0.770	0.861	0.754	0.769
- Transportation	-0.085	-0.074	-0.090	0.042	0.062
- Service	0.278	-0.047	-0.028	-0.017	-0.017
(8) Ratio of real import to local goods (% Δ)	**0.872**	**0.714**	**0.798**	**0.731**	**0.756**
- Agricultural	0.659	0.709	0.601	0.610	0.658
- Manufacturing	0.932	0.890	1.011	0.904	0.941
- Transportation	0.099	0.087	0.106	-0.049	-0.073
- Service	0.113	-0.087	-0.082	-0.004	-0.121
(9) Net real export (% Δ)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
- Agricultural	0.004	-0.268	-0.033	-0.024	-0.050
- Manufacturing	-0.116	0.170	0.076	0.017	-0.059
- Transportation	-0.119	-0.230	-0.397	0.121	0.143
- Service	0.332	0.013	0.046	-0.071	0.131

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

Among the indirect tax measures, the aggregate real export has the highest increase in the case of ET followed by HIT, SBT, and VAT respectively. However, the strong increase in the real export in the case of ET does not mean that ET has a stronger stimulation effect on the exportation. Instead, it is driven by the fact that the expansion of aggregate production occurs at a faster rate than the expansion of composite demand[15] as indicated in Table 4-4 and Table 4-5.

4.2.5 Households

Table 4-7 shows the impacts of trade liberalization with and without revenue compensation measures on households. Without revenue compensation, tariff reduction induces the expansion of domestic production and raises the total aggregate factor income by ฿ 1.8 billion. Together with the change in consumption price, it contributes to the increase in the real consumption per-capita by ฿ 106.2 and raises welfare per-capita by ฿ 105.7 on average.

At a disaggregate level, trade liberalization asymmetrically contributes to the expansion of sectoral productions. As shown in the previous subsection, it contributes to the expansion of manufacturing production more than it does to agricultural production and the contraction of labor-intensive services production. Therefore, the increase in total factor income is driven by the increase of capital income in nonagricultural production by more than capital income in agricultural production.

As a result, the nonagricultural households benefit the most from trade liberalization followed by agricultural households. Government employed-households

[15] In addition, we test this implication in a separate auxiliary simulation. The result shows that ET alone reduces aggregate composite demand by 0.026 percent and aggregate real production output by 0.025 percent.

suffer from tariff reduction. This is because agricultural households derive 43.305 percent of their income from agricultural capital and 40.463 percent from labor, nonagricultural households derive 58.938 percent of their total income from nonagricultural capital, and the labor income accounts for 86.766 percent of the total income of government employed households. Therefore, different households benefit unequally from trade liberalization. These results are consistent with the standard trade theory and previous literature on the distribution effects of trade liberalization. Overall trade liberalization improves household welfare but benefits those households in modern sectors more than it does for other households.

Table 4-7: The impacts on households

	(a)	(b)	(c)	(d)	(e)
(1) Nominal factor income (Δ : ฿ billion)	**1.8**	**11.1**	**-3.1**	**-10.5**	**11.0**
- Labor	-8.5	5.2	-0.6	-3.0	4.2
- Agricultural capital	0.8	-1.7	-2.0	-1.9	-0.8
- Non agricultural capital	9.5	7.6	-0.5	-5.6	7.6
(2) Real consumption per-capita (Δ: ฿)	**106.2**	**-5.6**	**-66.9**	**-10.1**	**-47.3**
- Agricultural household	73.2	-47.2	-78.7	-4.2	90.0
- Non-agricultural household	171.6	20.9	-54.5	-15.1	-46.8
- Government-employed household	-78.4	36.9	-78.3	-10.3	-622.6
(3) Welfare per capita (C.V:฿))	**105.7**	**-5.9**	**-67.3**	**-10.3**	**-47.2**
- Agricultural household	72.8	-47.4	-79.0	-4.3	89.6
- Non-agricultural household	170.9	20.7	-55.1	-15.4	-46.7
- Government-employed household	-78.4	36.6	-78.9	-10.6	-620.4

Note: (a) : Tariff reduction
(b) : Tariff reduction, replace government revenue by VAT
(c) : Tariff reduction, replace government revenue by excise tax
(d) : Tariff reduction, replace government revenue by SBT tax
(e) : Tariff reduction, replace government revenue by household income tax

Columns (b), (c), (d) and (e) show the impact of trade liberalization in conjunction with revenue compensation measures. Overall, the aggregate nominal factor income is higher in the cases of VAT and HIT than without revenue compensation but lower in the cases of ET and SBT. With VAT, the income from agricultural capital decreases as it distorts against the agricultural production while the income from nonagricultural capital increases by more than labor income. With ET and SBT, income from every primary factor decreases.

Although the aggregate factor income increases in the cases of VAT and HIT, households are worse off at an aggregate level. With VAT, consumption price increases and outweighs the contribution of higher income. Therefore, in aggregate, household per-capita consumption and per-capita welfare decreases. With HIT, the increase in household per-capita income insufficiently covers the increase of household income tax burden. Therefore, the consumption and welfare per-capita decrease at aggregate levels. In the cases of ET and HIT, the aggregate factor income decreases and results in the contraction of the real income per-capita and, hence, the real consumption and welfare per-capita. Therefore, the aggregate welfare decreases in all cases of revenue compensation. This indicates that VAT, ET, SBT and HIT are less efficient than tariffs.

Although households in aggregate are worse off in all cases of revenue compensation, the impacts of each measure differ significantly across households and in terms of welfare distribution. With VAT, government-employed households and nonagricultural households are better off because VAT raises labor income and income from nonagricultural capital. Therefore, the contraction of agricultural household welfare and the total welfare at an aggregate level is essentially attributable to the distortion effect of VAT on agricultural production. ET results in the contraction of income from every factor and, therefore, every household is worse off. Nevertheless, since the income from agricultural capital decreases more than incomes from other factors, agricultural households suffer the most followed by government-employed and non-agricultural households respectively. In the case of SBT, every factor income decreases and results in the contraction of welfare of every household. However, as SBT directly distorts against service production, the income from nonagricultural capital decreases more than agricultural capital and labor incomes. Therefore, nonagricultural households suffer the most. With HIT, agricultural households are better off while the nonagricultural households and government-employed households are worse off. This is because of the progressive nature of income tax system in the base year, where the effective rate is the highest for government-employed households, followed by nonagricultural and agricultural households respectively. With this income tax structure, the uniform percentage change of income tax rates raises the tax burden on government-employed households by more than nonagricultural and agricultural households. Therefore, with the HIT, government-employed households are much worse off than nonagricultural household.

5. Conclusion

This chapter investigates the impacts of trade liberalization in the context of a revenue constrained economy. The main focus of this chapter is at the impacts of tariff reduction with and without other revenue compensation measures, in particular the impacts on the aggregate income and household welfare. With revenue compensation, the effect of tariff reduction on government revenue is neutralized by the increase in the incomes from Value Added Tax (VAT), Excise Tax (ET), Special Business Tax (SBT) and Household Income Tax (HIT) respectively.

For the purpose of the analysis in this chapter, I develop a static CGE model for tax policy analysis. The model incorporates all major taxes of the Thai economy that are administered by the central government and explicitly model the invoices VAT rebate system. It is composed of 54 production sectors, 3 representative households and 2 primary factors of production. The findings can be summarized as follows.

Without revenue compensation measures, the impacts of trade liberalization are consistent with the standard trade theory. That is, tariff reduction induces the expansion of domestic production and results in higher aggregate income. Aggregate GDP increases by 0.036 percent led by the expansions of the real investment of 0.649 percent and the real private consumption of 0.257 percent. With the assumption of fixed government saving, government revenue decreases by ฿ 20.829 billion which is equivalent to government revenue loss of 0.450 percent of GDP and results in the contraction of government real consumption of 2.297 percent.

Aggregate production increases by 0.184 percent, which is driven by the strong expansion of aggregate exports of 0.653 percent. The increase in aggregate real income stimulates the expansion of domestic demand and raises the aggregate real imports by 0.889 percent, which is significantly higher than the increase in the domestic demand for domestic output of 0.033 percent. The domestic economy increasingly relies on the world market as, at a disaggregate level, tariff reduction reduces the import price but raises the export price relative to domestic producer price, and therefore shifts the domestic demand towards import goods and boosts exportation. At a disaggregate level, tariff reduction contributes more to the expansion of intermediate-input intensive manufacturing production than to value-added intensive agricultural and transportation productions.

The increase in private consumption improves household well-being. Measured by compensating variation, aggregate household welfare increases by ฿ 6.469 billion which is equivalent to 1.395 percent of GDP. In terms of distribution, trade liberalization improves the welfare of nonagricultural households in modern sectors more than the welfare of agricultural households.

In the context of a revenue constrained economy, I introduce tariff reductions with different revenue compensation measures. Overall, the simulation results show that the impacts of trade liberalization differ significantly from the case without revenue compensation. In the cases of VAT, SBT and HIT the GDP increases by 0.012, 0.015 and 0.017 which is significantly lower than the case without revenue compensation. With ET, it leads to contraction of GDP by 0.016 percent. In all cases of revenue compensation, aggregate real consumption decreases as compared to an increase in the case without revenue compensation and the aggregate real investment increases at a significantly slower pace.

Aggregate production increases at a slower pace. The strongest negative impact on production is observed in the case of ET. In all cases of revenue compensation, the expansion of aggregate production is entirely driven by real export while the domestic demand for domestic goods decreases. The aggregate domestic demand and the aggregate real import increase at a slower pace than in the case without revenue compensation, which reflects the slower expansion of the aggregate real income. At a more microeconomic level, simulation results show that VAT directly distorts against agricultural production through its higher tax burden on the purchased of intermediate-inputs. ET has an economy-wide distortion effect on production. This is because its base covers gasoline, diesel and crude petroleum productions. SBT directly distorts against services production. HIT reduces aggregate production through its impact on the production resources reallocation that raises the economy-wide wage rate.

The reduction of real consumption results in the contraction of aggregate household welfare in all cases of revenue compensation. With ET, the aggregate household welfare decreases by the largest followed by HIT and VAT respectively. In terms of welfare distribution, VAT biases against the low-income agricultural households in favor of nonagricultural and government-employed households. In contrast, HIT biases against the high and middle-income households in favor of the low-income agricultural households. In the cases of SBT and ET, every household is worse off.

Therefore, tax measures in simulations are less efficient than tariffs. This result contradicts the findings of some previous studies. However, the contradiction arises because there is a distortion effect of VAT on the production of informal sectors. This distortion effect can be captured only when the model incorporates the invoices rebate system. Nevertheless, this finding has an important implication for VAT policy decision and casts some doubts on previous literature in developing countries that ignore the potential production distortion of VAT in their analysis.

Lastly this study shows that, under certain conditions, proactive trade liberalization results in static household welfare contraction. In the longer run, the dynamic gains from trade liberalization can offset the static welfare contraction and improve household well-being which is the ultimate objective of trade liberalization. However, the long run is subject to uncertainties and many proactive developing countries continually reduce their tariff protection. In such a situation, households are more likely worse off on the trajectory path of trade liberalization. In addition, in the presence of informal sectors, the real consumption tax as it is required by optimal tax literature is hardly available. Therefore, the standard premise of trade liberalization for the revenue constrained economy should be carefully evaluated.

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Appendix A: List of parameters and variables in the model

A-1 List of parameters

α_c^q	Shift parameter of Armington function
α_c^t	Shift parameter of CET function
α_a^{va}	Shift parameter of value-added production function
$\beta_{c,h}^m$	Marginal share of consumption spending
δ_c^q	Share parameter of Armington function
δ_c^t	Share parameter of CET function
$\delta_{f,a}^{va}$	Share parameter of value-added production function
$\gamma_{c,h}^m$	Quantity of subsistence consumption
$\theta_{a,c}$	Yield parameter
θ_c^q	Exponential parameter of Armington function
θ_c^t	Exponential parameter of CET function
θ_a^{va}	Exponential parameter of value-added production function
ψ_c	Share of real investment in total saving
$cwts_c$	Weight of each consumption commodity in consumption basket
$ica_{c,a}$	Intermediate input commodity per unit of aggregate intermediate input
$insa_a$	Aggregate intermediate input per unit of activity
iv_a	Aggregate value-added input per unit of activity
$mpsbar_i$	Propensity to save

pwe_c	Export price in FCU
pwm_c	Import price in FCU
$qbag_c$	Demand for government consumption
$qdst_c$	Demand for stock investment
$shif_{i,f}$	Share of each institution in the total factor income
$shii_{i,i^*}$	Infra-institution transfer
$tinszo_i$	0-1 parameter for potential flexing of direct tax rate
$vatzo_i$	0-1 parameter for potential flexing of VAT rate
$exczo_i$	0-1 parameter for potential flexing of excise tax rate
$spbzo_i$	0-1 parameter for potential flexing of special business tax rate
$subzo_i$	0-1 parameter for potential flexing of subsidy rate
sub_a	Base year subsidy rate
tes_a	Base year excise tax rate
$tinsbar_i$	Base year direct tax rate of institution
tm_c	Base year tariff rate
$trnsfr_{i,row}$	Transfer between domestic institution and the rest of the world
$trnsfr_{i,gov}$	Transfer between domestic non-government institution and government
$tspb_a$	Base year special business tax rate
tv_c	Base year VAT rate

A-2 List of variables[16]

CPI	Consumer price index
Eg	Government expenditure
Eh_h	Disposable income of household
$ExcADJ$	Excise tax rate adjustment variable
Exr	Exchange rate (LCU per FCU)
$Fsav$	Foreign saving in FCU
$Gadj$	Government scaling factor
$Gsav$	Government saving
PA_a	Activity price
Pd_c	Price of domestic output sold domestically
Pe_c	Export price in LCU
$PinsA_a$	Price of aggregate intermediate input
Pm_c	Import price in LCU
Pq_c	Price of composite commodity (domestic market price)
PvA_a	Price of aggregate value-added
Px_c	Price of domestic output
QA_a	Level of activity
Qd_c	Quantity of commodity produced and sold domestically
Qe_c	Quantity of export

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16 Variables $ExcADJ, Exr, Fsav, Gsav, QFS_f, SpbADJ, SubADJ, VatADJ, TinsADJ$ and $WFdist_f$ are fixed in the base model.

$QF_{f,a}$	Quantity demand for primary factor
QFS_f	Quantity supply of primary factor
Qg_C	Quantity of government demand
$Qh_{c,h}$	Quantity of household consumption
$QCinA_{c,a}$	Quantity demand for intermediate commodity
$QinsA_a$	Quantity of aggregate intermediate input
$Qinv_c$	Quantity demand for investment
Qm_c	Quantity of import
Qq_c	Quantity of composite supply
QvA_a	Quantity of aggregate value-added
Qx_c	Quantity of domestic output
$REBATE_a$	VAT rebate
$SpbADJ$	Special business tax rate adjustment variable
$SubADJ$	Subsidy rate adjustment variable
$TexcR_a$	Rate of excise tax
$Trii_{i,i^*}$	Infra-institutional transfer between domestic non-government institutions
$Tins_i$	Direct tax rate
$TinsADJ$	Direct tax rate (income tax) adjustment variable
$Tsav$	Total saving
$TspbR_a$	Rate of special business tax
$TsubR_a$	Rate of subsidy

$TvatR_c$	Rate of VAT
$VatADJ$	VAT adjustment variable
$Walras$	Saving-investment imbalance
WF_f	Economy-wide rate of return on primary factor
$WFdist_{f,a}$	Sector specific rate of return on primary factor
YF_f	Factor income
Yg	Government revenue
Yi_i	Total gross income of domestic non-government institutions
Yif_i	Factor income of domestic institution

A-3 Set

A	Set of production activity
C	Set of commodities
F	Set of primary production factors
I	Set of institutions
H	Set of households

Appendix B: Parameters in the model

Table B-1: Elasticity of substitution

	K and L	Armington elasticity	CET elasticity
Agriculture	0.5	0.8	0.9
Industry	0.5	0.9	1.5
Transportation	0.5	0.7	0.6
Services	0.5	0.5	0.5

Table B-3: Income elasticity of demand

	Agricultural household	Nonagricultural household	Govt-employed household
Agriculture	0.95	0.90	0.90
Industry	1.50	1.40	1.30
Energy			
Transportation	1.50	1.30	1.10
Services	1.05	1.05	1.05

Frisch parameter = -2.8

Appendix C: Structure of the Thai economy as displayed by SAM

Table C-1: GDP balance sheet

	Expenditure			Income	
	฿ billion	(%)		฿ billion	(%)
Government consumption	500.70	10.80	GDP at factor cost	4,160.29	89.74
Private consumption	2,529.28	54.56	Indirect taxes	475.63	10.26
Investment	884.53	19.08			
Net export	721.41	15.56			
- Export	2,723.71	58.75			
- Import	-2,002.30	-43.19			
GDP (market prices)	4,635.92	100.00	GDP (market prices)	4,635.92	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-2: Population by household and income per-capita

Sector	Population		Income	
	Person (Million person)	(%)	Total (฿ billion)	Income per capita (฿)
Agriculture household	25.28	41.30	534.32	21,135.70
Non-agriculture household	29.86	48.80	2,138.98	71,640.60
Government-employed household	6.06	9.90	497.13	81,990.80
Total	61.20	100.00	3,170.43	-

Source: *Thailand 1998 Social Accounting Matrix*

Table C-3: Source of household income (%)

	Wage income	Rental Income	Government Transfer	Transfer from ROW	Total
Agriculture household	38.08	56.04	2.15	3.73	100
Non-agriculture household	38.99	58.14	1.21	1.65	100
Government-employed household	85.58	13.05	0.59	0.77	100
Total	38.08	56.04	2.15	3.73	100

Source: *Thailand 1998 Social Accounting Matrix*

Table C-4: Distribution of household spending (%)

	Agriculture Household	Non-agriculture household	Government-employed Household
Consumption spending	112.19	72.18	79.68
Transfer payment	0.19	1.36	2.8
Income tax	0.48	3.95	8.28
Saving (borrowing)	-12.86	22.50	9.25
Total	100.00	100.00	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-5: Distribution of household consumption spending (%)

	Agriculture Household	Non-agriculture household	Government-employed Household
Agricultural	**11.84**	**7.41**	**6.99**
- Paddy	0.00	0.00	0.00
- Other crops	0.21	0.13	0.12
- Vegetable and fruits	8.38	5.25	4.95
- Livestock	0.41	0.26	0.24
- Fishing	2.41	1.51	1.42
- Forest	0.17	0.11	0.10
- Other agricultural	0.25	0.16	0.15
Manufacturing	**63.08**	**46.13**	**46.45**
- Coal and lignite	0.00	0.00	0.00
- Crude petroleum	0.00	0.00	0.00
- Other mining	0.00	0.00	0.00
- Rice and flour	8.54	6.25	6.29
- Meat	5.18	3.79	3.81
- Canned food	1.02	0.74	0.75
- Other food	3.25	2.37	2.39
- Other agricultural products	1.25	0.92	0.92
- Beverage	9.88	7.23	7.28
- Tobacco	2.60	1.90	1.92
- Textile	2.68	1.96	1.98
- Apparel	14.63	10.70	10.77
- Leather and footwear	1.19	0.87	0.87
- Wood products	0.00	0.00	0.00
- Furniture	1.51	1.10	1.11
- Paper	0.00	0.00	0.00
- Printing and publishing	2.15	1.57	1.59
- Basic chemical	0.00	0.00	0.00
- Gasoline	0.42	0.31	0.31
- Diesel	0.10	0.07	0.07
- Aviation fuel	0.00	0.00	0.00
- Fuel oil	0.00	0.00	0.00
- Non-metal products	0.00	0.00	0.00
- Basic metal	0.00	0.00	0.00
- Fabric metal	0.00	0.00	0.00
- Transport equipment	2.23	1.63	1.64
- Electricity	0.78	0.57	0.58
- Gas distribution	0.21	0.16	0.16
- Water	0.65	0.47	0.48
- Construction	0.00	0.00	0.00
- Other industries	4.81	3.52	3.54
Transportation	**5.39**	**9.98**	**10.00**
Services	**19.70**	**36.48**	**36.56**
- Retail trade	0.43	0.80	0.80
- Restaurant	5.50	10.18	10.20
- Hotel	0.47	0.88	0.88
- Communication	1.43	2.65	2.65
- Banking	0.31	0.57	0.57
- Insurance	0.40	0.75	0.75
- Real estate	4.04	7.48	7.49
- Business service	0.05	0.08	0.09
- Public administration	0.00	0.00	0.00
- Education	0.38	0.71	0.71
- Health care and medical	4.04	7.47	7.49
- Nonprofit organizations	0.00	0.00	0.00
- Recreation	1.81	3.36	3.36
- Repairs	0.09	0.16	0.16
- Personel service	0.75	1.40	1.40
Total	100.00	100.00	100.00

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-6: Structure of government balance

	Spending			Revenue	
	฿ billion	%		฿ billion	%
Consumption	500.69	63.05	Taxes income	694.91	87.51
- Agricultural commodity	0.83	0.10	- Value added tax	220.12	27.72
- Manufacturing commodity	29.52	3.72	- Excise tax	175.58	22.11
- Transportation commodity	7.92	1.00	- Special business tax	32.56	4.10
- Services commodity	462.42	58.23	- Subsidy	-14.66	-1.85
Transfer	11.98	1.51	- Custom duties	62.03	7.81
- Agriculture household	11.44	1.44	- Income tax	219.28	27.61
- Non-agriculture household	25.7	3.24	Capital income	79.4	10.00
- Government-employed household	2.95	0.37	Transfer from ROW	19.81	2.49
- Enterprise	-28.11	-3.54			
Saving	281.45	35.44			
Total	794.12	100.00	Total	794.12	100.00

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-7: Saving-investment balance (฿ billion)

	Saving		Investment
Household	456.54	Gross fixed capital formation	1027.92
- Agricultural household	-68.39	- Agriculture	0.28
- Non-agricultural household	478.96	- Manufacturing	946.14
- Government-employed household	45.97	- Transportation	10.18
Enterprises saving	722.92	- Services	71.32
Government saving	281.45	Investment in stock	-143.39
Foreign saving	-576.38		
Total	884.53	Total	884.53

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-8: Capital account balance sheet (฿ billion)

	Expenditure		Income
Imports of goods and services	2,002.30	Exports of goods and services	2,723.71
		Net factor income payment from ROW	-145.01
		Net current transfer from ROW	-576.40
Total	2,002.30	Total	2,002.30

***Source**: Thailand 1998 Social Accounting Matrix*

Table C-9: Production structure (%)

	Output	Value added	Labor	Capital	Intermediate Input
Agricultural	**9.08**	**13.24**	**12.46**	**13.67**	**6.98**
- Paddy	1.55	3.13	5.79	1.69	0.66
- Other crops	0.39	0.69	0.52	0.78	0.23
- Vegetable and fruits	2.44	2.13	0.57	2.97	2.75
- Livestock	1.16	1.04	1.66	0.71	1.29
- Fishing	2.09	3.3	1.58	4.24	1.44
- Forest	0.05	0.11	0.04	0.14	0.02
- Other agricultural	1.41	2.85	2.29	3.14	0.59
Manufacturing	**57.62**	**34.39**	**41.42**	**30.6**	**70.59**
- Coal and lignite	0.09	0.17	0.07	0.23	0.03
- Crude petroleum	0.77	0.88	0.37	1.15	0.55
- Other mining	0.25	0.43	0.18	0.56	0.14
- Rice and flour	2.99	0.63	0.76	0.56	4.57
- Meat	0.97	0.47	0.56	0.42	1.32
- Canned food	2.16	1.18	1.42	1.05	2.86
- Other food	1.62	0.53	0.64	0.47	2.35
- Other agricultural products	2	1.64	1.97	1.47	2.29
- Beverage	1.74	1.01	1.22	0.9	1.45
- Tobacco	0.57	0.01	0.01	0.009	0.5
- Textile	2.79	2.24	2.69	2.00	3.18
- Apparel	5.05	3.69	4.43	3.3	5.97
- Leather and footwear	1.22	1.14	1.37	1.02	1.31
- Wood products	0.18	0.08	0.1	0.07	0.24
- Furniture	0.81	0.47	0.56	0.42	1.02
- Paper	1.05	0.61	0.73	0.54	1.33
- Printing and publishing	0.32	0.29	0.34	0.26	0.34
- Basic chemical	1.12	0.5	0.6	0.44	1.51
- Gasoline	0.85	0.33	0.39	0.29	0.81
- Diesel	1.03	0.29	0.34	0.26	0.98
- Aviation fuel	0.36	0.39	0.47	0.35	0.34
- Fuel oil	0.88	0.71	0.85	0.63	0.92
- Non-metal products	1.25	1.21	1.45	1.08	1.29
- Basic metal	0.77	0.004	0.004	0.003	1.23
- Fabric metal	1.05	0.68	0.82	0.61	1.27
- Transport equipment	1.44	0.44	0.53	0.4	1.94
- Electricity	1.5	2.19	2.63	1.95	1.14
- Gas distribution	0.26	0.1	0.12	0.09	0.34
- Water	0.21	0.38	0.46	0.34	0.11
- Construction	4.29	4.02	6.14	2.88	4.54
- Other industries	18.05	7.69	9.22	6.86	24.71
Transportation	**6.41**	**7.07**	**4.58**	**8.42**	**6.25**
Services	**26.89**	**45.29**	**41.54**	**47.31**	**16.18**
- Retail trade	8.16	16.26	4.73	22.49	3.63
- Restaurant	4.1	4.47	5.36	3.99	4.05
- Hotel	0.84	1.03	1.23	0.92	0.75
- Communication	0.71	1.55	1.01	1.85	0.21
- Banking	2.61	4.54	3.45	5.13	1.1
- Insurance	0.4	0.9	0.71	1.01	0.1
- Real estate	1.63	3	2.34	3.35	0.79
- Business service	0.4	0.22	0.27	0.2	0.52
- Public administration	1.84	4.53	11.91	0.54	0.28
- Education	1.92	4.41	5.29	3.94	0.51
- Health care and medical	1.76	1.74	2.09	1.55	1.83
- Nonprofit organizations	0.05	0.1	0.12	0.09	0.02
- Recreation	0.66	0.6	0.72	0.53	0.6
- Repairs	1.49	1.26	1.51	1.12	1.66
- Personel service	0.32	0.67	0.8	0.6	0.12
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: *Thailand 1998 Social Accounting Matrix*

Table C-10: Structure of production input (%)

	Value added			Intermediate input	Total
	Capital	Labor	Total		
Agricultural	**36.18**	**17.80**	**53.98**	**46.02**	**100.00**
- Paddy	26.18	48.45	74.63	25.37	100.00
- Other crops	47.66	17.34	65.00	35.00	100.00
- Vegetable and fruits	29.29	3.05	32.34	67.66	100.00
- Livestock	14.72	18.56	33.28	66.72	100.00
- Fishing	48.83	9.79	58.62	41.38	100.00
- Forest	68.76	10.90	79.65	20.35	100.00
- Other agricultural	53.77	21.15	74.92	25.08	100.00
Manufacturing	**13.38**	**9.77**	**23.15**	**76.85**	**100.00**
- Coal and lignite	64.44	11.13	75.57	24.43	100.00
- Crude petroleum	42.49	7.34	49.83	50.17	100.00
- Other mining	56.34	9.73	66.07	33.93	100.00
- Rice and flour	4.57	3.32	7.89	92.11	100.00
- Meat	10.40	7.54	17.94	82.06	100.00
- Canned food	11.79	8.55	20.34	79.66	100.00
- Other food	7.10	5.15	12.25	87.75	100.00
- Other agricultural products	17.80	12.91	30.71	69.29	100.00
- Beverage	17.47	12.67	30.15	69.86	100.00
- Tobacco	0.76	0.55	1.31	98.69	100.00
- Textile	17.62	12.78	30.40	69.60	100.00
- Apparel	16.04	11.63	27.67	72.33	100.00
- Leather and footwear	20.27	14.71	34.98	65.02	100.00
- Wood products	9.75	7.07	16.83	83.17	100.00
- Furniture	12.77	9.26	22.03	77.97	100.00
- Paper	12.75	9.25	22.00	78.00	100.00
- Printing and publishing	19.87	14.41	34.28	65.72	100.00
- Basic chemical	9.80	7.11	16.91	83.09	100.00
- Gasoline	11.59	8.41	19.99	80.01	100.00
- Diesel	8.85	6.42	15.27	84.73	100.00
- Aviation fuel	23.81	17.27	41.07	58.93	100.00
- Fuel oil	18.61	13.50	32.10	67.90	100.00
- Non-metal products	21.25	15.41	36.66	63.34	100.00
- Basic metal	0.11	0.08	0.19	99.81	100.00
- Fabric metal	14.41	10.45	24.86	75.14	100.00
- Transport equipment	7.19	5.21	12.40	87.60	100.00
- Electricity	31.51	22.86	54.36	45.64	100.00
- Gas distribution	8.61	6.24	14.85	85.15	100.00
- Water	39.55	28.69	68.25	31.75	100.00
- Construction	16.47	18.91	35.38	64.62	100.00
- Other industries	9.35	6.78	16.13	83.87	100.00
Transportation	**31.84**	**9.35**	**41.18**	**58.82**	**100.00**
Services	**43.00**	**20.37**	**63.38**	**36.62**	**100.00**
- Retail trade	65.96	7.49	73.45	26.55	100.00
- Restaurant	23.51	17.06	40.57	59.43	100.00
- Hotel	26.60	19.29	45.89	54.11	100.00
- Communication	63.23	18.56	81.79	18.21	100.00
- Banking	52.70	19.09	71.79	28.21	100.00
- Insurance	61.37	23.14	84.51	15.49	100.00
- Real estate	50.85	19.18	70.03	29.97	100.00
- Business service	12.14	8.81	20.95	79.05	100.00
- Public administration	7.07	83.98	91.04	8.96	100.00
- Education	48.79	35.39	84.19	15.81	100.00
- Health care and medical	21.48	15.58	37.05	62.95	100.00
- Nonprofit organizations	42.14	30.57	72.71	27.29	100.00
- Recreation	22.09	16.02	38.11	61.89	100.00
- Repairs	18.53	13.44	31.97	68.03	100.00
- Personel service	44.80	32.49	77.29	22.71	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-11: Structure of trade by output

	Export (%)	Import (%)	Net export (฿ billion)	Export / Output (%)	Import /Final demand (%)
Agricultural	**7.90**	**2.43**	**166.56**	**25.43**	**7.39**
- Paddy	0.00	0.00	0.00	0.00	0.00
- Other crops	0.84	0.28	17.44	52.17	22.22
- Vegetable and fruits	0.45	0.27	6.75	4.47	2.26
- Livestock	0.21	0.13	3.23	4.40	1.99
- Fishing	3.28	0.04	88.41	38.06	0.62
- Forest	0.06	0.49	-8.17	29.47	71.55
- Other agricultural	3.06	1.22	58.90	52.80	25.08
Manufacturing	**72.58**	**81.56**	**344.00**	**30.54**	**27.31**
- Coal and lignite	0.00004	0.08	-1.56	0.01	14.04
- Crude petroleum	0.14	5.19	-100.22	4.40	55.80
- Other mining	0.17	0.37	-2.69	17.03	25.06
- Rice and flour	3.86	0.07	103.62	31.26	0.79
- Meat	0.01	0.22	-4.27	0.18	3.97
- Canned food	3.45	1.52	63.55	38.66	17.02
- Other food	2.80	1.04	55.41	41.87	17.51
- Other agricultural products	0.16	0.65	-8.76	1.90	6.14
- Beverage	0.29	0.48	-1.60	4.05	5.85
- Tobacco	0.12	0.20	-0.88	4.99	6.91
- Textile	4.70	2.27	82.59	40.89	20.16
- Apparel	5.18	0.62	128.76	24.88	3.25
- Leather and footwear	4.07	0.69	97.11	80.65	34.86
- Wood products	0.58	0.80	-0.35	77.35	77.98
- Furniture	1.03	0.06	27.03	30.91	2.08
- Paper	0.83	1.23	-2.00	19.32	21.57
- Printing and publishing	0.44	0.87	-5.56	33.47	43.33
- Basic chemical	1.95	4.52	-37.60	42.15	56.76
- Gasoline	0.26	0.01	7.01	7.48	0.19
- Diesel	0.29	0.15	4.98	6.96	2.79
- Aviation fuel	0.65	0.12	15.28	43.50	9.75
- Fuel oil	0.13	0.68	-9.98	3.65	12.99
- Non-metal products	1.08	0.61	17.27	21.11	10.57
- Basic metal	1.99	7.14	-88.60	62.76	82.02
- Fabric metal	1.83	4.31	-36.28	42.49	57.37
- Transport equipment	2.40	1.25	40.44	40.54	21.99
- Electricity	0.01	0.06	-1.03	0.15	0.76
- Gas distribution	0.39	0.12	8.22	35.90	11.46
- Water	0.001	0.002	-0.01	0.11	0.15
- Construction	0.02	0.00	0.41	0.08	0.00
- Other industries	33.73	46.20	-6.27	45.31	46.18
Transportation	**5.13**	**3.55**	**68.69**	**19.41**	**10.91**
Services	**14.38**	**12.46**	**142.15**	**12.97**	**8.79**
- Retail trade	5.51	0.00	150.12	16.37	0.00
- Restaurant	2.61	1.67	37.46	15.40	7.91
- Hotel	2.00	1.55	23.31	57.58	43.67
- Communication	0.40	0.76	-4.33	13.63	18.10
- Banking	0.07	0.13	-0.72	0.62	0.86
- Insurance	0.14	0.58	-7.79	8.44	22.04
- Real estate	0.99	0.90	8.88	14.67	10.32
- Business service	0.84	0.86	5.79	50.93	43.71
- Public administration	0.00	0.00	0.00	0.00	0.00
- Education	0.003	0.01	-0.03	0.04	0.05
- Health care and medical	0.70	3.35	-47.98	9.64	28.36
- Nonprofit organizations	0.0001	0.000	0.00	0.05	0.00
- Recreation	0.03	0.23	-3.80	1.15	6.00
- Repairs	0.001	0.002	-0.01	0.01	0.02
- Personel service	1.10	2.44	-18.74	82.95	88.77
Total	**100.00**	**100.00**	**721.41**	**24.24**	**19.52**

***Source:** Thailand 1998 Social Accounting Matrix*

Table C-12: Structure of demand by composite commodity (net of stock investment) (%)

	Consumption demand	Intermediate demand	Investment demand	Government demand	Total
Agricultural	**25.63**	**74.24**	**0.03**	**0.10**	**100.00**
- Paddy	0.00	99.95	0.00	0.05	100.00
- Other crops	46.76	51.25	0.00	2.00	100.00
- Vegetable and fruits	56.13	43.83	0.00	0.04	100.00
- Livestock	5.71	94.00	0.22	0.07	100.00
- Fishing	29.56	70.42	0.00	0.02	100.00
- Forest	18.68	81.32	0.00	0.00	100.00
- Other agricultural	4.83	94.79	0.00	0.38	100.00
Manufacturing	**19.58**	**65.46**	**14.51**	**0.45**	**100.00**
- Coal and lignite	0.00	100.00	0.00	0.00	100.00
- Crude petroleum	0.00	100.00	0.00	0.00	100.00
- Other mining	0.00	100.00	0.00	0.00	100.00
- Rice and flour	62.04	37.96	0.00	0.01	100.00
- Meat	91.88	8.10	0.00	0.02	100.00
- Canned food	11.30	88.70	0.00	0.00	100.00
- Other food	55.94	44.04	0.00	0.01	100.00
- Other agricultural products	10.79	89.20	0.00	0.00	100.00
- Beverage	97.33	2.67	0.00	0.00	100.00
- Tobacco	78.39	21.61	0.00	0.00	100.00
- Textile	21.46	78.08	0.46	0.00	100.00
- Apparel	67.39	32.47	0.00	0.14	100.00
- Leather and footwear	84.74	15.25	0.00	0.01	100.00
- Wood products	0.00	99.72	0.28	0.00	100.00
- Furniture	45.05	31.12	23.83	0.01	100.00
- Paper	0.00	96.90	0.00	3.10	100.00
- Printing and publishing	96.54	1.77	0.00	1.69	100.00
- Basic chemical	0.00	100.00	0.00	0.00	100.00
- Gasoline	9.45	90.55	0.00	0.00	100.00
- Diesel	1.80	98.20	0.00	0.00	100.00
- Aviation fuel	0.00	100.00	0.00	0.00	100.00
- Fuel oil	0.00	99.59	0.00	0.41	100.00
- Non-metal products	0.00	98.55	1.44	0.01	100.00
- Basic metal	0.00	99.70	0.30	0.00	100.00
- Fabric metal	0.00	87.67	11.87	0.46	100.00
- Transport equipment	28.54	18.78	49.40	3.28	100.00
- Electricity	8.96	88.31	0.00	2.73	100.00
- Gas distribution	19.67	78.45	0.00	1.88	100.00
- Water	53.34	40.98	0.00	5.68	100.00
- Construction	0.00	27.58	72.31	0.11	100.00
- Other industries	4.77	78.85	15.87	0.51	100.00
Transportation	**34.39**	**62.84**	**1.56**	**1.21**	**100.00**
Services	**28.40**	**53.12**	**2.38**	**16.09**	**100.00**
- Retail trade	2.32	88.35	8.66	0.67	100.00
- Restaurant	54.04	45.02	0.00	0.93	100.00
- Hotel	27.12	67.62	0.00	5.26	100.00
- Communication	71.17	15.64	0.00	13.19	100.00
- Banking	4.36	95.53	0.00	0.11	100.00
- Insurance	32.14	67.80	0.00	0.06	100.00
- Real estate	96.57	1.01	2.07	0.35	100.00
- Business service	3.57	94.16	0.00	2.27	100.00
- Public administration	0.00	4.43	0.00	95.57	100.00
- Education	7.40	10.68	0.00	81.92	100.00
- Health care and medical	66.20	10.90	0.00	22.90	100.00
- Nonprofit organizations	0.00	100.00	0.00	0.00	100.00
- Recreation	96.48	3.26	0.00	0.26	100.00
- Repairs	2.17	97.18	0.00	0.65	100.00
- Personel service	52.16	44.71	0.00	3.13	100.00

Source: *Thailand 1998 Social Accounting Matrix*

Table C-13: Structure of tax revenue (%)

	Taxes					Subsidy
	Direct	VAT	Special business	Excise	Tariff	
% of total tax revenue	**30.90**	**31.02**	**4.59**	**24.74**	**8.74**	**-**
% GDP	**4.73**	**4.75**	**0.70**	**3.79**	**1.34**	**-0.32**
Effective rate						
Agricultural	0.00	0.15	0.00	0.01	3.48	-0.10
- Paddy	0.00	0.00	0.00	0.00	0.00	0.00
- Other crops	0.00	0.00	0.00	0.00	9.11	0.00
- Vegetable and fruits	0.00	0.02	0.00	0.00	10.05	0.00
- Livestock	0.00	0.04	0.00	0.00	0.67	0.00
- Fishing	0.00	0.00	0.00	0.00	5.06	0.00
- Forest	0.00	5.05	0.00	0.07	0.95	0.00
- Other agricultural	0.00	0.10	0.00	0.00	1.98	-0.10
Manufacturing	0.00	2.31	0.00	2.90	3.46	-0.03
- Coal and lignite	0.00	1.51	0.00	0.00	0.61	0.00
- Crude petroleum	0.00	5.96	0.00	9.51	0.00	0.00
- Other mining	0.00	4.24	0.00	2.04	3.50	0.00
- Rice and flour	0.00	0.71	0.00	0.00	23.60	0.00
- Meat	0.00	0.42	0.00	0.00	0.34	0.00
- Canned food	0.00	0.47	0.00	0.00	0.71	0.00
- Other food	0.00	3.26	0.00	0.00	7.54	0.00
- Other agricultural products	0.00	0.48	0.00	0.00	10.62	0.00
- Beverage	0.00	2.61	0.00	26.75	22.42	0.00
- Tobacco	0.00	2.16	0.00	46.98	10.78	0.00
- Textile	0.00	2.14	0.00	0.01	2.81	0.00
- Apparel	0.00	0.39	0.00	0.00	15.56	0.00
- Leather and footwear	0.00	2.57	0.00	0.00	2.80	0.00
- Wood products	0.00	8.47	0.00	0.00	1.46	0.00
- Furniture	0.00	0.75	0.00	0.00	17.19	0.00
- Paper	0.00	2.71	0.00	0.00	5.47	0.00
- Printing and publishing	0.00	3.13	0.00	0.00	3.46	0.00
- Basic chemical	0.00	4.39	0.00	0.00	5.38	0.00
- Gasoline	0.00	1.53	0.00	25.63	0.61	0.00
- Diesel	0.00	2.60	0.00	28.79	1.02	0.00
- Aviation fuel	0.00	2.25	0.00	0.23	0.63	0.00
- Fuel oil	0.00	1.98	0.00	5.44	4.80	0.00
- Non-metal products	0.00	2.59	0.00	0.07	6.32	0.00
- Basic metal	0.00	5.81	0.00	0.00	2.91	0.00
- Fabric metal	0.00	3.78	0.00	0.00	5.53	0.00
- Transport equipment	0.00	4.31	0.00	5.50	8.17	0.00
- Electricity	0.00	3.20	0.00	0.00	0.00	0.00
- Gas distribution	0.00	0.28	0.00	10.38	0.24	-6.50
- Water	0.00	3.65	0.00	0.00	0.00	0.00
- Construction	0.00	1.80	0.00	0.00	0.00	0.00
- Other industries	0.00	2.21	0.00	0.07	2.90	0.00
Transportation	0.00	0.50	0.00	0.00	0.00	-0.27
Services	0.00	2.35	6.84	10.29	5.74	-0.66
- Retail trade	0.00	4.64	0.00	0.00	0.00	-0.78
- Restaurant	0.00	0.32	0.00	0.00	0.00	0.00
- Hotel	0.00	2.82	0.00	0.00	0.00	0.00
- Communication	0.00	0.25	0.00	0.00	0.00	0.00
- Banking	0.00	0.41	9.72	0.00	0.00	-0.09
- Insurance	0.00	0.16	0.00	0.00	0.00	0.00
- Real estate	0.00	0.33	2.24	0.00	0.00	-0.04
- Business service	0.00	6.60	0.00	0.00	0.00	0.00
- Public administration	0.00	0.02	0.00	0.00	0.00	0.00
- Education	0.00	0.02	0.00	0.00	0.00	-1.46
- Health care and medical	0.00	1.80	0.00	0.00	5.74	0.00
- Nonprofit organizations	0.00	0.04	0.00	0.00	0.00	0.00
- Repairs	0.00	0.74	0.00	0.00	0.00	0.00
- Personel service	0.00	9.01	0.00	0.00	0.00	0.00
Agricultural household	0.48	0.00	0.00	0.00	0.00	0.00
Nonagricultural household	3.95	0.00	0.00	0.00	0.00	0.00
Agricultural household	8.28	0.00	0.00	0.00	0.00	0.00
Private enterprise	12.63	0.00	0.00	0.00	0.00	0.00
State enterprise	0.00	0..00	0.00	0.00	0.00	0.00