# IMPACTS OF SUSTAINED LOW PETROLEUM PRICE ON THAILAND'S ECONOMY AND QUANTITY OF THE RELEASE OF $CO_2$ RESULTING FROM PETROLEUM CONSUMPTION FROM THE PERSPECTIVE OF FORECASTING COMPUTABLE GENERAL EQUILIBRIUM MODEL

**Chatsamee Chanitnan**

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**Chatsamee Chanitnan**

**The Graduate School of Environmental Development Administration**

---

Associate Professor.....Major Advisor

(Sompote Kunnoot, Ph.D.)

.....Co-Advisor

(Karika Kunta, Dr.sc. ETH Zurich)

The Examining Committee Approved This Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Environmental Management).

.....Committee Chairperson

(Krit Iemthanon, Ph.D.)

Associate Professor.....Committee

(Sompote Kunnoot, Ph.D.)

.....Committee

(Karika Kunta, Dr.sc. ETH Zurich)

Assistant Professor.....Dean

(Pakpong Pochanart, Ph.D.)

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# ABSTRACT


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| **Title of Dissertation** | Impacts of Sustained Low Petroleum Price on Thailand's Economy and Quantity of the Release of $CO_2$ Resulting from Petroleum Consumption from the Perspective of Forecasting Computable General Equilibrium Model |
| **Author** | Miss Chatsamee Chanitnan |
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The increase of world supply of shale gas and shale oil had sustained the low level of oil price at about 50% of the previous level for the extended period since 2014. There are opinions as found in the media of different perspectives suggesting both positive and negative sides of the economic effects.

This study designed a model of the economic change in 5 years by applied the forecasting computable general equilibrium, for the purpose of studying the impact of oil prices that had remained low since 2014 was estimated to be 50% in comparison with that of 2012. The estimation was conducted by comparing two cases of economic changes, consist of 1) the spontaneous economic change due to the net increase in capital factor, which was resulted from the capital accumulation caused by fixed investment of several branches of production. 2) the spontaneous economic change due to the net increase in capital factor, which was resulted from the capital accumulation caused by fixed investment of several branches of production combined with the 50% decrease in oil prices , the level that had had the visible impacts since 2014.

The purpose of this study is to report the findings about Thailand's economic impacts from the perspective of the forecasting computable general equilibrium model. The economic impacts were further used in assessing the release of $CO_2$ resulting from change in oil consumption. It was found that low oil price gave positive effects on the

real GDP of Thailand. The oil consumption has increased in greater percentage than the real GDP. From the perspective of economic analysis, this study concludes with an opinion that the generation of $CO_2$ which follows the growth of private income can be contained by the policy that turns the growth of private consumption into saving which is used for public infrastructural investment. The external effect can create opportunity for the investment of the private sector which expands the potential for future income generation.

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Chatsamee Chanitnan

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# TABLE OF CONTENTS

# LIST OF TABLES

**Tables** **Page**

# LIST OF FIGURES

**Figures** **Page**

# ABBREVIATIONS

| Abbreviations | Equivalence |
|---|---|
| CGE Model | Computable General Equilibrium Model |
| FCGE Model | Forecasting Computable General Equilibrium Model |
| GDP | Gross Domestic Products |
| OPEC | The Organization of the Petroleum Exporting Countries |

# CHAPTER 1

# INTRODUCTION

## 1.1 Statement and Significance of the Study Research Objectives

Starting in 2012, petroleum prices in the world market had continued to decline until it went 50% lower in 2014. This phenomenon arose from the increase in the supplies of natural shale oil and gas that extracted from shale rock. Consequently, the USA, the world's top oil consumer, reduced large import quantity of natural oil and gas. Based on the World Bank data, although the global gross domestic product (GDP) of current prices for the years 2015 to 2016 were -5.53% and -4.22% respectively, compared to 2014, as a result of cheap oil prices, it was found that the GDP of all countries in the world in 2011 had increased continuously with a growth rate of 3.31% in 2015 and 3.13% in the year 2016. These occurrences indicated the uplift of the living standard amidst the low oil prices context.

Figure 1.1 shows the movement of oil prices from 1960 to 2016, showing the volatility of oil prices at various timeframes. Oil prices reached a record peak in 2012 at 105.87 USD per barrel and dropped to 39.69 USD per barrel in 2016. This is the sharpest and rapid decline in oil prices since 1960. In the article "The Economics of Lower Oil Prices" by Moody's Analytics (Lafakis et al., 2015), it suggested that despite the decrease in oil prices, there would be the net gain in several countries such as Singapore, Taiwan, South Korea, China, the USA , and Japan, which resulted in the increase in real GDP. In another article such as "Who's afraid of cheap oil?" (The Economist, 2016) stated that the net gain hadn't been clearly noticed since this severe and acute fluctuation had affected the stock market, which might consequently lead to the lack of confidence among the consumers. In the past, the 1973 Arab Oil Embargo had resulted in the Great Depression (Amadeo, 2017). Later, another incident that gave the entirely different outcome was the decline of oil prices in 1986, which turned

to be the factor that fostered economic growth. The notice was that the 10% decrease of oil prices prone to increase by 0.1% to 0.5% of economic growth.

The International Energy Agency (IEA) had predicted that the shale oil would take up to 50% of the supply share (Thailand Investment Forum, 2015). According to the Economics of Shale Gas Development report by Resources for the Future (Mason et al., 2015), the production of oil and gases of the USA had increased rapidly from approximately 1 trillion cubic feet in 2006 to approximately 9.7 trillion cubic feet in 2012; the production was predicted to reach 19.8 trillion cubic feet in 2040. According to the report of US Energy Information Administration (2014), it suggested that in 2014, the shale gas would account for more than 40% of the US natural gas supply. This information corresponded with the article "Shale Revolution: Opportunity to Jump-Start Economic Growth" and the article in Forbes Magazine which proposed that shale energy was the phenomenon that gave rise to the USA rapid economic growth. Consequently, it was predicted that from 2007 to 2012, the high-paying jobs would reach 135,000 positions. Including the indirect results, it was expected that the positions would increase to a total of 1.7 million and this could widely stimulate other countries to invest in shale energy production.

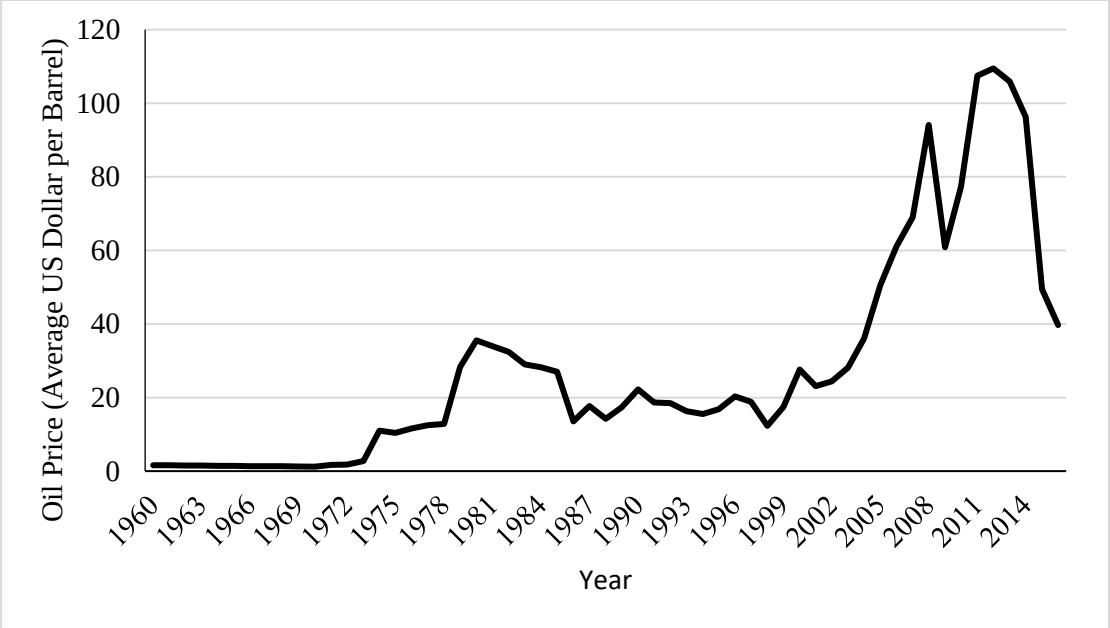


**Figure 1.1** Oil Prices (USD per barrel) from 1960 to 2016

**Source:** Adapted from Statista, 2016.

The global crude oil price has continuously fallen since the middle of 2014 due to the dynamics of supply and demand. It is well realized that the global economy has not expanded as significantly as predicted; especially in Europe, Japan, and China where the growth of the economy has witnessed disappointment, which consequently maintains a relatively mild demand for crude oil in the global market. On the contrary, the oil manufacturers remain their production to supply crude oil into the market, especially countries outside the OPEC (The Organization of the Petroleum Exporting Countries), such as the United States which has developed shale drilling. This further increases a number of crude oil circulated into the global market and becomes a factor lowering the oil price consecutively. The overall global market has gained profits from a decrease in the oil price, and in which the IMF has estimated that the oil price decline, mainly caused by the growing supply, would foster the global GDP to grow approximately 0.3-0.7%. As the top economies such as the United States, Europe, Japan, China, and India, which conquers 60 percent of the global economy, are all importers of pure crude oil. A decrease in the oil price brings about a large amount of money used for consumption; simultaneously, the business sector has lesser costs. In this case, the exporters of crude oil in the OPEC, which have lost some benefits, are not big-scale economies.

Thailand should be one of the nations which gain benefits from this matter, as Thailand is an importer of oil and fuel estimated as 10% of the GDP, which is higher than China and India; In other words, Thailand imports totaled 320 million barrels of crude oil in a year. Thailand has thus saved 5 million baht for the expenditure on crude oil import. From the perspective of energy consumers, this means the household and business sectors consumed a total of 29,000 million liters of benzene and diesel fuel in a year. This also helps the two sectors save 1.5 million baht per year. In this respect, EIC estimated that a decrease in oil price would catalyze Thailand’s GDP to grow 0.2 percentage point (pp) in 2015, and lessen inflation to 0.8 pp. The deceleration of inflation further exterminated impediments in facilitating policies to nurture the Bank of Thailand’s economy. It, nonetheless, should be noted that, in Thailand, both stakeholders gain and lose benefits from the fall in oil prices.

A condition to be monitored as the priority is the falling oil price which is prone to affect the import to Middle Eastern countries. This is rooted in the fact that the major revenues of most of these Middle Eastern countries are generated by the export of crude oil. The falling oil price hence inevitably affects the economies of these countries, and in which the imports from Thailand to these countries are likely affected; especially in the domain of automobile exports, the net automobile exports from Thailand to Saudi Arabia is ranked third in the overall automobile export. This indicates that the falling oil price is a factor championing the exports of Thailand to soar despite the fragile global economy.

The most concerning factor nevertheless remains the urban-rural divide among Thai households. As those gaining benefits from the fall in oil price are middle-incomers to high-incomers who reside in cities and use automobiles in a regular manner. Not only has this group of incomers consumed a high number of fuels and gasohol, but the decline in the benzene and gasohol prices is also more likely to occur than the decline in the benzene, which consequently helps this group save more expenditures than others. As city residents earn regular incomes, they are therefore not considerably affected by oil prices. Overall, this group of households gains benefits from the fall in oil prices at the maximum. On the other hand, those who lose benefits are in the agriculture sector residing in rural areas. This is due to the fall in crude oil prices in the global market, which affects commodity prices such as rubber, sugar cane, palm, and etc. Particularly, the current year has witnessed the lowest rubber price in 5 years, concurrently with the fall in synthesis rubber prices produced by petroleum products subject to the fall in crude oil prices. This condition, in consequence, rubber prices are unlikely to increase if prices of synthesis rubbers-which are replaceable products-remain low. There has been a decline in the demand for renewable energy like biodiesel, as global oil prices have greatly fallen. This condition affects sugar cane, cassava, palm oil prices which are all ethanol producers. This further affects the export values of Thai commodities estimated as 15% of the gross exports of Thailand, which are subject to prices in the global market. Apart from gaining benefits from having less expenditure on fuels than other groups of households due to the lack of regular automobile uses, agricultural households are more affected by lower incomes than other groups.

Moreover, the urban-rural divide takes place in the tourism industry as well. The crude oil prices heavily affect the Russian economy where the oil exports are mainly relied upon, and considerably lower than 50% of the Russian ruble. The Russian ruble's recent weakness conduces to the decreasing trend of Russian tourists traveling abroad, due to the soar of expenditure in foreign currencies. It is certain that this will affect the tourism industry in Thailand, as Russian tourists are ranked the third most important of all foreign tourists in Thailand. Specifically, in Pattaya and Phuket, there are 23% and 19% of Russian tourists respectively. In this manner, the impact is evident from a 20% decrease in the number of Russian tourists in Thailand at the end of 2014 (Tanakorn Limvittaradol, 2015).

At the end of 2015, the global oil prices substantially hit the fall, and at the beginning of 2016, it took a fall at 30 dollars per barrel. In this respect, the demand for oil consumption declined respectively from the decreasing expansion of the economy aligned with discoveries of renewable energy from petroleum which continue to cost less than previous forms of energy. A rapid decrease in oil prices consequently alters the structures of manufacturing and consumption between crude oil, natural gas, and coal. This being the case, the impact on coal prices is expected to be the most evident, followed by natural gas prices.

Countries obtaining benefits from the fall in oil prices are large countries which currently expands their economies to a great extent, and in which the trend of the economic expansion is likely to slowly decline. As importers of net energy, China and India fully obtain benefits from a fall in oil prices, followed by Japan, South Korea, Singapore, and in which this list might include Indonesia as well as Thailand. As the disadvantages are taken out of the agricultural export prices, the overall impact remains uncertain. South Asia and South East Asia might come to obtain benefits from this fall in oil prices, as it appropriately serves to decelerate the regional economies' weakness (Veerapong Ramangkul, 2016).

This research aims to study the actual economic growth in Thailand, which has been influenced by the oil prices that have fallen 50% since 2014. The computable general equilibrium model is used as a forecast method. Additionally, the economic forecast results are further used for an amount of carbon dioxide, which is influenced by economic changes. The findings of the two forms of study serve as

guidelines for economic development in the future, as well as guidelines for managing carbon dioxide emissions, which are main elements of greenhouse gasses that form causes of the global climate change.

## 1.2 Research Objectives

1) To study the impacts of oil prices fall on Thailand economy from the perspective of the prediction from the Forecasting Computable General Equilibrium Model (FCGE Model) over 5-year period from 2014 and 2019.

2) To evaluate the amount of carbon dioxide produced by the changes in petroleum demand.

3) To recommend the energy policies of the country.

## 1.3 Research Scope

1) The literary review on the movement of demand, supply, oil prices and the relationship between energy and economy.

2) Design the Forecasting Computable General Equilibrium Model (FCGE Model) to use as the tool for analyzing the impacts of oil prices fall on economic change.

3) Test the oil prices fall on the economic system.

4) Analyze the changes in oil demand and the amount of carbon dioxide.

## 1.4 Limitation of the Study

This study uses the FCGE Model because it has abilities to capture effects in all economics that occur around economic structure of the whole country, which allow to know the direction and size of the impacts of changes from applicable measures. Also, it is capable to process the net impacts that is measured by GDP growth. However, the use of the FCGE Model is limited only to a closed system within the country, which can not bring any changes of externality factors to calculate

together with this model, such as, when purchasing power of foreign countries decreased, we may export fewer products.

## 1.5 Research Expected Benefit

The study of oil price slump in 2014 on the Thai economy and environmental impacts by using a general equilibrium model of the domestic economy has expected advantages (Figure 1.2) as follows:

1) Know economic impacts from oil price change

2) Understand environmental impacts in the forms of the amount of carbon dioxide that is released from oil consumption

3) Offer appropriate alternative choice in designing oil price and marketing system and oil price structure changes

4) Provide insights regarding the effects of oil price slump in Thailand

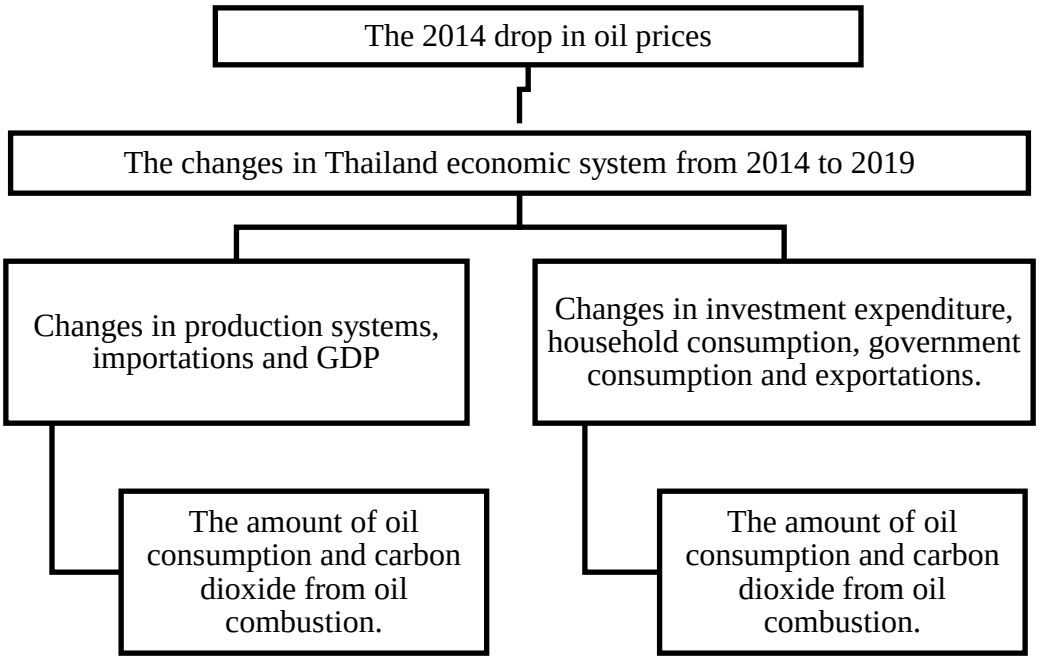


**Figure 1.2** The Analysis of Economic Impacts of the Changes in Oil Prices and Environmental Impacts

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Oil Price Slump in Thailand

Crude oil prices in the global market have declined at the end of 2014. In this respect, crude oil prices in Dubai, which are the main referential prices of Thailand, decreased from 105 dollars per barrel at the beginning of 2014 to 30 dollars per barrel at the beginning of 2016. This is regarded as the lowest price in the decade (figure 1.1). Consequently, retail prices of domestic oil decreased, and in which in 2015 oil consumption exponentially expanded by 13% for benzene and 4% for diesel, compared to the economic expansion in Thailand at 2.81%. To which extent is the expansion of oil consumption beneficial to Thailand's economy in a long-term and what is the government's role to foster the oil consumption in a more effective manner, and conduce to sustainable benefit to Thailand's economy (PIER, 2016).

The IMF estimated that a 10% change in oil prices would stir a 0.2% change in the global GDP. Typically, declining oil prices facilitate the rise of GDP, as consumers use the remaining money for other aspects of expenditure such as the aspect of consumption. This assumed impact is more evident if the declining oil prices are the result of growing supply. An example can be drawn from the case of shale gas in the United States where there was an increase of oil demand, which further caused energy prices in the United States to be lower than in Europe. As a result, the American industrial sector has grown 6% higher than in other countries. In the case of the fall in oil prices caused by low demand, the supplied degree is subject to an amount of oil production of each country, OPEC's oil production quota, and discoveries of oil sources (Peraphan, 2015).

Currently, Thailand produces only 15% of the national oil demand and has proven crude oil reserves of 3 years of production. Thailand, therefore, has to import the rest 85% of oil, which is estimated at 10% of the national GDP (Ramangkul, 2016). Apart from the fundamental dependency on a large number of oil imports, it was found that Thailand's oil consumption has not been efficient. This was reflected from the intensity of Thailand's relatively high oil consumption (or known as oil intensity), which is at 3.6 in 2015; this means Thailand had to consume 3.6 barrels of oil per day in order to generate 11 million of GDP annually. Thailand's oil intensity has been consistent for the past 5 years, which is considered to be higher than countries that are leading oil importers such as the United States and Japan, which have 1.1 and 1.0 of oil intensity respectively. The low efficiency of oil consumption is likely caused by 3 structural problems. First, Thailand's transportation systems mainly depend on road transport, which in turn causes a large amount of oil consumption in Thailand; while other countries mainly use rail transport, and have better transport systems. Second, Thailand's oil excise tax is considered as low in comparison with other oil importers. This condition might result in the lack of awareness of economical oil consumption among consumers. Third, oil that has been used for the product and services of products remains to have low values.

In addition, structural limitations result in Thailand's economy being sensitive to high oil prices, and in which they additionally affect the economy in 3 aspects. First, the impacts on inflation: this brings about an impact on inflation. As Thailand's oil excise tax is lower than other countries, retail oil prices are therefore considerably subject to global oil prices. Additionally, Thailand's inflation is more sensitive to global oil prices than other countries. Second, the impacts on the consumption and production of the private sector: the consumption by the private sector is considerably sensitive to oil prices. This is because the proportion of expenses on oil and transportation is high. In this regard, there are 2 factors causing the Thai manufacturing sector's sensitivity to oil prices. The first factor is high cost reflected by Thailand's oil intensity which is higher than other countries. The second factor is from the demand for Thai products. As the demand for Thai products is proportionally conditional on oil prices, such as automobiles and automobile parts, Raney and Vine (2011) discovered that, since 1967-2009, the automobile industry is the main medium

for the US market to transfer the fluctuation of oil prices to the overall domestic production. Third, the impacts on the environment and health: this is the consequence of pollution and $CO_2$ emissions, which further deteriorates the health. It is, in addition, a latent cost of oil consumption. The $CO_2$ emissions per capita of Thailand are prone to consistently grow in contrary to the global attempt to reduce $CO_2$ emissions under the Conference of the Parties or COP21.

The conclusion of the structural problems of Thailand's oil consumption should be urgently solved, as we all gain benefits from the period of the fall in oil prices inefficiently. This is considered to be a risk to Thailand's energy security. It is the time for Thailand to adjust itself under the concern to future generations. Oil prices should truly reflect the actual social capital, and create secure income sources for the government to invest in transportation systems and develop alternative energies. Eventually, consumers are the ones gaining benefits in the aspect of lower spending on energy, whereas the country becomes economical in energy spending from oil imports. (Pier Puey Ungphakorn Institute for Economic Research, 2016)

## 2.2 The Impact of Oil Price

The study of the Economics of Lower Oil Prices by Moody's Analytic, explores the dynamics between the economies of falling oil prices, by initially tracing back to the origins of this condition, including a large number of supply growth, shortcomings of the growth in global demand, the soaring value of the U.S. dollar, and the mild perception towards the unpredictability of the global domain of oil production. In terms of the correlations between oil and the overall economy in the context of falling oil prices, on the demand end, significant changes are found in disposable income in the consumption outside of the energy domain. On the supply end, overall business investment has been involved in the oil industry to a greater extent in the past decade that it is sensitively subject to oil price changes. In relation to inflation, it was found the top-notch consumer price index (CPI) is directly affected by oil price changes. On average, following 20% of oil price decline, oil-exporting countries' real GDP growth is likely to witness a 1% reduction (Lafakis et al., 2015)

In the case study of the oil prices impacts, which employed the FCGE Model, there was the Analysis of the Impact of Petroleum Prices on the State of Hawaii's Economy (Coffman et al., 2007). The 20-year prediction mentioned in this analysis suggested that the rise in oil prices had the negative impacts upon the State of Hawaii's economic system, in which the consumption potential decreased by 2.5% per year.

The oil price volatility poses a temporary negative impact on GDP growth and inflation (Salim and Rafiq, 2011). Moreover, the study of the effects of the oil price boom on the Czech economy from 2002-2007 by applied the CGE ( Computable General Equilibrium) model, suggested that 10% increase in oil prices had resulted in 1.5% of short-term decline in GDP and 0.8% in long-term (Dybczak et al., 2008).

In the study of the Impact of Falling Oil Prices on Canadian Economy, it was found that the 10% decrease in oil prices led to 1% decline of products and 0.9 % decrease of fringe benefits (Carbone and McKenzie, 2016).

According to the study of the general equilibrium costs and impacts of oil price shocks in Newfoundland and Labrador, the decrease in oil prices tended to be the negative factor that contributed to 2.1% decrease in the GDP of Newfoundland and Canada (Millard et al., 2017).

## 2.3 Related Research

African Development Bank (2007) published the article entitled the impact of high oil prices on African Economics, of which a "dynamic stochastic general equilibrium model" was constructed to determine the effect of the rise in oil prices on the African economies including oil manufacturing and importing nations. The result points out that, in the first initial year of the doubling of oil prices in the global market, there appears a 6% contraction of the median African oil importers. On the contrary, under the same circumstance, the GDP of the African oil exporters would increase by 4% and 9% under the influence of two monetary exchange regimes, namely the managed float regime and the fixed exchange rate respectively. In relation to the aspect of inflation, it was argued that, in the context of the median oil exporters, the managed float regime would contribute to a greater proportion of inflation than

the fixed exchange rate. It should nevertheless be noted that the model does not take into account the aspects of the impact of the rise in oil prices on poverty, which is a significant factor in the African region.

Akram and Mortazavi (2011) assesses the impact of the changes of crude oil prices in the regions of India, Pakistan, and Bangladesh in the course of 1981 to 2010, by using a multivariate Vector Autoregressive analysis along with the Wald Granger causality test, and Impulse Response Function (IRF). The result indicated that the rise in crude oil prices causes a negative effect on all three countries in the beginning. In the context of Pakistan, the impact, however, becomes positive after the first year. Even though India encounters a greater impact than other two nations, the conclusion suggests that the rise in crude oil prices poses an insignificant impact on the three economies. On the contrary, the drop in crude oil prices causes a significant effect on the Indian-Subcontinent region in the first year. The Wald Granger causality test results show that the oil price decline heavily affects the Indian economy. The impact becomes more moderate for India and Bangladesh after the first year, but rather positive for Pakistan. The impact on these countries is nevertheless smaller than developed countries like the United States and OECD countries.

Gomez et al. (2011) studied the impact of oil shocks on the Spanish Economy, by employs the Qu and Perron (2007) method to determine the evidence of the impact of the oil price shock on the GDP and inflation in the Spanish economy in the course of 1970s to 2008. Based on the same timeline, the Bai and Perron method was used to investigate at the regional level, specifically concentrate on industrial ventures and relevant consequences. The results revealed that, after the period of the 1970s, it was documented that the impact of the macroeconomic volatility in Spain lessens. Starting from 2000, in the Spanish region, the impact of the oil price shocks on the domains of production and inflation shrank steadily. Moreover, it was revealed that the impact of the oil price shocks on inflation in the region always appears to be positive. The only difference between the inflation in the 1970s and the inflation in later decades is the degrees of the impact, which appears to be less severe in later years.

Spence (2016) entitled crude reckoning, what will oil price slump mean for the global economy, economics correspondent, Telegraph offers a perspective on the impact of the oil price decline in the context of the developed nations. Several

analysts have claimed that there is a possibility of the further plunge in crude oil prices, and in which Dansk Bank deemed this condition as a risk to the US economy, due to its following impact on the oil division. It was recorded that the oil price declines caused a drop in the GDP by 0.4%. The Danish bank's analysts forecast that the decline could possibly drag the US GDP down again in 2016. According to Bank of America, as a decline in oil prices has brought about a significant decrease in investments, there was consequently a higher number of bankruptcies in the second half of 2015 than a number recorded in the previous financial crisis. As for the European continent, the German bank was of the opinion that this oil price slump held a promising future for the European economies. In this case, the oil sell-off would contribute to the development of the European economies in 2016, and the lower oil prices would better the currency regime.

Yeroen et al. (2015) present an overview of direct and indirect impacts of the fall in oil prices. In general, direct impacts point to oil exporters such as Russia, Venezuela, and Malaysia whose national revenues are proportionally determined by oil prices; they suffer from following consequences such as a reduction in national budgets, a higher number of deficits, and the fluctuations of the monetary exchange regime. For Russia, its economy has heavily depended on oil and gas, it is thus expected that its GDP to decline by 3-5% along with a high degree of inflation. The decrease in Ruble and the national demand for oil imports also play a part in hurting the Russian economy, concurrently worsen by the Sanction from the EU. As for the major oil exporter like Nigeria where 90% of the revenues are generated by oil exports, its great dependency on oil exports result in a heterogenic economy and further worsen its existing poor economic conditions. Consequently, the Central Bank of Nigeria responded by putting some segments of its reserves on hold and accepting exchange rates that are more flexible than its Naira currency. There are importers who allegedly gain benefits from this oil price decline, such as China and India. China, as the world's biggest oil importing nation, exploits the decline to establish the Strategic Petroleum Reserve. In addition, due to the oil price drop, the World Bank forecasted that 0.1-0.2 of the Chinese GDP will climb up, and in which the current account surplus is, in consequence, widen by 0.4-0.7 of the GDP level. India, on the other hand, as a newcomer in the oil industry, has managed to gain 0.64 billion U.S. dollars

in each oil price drop, as 30% of the nation's total imports is energy. In terms of indirect impacts, the growth markets in the regions of governments, businesses, and consumers are affected simultaneously. For the governmental sector, with fewer expenditures on oil imports, rooms for other development endeavors that require more budgets are therefore wider. As for the business sector, specifically oil and commodity-oriented businesses, it is evident that they benefit from reductions in production costs. Finally, the markets which rely upon proportions of "oil-fuelled generators" appear to clearly benefit from the oil price decline.

Vrontisi et al. (2015) discuss the possibility of economic impacts on the EU28 economies following the oil price slump since mid-2014. By using a comparative static analysis accompanied with scenarios in comparison with the baseline in 2015, the results revealed that having the consumption and investment in the private domain as a catalyst, the average GDP of the EU28 nations is expected to increase by 0.7% from a reduction in the oil price from 100 U.S. dollars to 50 U.S. dollars. In this regard, oil-oriented nations and ventures are likely to benefit from this condition more than others. Additionally, there is a possibility that 3 million jobs might be generated by a 50% reduction of the oil price.

Mohaddes and Pesaren (2017) use a quarterly multi-country econometric model to confirm an assumption that the recent 2016 fall in oil prices is proved to be beneficial to the United States and the global markets. In this manner, it was found that the oil price decline results in a lower degree of interests and inflation, and a higher level of global real equity prices. Despite taking a course of 4 quarters after the decline, it was reported that the actual production was positively affected. By investigating the impact of the oil price plunge on the US economy across several sub-periods in a form of monthly observations on real oil prices, real equity prices, and real dividends; it was discovered that the interplay between oil prices and equity prices since the financial crisis in 2008 had been positively unsecured from 1946-2016. On the other hand, an allegedly better substitute for economic ventures in comparison to equity prices was proposed to be a negatively secured interplay between oil prices and real dividends. In the perspective of the supply sector, the effects vary from one oil producer to another; it is a combination of the reduction in the US production and the rise in the OPEC production. In this case, the effects might

be contrary from the expected result, due to the fact that a proportion of major oil manufacturers make an effort to counteract this dilemma by increasing the production. This indicates that oil markets are brought into equilibrium in a rather slow manner. In this respect, it is possible that oil prices are to be in discursive fluctuation, and in which the highest level of the shale oil marginal cost is at approximately 60 U.S. dollars of per barrel.

González and Nabiyev (2009) examine the consequences of the crude oil price fluctuations on the GDP growth in the context of the United States and Sweden, by using the Mork & Olsen model (1994) extended to be viable in the course of 1993 towards the third quarter of 2008. The bivariate conclusion reveals that there is no evidence of negative relationships between the Swedish GDP growth and oil price rises. On the contrary, oil prices rise appear to be more influential to the US GDP growth. Regarding this, it should be noted that both United States and Sweden have shown a considerable reduction of oil consumption in the last decade. For Sweden, the result shows that the GDP growth depends less on oil prices, and in which a negative correlation between crude oil price declines and GDP growth is found. On the other side of the spectrum, the United States witnesses a negative impact following the rise in oil prices, and vice versa following the fall in oil prices. Whereas the revenues generated in the stock market of the United States, the United Kingdom, and France suffer from the soaring oil prices, major energy exporters such as Canada and Australia witness positive impacts.

Magnani (2016) discusses the impacts of falling oil prices that the shock of commodity prices since 2011 poses as an instability for global economies. Manufactures of oil, gas, and raw materials encounter economic difficulties. The immediate impact is the fall in consumption and investments in emerging countries such as Venezuela, Russia, Brazil, and South Africa. On the other end, the industrialized countries are negatively struck by a crowding out effect on some sectors such as i.e. the green economy and the agricultural sector. Since 2014, US oil prices have been dragged down from 110 dollars per barrel to 40 dollars per barrel. This price fall is the cause of lower competitiveness in oil shale extractions; simultaneously, relevant ventures such as the development of raw materials and new technologies are put on hold, which consequently affects American and European

companies negatively. Deemed as the current concern of the Fed and the ECB, deflation is a result of the expectation from households and corporates on the fall in commodity prices that triggers them to slow down consumption and investment. Another significant concern is the financial instability which is likely to affect emerging economies and hence the following international ramifications. Additionally, there are the social and political aspects that could be triggered by the fall in oil prices. The Arab Spring, for instance, was stirred by frail social and political coherence triggered by decreasing revenues. In war-zone nations such as Nigeria, Algeria, and some parts of the Middle East, this falling revenues may devastate the governments' attempt to battle against terrorism. The last aspect is concerned with the market volatility at the global level in a manner that the industrialized nations still encounter the financial recession that is implicated in a slow pace of the economic growth. In this respect, rather than posing as economic opportunities, the slump in commodity prices present itself in a form of a risky and uncertain entity.

Alazraque et al. (2016) attempt to arrive at the conclusion on the possibility of the Chinese renewable energy sector being affected by the reduction in oil import expenses. It is nevertheless more difficult to predict the future of the renewable energy sector, by using a quantitative model, the article offers a comparison between oil demand and prices in the course of recent years with the effect on investments in the sphere of renewable energy, under the premise that the major competitor is coal. In a short-term manner, it is likely that the plunge in oil prices since 2014 would better China's supply security and economy. If this condition were to last in a long-term, it might cause a drop in investments in the sector of domestic oil and gas. This potentially brings about a halt in domestic production. Over an extended period, it is in turn likely that there will be a rise in China's dependency on oil imports, and subsequently a negative impact on energy security and implementations on renewable energy. In this regard, the findings point to a promising reciprocity between oil prices and the investments in wind and solar energy, albeit a possibility of this being moderated by high price volatility. It should be added that impact of oil prices on the aspect of renewable energy is subject to the falling period that contributes to the level of impacts, and on the renewable energy development course. Although it is possible that oil prices may distort the renewable energy development in a short run; in a short

run, investments for such development involve political schemes, which could lessen turmoil caused by low oil prices.

Naim (2015) had studied traces back to 1973-1974 which is the origin of the emergence of modern economic powers, such as those in the Middle East and North America, with the help of oil price shift from 3 U.S. dollars per barrel to 12 U.S. dollars per barrel. Oil importers such as the United States, Japan, and European countries, on the other end, were struck with a severe backlash. Currently, the oil price rise since 2014 is predicted to cause as much turmoil as the 1974 oil price. In Russia, the reduction in oil and gas revenues and economic sanctions conduce to economic suffering. Venezuela-that has been economically affected when the oil price reaches 120 U.S. dollars-is currently in shatters upon the decline in oil prices. On the global outlook, Goldman Sachs predicted that one trillion-US dollar investment could be faced with the risky financial prospect. In a short-term, energy companies are prone to be negatively affected. In a long-term, the global economy might witness a lower number of oil production and higher values of oil. The impact is nevertheless positive in countries such as Malaysia, Indonesia, and India that make use of this opportunity to lessen or demolish fuel subsidies. Lower oil prices could also lead to less production of environmentally harmful oil as well as renewable energy. Moreover, oil price declines can also remodel the financial market structure by devaluing marketable reserves like oil supply to be “stranded asset”, which in turn results in new transformations of the fuel industry.

According to the Associated Press in New York (2016) investigate the crude oil price decreased by 28% since 2015, which further dragged the US index down by 9%. In this case, analysts roughly calculated that all Standard & Poor companies’ profits would drop to 5.8% in 2015. It was additionally estimated that the major 20 company shares in the Standard & Poor’s 500 index would be lost; of which, 13 companies are in the energy domain. This also propels investors to sell their company shares that are associated with the oil industry. In this respect, Julian Jessop, head of commodities research with London-based researchers Capital Economics, expressed that lower oil prices are expected to be positive, or neutral in the worst-case scenario, in a long-term, due to the fact that the oil price decline simply transfers benefits from oil manufacturers to consumers. On the other end, Bruce Kasman, chief economist at

JPMorgan Chase, is of the opinion that falling oil prices rather represent a foreshadowing of the weak global economy, as experienced in the history. Kasman further suggested figures for consumption expenditures in the United States, Europe, and Japan are certainly lower than expected. In the United States, the growth of consumption expenditures is merely at 1.5% in the last three months of 2015. The impact is evident in the energy market in which it was revealed that, according to Dealogic, there is 500 billion dollar worth of outstanding debt circulated in the oil and gas industry. Additionally, the Federal Reserve reported that 11 trillion dollar worth of outstanding residential mortgage debt was found. This, in consequence, conduces to the rise of bankruptcies in oil and gas companies, and the "junk bonds" being affected by these companies' defaults. Big corporates such as JPMorgan Chase, Wells Fargo, Citigroup, and Bank of America were all inevitably affected by the reduction in their values of energy loans, and forced to compensate for financial loses.

Creti et al. (2013) examine the level of cross-cutting dependency between the index of oil prices and the stock market in the context of oil importing nations and oil exporting nations, by using Priestley and Tong (1973)'s evolutionary co-spectral analysis. The data was provided with monthly stock and oil prices from oil importing nations, namely the United States, Italy, Germany, Netherland, and France, and oil exporting nations, namely Emirate Arab Units, Kuwait Saudi Arabia, and Venezuela, in the course of 03 September 2000 to 03 December 2010. The analysis suggests that there is a higher of interdependence between oil prices and the stock market in the markets of oil importers and exporters. Regarding this, oil prices generated by demand shocks aligned with stock prices, especially in the context of exporters, whereas homogeneous interdependence patterns are found in both exporters and importers. Additionally, higher coherence generated by supply shocks can only be found in oil exporting nations. In the aspect of diversification potential, oil thus tends to counteract volatilities in the economic cycle in accordance with stock markets. On the contrary, if the demand is the cause of the shock, it is likely that oil prices and the stock market are aligned with each other both in the context of importing and exporting nations, under the premise that there is a variety of the strength that demands on the shock source. In such prospect, oil plays no part in neutralizing changing returns of stocks in any of the countries.

Global Network Faculty (2015) gathering opinions from experts across the Global Network for Advanced Management upon the impact of oil price fluctuations on their respective economies. In Brazil, Julia Von Maltzan Pacheco, professor and associate dean for international relations, FGA Escola De Administracao De Empresas De Sao Paulo, used Petrobras, the largest debt-bound oil company in the world, as an example for the issue of oil price influence. Petrobras, currently under revision of its investment strategy following the oil price decline, is likely going to cause a harmful ripple effect to Brazil's future oil production and hence the global production in 10 to 15 years, as well as the growth in industries and the construction sector, which are both associated with the oil production in Brazil. On the other end, the oil price fall is advantageous to the Brazilian government which can now reduce its subsidies, as companies are now able to compensate for their capital loses. For China, Lihong Yang, assistant professor of economics, Department of Trade & Economics, School of Business, Renmin University of China, articulated that China has been experiencing the economic growth at a sluggish pace. The drop in oil prices could play a significant role in strengthening the Chinese economic growth, especially in investments in the industrial domain. As the Chinese import is reliant on oil reservoirs, the drop in oil prices means a greater amount of savings from foreign exchange. On the outlook, not only low oil prices will benefit the business sector, lower inflation will raise public consumption as well. For Germany, Jens Weinmann, program director, suggested that low oil prices result in a greater number of car purchases, the German economy is therefore likely to gain significant revenues following this. In an extended period of time, oil prices will play less role in determining the German wealth, due to new innovative combustion-engine cars; German car producers are nevertheless braced for this emerging market. For Mexico, Dr. Alejandro Ibarra Yunez, professor of economics and public policy, EGADE Business School, Technologico de Monterrey, perceived that the reduction in Pemex's oil production worsens the circumstance. The Mexican economy is likely to be negatively affected by the drop in oil prices, as 30% of Mexican public finances is reliant on oil revenues. In addition, the reduction in federal subsidies and payment delays to federal suppliers result in a lower number of public contracts. The government nonetheless approved the Energy Reform in hope to strengthen the

Mexican economy in the wake of oil price falling. In the case of Nigeria, Doyin Salami, economist, and professor, Lagos Bus

Pan-Atlantic University, the oil price change has lowered the Nigerian account balance to 69.3%, from 3.14 trillion nairas in 2013 to 964.6 billion nairas in 2014. Following the oil price decline, its currency was also devalued twice in the course of one year. Oil revenues, as the major source of the federal revenue and the foreign reserve, also witnessed steep declines. For Canada, Werner Antweiler, associate professor, Sauder School of Business, University of British Columbia, expressed that there are different factors determining the oil price, including operating gasoline refineries and inventories in different regions of the country, as well as local demand and supply. In the context of Canada, the impact of the changing oil price, therefore, tends to vary.

Bell (2016) vice president of recycling operations for Waste Management, offered an insight into the impact of low oil prices on the domain of recycling industry that plastic resin prices are subject to oil prices. Due to the decline in oil prices, manufacturers purchase cheaper virgin plastic instead of recycled plastic. As oil prices play a part in strengthening the US economy and its currency, the prices of waste paper and metal in the United States have in turn been raised higher than those of other parts of the world. The declining oil prices additionally contribute to the decreasing trend in oil exploration and energy infrastructures, which further results in less demand for recycled scrap metal. All in all, this reality is not an indication of a promising future for the US recycling market.

Klevnäs et al. (2015) discuss the impact of low oil prices in different dimensions, based on the publication entitled Better Growth, Better Climate: The New Climate Economy Report by the Global Commission on the Economy and Climate. In general, the drop in oil prices catalyzes economic betterment for consumers in the short run. As the world currently consumes 90 million barrels of oil on a daily basis, it is likely that declining oil prices will stimulate the global economy in different degrees of effects. The overall impact at the global level is nevertheless positive, under oil producers' loses. According to the International Monetary Fund (IMF), there is an indication that, in the case of oil prices remaining low, the global GDP is likely to be 0.3-0.7% higher in 2015 and 0.2-0.8% higher in 2016. As the oil

price is accounted for 5% of the global GDP, the volatility of energy price, which causes a 50% change within a course of a few months, is, therefore, thought be a major concern for the global economy in the energy sector. On the contrary, declining oil prices bring about reform opportunities. Across the globe, there is a momentum of energy price improvement, and in which there are 27 countries on the progress to reform energy subsidies, and, currently, there are 26 countries scheduled to introduce a carbon price. In this respect, this is expected to be an opportunity to diminish short-term resistance and transition costs, caused by these implementations. In terms of investments in renewable energy in the domain of electricity production, the drop in renewable energy prices makes it an appealing alternative, and in which the dependency on fossil fuels is prone to be lessened. In a longer course, the low-carbon policy could play a part in maintaining the lower levels of fossil fuel prices, which is predicted to be reduced by approximately 30-50%. Additionally, it is likely that an opportunity to prevent future asset stranding and commitment to the utilization of fossil fuel could simultaneously come out of this.

# CHAPTER 3

# METHODOLOGY

## 3.1 Research Conceptual Framework

In this study, a computable general equilibrium model is used to investigate economic impacts of a hypothetical situation where the price of Thai petrol fuel is a Computable General Equilibrium projection of economic impact and $CO_2$ emission potential in Thailand following oil price slump in 2014. The investigation is extended to discover environmental impacts that couple with economic impacts. Economic growth is the primary expectation of better economic efficiency. Scope for the measurement of environmental impacts is particularly limited to $CO_2$ emission which coupled with fuel consumption across economic sectors. Regarding general equilibrium, the magnitude of environmental impacts is not necessarily proportional to economic impacts. Many factors influence the unequal distribution of economic and environmental impacts across economic sectors. Net general equilibrium effects can produce higher economic impacts than environmental impacts. Also, it is possible for net general equilibrium effects to produce more significant environmental impacts than economic impacts. These two possibilities are the subject for investigation. Knowledge gained from a computable general equilibrium analysis contributes to appropriate policy formulation. The contribution is shown in Figure 3.1.

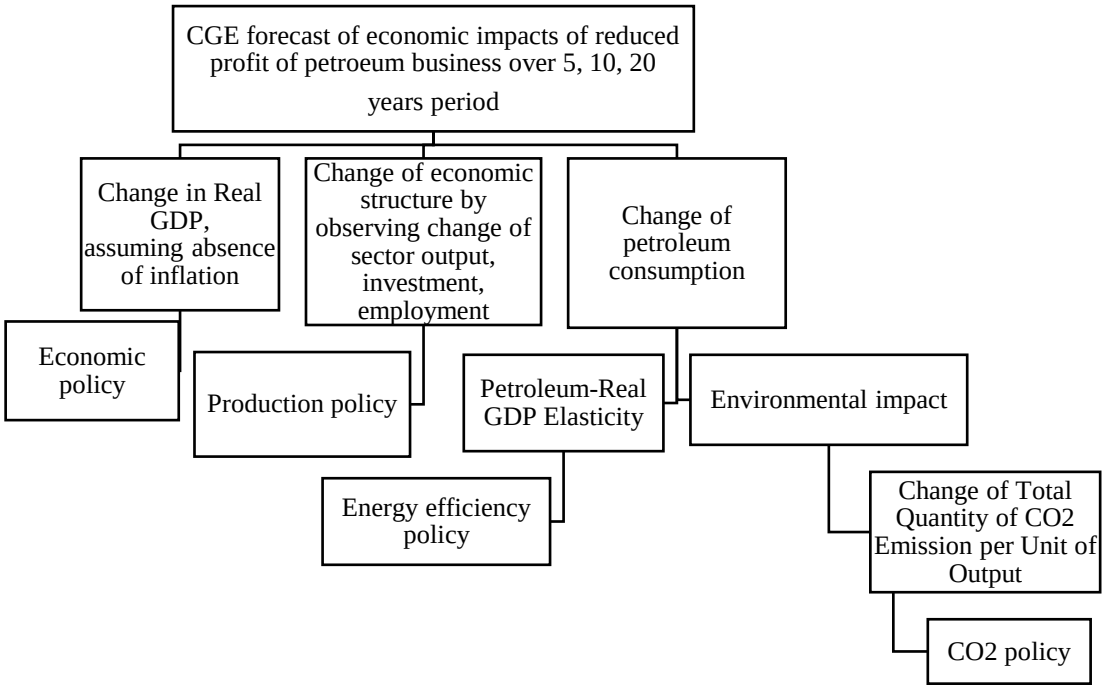


**Figure 3.1** Study Contribution

To assess the economic impacts of the hypothetical shift in oil price slump in 2014, industry, household consumption, government, export-import and 180 of production sectors in Thailand. This study uses the computable general equilibrium (CGE) model to discover the change in the economic system impacted from oil price slump 2014 in Thailand. The environmental impact associated with economic changes is discovered concerning the amount of carbon dioxide released from oil uses at both aggregate and sector levels. The CGE model is specified based on ORANI-F approach (Horridge et al., 1993) which offers the convenience in using Thailand's input-output table as the primary database for the model.

The CGE model offers the possibility of applying economic theories to form the relationship between all parties within the economic system as shown in Figure 3.2. A general equilibrium system computes all changes within the economic system into net change. This approach offers a convenience in impacts assessment for oil price slump in 2014.

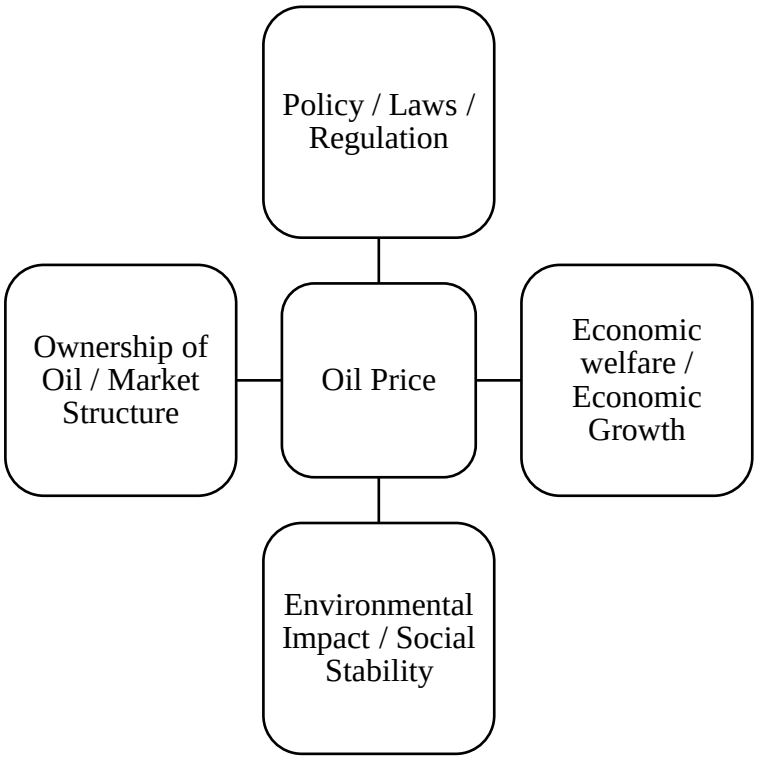


**Figure 3.2** Research Conceptual Framework

In this study, a CGE model is used to expose economic changes triggered by oil policy shift as depicted in Figure 3.3. Environmental changes can be studied by coupling environmental variables to economic changes. Study of environmental changes is scoped within changes in $CO_2$ emission produced by the change in oil use. Aggregate economic changes will be observed regarding real GDP. Micro picture of economic changes can be observed concerning change in the output of goods and services, which is organized into 180 sectors based on Thai input-output table.

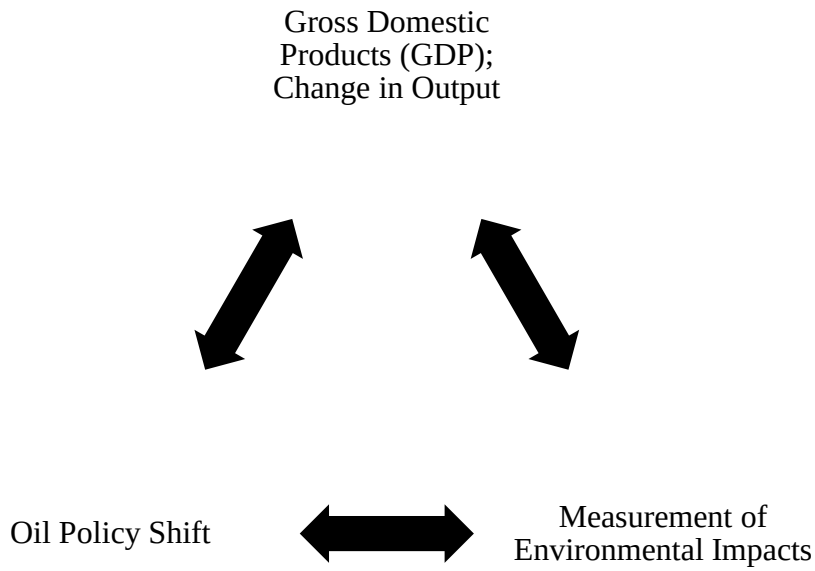


**Figure 3.3** Algorithm of Research

Environmental impacts which couple with economic changes are not necessarily proportionate with economic changes. Several underlying factors explain the unequal change. First, oil intensity differs for different goods and services. Second, growth rate differs for different goods and services which is attributable to different types of constraints, including demand and supply sides. Thus, both economic and environmental impacts of oil policy shift are unknown until a general equilibrium results are produced.

## 3.2 Underlying Principle

This research aims to study the growth of the real economy of the country. This is influenced by falling oil prices by 50 percent from 2014, using the Computable General Equilibrium Model as a tool for forecasting. Using the results to assess the economic forecast for the amount of carbon dioxide that is attributable to changes in the economy. The study is the knowledge on both sides to find ways to develop the economy in the future and guidelines for controlling the amount of carbon

dioxide, the main component of greenhouse gases, which is a factor of change in the global climate and associated environmental impacts of hypothetical oil price restructuring. One is the standard 5 year-projection in the absence of hypothetical oil price slump. The other is the 5 year-projection with the presence of hypothetical oil slump. The forecasting CGE model is input with the reduced capital price to represent hypothetical oil price slump in 2014.

## 3.3 Data and Arrangement for Input-Output Table for CGE Model

Since, Thailand's Input-Output Table did not have the capital goods prod matrix, the researcher, then, set the following matrix up based on the data from Thailand's Input-Output Table as shown in Figure 3.4

The process of generating the investment expenditure matrix from the data in the input-output table as shown in figure 6 are as followed:

Calculate the weight of capital goods output ($z1_j$) from the depreciation ($D_j$) in the input-output table $H_j = \frac{D_j}{\sum_{j=1}^{180} D_j}$

Calculate the total investment expenditure (C1) $c1 = \sum_{i=1}^{180} x1_{i1} + \sum_{i=1}^{180} x1_{i2}$

Calculate the weight of capital goods output (z1) $z1_j = H_j \cdot c1$

Calculate the weight of domestic products that were used as the factors in capital goods production from input-output table $S_{i1} = \frac{\sum_{i=1}^{180} x1_{i1}}{c1} z1j$

Calculate the weight of imported goods that were used as the factors in capital goods production from input-output table $S_{i2} = \frac{\sum_{i=1}^{180} x1_{i2}}{c1}$

Calculate the number of domestic products demand used as the factors of capital goods production $x1_{ij1} = S_{i1} \cdot z1_j$

Calculate the number of imported goods demand used as the factors of capital goods production $x1_{ij2} = S_{i2} \cdot z1_j$ resulted in 180 x 180 matrix of $x1_{ij1}$ and 180 x 180 matrix of $x1_{ij2}$

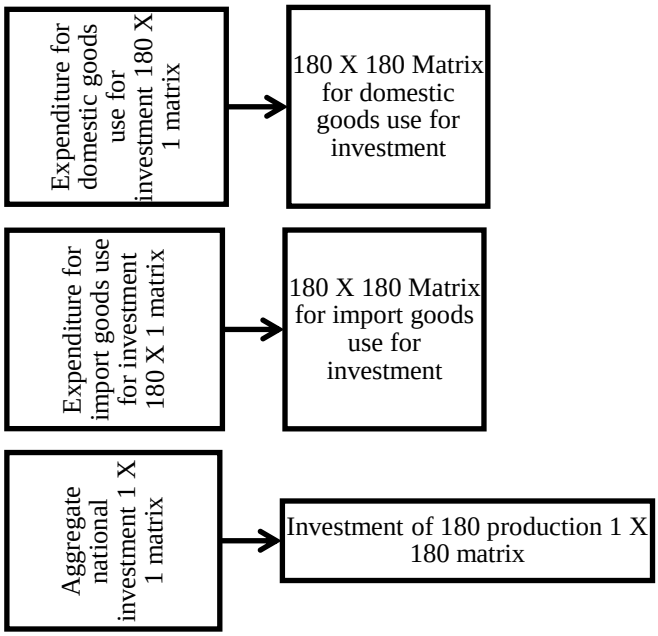


**Figure 3.4** Modification of Input-Output Investment Cost Data Table for CGE

The reconfiguration of Thailand's input-output table is shown in Figure 3.5. The 2010 edition of Thailand's input-output table is available on the website by the Office of National Economic and Social Development Board (NESDB). The sector classification of Thailand's input-output table is shown in Appendix A.

Figure 3.5 displays a matrix configuration of variables named for the CGE model. Domestic intermediate input is denoted by $x0_{i,j,1}$ whereas import intermediate input is denoted by $x0_{i,j,2}$. Labor input, capital input, and indirect taxes are denoted by $x01_j$, $x02_j$, and $x03_j$ respectively. Investment expenditure for domestic goods and import goods is denoted by 180 X 180 matrix $x1_{i,j,1}$ and $x1_{i,j,2}$ respectively. Household consumption for domestic goods and import goods is denoted by 180 X 1 matrix $x2_{i,1}$ and $x2_{i,2}$ respectively. Government consumption for domestic goods and import goods is denoted by 180 X 1 matrix $x3_{i,1}$ and $x3_{i,2}$ respectively. Export of 180 goods is denoted by matrix $x4_i$. Inventory of 180 goods and services is denoted by 180 X 1 matrix $x5_{i,1}$ and $x5_{i,2}$ respectively. Special export of 180 goods is denoted by matrix $x6_i$.

Value-added originated by wage, profit, and indirect taxes sum to $va1$, $va2$, $va3$, which sums to $gdpi$, representing gross domestic products computed from income.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Domestic | $x0_{ij1}$ | $x1_{ij1}$ | $x2_{i1}$ | $x3_{i1}$ | $x4_i$ | $x5_{i1}$ | $x6_i$ | $z01_i$ |
| Import | $x0_{ij2}$ | $x1_{ij2}$ | $x2_{i2}$ | $x3_{i2}$ | | $x5_{i2}$ | | $z02_i$ |
| | $x01_j$ | | | | | | | va1 |
| | $x02_j$ | | | | | | | va2 |
| | $x03_j$ | | | | | | | va3 |
| | $z01_j$ | | | | | | | GDPI |

**Figure 3.5** Arrangement of Input-Output Table of Thailand's Economic System for Forecasting computable general equilibrium model

Thailand'180 sectors input-output table is released at the interval of five years by the Office of National Economic and Social Development Board (NESDB). The 2010 edition of Thailand's input-output table was used in this study.

The input-output table consists of 1) Intermediate demand for domestically produced goods 2) Intermediate demand for imported goods 3) Value added of good production consisting of 4 part as (including 3.1) wage, 3.2) profit, 3.3) depreciation, and Indirect taxes) 4) gross domestic product 5) Household consumption of domestic and imported goods and services 6) investment expenditure on domestic and imported goods 7) government expenditure on domestic and imported goods and 8) export of goods and services.

## 3.4 CGE Model Specification

The analysis of economic changes by using the Forecasting Computable General Equilibrium Model (FCGE Model) helped to foster the comprehension of the connections between several markets in economic system by contemplating both positive and negative impacts as the net effect. This concept was useful in providing information about the advantages and business cost, which played a significant role in the policy design that would later benefit the economic system and public.

The FCGE Model in this study had 180 manufacturing branches to correspond to the number of branches in the Input-Output Table of Thailand, which was classified into 41 branches of agricultural and primary products, 93 branches of industrial products and 46 branches of services.

The forecasting CGE system consists of system variables described in Table 3.1, equation system in Table 3.2, the partition of structural exogenous variables in Table 3.3, and the formula for the computation of parameters, shares, and data values in Table 3.4. The forecasting CGE model consists of 135,208 variables and 133,946 equations which leave 1,262 variables available for exogenous.

The simulation of 5-year-period economic change from 2014 to 2019 could be divided out into 2 comparable cases 1) the spontaneous economic change due to the net increase in capital factor, which was resulted from the capital accumulation caused by the fixed investment of several branches of production. 2) the spontaneous economic change due to the net increase in capital factor, which was resulted from the capital accumulation caused by the fixed investment of several branches of production combined with the 50% drop of oil prices, the level that had had the visible impacts since 2014.

The simulation in case 1 was based on the input =1 to the delfudge variable in Table 3.1.

The simulation in case 2 was based on the input =1 to the delfudge variable in Table 3.1 and the input =-50 to the variables, which were related to the oil prices included the prices of imported goods in foreign currency $pw2_i$ for crude oil and

petroleum products and $v1_i$ for crude oil and petroleum products as shown in Figure 3.6.

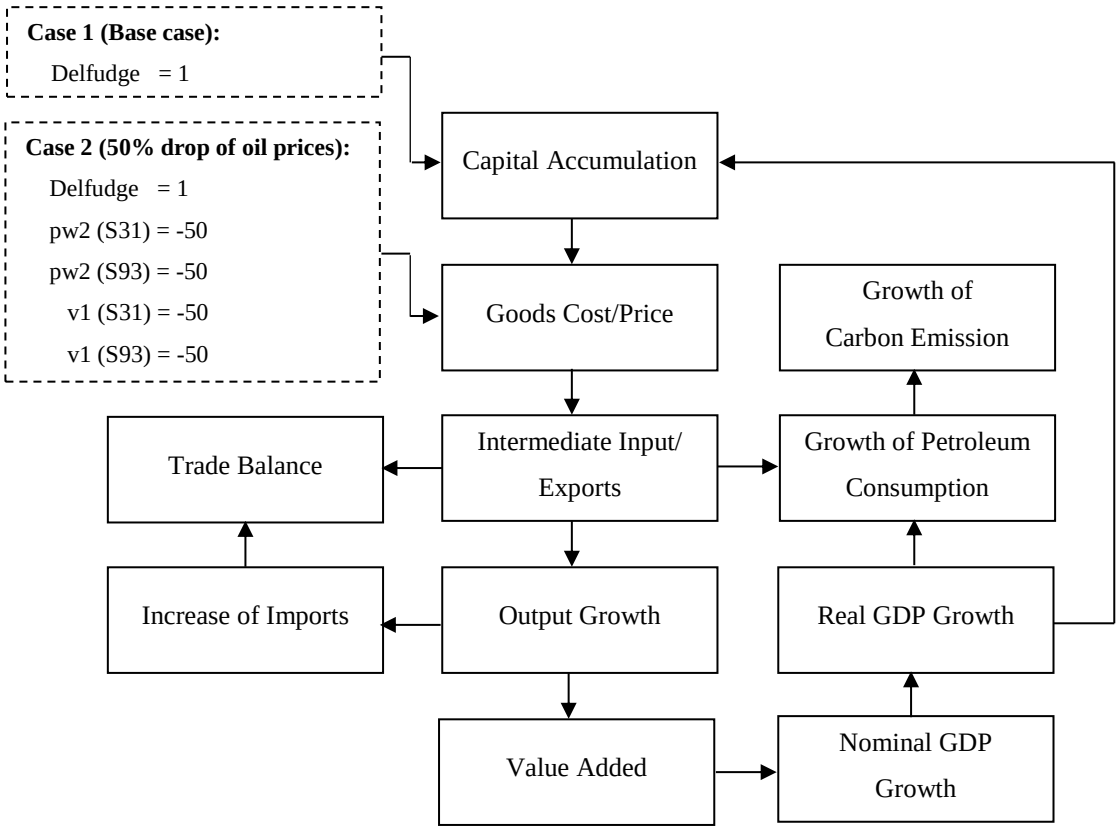


**Figure 3.6** The Simulation of 50% drop of oil prices and Shock Variable

The theory used in the process of designing derived from the ORANI Model (Dixon et al., 1982) and the ORANI-F Model (Horridge et al., 1993) which possessed the prediction qualities. In this case, the final demand theory (Figure 3.7), the inputs demand theory (Figure 3.8) and the capital factors demand and the capital goods production theory (Figure 3.9) were applied.

Nominal GDP is computed from supply and demand sides which helps to calibrate the precision of the CGE model. Net change in price is computed in the various form including consumer price index, government consumption price index, the investment price index, and GDP deflator. Real GDP is the difference between nominal GDP and GDP deflator.

The core structure of a CGE model consists of 5 sets of equations: 1) Final demand 2) Production function 3) Price definitions 4) Market equilibrium and 5) Numeraire.

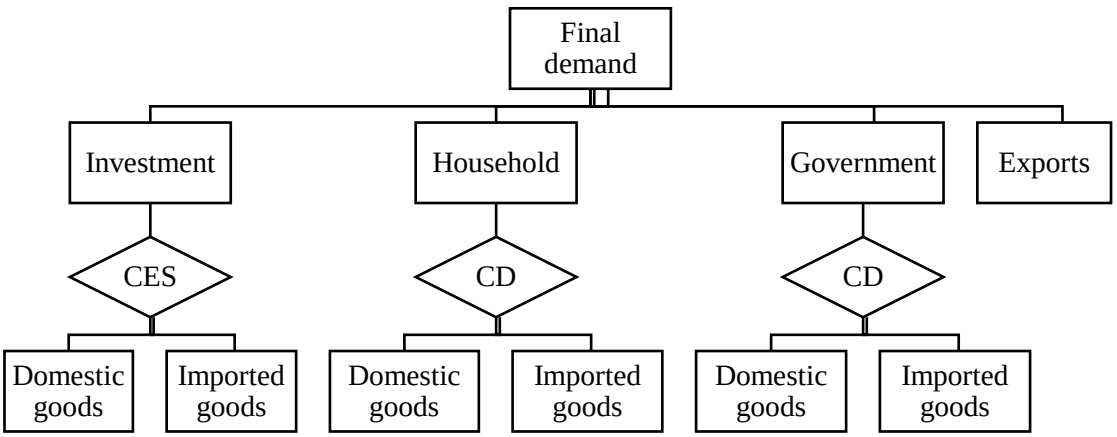


**Figure 3.7** Final Demand Theory

**Notes:** CES= Constant Elasticity of Substitution form of production function;

CD = Cobb-Douglas form of production function

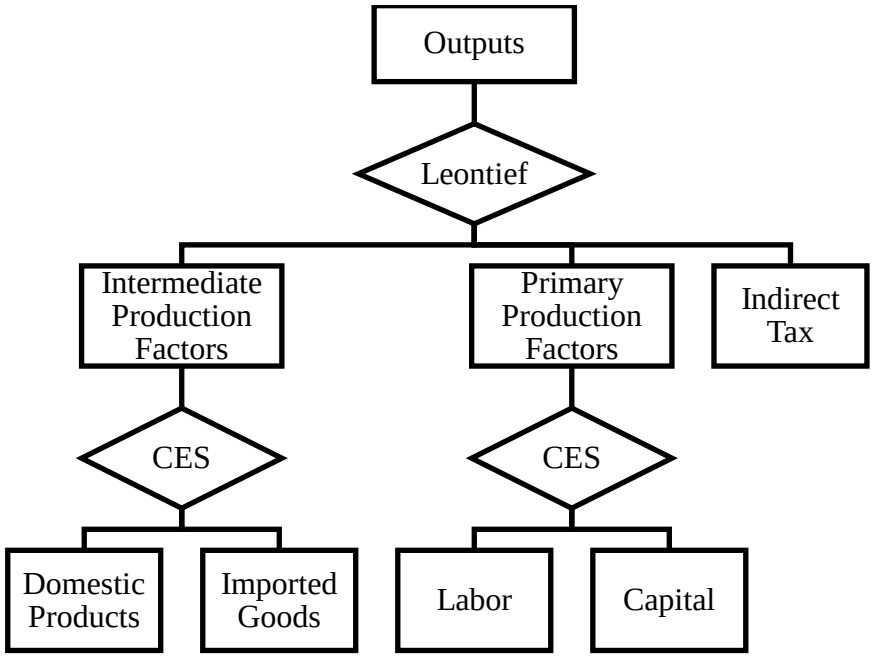


**Figure 3.8** The Theory for the Factors of Production Demand

**Notes:** Leontief = Leontief form of production function,

CES = Constant Elasticity of Substitution form of production function

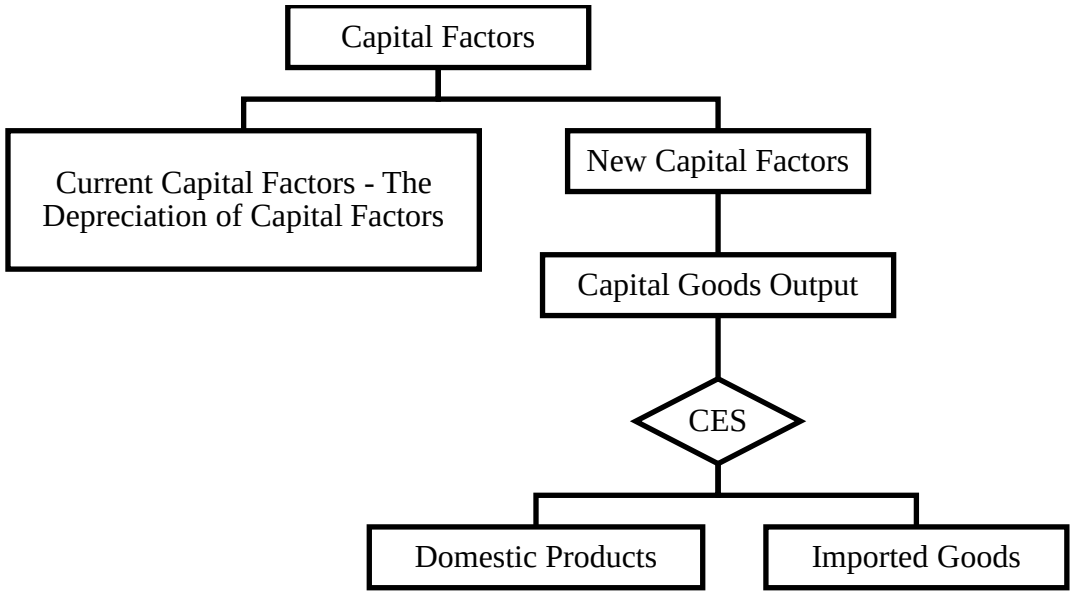


**Figure 3.9** The Theory of Capital Factors Demand and Capital Goods Production

**Notes:** CES = Constant Elasticity of Substitution form of the production function

In this approach, examination of economic and environmental impact from oil price slump in 2014 consists of two main steps: 1) calculation of economic impacts from oil price slump; and 2) calculation of environmental cost regarding the amount of carbon emission.

The environmental cost is measured concerning the quantity of carbon dioxide emission across the economy due to change in 180 sectors of the production system in Thailand when the oil price slump in 2014. In this study, the $CO_2$ emission is calculated in two methods: 1) $CO_2$ emission calculated based on published emission factor; and 2) $CO_2$ emissions calculated based on carbon credit price.

With the first methods, one of the primary determinants of carbon dioxide ($CO_2$) emissions from mobile source are the amount of carbon in the fuel. Carbon content varies, but typically we use average carbon content values to estimate $CO_2$ emissions (EPA, 2015). The code of Federal Regulations (40 CFR 600.113) provides values for carbon content per gallon of gasoline and diesel fuel which EPA uses in calculating the fuel economy of vehicles:

Gasoline carbon content per gallon: 2,319 grams

Diesel carbon content per gallon: 2,697 grams

**Table 3.1** Composition of Variables, their Representation, and Range

| | Variable | Description | Range |
|---|---|---|---|
| 1 | $p0_{i,s}$ | Commodity price | 360 |
| 2 | $p01_j$ | Labor price | 180 |
| 3 | $p02_j$ | Capital rental price | 180 |
| 4 | $p03_j$ | Indirect tax rate | 180 |
| 5 | $pz1_j$ | Investment cost | 180 |
| 6 | cpi1 | Investment price index | 1 |
| 7 | cpi2 | Consumer price index | 1 |
| 8 | cpi3 | Government consumption price index | 1 |
| 9 | $rp01_j$ | Real Labor Price | 180 |
| 10 | $rp02_j$ | Real Capital Rental price | 180 |

**Table 3.1** (Continued)

| | Variable | Description | Range |
|---|---|---|---|
| 11 | xr | Exchange Rate | 1 |
| 12 | $pw1_i$ | Export Price | 180 |
| 13 | $pw2_i$ | Import Price | 180 |
| 14 | $v1_i$ | Export tax | 180 |
| 15 | $v2_i$ | Import tax | 180 |
| 16 | $fx4_i$ | Shift export | 180 |
| 17 | $x0_{i,j,s}$ | Produced inputs used by commodity production | 64,800 |
| 18 | $x01_j$ | Labor input used by commodity production | 180 |
| 19 | $x02_j$ | Capital input used by commodity production | 180 |
| 20 | $x03_j$ | Indirect taxes | 180 |
| 21 | $z01_j$ | Commodity supply and demand | 180 |
| 22 | $z02_i$ | Imports commodity i | 180 |
| 23 | $z1_j$ | Investment by sector | 180 |
| 24 | $cx1_{i,s}$ | Investment by column | 360 |
| 25 | gdpi | Nominal gross domestic products computed from value added (income side GDP) | 1 |
| 26 | $va_1$ | Total Labor input | 1 |
| 27 | $va_2$ | Total Capital input | 1 |
| 28 | $va_3$ | Total indirect taxes | 1 |
| 29 | gdpe | Expenditure side GDP | 1 |
| 30 | gdpr | Real GDP | 1 |
| 31 | gdpdf | GDP deflator | 1 |
| 32 | c1 | Total investment consumption | 1 |
| 33 | c1r | Real total investment consumption | 1 |
| 34 | c2 | Total household consumption | 1 |
| 35 | c2r | Real total household consumption | 1 |
| 36 | c3 | Total government consumption | 1 |

**Table 3.1** (Continued)

| | Variable | Description | Range |
|---|---|---|---|
| 37 | c3r | Real total government consumption | 1 |
| 38 | $k0_j$ | Current capital stock | 180 |
| 39 | e | Total nominal export in foreign currency | 1 |
| 40 | m | Total nominal import in foreign currency | 1 |
| 41 | delBT | Change in trade balance | 1 |
| 42 | delDT | Change in trade balance-GDP ratio | 1 |
| 43 | $x1_{i,j,s}$ | Investment | 64,800 |
| 44 | $x2_{i,s}$ | Household consumption | 360 |
| 45 | $x3_{i,s}$ | Government consumption | 360 |
| 46 | $x4_i$ | Exports of commodity i | 180 |
| 47 | $x5_{i,s}$ | Inventory commodity i | 360 |
| 48 | $x6_i$ | Special export commodity i | 180 |
| 49 | Del Fudge | Forecast variable | 1 |
| 50 | $F\_accum_j$ | Capital shift | 180 |
| 51 | $oil$ | Oil consumption (Quantity) | 1 |
| 52 | $oil\_v$ | Oil consumption (Value) | 1 |
| 53 | $oil\_fd$ | Oil consumption in final demand (Quantity) | 1 |
| 54 | $oil\_fdv$ | Oil consumption in final demand (Value) | 1 |
| 55 | $oil\_int$ | Oil consumption in intermediate (Quantity) | 1 |
| 56 | $oil\_intv$ | Oil consumption in intermediate (Value) | 1 |
| | | **Total** | **135,208** |

**Table 3.2** Specification of Equation of CGE Model

| | Equation | Range |
|---|---|---|
| 1 | $z01_j = \sum_{j=1}^{180} RX0_{ij1} \cdot x0_{ij1} + \sum_{j=1}^{180} RX1_{ij1} \cdot x1_{ij1} + RX2_{i1} \cdot x2_{i1} + RX3_{i1} \cdot x3_{i1} + RX4_i \cdot x4_i + RX5_{i1} \cdot x5_{i1} + RX6_i \cdot X6_i$ | 180 |
| 2 | $z02_j = \sum_{j=1}^{180} RX0_{ij2} \cdot x0_{ij2} + \sum_{j=1}^{180} RX1_{ij2} \cdot x1_{ij2} + RX2_{i2} \cdot x2_{i2} + RX3_{i2} \cdot x3_{i2} + RX5_{i2} \cdot x5_{i2}$ | 180 |
| 3 | $x0_{ijs} = z01_j - \eta\left(p0_{is} - \sum_{s=1}^{2} SZX0_{ijr} \cdot p0_{ir}\right)$ | 64,800 |
| 4 | $x01_j = z01_j - \theta\left(p01_j - \left(SFAC1_j \cdot p01_j + SFAC2_j \cdot p02_j + SFAC3_j \cdot p03_j\right)\right)$ | 180 |
| 5 | $x02_j = z01_j - \theta\left(p02_j - \left(SFAC1_j \cdot p01_j + SFAC2_j \cdot p02_j + SFAC3_j \cdot p03_j\right)\right)$ | 180 |
| 6 | $x03_j = p03_j + p0_{j1} + z01_j$ | 180 |
| 7 | $va1 = \sum_{j=1}^{180} S01_j \cdot \left(p01_j + x01_j\right)$ | 1 |
| 8 | $va2 = \sum_{j=1}^{180} S02_j \cdot \left(p02_j + x02_j\right)$ | 1 |
| 9 | $va3 = \sum_{j=1}^{180} S03_j \cdot x03_j$ | 1 |
| 10 | $gdpi = H01 \cdot va1 + H02 \cdot va2 + H03 \cdot va3 + H04 \cdot va4$ | 1 |
| 11 | $x1_{ijs} = z1_j - CES\left(p0_{is} - \sum_{s=1}^{2} SZX1_{ijr} \cdot p0_{ir}\right)$ | 64,800 |
| 12 | $x2_{is} = c2 - p0_{is}$ | 360 |
| 13 | $x3_{is} = c3 - p0_{is}$ | 360 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 14 | $pw1_i = -\gamma \cdot x4_i + fx4_i$ | 180 |
| 15 | $x5_{is} = c2r$ | 360 |
| 16 | $x6_i = c2r$ | 180 |
| 17 | $k0_j = K\_TERM_j \cdot delfudge + M\_TERM_j \cdot R\_T_j \cdot z1_j + f\_accum_j$ | 180 |
| 18 | $x02_j = k0_j$ | 180 |
| 19 | $p0_{j1} + z01_j = \sum_{i=1}^{180} HX0_{ij1} \cdot (p0_{j1} + x0_{ij1}) + \sum_{i=1}^{180} HX0_{ij2} \cdot (p0_{j2} + x0_{ij2}) + HX01_j \cdot x01_j + HX02_j \cdot X02_j + HX03_j \cdot X03_j + HX04_j \cdot (p04_j + p0_{j1} + z01_j)$ | 180 |
| 20 | $p0_{i1} = pw1_i + v1_i + xr$ | 180 |
| 21 | $p0_{i2} = pw2_i + v2_i + xr$ | 180 |
| 22 | $pz1_j + z1_j = \sum_{i=1}^{180} HZ1_{ij1} \cdot (p0_{i1} + x1_{ij1}) + \sum_{i=1}^{180} HZ1_{ij2} \cdot (p0_{i2} + x1_{ij2})$ | 180 |
| 23 | $z1_j = c1 - pz1_j + p02_j$ | 180 |
| 24 | $cpi1 = \sum_{j=1}^{180} SZ1_j \cdot pz1_j$ | 1 |
| 25 | $cpi2 = \sum_{i=1}^{180} SX2_{i1} \cdot x2_{i1} + \sum_{i=1}^{180} SX2_{i2} \cdot x2_{i2}$ | 1 |
| 26 | $cpi3 = \sum_{i=1}^{180} SX3_{i1} \cdot x3_{i1} + \sum_{i=1}^{180} SX3_{i2} \cdot x3_{i2}$ | 1 |
| 27 | $c1r = c1 - cpi1$ | 1 |
| 28 | $c2r = c2 - cpi2$ | 1 |
| 29 | $c3r = c3 - cpi3$ | 1 |
| 30 | $c1 = gdpe$ | 1 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 32 | $c3 = gdpe$ | 1 |
| 33 | $e = \sum_{i=1}^{180} HX4_i \cdot (pw1_i + x4_i)$ | 1 |
| 34 | $m = \sum_{i=1}^{180} HM_i \cdot (pw2_i + z02_i)$ | 1 |
| 35 | $100 \cdot delbt = VE \cdot e - VM \cdot m$ | 1 |
| 36 | $100 \cdot VGDPE \cdot deldt = VE \cdot e - VM \cdot m - (VE - VM) \cdot gdpe$ | 1 |
| 37 | $rp01_j = p01_j - cpi2$ | 180 |
| 38 | $rp02_j = p02_j - cpi2$ | 180 |
| 39 | $cx1_{i1} = \sum_{j=1}^{180} RCX1_{ij1} \cdot x1_{ij1}$ | 180 |
| 40 | $cx1_{i2} = \sum_{j=1}^{180} RCX1_{ij2} \cdot x1_{ij2}$ | 180 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 41 | $gdpe = \sum_{i=1}^{180} SHZCX1_{i1} \cdot (p0_{i1} + cx1_{i1}) + \sum_{i=1}^{180} SHZCX1_{i2} \cdot (p0_{i2} + cx1_{i2}) + \sum_{i=1}^{180} SHX2_{i1} \cdot (p0_{i1} + x2_{i1}) + \sum_{i=1}^{180} SHX2_{i2} \cdot (p0_{i2} + x2_{i2}) + \sum_{i=1}^{180} SHX3_{i1} \cdot (p0_{i1} + x3_{i1}) + \sum_{i=1}^{180} SHX3_{i2} \cdot (p0_{i2} + x2_{i2}) + \sum_{i=1}^{180} SHX4_{i} \cdot (p0_{i1} + x4_{i}) + \sum_{i=1}^{180} SHX5_{i1} \cdot (p0_{i1} + x5_{i1}) + \sum_{i=1}^{180} SHX5_{i2} \cdot (p0_{i2} + x5_{i2}) + \sum_{i=1}^{180} SHX6_{i} \cdot (p0_{i} + x6_{i}) - \sum_{i=1}^{180} SHZ02_{i} \cdot (p0_{i2} + z02_{i})$ | 1 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 42 | $gdpdf = \sum_{i=1}^{180} SHZCX1_{i1} \cdot p0_{i1} + \sum_{i=1}^{180} SHZCX1_{i2} \cdot p0_{i2} + \sum_{i=1}^{180} SHX2_{i1} \cdot p0_{i1} + \sum_{i=1}^{180} SHX2_{i2} \cdot p0_{i2} + \sum_{i=1}^{180} SHX3_{i1} \cdot p0_{i1} + \sum_{i=1}^{180} SHX3_{i2} \cdot p0_{i2} + \sum_{i=1}^{180} SHX4_{i} \cdot p0_{i1} + \sum_{i=1}^{180} SHX5_{i1} \cdot p0_{i1} + \sum_{i=1}^{180} SHX5_{i2} \cdot p0_{i2} + \sum_{i=1}^{180} SHX6_{i} \cdot p0_{i1} - \sum_{i=1}^{180} SHZ02_{i} \cdot p0_{i2}$ | 1 |
| 43 | $gdpr = gdpe - gdpdf$ | 1 |
| 44 | $oil = \sum_{j=1}^{180} SCX0_{93,j,1} x0_{93,j,1} + \sum_{j=1}^{180} SCX0_{93,j,2} x0_{93j,2} + \sum_{j=1}^{180} SCX1_{93,j,1} x0_{93,j,1} + \sum_{j=1}^{180} SCX1_{93,j,2} x0_{93j,2} + SCX2_{93,1} x2_{93,1} + SCX2_{93,2} x2_{93,2} + SCX3_{93,1} x3_{93,1} + SCX3_{93,2} x3_{93,2} + SCX4_{93} x4_{93} + SCX5_{93,1} x5_{93,1} + SCX5_{93,2} x5_{93,2} + SCX6_{93} x6_{93}$ | 1 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 45 | $oil\_v = \sum_{j=1}^{180} SCX0_{93,j,1}(p0_{93,1} + x0_{93,j,1}) + \sum_{j=1}^{180} SCX0_{93,j,2}(p0_{93,2} + x0_{93,j,2}) + \sum_{j=1}^{180} SCX1_{93,j,1}(p0_{93,1} + x0_{93,j,1}) + \sum_{j=1}^{180} SCX1_{93,j,2}(p0_{93,2} + x0_{93j,2}) + SCX2_{93,1}(p0_{93,1} + x2_{93,1}) + SCX2_{93,2}(p0_{93,2} + x2_{93,2}) + SCX3_{93,1}(p0_{93,1} + x3_{93,1}) + SCX3_{93,2}(p0_{93,2} + x3_{93,2}) + SCX4_{93}(p0_{93,1} + x4_{93}) + SCX5_{93,1}(p0_{93,1} + x5_{93,1}) + SCX5_{93,2}(p0_{93,2} + x5_{93,2}) + SCX6_{93}(p0_{93,1} + x6_{93})$ | 1 |
| 46 | $oil_{fd} = \sum_{j=1}^{180} SFDX1_{93,j,1}x0_{93,j,1} + \sum_{j=1}^{180} SFDX1_{93,j,2}x0_{93j,2} + SFDX2_{93,1}x2_{93,1} + SFDX2_{93,2}x2_{93,2} + SFDX3_{93,1}x3_{93,1} + SFDX3_{93,2}x3_{93,2} + SFDX4_{93}x4_{93} + SFDX5_{93,1}x5_{93,1} + SFDX5_{93,2}x5_{93,2} + SFDX6_{93}x6_{93}$ | 1 |

**Table 3.2** (Continued)

| | Equation | Range |
|---|---|---|
| 47 | $oil\_fdv = \sum_{j=1}^{180} SFDX1_{93,j,1}(p0_{93,1} + x0_{93,j,1}) + \sum_{j=1}^{180} SFDX1_{93,j,2}(p0_{93,2} + x0_{93j,2}) + SFDX2_{93,1}(p0_{93,1} + x2_{93,1}) + SFDX2_{93,2}(p0_{93,2} + x2_{93,2}) + SFDX3_{93,1}(p0_{93,1} + x3_{93,1}) + SFDX3_{93,2}(p0_{93,2} + x3_{93,2}) + SFDX4_{93}(p0_{93,1} + x4_{93}) + SFDX5_{93,1}(p0_{93,1} + x5_{93,1}) + SFDX5_{93,2}(p0_{93,2} + x5_{93,2}) + \mathrm{SFDX6}_{93}(\mathrm{p0}_{93,1} + \mathrm{x6}_{93})$ | 1 |
| 48 | $oil\_int = \sum_{j=1}^{180} SINX0_{93,j,1} x0_{93,j,1} + \sum_{j=1}^{180} SINX0_{93,j,2} x0_{93j,2}$ | 1 |
| 49 | $oil\_intv = \sum_{j=1}^{180} SINX0_{93,j,1}(p0_{93,1} + x0_{93,j,1}) + \sum_{j=1}^{180} SINX0_{93,j,2}(p0_{93,2} + x0_{93,j,2})$ | 1 |
| | **Total** | **133,946** |

The structure of exogenous variables indicated the economic theory or assumptions that were related to the FCGE model as followed: 1) Wage adjustment based on the changes in selling prices indicated that the labors, who were also the consumers, did not have lower welfare if prices rose. However, welfare would increase or decrease as a result of changes in real GDP. 2) Constant policy assumptions included indirect tax rates, export subsidy rates (if any) and import

tariffs. However, the change in government revenue would depend on the general economic changes namely the output of GDP. 3) Export demand was inversely proportional to the selling prices; for instance, the demand might increase if the price of exported goods decreased. This might happen as a result of the increase in competitive capability of the production as the cost decreased, and/ or the exchange rates got weaker. On the contrary, the export demand might decrease if the prices of exported goods rose as a result of the decline in production potential due to higher production costs, and/ or the increase in exchange rates. 4) Demand for imported goods was inversely proportional to the price of imported goods; for instance, the demand would increase if the prices of imported goods went lower due to the appreciation of exchange rates. On the other hand, the demand would decline if the prices of imported goods increased due to the fall in exchange rates. 5) Expenditures and investment assumptions of the government changed according to the margin of government revenue which altered in accordance with the GDP. 6) Assumptions of trade balance (deficit or surplus) changed according to the alteration of GDP; the Debt-GDP Ratio, thus, had been fixed. As a result, Thailand economic system owed a large amount of foreign debt, in the case of the trade deficit that didn’t increase, beyond its debt repayment capacity. In the same way, the Thailand economic system had the influx of money from trade surplus at the same rate as GDP. This had resulted in exchange rate stability.

**Table 3.3** Structural Exogenous Variables and Range

| | Variable | Comment | Range |
|---|---|---|---|
| 1 | $rp01_j$ | Real price of labor | 180 |
| 2 | $p03_i$ | Indirect tax rate | 180 |
| 3 | $v1_i$ | Export subsidy | 180 |
| 4 | $v2_i$ | Import tax | 180 |
| 5 | $fx4_i$ | Foreign demand independent shift | 180 |
| 6 | $pw2_i$ | Import price | 180 |
| 7 | delFudge | Forecast Variable | 1 |
| 8 | $f\_accum_j$ | Capital Shift | 180 |
| 9 | delBT | Change in trade balance | 1 |
| | **Total** | | **1,262** |

**Table 3.4** Computation of Coefficients, Shares and Parameters

| Shares and Constants | Description |
|---|---|
| Domestic goods | |
| $RX0_{ij1}$ | Share of domestic goods in total demand |
| $RX1_{ij1}$ | Share of domestic goods in total demand |
| $RX2_{i1}$ | Share of domestic goods used by households in total demand |
| $RX3_{i1}$ | Share of domestic goods used by government in total demand |
| $RX4_i$ | Share of export goods in total demand |
| $RX5_{i1}$ | Share of domestic goods used by inventory in total demand |
| $RX6_i$ | Share of special export goods in total demand |
| Import goods | |
| $RX0_{ij2}$ | Share of import goods in total import demand |
| $RX1_{ij2}$ | Share of import goods in total import demand |

**Table 3.4** (Continued)

| Shares and Constants | Description |
|---|---|
| $RX2_{i2}$ | Share of import goods used by households in total import demand |
| $RX3_{i2}$ | Share of import goods used by government in total import demand |
| $RX5_{i2}$ | Share of import goods used by inventory in total import demand |
| Intermediate inputs | |
| $SZX0_{ijr}$ | Share of domestic goods: r=1; import goods: r=2 in intermediate input |
| Primary inputs | |
| $SFAC1_j$ | Share of labor in primary input |
| $SFAC2_j$ | Share of capital in primary input |
| Value added | |
| $S01_j$ | Share of sector j labor in total demand for labor |
| $S02_j$ | Share of sector j capital in total demand for capital |
| $S03_j$ | Share of sector j indirect taxes in total indirect taxes |
| GDP computed from income | |
| $H01$ | Share of total labor value added in GDP computed from income |
| $H02$ | Share of total capital value added in GDP computed from income |
| $H03$ | Share of total indirect taxes value added in GDP computed from income |
| Capital goods production | |
| $SZX1_{ijr}$ | Share of domestic goods: r=1; import goods: r=2 in input for capital goods production |

**Table 3.4** (Continued)

| Shares and Constants | Description |
|---|---|
| Foreign trade | |
| $\gamma$ | Export elasticities |
| Capital accumulation | |
| $K\_TERM_j$ | Computed constant of return on investment |
| $M\_TERM_j$ | Computed constant of capital stock depreciation |
| $R\_T_j$ | Computed constant of investment-capital supply ratio |
| Cost computation | |
| $HX0_{ij1}$ | Share of domestic intermediate input in output |
| $HX0_{ij2}$ | Share of import intermediate input in output |
| $HX01_j$ | Share of labor input in output |
| $HX02_j$ | Share of capital input in output |
| $HX03_j$ | Share of indirect taxes in output |
| Capital goods | |
| $HZ1_{ij1}$ | Share of domestic input in output of capital goods |
| $HZ1_{ij2}$ | Share of import input in output of capital goods |
| Final demand | |
| $SZ1_j$ | Share of output of capital goods in aggregate investment |
| $SX2_{i1}$ | Share of domestic goods in aggregate household consumption |
| $SX2_{i2}$ | Share of import goods in aggregate household consumption |
| $SX3_{i1}$ | Share of domestic goods in aggregate government consumption |
| $SX3_{i2}$ | Share of import goods in aggregate government consumption |
| $HX4_i$ | Share of export of sector i in total export |
| $HM_i$ | Share of import of sector i in total import |

**Table 3.4** (Continued)

| Shares and Constants | Description |
|---|---|
| Trade balance | |
| $VE$ | Value of aggregate export |
| $VM$ | Value of aggregate import |
| $VGDPE$ | Value of GDP computed from demand |
| GDP computed from demand | |
| $RCX1_{ij1}$ | Share of domestic goods in total demand of investment goods |
| $RCX1_{ij2}$ | Share of imported goods in total demand of investment goods |
| $SHZCX1_{i1}$ | Share of total demand of domestic investment goods of sector i in GDP |
| $SHZCX1_{i2}$ | Share of total demand of domestic investment goods of sector i in GDP |
| $SHX2_{i1}$ | Share of domestic household goods of sector i in GDP |
| $SHX2_{i2}$ | Share of imported household goods of sector i in GDP |
| $SHX3_{i1}$ | Share of domestic government consumption goods of sector i in GDP |
| $SHX3_{i2}$ | Share of imported government consumption goods of sector i in GDP |
| $SHX4_i$ | Share of export goods of sector i in GDP |
| $SHX5_{i1}$ | Share of domestic inventory goods of sector i in GDP |
| $SHX5_{i2}$ | Share of imported inventory goods of sector i in GDP |
| $SHX6_i$ | Share of special export goods of sector i in GDP |
| $SHZ02_i$ | Share of total imported goods of sector i in GDP |
| Oil | |
| $SCX0_{93,j,1}$ | Share of domestic petroleum by sector j in total demand for petroleum |

**Table 3.4** (Continued)

| Shares and Constants | Description |
|---|---|
| $SCX0_{93,j,1}$ | Share of domestic petroleum by sector j in total demand for petroleum |
| $SCX0_{93,j,2}$ | Share of imported petroleum by sector j in in total demand for petroleum |
| $SCX1_{93,j,1}$ | Share of domestic petroleum for investment use of sector j in total demand for petroleum |
| $SCX1_{93,j,2}$ | Share of imported petroleum for investment use of sector j in total demand for petroleum |
| $SCX2_{93,1}$ | Share of domestic petroleum for household use in total demand for petroleum |
| $SCX2_{93,2}$ | Share of imported petroleum for household use in total demand for petroleum |
| $SCX3_{93,1}$ | Share of domestic petroleum for government use in total demand for petroleum |
| $SCX3_{93,2}$ | Share of imported petroleum for government use in total demand for petroleum |
| $SCX4_{93}$ | Share of domestic petroleum for export in total demand for petroleum |
| $SCX5_{93,1}$ | Share of domestic petroleum for inventory use in total demand for petroleum |
| $SCX5_{93,2}$ | Share of imported petroleum for inventory use in total demand for petroleum |
| $SCX6_{93}$ | Share of domestic petroleum for special export in total demand for petroleum |
| $SFDX1_{93,j,1}$ | Share of domestic petroleum for investment use of sector j in total final demand for petroleum |

**Table 3.4** (Continued)

| Shares and Constants | Description |
|---|---|
| $SFDX1_{93,j,2}$ | Share of imported petroleum for investment use of sector j in total final demand for petroleum |
| $SFDX2_{93,1}$ | Share of domestic petroleum for household use in total final demand for petroleum |
| $SFDX2_{93,2}$ | Share of imported petroleum for household use in total final demand for petroleum |
| $SFDX3_{93,1}$ | Share of domestic petroleum for government use in total final demand for petroleum |
| $SFDX3_{93,2}$ | Share of imported petroleum for government use in total final demand for petroleum |
| $SFDX4_{93}$ | Share of domestic petroleum for export in total final demand for petroleum |
| $SFDX5_{93,1}$ | Share of domestic petroleum for inventory use in total final demand for petroleum |
| $SFDX5_{93,2}$ | Share of imported petroleum for inventory use in total final demand for petroleum |
| $SFDX6_{93}$ | Share of domestic petroleum for special export in total final demand for petroleum |
| $SINX0_{93,j,1}$ | Share of domestic petroleum by sector j in total intermediate use |
| $SINX0_{93,j,2}$ | Share of imported petroleum by sector j in total intermediate use |

## 3.5 Computation Software

The data processing was conducted via GEMPACK program (Harrison et al., 2014), under the license of Graduate School of Environmental Development Administration (GSEDA), NIDA.

# CHAPTER 4

# RESEARCH RESULTS

## 4.1 Results

This research aims to study the growth of Thailand's real economy, which is influenced by low oil prices by 50 percent from 2014, using the Computable General Equilibrium Model. The economic forecasts is used to quantify the amount of carbon dioxide that is a consequence of economic change. The forecast results provide the knowledge for the development of strategies for both future economic and environmental managements. And the way to control the amount of carbon dioxide, which is a significant component of greenhouse gases, which is a factor of global climate change.

In this study, the forecasting computable general equilibrium model (FCGE) is used as a tool to find the trajectory for economic growth which is used to find the trajectory of the growth of $CO_2$. The FCGE model is adapted from ORANI (Dixon et al., 1982) and ORANI-F (Horridge et al., 1993).

The FCGE model has multi-sectors features, which is inherited from the Input-Output Model (Leontief, 1936) and economic structure, which gives the image a closer look, based on the net change of positive and negative changes in various sectors of the economy. The difference in the dynamics of a branch production is due to the difference in economic power. This is due to the difference in length, complexity, and weight of the inputs chain and the marketing chain and the density of the use of inputs and energy.

The simulation of 5-year-period economic change from 2014 to 2019 could be divided out into 2 comparable cases 1) the spontaneous economic change due to the net increase in capital factor, which was resulted from the capital accumulation 2) the spontaneous economic change due to the net increase in capital factor, which was

resulted from the capital accumulation combined with the 50% decreasing oil prices, the level that had had the visible impacts since 2014 as shown in the Table 4.1.

**Table 4.1** Forecasts from the FCGE Model for Macro Variables and the Volume and Value of Oil

Unit: Percentage change

| | Description | Macro Variable | Base Case | Case of 50% drop of oil price | Change |
|---|---|---|---|---|---|
| 1 | Aggregate value of investment expenditure | c1 | 20.26 | 20.85 | 0.59 |
| 2 | Aggregate value of household expenditure | c2 | 20.26 | 20.85 | 0.59 |
| 3 | Aggregate value of government expenditure | c3 | 20.26 | 20.85 | 0.59 |
| 4 | Investment price index | cpi1 | 7.50 | -0.12 | -7.62 |
| 5 | Consumer price index | cpi2 | 6.32 | -2.33 | -8.65 |
| 6 | Government price index | cpi3 | 5.83 | -2.63 | -8.46 |
| 7 | Trade balance (change) | delBT | Deficit increased by 139,995,424 Million Bath | Deficit increased by 147,204,432 Million Bath | Deficit increased by 7,209,008 Million Bath |
| 8 | Debt_GDP Ratio (change) | delDT | 0 | 0 | 0 |
| 9 | Aggregate value of import | M | 12.82 | 10.45 | -2.37 |
| 10 | Aggregate value of exports | E | 12.03 | 9.26 | -2.77 |
| 11 | GDP deflator | Gdpdf | 4.51 | 0.62 | -3.89 |
| 12 | Expenditure side GDP | Gdpe | 20.26 | 20.85 | 0.59 |
| 13 | Income side GDP | Gdpi | 20.26 | 20.85 | 0.59 |
| 14 | Real GDP | Gdpr | 15.07 | 20.10 | 5.03 |

**Table 4.1** (Continued)

Unit: Percentage change

| | Description | Macro Variable | Base Case | Case of 50% drop of oil price | Change |
|---|---|---|---|---|---|
| 15 | Exchange Rate | Xr | 10.18 | 0.81 | -9.37 |
| 16 | Oil consumption (Quantity) | Oil | 12.31 | 25.50 | 13.19 |
| 17 | Oil consumption for final demand (Quantity) | oil_fd | 8.35 | 26.50 | 18.15 |
| 18 | Oil consumption for intermediate demand (Quantity) | oil_int | 14.81 | 24.82 | 10.01 |

While oil prices have decreased 50% of usual prices affecting to the Consumer Price Index to be declined consequently, the prices of goods and services are then reduced as factors that induce a growth of consumption and cause the Real Gross Domestic Product (Real GDP) raising up 5.03% accordingly. Real GDP growth of 20.10% is influenced by oil prices decreasing by 50% compared to 15.07% for old oil prices. The comparative growth rate of 2 cases is shown in Figure 4.1.

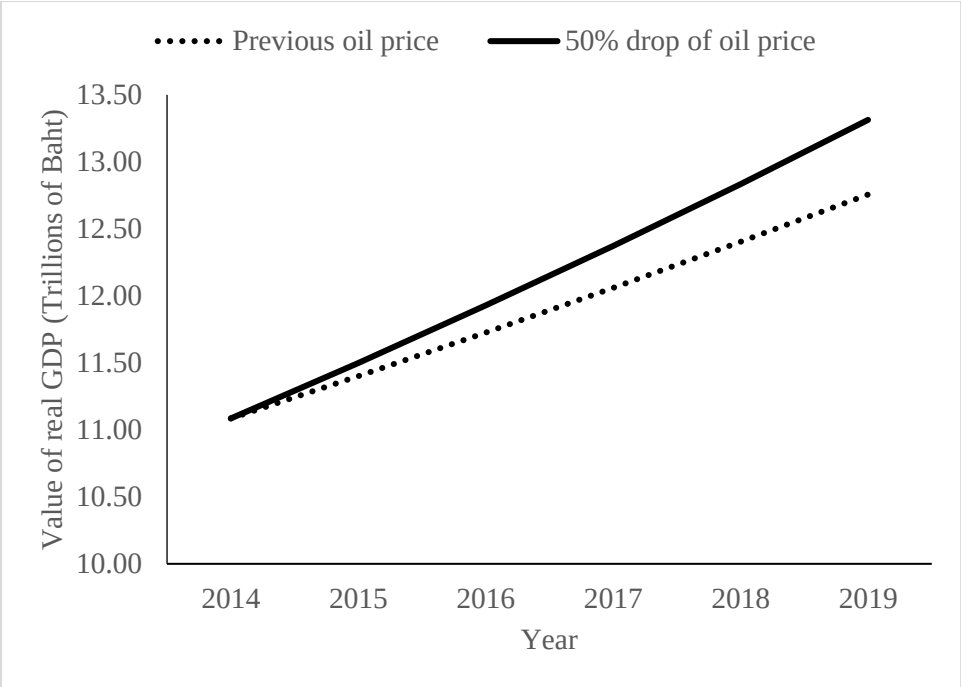


**Figure 4.1** Trajectory Forecast of 5 Years Growth of Real Gross Domestic Product (Real GDP), for the Case of 50% Decrease of Oil Prices Compared with the Case of the Absence of Oil Prices Decrease.

The 50 percent drop of oil prices has been instrumental in slowing down inflation from 4.51 percent to 0.62 percent, resulting in real GDP growth. Real GDP = Nominal GDP - GDP deflator. The gross domestic product is the difference Gross domestic product at market price with total inflation. Inflation of 0.62 percent, which has been positively influenced by falling oil prices, makes Real GDP close to the nominal GDP. Consumption benefits from a higher volume of goods and services, resulting in higher quality of life. In addition, Oil known as an imported good is decreased its price causing higher consumed demand and finally making more money flowing out of the country. This incident influence Thai Bath appreciation, following exchange rate of the Baht from 10.18 to 0.81. Moreover, in the case of oil price decrease 50%, it also affects to the volume of oil consumption for final demand and oil consumption for intermediate demand increasing to be 18.15% and 10.01% respectively.

Likewise, the changes of economic sectors which get impacts from the reduction of oil prices are illustrated in the first ten sectors of the maximum and minimum growth. The first ten sectors of maximum growth in the case of no change of base case will have an average value of the growth at 20.50%, as shown in the Table 4.2, whereas the sector that gain the most advantage at the first order is the sector 33 Tin ore which has a growth rate at 29.02%. While, the second order is the sector 36 Fluorite which has a growth rate at 23.06%. Moreover, the third order is the sector 37 of Chemical which has a growth rate at 21.54%. Furthermore, the third order is the sector 43 Canning and preserving of meat which has a growth rate at 29.48%.

On the other hand, in the case of dropping oil price at 50%, it shows that the most growth sector of the first ten sectors has an average growth rate at 27.86%, which is higher than the base case, as shown in the Table 4.3, whereas the sector that gain the most advantage at the first order is the sector 151 Road freight transport which has a growth rate at 33.93%. While, the second order is the sector 150 Road passenger transport which has a growth rate at 30.04%. Moreover, the third order is the sector 105 Iron and steel which has a growth rate at 29.57%. Furthermore, the fourth order is the sector 154 Coastal and inland water transport which has a growth rate at 29.48%. Obviously, these four sectors have a growth rate higher than the sector 33 Tin ore the Base case. In summary, the sector that gain advantage and has high growth rate from dropping oil price is the transport and construction sector.

**Table 4.2** Top 10 sectors found to having strong output growth for the case of the absence of oil price decrease (Base Case)

Unit: Percentage change

| Order | Sectors | Description | Base Case |
|---|---|---|---|
| 1 | 33 | Tin ore | 29.02 |
| 2 | 36 | Fluorite | 23.06 |
| 3 | 37 | Chemical Fertilizers | 21.54 |
| 4 | 43 | Canning and Preserving of meat | 20.70 |
| 5 | 3 | Other cereals | 19.89 |
| 6 | 25 | Logging | 19.02 |
| 7 | 35 | Other non-Ferrous metals | 18.31 |
| 8 | 45 | Canning fruit and vegetables | 18.04 |
| 9 | 97 | Other rubber product | 17.95 |
| 10 | 27 | Other forest product | 17.71 |
| | | **Average** | **20.52** |

**Table 4.3** Top 10 sectors found to having strong output growth for the case of oil price decrease.

Unit: Percentage change

| Order | Sectors | Description | Case of 50% drop of oil price |
|---|---|---|---|
| 1 | 151 | Road freight transport | 33.93 |
| 2 | 150 | Road passenger transport | 30.04 |
| 3 | 105 | Iron and steel | 29.57 |
| 4 | 154 | Coastal and inland water transport | 29.48 |
| 5 | 127 | Repair of motor vehicles | 26.02 |
| 6 | 143 | Construction of communication facilities | 25.93 |
| 7 | 141 | Non-agriculture public works | 25.93 |
| 8 | 142 | Construction of electric plants | 25.93 |
| 9 | 140 | Public works for agriculture and forestry | 25.93 |
| 10 | 156 | Air transport | 25.81 |
| | | **Average** | **27.86** |

Besides, the base cases with no decreasing oil prices show the first ten minimum growth sectors, which has an average growth rate at 11.85%, as shown in the Table 4.4; whereas the minimum growth sector is the sector 179 Other service not classified elsewhere, which has a growth rate only 4.08%. While, the second rank is the sector 118 Radio, television and communication equipment and apparatus, which has a growth rate at 10.89%. Meanwhile, the third rank is the sector 117 Electrical industrial machinery and appliances apparatus, which has a growth rate at 12.18%. Moreover, the fourth rank is the sector 93 Petroleum refineries apparatus, which has a growth rate at 12.27%. However, the ninth rank is the sector 150 Road passenger transport, which has a growth rate at 13.35%. On the other hand, the case of decreasing oil price at 50%, it shows an average of the first ten minimum growth at 12.49%, which is higher the base case, as shown in the Table 4.5. Whereas, the minimum growth is the sector 33 Tin ore, which has a growth rate at 4.99%. While, the second rank in the sector 117 Electrical industrial machinery and appliances, which has a growth rate at 7.54% and the sector 118 Radio, television and communication equipment and apparatus, which has a growth rate at 11.49%. Obviously, the sector 117 and the sector 118 have only small changes of the growth rates from decreasing oil prices.

However, the data from the Table 4.2 - 4.5 can be summarized the impacts from decreasing oil prices, as following, the sector 33 Tin ore has lower advantage, comparing with it has a growth rate at 29.02% in the normal case (Table 4.2) and has a growth rate at 4.99% in the case of decreasing oil prices 50% (Table 4.5). Nevertheless, the sector 150 Road passenger transport has higher advantage, comparing with a growth rate of 13.35% in the normal case (Table 4.4) and has a growth rate at 30.04% in the case of decreasing oil prices 50% (Table 4.3).

**Table 4.4** Top 10 Sectors found to having weak output growth for the case of the absence of oil price decrease (Base Case)

Unit: Percentage change

| Order | Sectors | Description | Base Case |
|---|---|---|---|
| 1 | 179 | Other service not classified elsewhere | 4.08 |
| 2 | 118 | Radio, television and communication equipment and apparatus | 10.89 |
| 3 | 117 | Electrical industrial machinery and appliances | 12.18 |
| 4 | 93 | Petroleum refineries | 12.27 |
| 5 | 48 | Animal oil, animal fat, vegetable oil and by- products | 12.62 |
| 6 | 153 | Ocean transport | 13.11 |
| 7 | 129 | Scientific equipment | 13.13 |
| 8 | 178 | Personal service | 13.35 |
| 9 | 150 | Road passenger transport | 13.35 |
| 10 | 177 | Repair not classified elsewhere | 13.50 |
| | | **Average** | **11.85** |

**Table 4.5** Top 10 Sectors found to having weak output growth for the case of oil price decrease.

Unit: Percentage change

| Order | Sectors | Description | Case of 50% drop of oil price |
|---|---|---|---|
| 1 | 33 | Tin ore | 4.99 |
| 2 | 117 | Electrical industrial machinery and appliances | 7.54 |
| 3 | 118 | Radio, television and communication equipment and apparatus | 11.49 |
| 4 | 37 | Chemical Fertilizers | 12.20 |
| 5 | 43 | Canning and Preserving of meat | 12.62 |
| 6 | 75 | Tanneries and leather finishing | 13.13 |
| 7 | 129 | Scientific equipment | 13.44 |
| 8 | 121 | Electric accumulators and batteries | 13.70 |
| 9 | 32 | Iron ore | 14.24 |
| 10 | 90 | Cosmetic | 14.36 |
| | | **Average** | **12.49** |

Moreover, the table 4.6-4.7 revealed a 5-years forecast in the case of no decreasing oil price (Base case) that the most growth sectors which use crude oil (S31) are Tin ore, Fluorite, Chemical fertilizers, Canning and preserving of meat and Other cereals, respectively. However, in the case of decreasing oil price at 50%, the sectors that the most growth sectors which use crude oil (S31) are Pipe line and gas distribution, Petrochemical products, Petroleum and natural gas, Road freight transport and Road passenger transport, respectively.

Likewise, the table 4.8-4.9 revealed a 5-years forecast in the case of no decreasing oil price (Base case) that the most growth sectors which use Petroleum products (S93) are Tin ore, Fluorite, Chemical fertilizers, Canning and preserving of meat and Other cereals. However, in the case of decreasing oil price at 50%, the sectors that the most growth sectors which use Petroleum products (S93) are Road freight transport, Iron and steel, Road passenger transport, Coastal and inland water transport and Air transport.

**Table 4.6** Top 10 sectors found to having strong growth of oil use for the case of the absence of oil price decrease.

Unit: Percentage change

| Order | Sectors | Description | Domestic | Import |
|---|---|---|---|---|
| 1 | 33 | Tin ore | 29.12 | 27.91 |
| 2 | 36 | Fluorite | 23.18 | 22.03 |
| 3 | 37 | Chemical fertilizers | 21.63 | 20.49 |
| 4 | 43 | Canning and preserving of meat | 20.80 | 19.67 |
| 5 | 3 | Other cereals | 19.98 | 18.86 |
| 6 | 25 | Logging | 19.10 | 17.99 |
| 7 | 35 | Other non-ferrous metals | 18.40 | 17.30 |
| 8 | 32 | Iron ore | 18.22 | 17.11 |
| 9 | 45 | Canning and preservation of fruit and vegetables | 18.13 | 17.03 |
| 10 | 97 | Other rubber products | 18.04 | 16.94 |

**Table 4.7** Top 10 sectors found to having strong growth of oil use for the case of oil price decrease.

Unit: Percentage change

| Order | Sectors | Description | Domestic | Import |
|---|---|---|---|---|
| 1 | 151 | Road freight transport | 32.26 | 53.77 |
| 2 | 105 | Iron and steel | 28.61 | 49.53 |
| 3 | 150 | Road passenger transport | 28.47 | 49.36 |
| 4 | 154 | Coastal and inland water transport | 27.89 | 48.70 |
| 5 | 156 | Air transport | 24.40 | 44.62 |
| 6 | 140 | Public works for agriculture and forestry | 24.26 | 44.47 |
| 7 | 143 | Construction of communication facilities | 24.24 | 44.45 |
| 8 | 127 | Repair of motor vehicles | 24.19 | 44.38 |
| 9 | 138 | Residential building construction | 24.11 | 44.30 |
| 10 | 103 | Concrete and cement products | 24.06 | 44.24 |

In summary, it must be noted that whenever oil price has decreased at 50%, the sectors that use more crude oil are the sectors that involve with productions and transportations for Petroleum and Petrochemical goods, also, Road passenger transportation and Road freight transportation. However, the sectors that use more Petroleum are the sectors that involve with road, water and air transportations, including iron, steel and construction sectors.

The analysis revealed that the 50% fall in the oil price as shown in Figure 4.2. The slowdown in inflation from 4.51 percent to 0.62 percent resulted in a depreciation of the exchange rate from 10.18 percent to 0.81 percent, which resulted in a slowdown in volume and value of exports from a growth rate of 12.02 percent. 9.26 percent. For importing goods the slowdown in inflation from 4.51 percent to 0.62 percent initially resulted in an advantage for imported goods. Domestic production is benefited from a lower cost of production. Influenced by lower oil prices, 50 percent are in a better position to compete with imported products. Therefore, the net effect of the slowdown in imports of goods and the trade balance remains in parallel with the growth in the gross domestic product at market prices or Nominal GDP.

The net effect of the 50% drop in oil prices is a boon to the strengthening of the domestic economy, ie the domestic economy has a higher share of the domestic economy with the Foreign economy (Total economy = Domestic economy + Foreign economic growth). But the expansion of the domestic economy has weighed heavily on the overall economy.

As a result of the 50% drop in oil prices, oil consumption was higher than the real growth rate shown in Table 4.10.

$$\text{Flexibility of oil use} = \frac{\%\Delta\text{Oil consumption}}{\%\Delta\text{Real economy}}$$

The FCGE forecast is calculated from the% ΔOil consumption (Quantity) (Item 16 in Table 4.1) ÷% ΔReal GDP (item 14 in Table 4.1)

The old oil price

$$\text{Oil use elasticity} = \frac{\%\Delta\text{Oil use}}{\%\Delta\text{Real GDP}} = \frac{12.31}{15.07} = 0.82$$

Oil prices fall 50%

$$\text{Oil use elasticity} = \frac{\%\Delta\text{Oil use}}{\%\Delta\text{Real GDP}} = \frac{25.50}{20.10} = 1.27$$

FCGE forecasts suggest that 50% reduction in oil prices would result in higher oil consumption than oil use elasticity of 1.27 that compared with oil use elasticity 0.82, respectively, high oil consumption in the case of 50% drop of oil price was caused by two factors, namely, fuel consumption, final demand and oil consumption (Intermediate demand). Oil use elasticity 0.82 was influenced by final demand was 8.36% and intermediate demand was 14.81%, including 12.31% and oil use elasticity 1.27 was influenced by final demand was 26.48% and intermediate demand was 24.82%, including 25.47%.

**Table 4.8** Oil Consumption Rates in Various Parts of the Thai Economy and the Elasticity Between the Change in Oil Consumption and the Change in Gross Domestic Product

Unit: Percentage change

| | **Description** | | **Base Case** | **Case of 50% drop of oil price** |
|---|---|---|---|---|
| 1 | Oil consumption (Quantity) | [1] | 12.31 | 25.47 |
| 2 | Oil consumption in intermediate (Quantity) | [2] | 14.81 | 24.82 |
| 3 | Oil consumption in final demand (Quantity) | [3] | 8.36 | 26.48 |
| 4 | Real GDP | [4] | 15.10 | 20.11 |
| 5 | Petroleum-GDP elasticity | [5] = [1]/[4] | 0.82 | 1.27 |

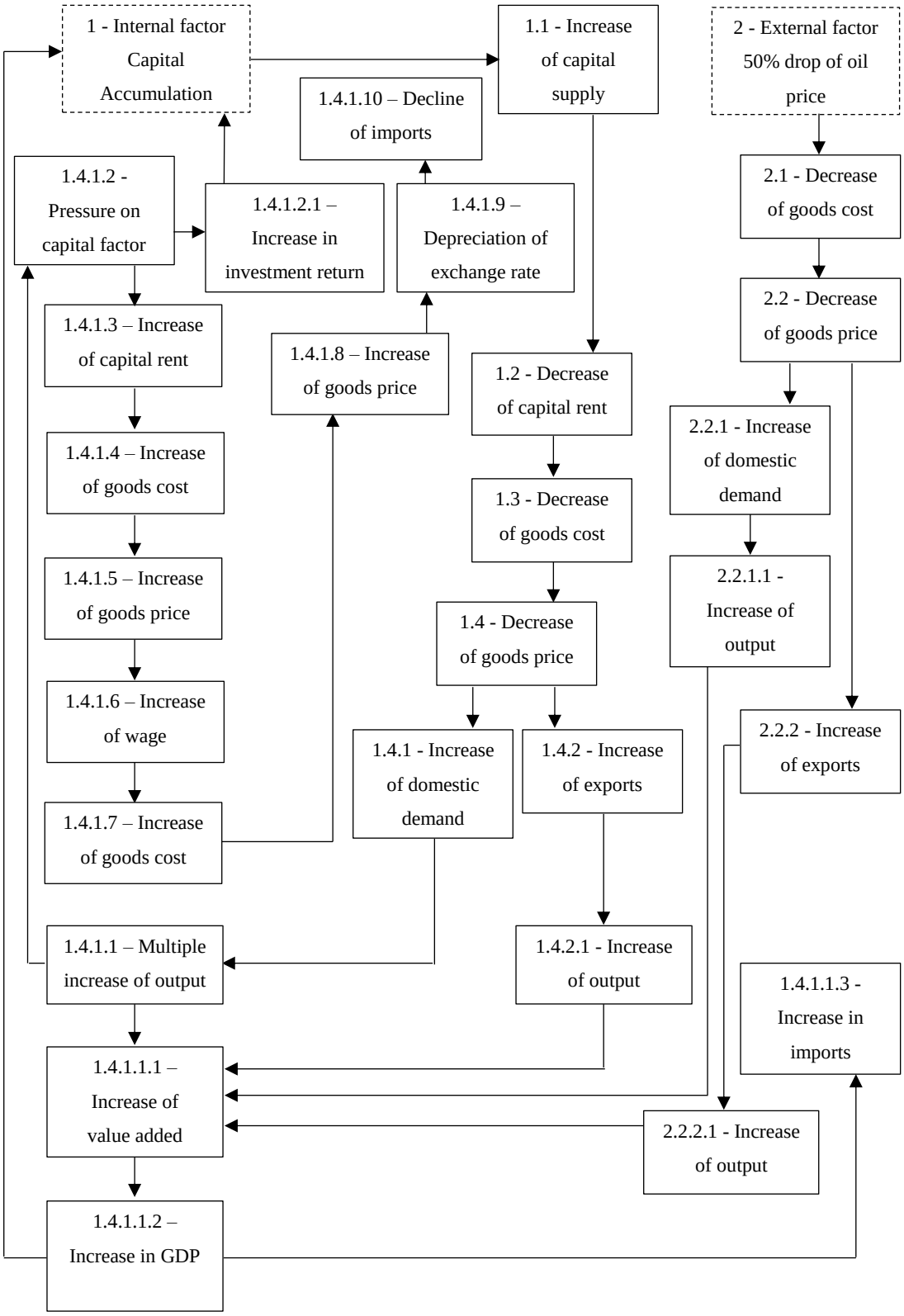


**Figure 4.2** Net Impacts of Capital Accumulation and Decrease in Oil Price

## 4.2 Carbon Dioxide Emission

High oil prices influence low fuel consumption and have a low carbon dioxide effect. On the other hand, low oil prices influence high oil consumption and a high carbon dioxide effect. In this study, it is assumed that in the absence of change in technology, the quantity of carbon dioxide is proportional to change in oil demand, which is the basis for the calculation shown in table 4.11.

FCGE forecasts show that oil prices have fallen by 50%, fueling domestic oil consumption growth from 12.31% to 25.47%, as shown in Table 4.11 row [15]. The old oil price use of gasoline increased from the base year 10,545,851,153 liters to 13,620,652,245 liters in the fifth year. Diesel consumption increased from the base year 30,683,505,451 liters to 39,629,741,718 liters in the fifth year.

The case after oil prices decreased. The use of gasoline increased from the base year 10,545,851,153 liters to 15,216,661,359 liters in the fifth year. Diesel consumption increased from the base year. 30,683,505,451 liters to 44,275,383,433 liters in year 5.

The old oil price carbon dioxide increased from base year 106,391,334 tons to 137,411,410 tons in year 5, classified as carbon dioxide for gasoline increased from year base to 24,466,375 tons to 31,599,913 tons in the fifth year, carbon dioxide for diesel fuel, it increased from 81,924,960 tons to 105,811,410 tons in the fifth year.

The case after oil prices that affected to carbon dioxide increased from base year 106,391,334 tons to 155,512,588 tons in year 5, classified as carbon dioxide For gasoline increased from year base to 24,466,375 tons to 35,302,654 tons in the fifth year, the amount of carbon dioxide For diesel fuel, it increased from 81,924,960 tons to 118,209,934 tons in the fifth year.

**Table 4.9** Carbon Dioxide Content Calculated from FCGE (Unit / Tonne)

| | Description | | Base Case | Case of 50% drop of oil price |
|---|---|---|---|---|
| [1] | The total value of domestic and imported oil (thousand Baht) from I-O Table base year | | 1,289,139,391 | 1,289,139,391 |
| [2] | Proportion of gasoline | | 0.29 | 0.29 |
| [3] | Proportion of diesel | | 0.71 | 0.71 |
| [4] | Price of gasoline (Baht) base year | | 35.45 | 35.45 |
| [5] | Price of diesel (Baht) base year | | 373,850,423 | 373,850,423 |
| [6] | Total value for gasoline (thousand Baht) | [2] x [1] | 915,288,968 | 915,288,968 |
| [7] | Total value for diesel (thousand Baht) | [3] x [1] | 12,127,728,826 | 12,127,728,826 |
| [8] | Total liter of gasoline | [6] x 1150 / [4] | 35,286,031,269 | 35,286,031,269 |
| [9] | Total liter of diesel | [7] x 1150 / [5] | 0.00232 | 0.00232 |
| [10] | Gasoline $CO_2$ emission factor ($tCO_2$/liter) | | 0.00267 | 0.00267 |
| [11] | Diesel $CO_2$ emission factor ($tCO_2$/liter) | | 28,136,331 | 28,136,331 |
| [12] | Gasoline $CO_2$ emission base year | [8] x [10] | 94,213,703 | 94,213,703 |
| [13] | Diesel $CO_2$ emission base year | [9] x [11] | 122,350,034 | 122,350,034 |
| [14] | Total oil $CO_2$ emission | [12] + [13] | 12.31 | 25.47 |
| [15] | Growth factor for oil quantity from FCGE (%) | | 373,850,423 | 373,850,423 |

**Table 4.9** (Continued)

| | Description | | Base Case | Case of 50% drop of oil price |
|---|---|---|---|---|
| [16] | Projection of total liter of gasoline year 5 | [8] x 1+[15]/100 | 13,620,652,245 | 15,216,661,359 |
| [17] | Projection of total liter of diesel year 5 | [9] x 1+[15]/100 | 39,629,741,718 | 44,273,383,433 |
| [18] | Projection of gasoline $CO_2$ emission | [16] x [10] | 31,599,913 | 35,302,654 |
| [19] | Projection of diesel $CO_2$ emission | [17] x [11] | 105,811,410 | 118,209,934 |
| [20] | Projection of total oil $CO_2$ emission | [18] + [19] | 137,411,324 | 153,512,588 |

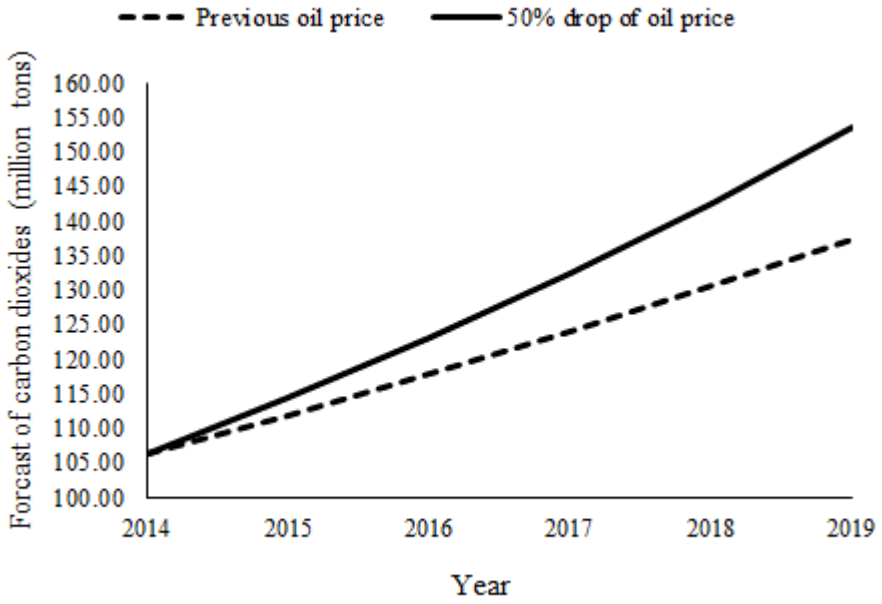


**Figure 4.3** Estimated Carbon Dioxide (Million Metric Tons) for 5 Years, Comparing Oil Inflows by 50%

# CHAPTER 5

# CONCLUSIONS

## 5.1 Conclusions

In this study, analysis of economic impacts and $CO_2$ emission potential in Thailand following oil price slump in 2014 that found the influence of low oil prices is the real gross domestic product. Economic growth trajectory created based on the FCGE model's shows real GDP growth forecast of 20.10% over a five-year period, compared with 15.07% in the case of the original oil price. The total economy consists of the internal economy and external front. In the case of lower oil prices, the level of external economic growth is lower than in the case of original oil prices. However, the domestic economy has a high growth rate and weight to expand the total economy. Real GDP grew in the face of declining oil prices.

Low oil prices have reduced inflation to 0.62 percent against 4.51 percent in the case of original oil prices. And it exerts an exaggerated depreciation rate of 0.81% against the depreciation rate of 10.18% in the case of original oil prices. Low inflation has resulted in increased consumption of goods and services. And the quality of life is higher.

Domestic goods and services have lower production costs, benefiting from low oil prices. And has a competitive advantage over imports from abroad. Therefore, the slowdown in the growth rate of imported goods, in line with the slowdown of export value growth. As a result, the trade balance remained in equilibrium with the increase in gross domestic product (Nominal GDP).

The result is that Thailand, which imports oil in large quantities to sustain the economy, benefited from low oil prices. Consumption can reach more and more goods and services with the reduced financial burden. It is an opportunity for the development of educational structures for human resource development. Investment in personnel education human capital accumulation in the field of high productivity.

R&D investment in science and technology paves the way for future economic growth.

Low oil prices have fueled higher demand for both final demand and intermediate demand, which is used as inputs for other products. Oil consumption grew at a rate 25.47 percent, which is 1.27 times higher than the GDP growth rate of 20.10 percent. For the trajectory of the growth of carbon dioxide to be created, it is assumed in this study that technology remains unchanged. Accordingly, the growth of carbon dioxide is similar to the growth of oil consumption. Knowledge of the increase in carbon dioxide excretion indicates the need for investment incentives to improve the efficiency of oil used to make economic growth use less oil.

## 5.2 Policy Implication

**1) Economic Policy**

The economic change leads to a change in oil demand as an intermediate factor in the production of goods and the final demand, namely investment expenditure, household consumption, and government consumption. Based on Thailand's economic structure, when the oil price decreases 50%, the economic growth would expand as shown in the Real GDP Growth. However, it also impacts oil consumption to be higher as well. Therefore, the savings policy should be adopted to slow down this consumption, in order to postpone the consumption to the future. However, this measure should be applied by the people's voluntary needs. It should be used to strengthen investment for the future income. This policy is adopted as the Policy Mix to delay the consumption in aspects of pollution controls and expanding channels for economic growth.

The savings promotion policy is to set up a voluntary measure for the people based on their capacities together with personal and family incomes. This mechanism would establish funds for governmental investments in making public goods, such as infrastructure investments for railway transportation, which will reduce energy consumption in the long term (Gritsana Patjakreng and Sompote Kunnoot, 2017). To promote the people's savings, this approach is a different measure from taxation,

which is a compulsory measure that may cause higher price products and make the poor people in trouble.

However, the savings promotion policy is to launch together with a public affair campaign, so that the people could understand and be aware of expenses for sustainable economic growth in the future as well. The people's savings would be enhanced if there are saving instruments, which are reliable and safety enough, for example, governmental development funds, which provide attractive returns and give public opportunities of ownership as semi-monopoly business for long-term compensation income. Since many investments are to be accompanied with human resource investment, in order to make businesses capable enough for economic growth ( Romer,1994), not to cause abandonment of labor factors, but make sustainable economic development by raising the level of well-being and quality of life of the people.

Moreover, the forecast model of decreasing oil prices 50%, as to the economic growth from the impacts of investments and low oil prices, revealed that low oil prices influence low increasing in production cost and goods prices (low inflation). These impacts are catalysts for consumptions, which give good results for a short-term export. However, when economic growth induces higher rental cost of capital factors both labor and physical capital, it also causes cost and product prices increase. These impacts would affect to Baht depreciation (exchange rate deteriorated), but it affects less weak of currency comparing with the case of no decreasing oil price.

Although this phenomenon gives a good result to economic growth; however, it is to make investment along with this implementation, in order to make more accumulated supply and prices of capital factor decreased as well. This investment may apply to human resource investment, so that not to lower quality labor factors and interrupt development later but make more continued productivity of labor factor in the long-term period.

**2) Environmental Policy**

The change in oil demand also culminates in a change in carbon dioxide emissions, which is regarded as a significant component of greenhouse gases.

The environmental impact triggered by expanding oil demand simultaneously triggers an increase of carbon dioxide, which is considered as a reason for implementing the policy to decelerate oil demand under the premise that the environment can be protected. From the forecast, it revealed that when oil price has decreased at 50%, the sectors that use more oil are the sectors that involve with productions and transportations for Petroleum and Petrochemical, and also Road passenger transportation and Road freight transportation. However, the sectors that use more Petroleum are the sectors that involve with road, water and air transportations, including iron, steel and construction.

Therefore, to control a level of carbon dioxide emissions from oil consumption, the policy to promote a system of transforming growing oil demand into growing savings. In this case, these savings can be accumulated and allocated to the governmental investment for infrastructure development, which is likely to create a ripple effect to stimulate more investment in the private sector; this condition is, in turn, likely to enhance more capacities to generate more revenue and the future economic growth.

The environmental policies for pollution control are to modify the transportation model to be more energy saving, especially rail transport. Since road transport cost is a factor that undermine Thailand’s competitiveness throughout the past; therefore, it is to promote the use and development of fuel-saving technologies and reduce pollution, such as Electric vehicle (EV). This campaign could also reduce dependence on oil in the country and create added value for Thailand’s industry as well. Furthermore, it is to support sustainable renewable energy development through researches and improve agricultural efficiency, in order to reduce the production cost of ethanol and biodiesel.

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# APPENDICES

# Appendix A

## Structure and Classification of Thailand 180 Sectors Input – Output Table

# Appendix A

## Structure and Classification of Thailand 180 Sectors Input – Output Table

**Table A1** Structure and Classification of Thailand 180 Sectors Input – Output Table

| Code | Sector | Description |
|---|---|---|
| 001 | Paddy | This sector covers the combined the production of both glutinous and no glutinous paddy. The by-product is straw. |
| 002 | Maize | This sector covers the combined the production of fresh, dried and young maize includes by-product. |
| 003 | Other cereals | Production in this sector combines sorghum and barley includes by-product. |
| 004 | Cassava | The only product included in this sector is fresh cassava roots. |
| 005 | Other root crops | The potato, sweet potato, taro root and root-crops not mentioned elsewhere |
| 006 | Beans and nuts | This sector covers beans and nuts of all kinds such as mung bean, castor seed, kindney bean, red bean, sesame and ground nut. |
| 007 | Vegetable | Vegetable such as chili, ginger, Chinese radish, onion, shallot, garlic, cabbage, tomato and other vegetables not mentioned elsewhere are included in this sector. |
| 008 | Fruits | This sector includes the production of oranges, grapes, durians, rambutans, mangoes, pineapples, water melons, bananas, mangosteens, pomeloes, longens, jack fruits, lychees and other fruits not mentioned elsewhere. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 009 | Sugar cane | The product included in this sector is sugar cane which was consumed by household and put to industrial. |
| 010 | Coconut | Fresh coconut is the main product of this sector. Coconut leaf, coconut fiber, copra and coconut shell are the by-product. |
| 011 | Oil palm | Production in this sector combines oil palm and palm lily includes by-product. |
| 012 | Kenaf and jute | This sector covers the production of kenaf, jute and ramie. |
| 013 | Other crops for textile and matting | This sector includes the fiber and seed of kapok and other fiber crops. |
| 014 | Tobacco | Fresh tobacco leaf and seed are the two main agricultural products of this sector. Production is classified into Virginia Barley, Turkish and Native varieties. |
| 015 | Coffee and tea | This sector covers the production of all fresh coffee bean, tea leaf and cocoa. |
| 016 | Rubber | Latex from the rubber tree is the main product of this sector. |
| 017 | Other agricultural product | This sector covers flowers and seed of all kinds, including sunflower seed, ornamental plants, horse tamarind, mint and the like. |
| 018 | Cattle and buffalo | This sector covers the production of cattle and buffalo for slaughter, export and breeding. Also included in this sector is fresh milk for dairying. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 019 | Swine | The only product included in this sector is swine. |
| 020 | Other livestock | Goat, sheep, horse, rabbit, crocodile, elephant and others are covered under this sector. |
| 021 | Poultry | This sector covers the production of chickens, ducks and geese. |
| 022 | Poultry products | The product covered by this sector is egg derived from raising fowl. |
| 023 | Silk worm | This sector includes the products of silk-worm and silk cocoons. |
| 024 | Agricultural services | This sector covers the plough services using both animals and tractors. |
| 025 | Logging | This sector includes logs of all kinds such as teak, yang, etc. |
| 026 | Charcoal and fire-wood | This sector covers the production of charcoal and firewood. |
| 027 | Other forest products | Products of this sector are bamboo, bamboo shoot, rattan and other forest products. |
| 028 | Ocean and coastal fishing | Covered in this sector are ocean fishing, coastal fishing and coastal fish-cultivation. |
| 029 | Inland fishing | This sector covers the activities of both inland fish catching and cultivation. |
| 030 | Coal and lignite | This sector includes establishments primarily engaged in mining coal and lignite. |
| 031 | Petroleum and natural gas | This sector covers the exploration activities for crude petroleum and natural gas, the drilling, completing and equipping of wells carried out on an own-account basis, and the operation of oil and natural gas wells. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 032 | Iron ore | This sector includes activities primarily involving the extraction and extraction and dressing and dressing of iron ore. |
| 033 | Tin ore | The coverage of this sector includes activities involving in extracting and dressing of tin ore. |
| 034 | Tungsten ore | This sector includes activities involved in extraction and preparing tungsten ore. |
| 035 | Other non-ferrous metals | This sector includes activities involved in extraction and dressing non-ferrous ore, such as antimony, chromite, columbite, copper, manganese, monazite, tantalite, zenotize, zinc, zircon and lead ore. |
| 036 | Fluorite | This sector covers the activities of exploring for and extraction of fluorite. |
| 037 | Chemical fertilizers | Covered in this sector are activities related to the mining or other extraction of mineral such as fluorite, phosphate and nitrate mineral. |
| 038 | Salt | Covered in this sector are activities related to extraction of rock salt and the production of salt from sea water. |
| 039 | Limestone | This sector primarily covers the activity involved in the extraction of limestone. |
| 040 | Stone quarrying | This sector covers the activities of stone quarrying, clay extraction, gravel and sand pit operation, clay pit operation, and marble mining. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 041 | Other mining and quarrying | Excluding stone quarrying, this sector covers activities of mining and other quarrying of produce such as asbestos, calcite, diatomite, dolomite, feldspar, gypsum, marl quartz, silica sand and jewelry stone. |
| 042 | Slaughtering | This sector covers the activity of slaughter-houses and products such as fresh meat, pork, chicken and duck. Also included are hides of cattle and buffalo, feathers of chicken and duck, buffalo horns and other by-products of cattle, buffalo, swine, chicken and duck. |
| 043 | Canning and preserving of meat | This sector covers the activity of canning and preserving meat, and the preparation of ham, and sausage. |
| 044 | Dairy products | This sector covers pasteurized milk, condensed milk, cream, butter, cheese, margarine and ice cream. |
| 045 | Canning and preservation of fruit and vegetables | This sector covers dried and frozen fruits, canned and bottled fruits and vegetables, fruit and vegetable juice, jam, jellies and others. |
| 046 | Canning and preservation of fish and other sea foods | This sector covers frozen fish, salted and dried fish and preserved fish. |
| 047 | Coconut and palm oil | This sector covers coconut oil. palm oil, coconut cake and palm cake. |
| 048 | Animal oil, animal fat, vegetable oil and by-products | The products are lard, animal fat, soy-been oil, cotton-seed oil, kapok-seed oil, sunflower-seed oil, rice-bran oil, other vegetable oil, and their by-products. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 049 | Rice milling | This sector covers production of husked-cleaned-polished rice, parboiled rice, broken rice, rice bran and rice husk. |
| 050 | Tapioca milling | This sector covers milled products of cassava of all kinds such as tapioca flour, tapioca chips and tapioca pellets. |
| 051 | Grinding of maize | This sector covers maize milling activities such as the grinding corn, corn cob and other maize products. |
| 052 | Flour and other grain milling | This sector covers the activity of flour and other grain milling. |
| 053 | Bakery products | This sector covers all bakery products such as bread, cake, pies, crackers. |
| 054 | Noodles and similar products | Covers in this sector are noodles of all kinds such as yellow noodles, white noodles made from rice flours, spaghetti, macaroni, etc. Also included in this sector is the production of instant noodles. |
| 055 | Sugar | This sector covers and refined sugar made from sugar-cane and coconut tree as well as the by-products of sugar such as syrup, molasses and bagasse. |
| 056 | Confectionery | Candies, chocolate, chewing gum and other confectioneries are covered by this sector. |
| 057 | Ice | Ice is the sole product of this sector. |
| 058 | Monosodium glutamate | Monosodium glutamate is covered in this sector. |
| 059 | Coffee and tea | This sector covers the activities involved in the processing of coffee and tea. The productions covered by this sector are coffee and tea powers, instant coffee and tea as well as roasted coffee beans and tea leaves. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 060 | Other food products | This sector includes soy sauce, bean curd, fish sauce, vinegar, salted and fermented eggs, spices, table salt, other sauces and other prepared food. |
| 061 | Animal feed | Covered in this sector is the production of all kinds of animal feed such chicken feed, fish meal. |
| 062 | Distilling and spirits blending | This sector covers brandy, liqueurs and wine. |
| 063 | Breweries | Malt and beer are included in this sector. |
| 064 | Soft drinks and carbonated water | This sector covers soda water, carbonated fruit drinks, distilled water and the other soft drinks. |
| 065 | Tobacco processing | This sector covers the activities of tobacco-leaf processing. Only dried tobacco-leaf is included in this sector. There are four kinds of dried tobacco-leaf, i.e., Virginia, Burley, Turkish and Native. |
| 066 | Tobacco products | This sector consists of cigar, cigarettes, cut tobacco and chewing tobacco. |
| 067 | Spinning | This sector includes cotton, synthetic silk yarn, spun, short and long synthetic staple. Excluded from this sector are yarns from jute and kenaf. |
| 068 | Weaving | Covered in this sector are cotton fabrics, mixed-cotton fabrics, synthetic fabrics and silk fabrics. Jute and kenaf fabrics are not included here. |
| 069 | Textile bleaching, printing and finishing | This sector covers the activities of printing, bleaching and finishing textile. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 070 | Made-up textile goods | This sector covers all textile processed products not classified elsewhere. Products included are household textile furnishing materials, textile bags, canvas products, lace and lace products, textile-coated fabrics, felt and felt products and textile wadding material. |
| 071 | Knitting | Covered in this sector are knitted fabrics and products from knitted fabrics. Knitting products made directly from yarn such as stocking are also included. |
| 072 | Wearing apparel | This sector covers the products of wearing apparel and allied clothing produced in factory, except woven products such as handkerchiefs, neckties, shawls and veils Excluded are all kind of wearing apparel made by tailors. |
| 073 | Carpets and rugs | This sector covers only the products of carpets and rugs made from textile materials. Carpets and rugs from straw or material other than textile were not included. |
| 074 | Jute mill products | Covered in this sector are products made from kenaf and jute. Other products included are yarn and fabrics of kenaf and jute except for those used in gunny bags. However, fishing nets made from materials of all kinds are included in this sector. |
| 075 | Tanneries and leather finishing | The tanning and finishing of animal leather and skin are included in this sector. Excluded are all kinds of artificial leathers. |
| 076 | Leather products | Leather and artificial leather products are covered in this sector. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 077 | Footwear, except of rubber | This sector covers footwear made of leather, fabrics and other materials. It excludes that wholly made of wood or moulded rubber or plastic. |
| 078 | Saw mills | This sector covers sawn timber and other wooden construction materials such as plywood and chip board. |
| 079 | wood and cork products | Except for furniture and fixtures, this sector covers products made from wood, rattan and bamboo such as wooden boxes and containers. Also included are handicraft utensils, articles and parts of equipment which can be commonly installed in different kinds of equipments. |
| 080 | Wooden furniture and fixtures | This sector covers all kinds of furniture and fixtures except those made of metal. |
| 081 | Pulp, paper and paperboard | This sector covers pulp, paper and paperboard. |
| 082 | Paper and paperboard products | This sector included all kinds of paper and paperboard products such as paper boxes, book covers, writing-pads, envelopes, labels, paper bags and sanitary paper. Publishing house production such as books magazines and newspapers are not included. |
| 083 | Printing and publishing | This sector covers printing activities by one or more of the common processes such as the use of the letter-press, lithographing, offset printing and bookbinding. Also included are the publishing of newspapers, periodicals, books and maps. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 084 | Basic industrial chemicals | This sector covers the manufacture of basic industrial chemicals such as hydrogen, oxygen, nitrogen, chlorine, sulfur and other chemical elements; inorganic acids and other oxygen compounds of metalloids such as hydrochloric acid, sulfuric acid, nitric acid and carbon dioxide; inorganic bases and metallic oxides such as ammonia and caustic soda; salts of inorganic acids such as aluminum sulfate, potassium nitrate, soda ash, sodium silicate and calciumhypochloride; carbides; and organic chemicals such as methylalcohol, polyhydric alcohols, esters of polyhydric alcohols, acetic acid and aldehydes. |
| 085 | Fertilizer and pesticides | The products of this are urea, ammonium sulfate, phosphate, chemical fertilizer, organic fertilizer, pesticides and insecticides. |
| 086 | Petrochemical products | This sector covers the activities involved in the processing of petrochemical. The productions covered by this sector are upstream production such as Ethylene, Propylene; intermediate production such as Vinyl chloride monomer, Styrene monomer and downstream production such as Polyvinyl chloride, Polyethylene, etc. |
| 087 | Paints | This sector covers the manufacture of paints, varnishes, stains and shellac, lacquers, enamels and japans. Also included are the manufacture of allied products such as composite thinners, paint removers, paint brush cleaners, putty and other coating and filling material. Dyes, organic and inorganic pigments are not included. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 088 | Drugs and medicines | This sector includes the production of drugs and medicines in all forms such as tables, capsules, powder, syrup and liquids for injection. Traditional medicine such as herbs is also included. |
| 089 | Soap and cleaning preparations | This products includes in this sector are soap, detergent, shampoo, glycerine and toilet preparation. |
| 090 | Cosmetic | This sector includes the production of perfumes, cosmetic, hair cream, toothpaste, talcum powder and deodorant. |
| 091 | Matches | This sector covers matches of all kinds. |
| 092 | Other chemical products | Included in this sector are the manufacture of chemical products such as furniture and metal polishes, leather polishes, waxes, adhesive and glues, candles, inks, carbon black and essential oil. Also included are tanning and dyeing material such as natural indigo, vegetable dye, tanning agents and inorganic pigments. Wood chemicals such as gums and incense products such as joss sticks are also covered. |
| 093 | Petroleum refineries | This sector covers oil-processing refineries. The products if this sectors are gasoline, jet oil, LPG, asphalt, paraffin, sulfur, kerosene, diesel and fuel oil. |
| 094 | Other petroleum products | This sector covers refined oil, refined grease and lubricating oil |
| 095 | Rubber sheet and block rubber | This sector covers rubber sheets, block rubber, crepe rubber and other processed rubber. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 096 | Types and tubes | This sector covers all types and tubes such as those for passenger car, truck and bus, tractor, motorcycle and bicycle. |
| 097 | Other rubber products | This sector covers the manufacture of rubber products not classified elsewhere such as rubber raincoats, rubber gloves, rubber bags, rubber mats, rubber toys, rubber bands, rubber hose and tubes, rubber bottles and rubber sponges. |
| 098 | Plastic ware | This sector covers the moulding, extruding and fabricating of plastic articles such as plastic household articles, plastic containers and cups, plastic mats, laminated sheets. Also included are plastic components for insulation, plastic furniture, and plastic industrial supplies. |
| 099 | Ceramic and earthen ware | The sector covers pottery, ceramic and earthenware for industrial and construction use. Sanitary supplies are also included. |
| 100 | Glass and glass products | This sector consists of window flat glass, bottles, drinking glasses, lamp chimneys and other. |
| 101 | Structural clay products | This sector covers bricks, tiles pipes, refractory bricks and other similarly structural clay products. |
| 102 | Cement | This sector consists of portland cement, white cement and lime. |
| 103 | Concrete and cement products | This sector covers the manufacture of concrete products such as blocks, posts and piles, precast elements for prefabricates construction materials, other reinforced and pre-stressed concrete products as well as Buddha images and spirit houses. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 104 | Other non-metallic products | Included in this sector are the manufacture of gypsum plaster products, wood-wool board (cellocrete) and other asbestos product. Cut stone products which were not produced in conjunction with quarrying and all other non-metallic mineral products not classified elsewhere are also included. |
| 105 | Iron and steel | The sector covers pig iron, ingot, ferro-silicon, ferro-manganese and (by-product of pig iron). |
| 106 | Secondary steel products | The products of this sector are galvanized sheet, tin plate, angle bar and rod wire, tube and pipe. Steel forging, steel casting, polished steel are also included. |
| 107 | Non-ferrous metal | This sector covers the activities relating to the manufacture of primary non-ferrous metal products consisting of primary and secondary smelting, alloying, refining, rolling and drawing, founding and casting. |
| 108 | Cutlery and hand tools | This sector covers the manufacture of table, kitchen and other cutlery, hand and edge tools such as axes, sickles, shovels, rakes and other agricultural and garden tools, hammers, screw drivers, files and handsaws. Plumbers', masons', mechanics' and machinists' precision hand tools, hinges, locks key sets, builders' hardware and marine luggage and vehicles hardware are also included. |
| 109 | Metal furniture and fixtures | This sector covers the manufacture and alteration of furniture and fixtures consisting primary of metal for household, office, public building, transport equipment, professional and restaurant uses. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 110 | Structure metal products | This sector covers the manufacture of steel or other metal structure components such as bridges, tanks, building structure, doors and screens, window frames and sashes, shutter, staircases, wrought iron gates. Other architectural metalwork such as metal components for ventilating and air-conditioning systems as well as steam and water-tanks are also included. |
| 111 | Other fabricated metal products | This sector covers the manufacture of fabricated metal products such as metal cans from tinplate, enameled sheet metal, metal conveyances, metal shipping containers, metal stamping, fabricates wire and wire products from purchased wire rods (excluding insulated wire and cable). Sanitary ware, plumbers' brass good, pipe fittings, enameling, lacquering, galvanizing, electroplating and polishing metal products and a variety of metal products not classified elsewhere are also included. In addition, the sector covers common machinery part such as bearing an spring, except specialized parts for motor vehicles, aircraft and ships which belong to their respective machinery sectors. |
| 112 | Engines and turbines | This sector covers the assembling of stream engines, other engines and turbines. Also included are the parts and repair of engines and turbines. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 113 | Agricultural machinery and equipment | This sector covers the assembling of cultivating machines and equipment, sawing and planting machines, harvesting machines and equipment. parts and repair of agricultural machines and equipment. |
| 114 | Wood and metal working machines | This sector covers the activities relating to the assembling of wood and metal working machines such as sawing machines, and the parts and repairing of such machines. |
| 115 | Special industrial machinery | This sector covers all kinds of industrial machines except those used for wood and metalworking, agricultural machines as well as electrical machines. Machinery included in the sector is for example, construction and mining machines, food and chemical machines, leather and textile machines, etc. Also included in this sector are pneumatic tools, carrying and loading equipment such as cranes, forklifts and loading trucks, etc. Parts of such machinery and their repair are also included. |
| 116 | Office and household machinery and appliances | This sector covers the assembling of office and household machinery and appliances such as air conditioners, refrigerator, freezers, water cooler, sewing machines, typewriters, electric calculators and all parts. Since the repair of them are not covered in this sector. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 117 | Electrical industrial machinery and appliances | This sector covers the products of electrical industrial machinery and appliances such as generators, transformer, rectifiers, motors, electrical hand tools, electrical motors, electrical welding machines and other electrical machines. Parts for these machines are also are also included. |
| 118 | Radio, television and communication equipment and apparatus | This sector covers the assembly of radios, television sets, tape and cassette recorders, stereo components, telephone and other communication equipment. Also included are their parts but repairing is excluded. |
| 119 | Household electrical appliances | This sector covers the production of household electrical appliances such as electric stoves, electric iron, electric fans, rice cooker, toasters, food mixers and all their parts. |
| 120 | Insulated wire and cable | This sector covers the production of insulates wire and cable. |
| 121 | Electric accumulators and batteries | This sector covers the production of batteries and dry cells Parts such as lead plate are also included |
| 122 | Other electrical apparatus and supplies | This sector covers electrical apparatus and supplies not classified elsewhere, such as electric bulbs, and related light sources. Other products included are conductors, fuses, connectors, etc. |
| 123 | Ship building and repairing | Covered in this sector are the building and repairing of ship, boat and other water transport vessels. Part for these vessels are also included in the sector. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 124 | Railroad equipment | This sector covers the production of railroad passenger cars and wagons. The parts and repairs of such equipment are also included in the sector. |
| 125 | Motor vehicles | This sector covers the production and assembly of motor vehicles. The products included are passenger cars, trucks, vans, pick-up, buses and the classis and parts of such vehicles. |
| 126 | Motor vehicles | The products of this sector are motorcycles, tricycles, bicycles, carriages and parts for such products. |
| 127 | Repair of motor vehicles | This sector covers automobile and motorcycle repair of all kinds. |
| 128 | Aircraft | This sector covers only aircraft repairing |
| 129 | Scientific equipment | The sector covers measuring equipment, medical equipment and the parts and repairs of such equipment. |
| 130 | Photographic and optical goods | This sector included optical goods, spectacles, telescopes, astronomical, instrument, microscopes, projectors, cameras, photo copying apparatus and parts for these products. |
| 131 | Watches and clocks | This sector covers the production and assembly of clocks and watches. |
| 132 | Jewelry and related articles | This sector covers activities primary related to the manufacturing of jewelry using precious metals, precious and semi-precious stones and pearls, silverware and plotted ware using silver, gold and other precious metal plating. The cutting and polishing of precious stones and the making of coins and medals from precious metal are also included. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 133 | Recreational and athletic equipment | The products in this sector include musical instruments, music recording, footballs, golf balls, badminton rackets, boxing gloves and other recreational and athletic equipment. |
| 134 | Other manufactured goods | This sector covers the products that have been excluded from the manufacturing sectors by code 042 to 133. The main products of this sector are stationary, toys, umbrella, zippers, buttons, fasteners, etc. |
| 135 | Electricity | This sector covers the generation, transmission and distribution of electric for sale to household, industrial, commercial and public users. Electricity generation plants owned by manufacturing enterprises for their own use are also included. |
| 136 | Pipe line and gas distribution | This sector covers gas distribution such as LPG, ethane, propane, natural gasoline (NGL). |
| 137 | Water work and supply | This sector covers the activities related of the purification and distribution of water to household, industrial, commercial and public users. The operation of irrigation system is not included in this sector. |
| 138 | Residential building construction | This sector covers the construction of new building for residential purposes such as homes, sop houses, apartment and dormitories. The activities of extending, repairing, painting and decorating buildings as well as the installation of electricity and air conditioning systems are also included. Excluded from this section is the cost of acquiring land. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 139 | Non-residential building construction | This sector covers the construction of new non-residential building such as business building, factories, hotels, school, hospitals, and warehouse as well as related activities of extension and repair. Excluded are the constructions of railway station, power station or communication plants. |
| 140 | Public works for agriculture and forestry | This sector covers the construction and extension of irrigation works for agriculture and forestry. Only new construction is included. |
| 141 | Non-agriculture public works | This sector covers the construction and repair of highway, streets, roads, bridges, airports, water supplies and sewage systems. |
| 142 | Construction of electric plants | This sector covers the construction and repair of electricity generating plants and transmission systems. |
| 143 | Construction of communication facilities | This sector covers the construction and repair of broadcasting and communication systems such as radio station, town telephone installation and other facilities. |
| 144 | Other construction | This sector covers the construction work not classified elsewhere such as the construction of public parks, parking lots, golf courses, tennis courts, swimming pools and athletic fields of all kinds. |
| 145 | Wholesale trade | This sector includes establishments for the re-sale of new and used goods to retail, industrial, commercial, institutional and professional outlets, as well as for other wholesale uses. Agents engaged in buying or selling merchandise are also covered in the sector. The principal type of business included are wholesale |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| | | merchants engaged in own-account buying and selling, industrial distributors, exporters and co-operative buying associations and sales offices maintained by mining or manufacturing enterprises for the purpose of marketing their products. Also included are co-operative associations engaged in the marketing of farm produce, scrap metal and waste dealers, junk yards, wholesalers who sort and grade goods in large lots wholesale packers, bottling companies except those engaged in packing or bottling in airtight containers. |
| 146 | Retail trade | This sector included establishments engaged in the sale to the general public of new and used goods for personal or household consumption. Retailing establishments include shops, department stores, stalls, gasoline service stations, retail motor vehicle dealers, peddlers, consumer co-operatives, and auction houses. Included also are own-account retailers who act as agents, buying and selling on consignment or on a commission basis. Establishments engaged in selling displayed merchandise such as typewriters, stationary and petrol to the general public are classified in this group though these goods may not be for personal or household uses. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 147 | Restaurants and drinking places | The sector includes establishments engaged in selling prepared food or drink for immediate consumption such as nightclubs, restaurants, bard, coffee shops, etc. Also included are canteens and eating facilities in plants and offices. Restaurants operated by hotels and massage parlors for the general public are also included. Peddlers of food and noodle stands are also covered in this sector. |
| 148 | Hotels and places of loading | This sector includes establishments engaged in the provision for fee of lodging and camping facilities, whether open to the general public or restricted to members of a particular organization. Related restaurant facilities operated for the purpose of serving the establishment's customers are also included. |
| 149 | Railways | This sector covers the service related to the transportation of both passengers and cargo. Also included are dining car services. Since the repair of railway equipment is not covered in this sector. |
| 150 | Road passenger transport | This sector covers only the transport of passengers by taxicabs, buses, inter-city buses and other vehicles such as tricycles. Private vehicles for personal transportation are excluded. |
| 151 | Road freight transport | This sector cover local and long distance trucking. Also included are such services for one's own business purposes. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 152 | Land transport support service | This sector includes all land transport support services such as the operation of parking lots, toll roads rental of automobiles and self-driven trucks. |
| 153 | Ocean transport | This sector covers the ocean transport of both passengers and freight. |
| 154 | Coastal and inland water transport | This sector refers to the operation of freight and passenger vessels along various parts of the coast of Thailand. Those operated on inland waterways, river ferries and tugboats are included. |
| 155 | Water transport services | Included in this sector are the provision of supporting services for water transport of all kinds such as the maintenance and operation of harbors, docks, lighthouses and other navigation aids, loading and unloading services, the salvaging of vessels, ship leasing and rental. Included in this sector are the activities of the Port Authority of Thailand. |
| 156 | Air transport | The transportation of passengers and freight by air by regular services or by charter are covered in this sector. The operation of airports, landing fields and navigational facilities such as flight control centers, radar stations and the rental of aircraft are also included in the sector. |
| 157 | Other services | This sector covers the activity of establishments engaged in providing travel information and arranging tours and transportation for passengers. The activities of establishments engaged in cargo transportation are also covered. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 158 | Storage and warehousing | This sector covers the operation of storage facilities and warehouse. Silo services for drying maize are also included. |
| 159 | Post and telecommunication | This sector covers the services of central and provincial offices of the Telephone Organization of Thailand. Construction and radio-communication activities of the Post and Telegraph Department are not included. |
| 160 | Banking services | This sector covers all activities of monetary and financial institutions. Included are the central bank, commercial banks, development banks, saving bank, rural banks, pawnshops, credit cooperatives and foreign exchange dealers. |
| 161 | Life insurance services | Life insurance is defined as the activities of life insurance institutions and related services. |
| 162 | Other insurance services | This sector covers all insurance other than life such as fire, accident, marine and health insurance. |
| 163 | Real estate | This sector covers the activities of real estate agents and brokers |
| 164 | Business services | The sector includes service such as accounting, auditing and book-keeping services, data processing and tabulating services, engineering, architectural and technical services, parliament and the judicial authorities. |
| 165 | Public administration | The sector covers the central, provincial and local government, as well as the royal household, parliament and the judicial authorities. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 166 | Sanitary and similar services | This sector covers the activities related to sanitary and similar services such as garbage and sewage disposal, the operation of drainage systems and the purification of water for consumption. Also included are cleaning services |
| 167 | Education | This sector covers all public and education institution at all levels such as kindergartens, primary schools, secondary schools, colleges and universities. Also included are vocational schools and others providing specialized education such as language and painting schools. Research institute, hospitals belonging to universities, as well as education provided neither by government nor household are not included. |
| 168 | Research | This sector includes institutions primarily engaged in basic and general research in the biological, physical and social sciences. Since information on private research institutes in Thailand are not available, only research accomplished by government offices, universities and public enterprises are included. |
| 169 | Hospital | Covered in this sector are medical, surgical, dental and other health services. This includes hospitals, sanitariums, nursing homes and similar institution, maternity and child welfare clinics, consulting offices of physicians, surgeons and other medical practitioners such as dentists, the services of midwives and nurses in private practice ambulance service and medical and dental laboratories that provide testing, diagnostic and other service to the medical and dental |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| | | professions. Activities primary relating to the manufacture of dental supplies and artificial teeth to order are also included. |
| 170 | Business and labor associations | This sector includes private business institution such as the Board of Trade of Thailand, the Thai Chamber of Commerce, The Association of Thai industries and professional organizations such as the Engineering Institute of Thailand, labor unions and labor organization. |
| 171 | Other community service | This sector includes institution engaged in providing social welfare services such as the Red Cross Society and other organization for the collection and allocation of charitable contribution such as children and societies, dry nurseries, orphanages, home for destitute adults, homes for handicapped person, home for aged, family welfare society and other charitable organization. This section was classified broadly into three types of organizations, namely, Red Cross Society, other charitable organizations and religious organizations. |
| 172 | Movie theatres | This sector covers the activities relating to the production of motion pictures for showing. They also include both still and slide films. Other related services such as film developing, printing, film editing, titling, copying and distributing of both local and foreign films are also included. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 173 | Movie theatres | All theatres and movie houses are covered in this sector. |
| 174 | Radio, television and related services | Included in this sector are radio and television stations primarily engaged in the production and dissemination of audiovisual programs for the public. The activities of television and radio relay stations are also included in this sector. |
| 175 | Libraries and museums | This sector covers the operation of libraries, information centers, archeological and others museums, art galleries, botanical and zoological gardens and similar institutions. |
| 176 | Amusement and recreation | This sector covers the activities of theatres providing theatrical presentation such as classical drama, dance and concerts, entertainment services such as those provided by bands and orchestras and musical recording. This sector also includes the services related to theatrical presentation such as those provided by booking agencies for plays. Self-employed artists and instructors such as actors, dancers, musicians, singer and other entertainers and producers for radio and television programs, motion picture, play and other presentations, composers and song writers, authors, painters and operators of dance halls, bowling alleys, billiard and pool rooms, race tracks, boxing stadiums, football fields, sports clubs, gymnasiums, tennis courts and golf courses, sport promoters, operators, of amusement parks and renters of pleasure boats, motorcycles, golf carts, saddle. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| | | horses and similar recreation goods are also included in this sector. |
| 177 | Repair not classified elsewhere | This sector included establishments specialized in the repair of household appliances, equipment and furnishing, motor cars and other consumers goods which are not classified elsewhere. Also included in this sector are establishments specialized in the installation of household appliances such as stoves and ranges, refrigerators, air-conditioning apparatus and television sets. |
| 178 | Personal service | This sector included establishments primarily engaged in washing, ironing, dry cleaning, pressing and dyeing apparel, house furnishing or household fabrics. The repair of clothing, bedspreads, blanket, curtains and other personal and household textiles are also included in this sector. This sector also included the services of maids, cooks, gardeners, caretakers and other maintenance workers for household, whether provided by individuals who are employed by these households or by business units primarily engaged in furnishing these services. In addition, establishments engaged in rendering personal care and services not classified elsewhere such as barber hairdressing and beauty shop, photographic studios, Turkish baths establishments, massage parlors and crematories are also included. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 179 | Other service not classified elsewhere | This sector included all service that are not covered by other sectors. |
| 180 | Unclassified | This sector includes mainly activities not classified elsewhere. |
| 190 | Total intermediate transactions | This is the sum of sectors 001 to 180 |
| 201 | Wages and salaries | This sector covers compensation by employers to employees both in cash and in kind. Employees are classified as long-term workers, temporary workers, temporary workers, executives and hired laborers in the agricultural sector, but not family workers. |
| 202 | Operating surplus | The operating surplus is defined as the total value added including business income tax, minus wages and salaries, depreciation and indirect taxes, less subsidies. |
| 203 | Depreciation | Depreciation consists of capital consumption allowances for all fixed assets. The imputation of depreciation of government buildings is describe in the public administration sector and that of self-occupied dwellings is in real estate sector. The depreciation on fixed assets for leasing such as computers is shown in the sector of owner of fixed assets for leasing such as computers is show in the sector of owner of fixed assets. |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 204 | Indirect taxes less subsidies | Indirect taxes cover the domestic commodity sales tax, export duty, licensing frees, service tax of hotels, restaurant and the like, duty stamps and special commodity tax such as those on automobiles, electrical equipment, alcoholic drinks, cigarettes, petroleum products, ect. |
| 209 | Total value added | This is sum of all the primary inputs from 201 to 204. |
| 210 | Control total | This is sum of total intermediate transactions and value added. |
| 301 | Private consumption expenditures | Private consumption expenditures are the current expenditures on goods and service by households and private non-profit organizations. The expenditure also cover the expenditures of Thai nationals abroad as tourists and the expenditures of the family of a foreigner who is working for a private company or a non-profit organization in Thailand. |
| 302 | Government consumption expenditure | Government consumption expenditures cover all current expenditures of government for goods and services, including those for the police and military forces. Expenditures of Royal household are also included. However, consumption expenditures of public enterprises which are profit-making are not included. |
| 303 | Gross domestic fixed capital formation | Gross domestic fixed capital formation includes fixed assets such as land, buildings, machinery and equipment belonging to households, government and private enterprise except those for military use. Public infrastructure such as roads, dams and power stations |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| | | are also included. However, installation costs of equipment and machinery are not covered. |
| 304 | Increase in stock | Stocks or inventories comprise the followings : finished products stored in producers' factories or warehouses, unused raw materials purchased by producers, semi-processed products and products on processing lines and marketable stocks held by wholesalers and retailers. Stocks kept by households are not included. |
| 305 | Export | In the input-output table at purchasers' prices, exports were valued at f.o.b. prices. As for producers' prices, exports were valued by subtracting trade margins and transport costs from f.o.b. process. |
| 306 | Special exports | Special exports cover non-merchandised goods and services which are not included in the official export statistics. Item which are included here are freight and insurance related to export, expenditures of foreign tourists in Thailand and related transportation cost, expenditures of foreign government organization, international organizations and families of diplomats, expenditures of foreign military bases, other service charges which are paid by foreigners and estimated smuggling. |
| 309 | Total final demand | This is the sum of codes 301 to 306. |
| 310 | Total demand | This is the sum of codes 190 and 309 |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 401 | Imports | Imports were valued at c.i.f. process plus tariff. However, for valuation at domestic producers' prices, the transport costs and insurance paid by the Thai importers were subtracted in order to avoid double counting. A special treatment was used here. The redundant transport costs and insurance were regarded as special exports and are treated in the special export sector. |
| 402 | Import duty | Customs duty on imports is included under this code. |
| 403 | Import tax | The Import tax includes both import sales tax and municipal tax on imported. |
| 404 | Special imports | As in the case special exports, special imports are non-merchandised goods and services which are not covered in the official trade statistics, e.g. expenditures of Thai nationals abroad, expenditure of Thai government organizations and of the families of Thai diplomats outside Thailand and estimated smuggling into Thailand. |
| 409 | Total imports | This is the sum of codes 401 to 404 |
| 501 | Wholesale trade margin | Wholesale trade margin is margin of goods from factory toward retail trade. |
| 502 | Retail trade margin | Retail trade margin is margin of goods from retail toward household consumption. |
| 503 | Transport cost | The transport costs is value of transport goods process from factory toward consumer. |
| 509 | Total trade margin and transport costs | This is the sum of codes 501 to 503 |

**Table A1** (Continued)

| Code | Sector | Description |
|---|---|---|
| 600 | Control total | This is sum of total intermediate transactions and final demands which indicates the output distribution of the table and is equal to codes 190 + 309 + 409 +509. |
| 700 | Total supply | The total supply is equal to codes 600 – 409 – 509. |

# Appendix B

## GEMPACK Programming of a CGE Forecasting Model for 180 sectors for the Projection of Economic Impacts and $CO_2$ Emission Potential in Thailand Following Oil Price Slump in 2014

# Appendix B

## GEMPACK Programming of a CGE Forecasting Model for 180 sectors for the Projection of Economic Impacts and $CO_2$ Emission Potential in Thailand FollowingOil Price Slump in 2014

```
!------------------------------------------------------------------------!
! CGE Forecasting Model for 180 sectors                                  !
! for the PROJECTION OF ECONOMIC IMPACTS                                 !
! AND CO2 EMISSION POTENTIAL                                             !
! IN THAILAND FOLLOWING OIL PRICE SLUMP IN 2014                          !
!------------------------------------------------------------------------!

!-----------------!
!      SET        !
!-----------------!

SET SECT # Sectors # (s1-s180) ;
SET SOURCE # Source # (Domestic,Import) ;

!---------------------!
!   VARIABLE     !
!---------------------!

VARIABLE (all,i,SECT)(all,s,SOURCE) p0(i,s) # Commodity price # ;
VARIABLE (all,j,SECT) p01(j) # Labor Price # ;
VARIABLE (all,j,SECT) p02(j) # Capital Rent # ;
VARIABLE (all,j,SECT) p03(j) # Tax Rate # ;
VARIABLE (all,j,SECT) pz1(j) # Investment cost # ;
```

**VARIABLE** cpi1 *# Investment Price #* ;
**VARIABLE** cpi2 *# Consumer Price #* ;
**VARIABLE** cpi3 *# Government Price #* ;

**VARIABLE** (**all**,j,SECT) rp01(j) *# Real Labor Price #* ;
**VARIABLE** (**all**,j,SECT) rp02(j) *# Real Capital Rent #* ;

**VARIABLE** xr *# Exchange Rate #* ;

**VARIABLE** (**all**,i,SECT) pw1(i) *# Export Price #* ;
**VARIABLE** (**all**,i,SECT) pw2(i) *# Import Price #* ;
**VARIABLE** (**all**,i,SECT) v1(i) *# Export tax #* ;
**VARIABLE** (**all**,i,SECT) v2(i) *# Import Tax#* ;
**VARIABLE** (**all**,i,SECT) fx4(i) *# Shift export #* ;
**VARIABLE** (**all**,i,SECT) (**all**,j,SECT) (**all**,s,SOURCE) x0(i,j,s)
*# Breakdown produced inputs #* ;

**VARIABLE** (**all**,j,SECT) x01(j) *# Labor input #* ;
**VARIABLE** (**all**,j,SECT) x02(j) *# Capital input #* ;
**VARIABLE** (**all**,j,SECT) x03(j) *# Indirect taxes #* ;

**VARIABLE** (**all**,j,SECT) z01(j) *# Commodity supply and demand #* ;
**VARIABLE** (**all**,i,SECT) z02(i) *# Imports commodity i #* ;
**VARIABLE** (**all**,j,SECT) z1(j) *# Investment by sector #* ;
**VARIABLE** (**all**,i,SECT) (**all**,s,SOURCE) cx1(i,s) *# Investment by column #* ;

**VARIABLE** gdpi *# income side GDP #* ;
**VARIABLE** va1 *# Total labor input #* ;
**VARIABLE** va2 *# Total Capital input #* ;
**VARIABLE** va3 *# Total indirect taxes #* ;

**VARIABLE** gdpe *# expenditure side GDP #* ;
**VARIABLE** gdpr *# real GDP #* ;
**VARIABLE** gdpdf *# GDP deflator #* ;

**VARIABLE** c1 *# Total investment consumption #* ;
**VARIABLE** c1r *# Real Total investment consumption #* ;
**VARIABLE** c2 *# Total household consumption #* ;
**VARIABLE** c2r *# Real Total household consumption #* ;
**VARIABLE** c3 *# Total government consumption #* ;
**VARIABLE** c3r *# Real Total government consumption #* ;
**VARIABLE** (**all**,j,SECT) k0(j) *# Current capital stock #* ;

**VARIABLE** e *# Total exports #* ;
**VARIABLE** m *# Total import #* ;
**VARIABLE** (**change**) delBT *# Trade balance #* ;
**VARIABLE** (**change**) delDT *# Debt_GDP Ratio #* ;

**VARIABLE** (**all**,i,SECT) (**all**,j,SECT) (**all**,s,SOURCE) x1(i,j,s)

*# Breakdown investment #* ;
**VARIABLE** (**all**,i,SECT) (**all**,s,SOURCE) x2(i,s) *# Breakdown HH consumption #* ;
**VARIABLE** (**all**,i,SECT) (**all**,s,SOURCE) x3(i,s) *# Breakdown government #* ;
**VARIABLE** (**all**,i,SECT) x4(i) *# Exports commodity i #* ;
**VARIABLE** (**all**,i,SECT) (**all**,s,SOURCE) x5(i,s) *# Inventory commodity i #* ;
**VARIABLE** (**all**,i,SECT) x6(i) *# Special exports commodity i #* ;

**VARIABLE** (**change**) delFudge *# Forecast var #* ;
**VARIABLE** (**all**,j,SECT) f_accum(j) *# Cap shift #* ;
*!----------------------------------------!*
*! Read Files !*
*!----------------------------------------!*

```
FILE data2010 # Data # ;
FILE MDATA180 # Cap_accum # ;

!-----------------------------------------------!
!              COEFFICIENT                      !
!       base data , updates and reads           !
!-----------------------------------------------!

COEFFICIENT (all,i,SECT)(all,j,SECT) VDINPUT(i,j)
# Value domestic intermediate # ;
UPDATE(all,i,SECT)(all,j,SECT) VDINPUT(i,j)
= p0(i,"Domestic") * x0(i,j,"Domestic") ;

COEFFICIENT (all,i,SECT)(all,j,SECT) VMINPUT(i,j)# value import intermediate
# ;
UPDATE(all,i,SECT)(all,j,SECT) VMINPUT(i,j)
= p0(i,"Import") * x0(i,j,"import") ;

COEFFICIENT (all,j,SECT) VX01(j) # value labor inputs # ;
UPDATE (all,j,SECT) VX01(j) = p01(j) * x01(j);

COEFFICIENT (all,j,SECT) VX02(j) # value capital inputs # ;
UPDATE (all,j,SECT) VX02(j) = p02(j) * x02(j) ;

COEFFICIENT (all,j,SECT) VX03(j) # value indirect taxes # ;
UPDATE (all,j,SECT) VX03(j) = x03(j) ;

COEFFICIENT (all,i,SECT)(all,j,SECT) VDX1(i,j) # value domestic investment # ;
UPDATE (all,i,SECT)(all,j,SECT) VDX1(i,j)
= p0(i,"Domestic") * x1(i,j,"Domestic") ;
```

**COEFFICIENT** (**all**,i,SECT)(**all**,j,SECT) VMX1(i,j) *# value Import investment #* ;
**UPDATE** (**all**,i,SECT)(**all**,j,SECT) VMX1(i,j) = p0(i,*"Import"*) * x1(i,j,*"Import"*) ;

**COEFFICIENT** (**all**,i,SECT) VDX2(i) *# value domestic HH consumption #* ;
**UPDATE** (**all**,i,SECT) VDX2(i) = p0(i,*"Domestic"*) * x2(i,*"Domestic"*) ;

**COEFFICIENT** (**all**,i,SECT) VMX2(i) *# value Import HH consumption #* ;
**UPDATE** (**all**,i,SECT) VMX2(i) = p0(i,*"Import"*) * x2(i,*"Import"*) ;

**COEFFICIENT** (**all**,i,SECT) VDX3(i) *# value domestic government #* ;
**UPDATE** (**all**,i,SECT) VDX3(i) = p0(i,*"Domestic"*) * x3(i,*"Domestic"*) ;

**COEFFICIENT** (**all**,i,SECT) VMX3(i) *# value Import government #* ;
**UPDATE** (**all**,i,SECT) VMX3(i) = p0(i,*"Import"*) * x3(i,*"Import"*) ;

**COEFFICIENT** (**all**,i,SECT) VX4(i) *# value export #* ;
**UPDATE** (**all**,i,SECT) VX4(i) = p0(i,*"Domestic"*) * x4(i) ;

**COEFFICIENT** (**all**,i,SECT) VDX5(i) *# value domestic inventory #* ;
**UPDATE** (**all**,i,SECT) VDX5(i) = p0(i,*"Domestic"*) * x5(i,*"Domestic"*) ;

**COEFFICIENT** (**all**,i,SECT) VMX5(i) *# value Import inventory #* ;
**UPDATE** (**all**,i,SECT) VMX5(i) = p0(i,*"Import"*) * x5(i,*"Import"*) ;

**COEFFICIENT** (**all**,i,SECT) VX6(i) *# value special export #* ;
**UPDATE** (**all**,i,SECT) VX6(i) = p0(i,*"Domestic"*) * x6(i) ;
**COEFFICIENT** TINY *# Small Value #* ;
**FORMULA** TINY = 0.000001 ;

**COEFFICIENT** TINY2 *# Small Value 2 #* ;
**FORMULA** TINY2 = 0.000002 ;

**COEFFICIENT** TINY4 *# Small Value 4 #* ;
**FORMULA** TINY4 = 0.000180 ;

**COEFFICIENT** (**Parameter**)(**all**,i,SECT) GAM(i) *# Export elasticity #* ;
**READ** GAM **FROM FILE** mdata180 **HEADER** *"GAMM"* ;

*!----------!*

**READ** VDINPUT **FROM FILE** data2010 **HEADER** *"X0DO"* ;
**READ** VMINPUT **FROM FILE** data2010 **HEADER** *"X0IM"* ;

**READ** VX01 **FROM FILE** data2010 **HEADER** *"VA1"* ;
**READ** VX02 **FROM FILE** data2010 **HEADER** *"VA2"* ;
**READ** VX03 **FROM FILE** data2010 **HEADER** *"VA3"* ;

**READ** VDX1 **FROM FILE** data2010 **HEADER** *"DX1"* ;
**READ** VMX1 **FROM FILE** data2010 **HEADER** *"MX1"* ;
**READ** VDX2 **FROM FILE** data2010 **HEADER** *"DX2"* ;
**READ** VMX2 **FROM FILE** data2010 **HEADER** *"MX2"* ;
**READ** VDX3 **FROM FILE** data2010 **HEADER** *"DX3"* ;
**READ** VMX3 **FROM FILE** data2010 **HEADER** *"MX3"* ;
**READ** VX4 **FROM FILE** data2010 **HEADER** *"EXPD"* ;
**READ** VDX5 **FROM FILE** data2010 **HEADER** *"DX5"* ;
**READ** VMX5 **FROM FILE** data2010 **HEADER** *"MX5"* ;
**READ** VX6 **FROM FILE** data2010 **HEADER** *"EXPS"* ;
*!------ other coefficients and formulas---------!*
**ZERODIVIDE** (**NONZERO_BY_ZERO**) **DEFAULT** 0.000001;

```
COEFFICIENT (all,i,SECT) VZ01(i) # Total domestic demand # ;
FORMULA (all,i,SECT) VZ01(i) = SUM(j,SECT,[VDINPUT(i,j)+TINY])
+ SUM(j,SECT,[VDX1(i,j)+TINY]) + [VDX2(i)+TINY] + [VDX3(i)+TINY]
+ [VX4(i)+TINY] + [VDX5(i)+TINY] + [VX6(i)+TINY] ;

COEFFICIENT (all,i,SECT) VZ02(i) # Total demand import goods # ;
FORMULA (all,i,SECT) VZ02(i) = SUM(j,SECT,[VMINPUT(i,j)+TINY])
+ SUM(j,SECT,[VMX1(i,j)+TINY]) + [VMX2(i)+TINY] + [VMX3(i)+TINY]
+ [VMX5(i)+TINY] ;

COEFFICIENT (all,j,SECT) VSPLY(j) # Total supply # ;
FORMULA (all,j,SECT) VSPLY(j) = SUM(i,SECT,[VDINPUT(i,j)+TINY])
+ SUM(i,SECT,[VMINPUT(i,j)+TINY]) + [VX01(j)+TINY] + [VX02(j)+TINY]
+ [VX03(j)+TINY] ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) HX0(i,j,s)
# share X0 Supply # ;
FORMULA (all,i,SECT)(all,j,SECT) HX0(i,j,"Domestic")
= [VDINPUT(i,j) + TINY] / VSPLY(j) ;

FORMULA (all,i,SECT)(all,j,SECT) HX0(i,j,"Import")
= [VMINPUT(i,j) + TINY] / VSPLY(j) ;

COEFFICIENT (all,j,SECT) HX01(j) # Share X01 supply # ;
FORMULA (all,j,SECT) HX01(j) = [VX01(j) + TINY] / VSPLY(j) ;

COEFFICIENT (all,j,SECT) HX02(j) # Share X02 supply # ;
FORMULA (all,j,SECT) HX02(j) = [VX02(j) + TINY] / VSPLY(j) ;

COEFFICIENT (all,j,SECT) HX03(j) # Share X03 supply # ;
FORMULA (all,j,SECT) HX03(j) = [VX03(j) + TINY] / VSPLY(j) ;
```

```
COEFFICIENT (all,j,SECT) VFAC(j) # Total primary factor # ;
FORMULA (all,j,SECT) VFAC(j) = [VX01(j) + TINY] + [VX02(j) + TINY] ;

COEFFICIENT (Parameter) (all,j,SECT) SFAC1(j) # Share X01 Primary # ;
FORMULA (Initial)(all,j,SECT) SFAC1(j) = [VX01(j) +TINY] / VFAC(j) ;

COEFFICIENT (Parameter) (all,j,SECT) SFAC2(j) # Share X02 Primary # ;
FORMULA (Initial)(all,j,SECT) SFAC2(j) = [VX02(j) +TINY] / VFAC(j) ;

COEFFICIENT VA_1 # Total VA1 # ;
FORMULA VA_1 = SUM(j,SECT,[VX01(j)+TINY]) ;

COEFFICIENT VA_2 # Total VA2 # ;
FORMULA VA_2 = SUM(j,SECT,[VX02(j)+TINY]) ;

COEFFICIENT VA_3 # Total VA3 # ;
FORMULA VA_3 = SUM(j,SECT,[VX03(j)+TINY]) ;

COEFFICIENT (all,j,SECT) S01(j) # Share VA1 # ;
FORMULA (all,j,SECT) S01(j) = [VX01(j) + TINY] / VA_1 ;

COEFFICIENT (all,j,SECT) S02(j) # Share VA2 # ;
FORMULA (all,j,SECT) S02(j) = [VX02(j) + TINY] / VA_2 ;

COEFFICIENT (all,j,SECT) S03(j) # Share VA3 # ;
FORMULA (all,j,SECT) S03(j) = [VX03(j) + TINY] / VA_3 ;

COEFFICIENT VGDPI # Income GDP # ;
FORMULA VGDPI = VA_1 + VA_2 + VA_3 ;
```

```
COEFFICIENT H01 # Share ZVA1 # ;
FORMULA H01=VA_1 / VGDPI ;

COEFFICIENT H02 # Share ZVA2 # ;
FORMULA H02=VA_2 / VGDPI ;

COEFFICIENT H03 # Share ZVA3 # ;
FORMULA H03=VA_3 / VGDPI ;

COEFFICIENT (all,i,SECT)(all,j,SECT) VZX0(i,j) # Total sectoral x0 # ;
FORMULA (all,i,SECT)(all,j,SECT) VZX0(i,j)
= [VDINPUT(i,j) + TINY] + [VMINPUT(i,j) + TINY] ;

COEFFICIENT (Parameter)(all,i,SECT)(all,j,SECT)(all,s,SOURCE) SZX0(i,j,s)
 # Share sectoral x0 # ;

FORMULA (Initial)(all,i,SECT)(all,j,SECT) SZX0(i,j,"Domestic")
= [VDINPUT(i,j) + TINY] / VZX0(i,j)  ;
FORMULA (Initial)(all,i,SECT)(all,j,SECT) SZX0(i,j,"Import")
= [VMINPUT(i,j) + TINY] / VZX0(i,j)  ;

! Capital production parameter SZX1 !

COEFFICIENT (all,i,SECT)(all,j,SECT) VZX1(i,j) # Total sectoral x1 # ;
FORMULA (all,i,SECT)(all,j,SECT) VZX1(i,j)
= [VDX1(i,j)+TINY]  + [VMX1(i,j)+TINY]  ;

COEFFICIENT(Parameter)(all,i,SECT)(all,j,SECT)(all,s,SOURCE) SZX1(i,j,s)
# Sectoral share x1 investment # ;
FORMULA (Initial)(all,i,SECT) (all,j,SECT) SZX1(i,j,"Domestic")
= [VDX1(i,j)+TINY]  / VZX1(i,j)  ;
```

```
FORMULA (Initial)(all,i,SECT) (all,j,SECT) SZX1(i,j,"Import")
= [VMX1(i,j)+TINY]  / VZX1(i,j)  ;

! ---------------------------------- !

COEFFICIENT (all,i,SECT)(all,s,SOURCE) COLX1(i,s) # Column x1  # ;
FORMULA (all,i,SECT) COLX1(i,"Domestic") = SUM(j,SECT,[VDX1(i,j)+TINY])
;
FORMULA (all,i,SECT) COLX1(i,"Import") = SUM(j,SECT,[VMX1(i,j)+TINY])  ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,Source) RCX1(i,j,s)
# Share for column x1  # ;
FORMULA (all,i,SECT)(all,j,SECT) RCX1(i,j,"Domestic")
= [VDX1(i,j)+TINY] /COLX1(i,"Domestic") ;
FORMULA (all,i,SECT)(all,j,SECT) RCX1(i,j,"Import")
= [VMX1(i,j)+TINY] /COLX1(i,"Import") ;

! ---------------------- !

COEFFICIENT(all,j,SECT) VZ1(j) # Investment by sector # ;
FORMULA (all,j,SECT) VZ1(j) = SUM(i,SECT,[VDX1(i,j)+TINY])
+ SUM(i,SECT,[VMX1(i,j)+TINY]) ;

COEFFICIENT(all,j,SECT) G(j) # Z1 / K1 likes depreciation of capital# ;
FORMULA (all,j,SECT) G(j) = VZ1(j) / [VX02(j) + VZ1(j)] ;

COEFFICIENT VC1 # Total investment  # ;
FORMULA VC1 = SUM(j,SECT,[VZ1(j)+TINY]) ;

COEFFICIENT (all,j,SECT) SZ1(j) # Share total investment  # ;
FORMULA (all,j,SECT) SZ1(j) = [VZ1(j)+TINY]/VC1 ;
```

```
! Add share capital production !

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) HZ1(i,j,s)
# Share for z1  # ;
FORMULA (all,i,SECT)(all,j,SECT) HZ1(i,j,"Domestic") =
[VDX1(i,j)+TINY]/VZ1(j);
FORMULA (all,i,SECT)(all,j,SECT) HZ1(i,j,"Import") =
[VMX1(i,j)+TINY]/VZ1(j) ;

COEFFICIENT VC2 # Total HH consumption # ;
FORMULA VC2 = SUM(i,SECT,[VDX2(i)+TINY])  +
SUM(i,SECT,[VMX2(i)+TINY]) ;

COEFFICIENT (all,i,SECT)(all,s,SOURCE) SX2(i,s) # Share x2 # ;
FORMULA (all,i,SECT) SX2(i,"Domestic") = [VDX2(i)+ TINY]  / VC2  ;
FORMULA (all,i,SECT) SX2(i,"Import") = [VMX2(i) + TINY] / VC2  ;

COEFFICIENT VC3 # Total government # ;
FORMULA VC3 = SUM(i,SECT,[VDX3(i)+TINY]) +
SUM(i,SECT,[VMX3(i)+TINY]) ;

COEFFICIENT (all,i,SECT)(all,s,SOURCE) SX3(i,s) # Share x3 # ;
FORMULA (all,i,SECT) SX3(i,"Domestic") = [VDX3(i) + TINY] / VC3  ;
FORMULA (all,i,SECT) SX3(i,"Import") = [VMX3(i) + TINY] / VC3  ;



COEFFICIENT VC5 # Total inventory # ;
FORMULA VC5 = SUM(i,SECT,[VDX5(i)+TINY]) +
SUM(i,SECT,[VMX5(i)+TINY]) ;
```

```
COEFFICIENT VC6 # Total Special Export # ;
FORMULA VC6 = SUM(i,SECT,[VX6(i)+TINY]) ;

COEFFICIENT VE # Total Export # ;
FORMULA VE = SUM(i,SECT,[VX4(i)+TINY]) ;

COEFFICIENT VM # Total Import # ;
FORMULA VM = SUM(i,SECT,[VZ02(i)+TINY])  ;

COEFFICIENT VGDPE # Expenditure GDP # ;
FORMULA VGDPE = VC1 + VC2 + VC3 + VC5 + VC6 + VE - VM ;

COEFFICIENT (all,i,SECT) HX4(i) # Share x4 # ;
FORMULA (all,i,SECT) HX4(i) = [VX4(i) + TINY] / VE  ;

COEFFICIENT (all,i,SECT) HM(i) # Share z02 # ;
FORMULA (all,i,SECT) HM(i) = [VZ02(i) + TINY] / VM  ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) RX0(i,j,s)
# Share X0 in Total demand # ;

FORMULA (all,i,SECT)(all,j,SECT) RX0(i,j,"Domestic")
= [VDINPUT(i,j) + TINY] / VZ01(i) ;
FORMULA (all,i,SECT)(all,j,SECT) RX0(i,j,"Import")
= [VMINPUT(i,j) + TINY] / VZ02(i) ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) RX1(i,j,s)
# Share X1 in total demand # ;
FORMULA (all,i,SECT)(all,j,SECT) RX1(i,j,"Domestic")
= [VDX1(i,j) + TINY] / VZ01(i) ;
```

**FORMULA** (**all**,i,SECT)(**all**,j,SECT) RX1(i,j,*"Import"*)
= **[**VMX1(i,j) + TINY**]** / VZ02(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) RX2(i,s) *# Share X2 in total demand #*
;
**FORMULA** (**all**,i,SECT) RX2(i,*"Domestic"*) = **[**VDX2(i) + TINY**]** / VZ01(i) ;
**FORMULA** (**all**,i,SECT) RX2(i,*"Import"*) = **[**VMX2(i) + TINY**]** / VZ02(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) RX3(i,s) *# Share X3 in total demand #*
;
**FORMULA** (**all**,i,SECT) RX3(i,*"Domestic"*) = **[**VDX3(i) + TINY**]** / VZ01(i) ;
**FORMULA** (**all**,i,SECT) RX3(i,*"Import"*) = **[**VMX3(i) + TINY**]** / VZ02(i) ;

**COEFFICIENT** (**all**,i,SECT) RX4(i) *# Share X4 in total demand #* ;
**FORMULA** (**all**,i,SECT) RX4(i) = **[**VX4(i) + TINY**]** / VZ01(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) RX5(i,s) *# Share X5 in total demand #*
;
**FORMULA** (**all**,i,SECT) RX5(i,*"Domestic"*) = **[**VDX5(i) + TINY**]** / VZ01(i) ;
**FORMULA** (**all**,i,SECT) RX5(i,*"Import"*) = **[**VMX5(i) + TINY**]** / VZ02(i) ;

**COEFFICIENT** (**all**,i,SECT) RX6(i) *# Share X6 in total demand #* ;
**FORMULA** (**all**,i,SECT) RX6(i) = **[**VX6(i) + TINY**]** / VZ01(i) ;

*!----------created share SHZCX1----------!*

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) SHZCX1(i,s)
*# Share x1 by column in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHZCX1(i,*"Domestic"*)
= **[**COLX1(i,*"Domestic"*) + TINY**]** / VGDPE ;
**FORMULA** (**all**,i,SECT) SHZCX1(i,*"Import"*)

= **[**COLX1(i,*"Import"*) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) SHX2(i,s) *# Share x2 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHX2(i,*"Domestic"*) = **[**VDX2(i) + TINY**]** / VGDPE ;
**FORMULA** (**all**,i,SECT) SHX2(i,*"Import"*) = **[**VMX2(i) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) SHX3(i,s) *# Share x3 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHX3(i,*"Domestic"*) = **[**VDX3(i) + TINY**]** / VGDPE ;
**FORMULA** (**all**,i,SECT) SHX3(i,*"Import"*) = **[**VMX3(i) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT) SHX4(i) *# Share x4 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHX4(i) = **[**VX4(i) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,SOURCE) SHX5(i,s) *# Share x5 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHX5(i,*"Domestic"*) = **[**VDX5(i) + TINY**]** / VGDPE ;
**FORMULA** (**all**,i,SECT) SHX5(i,*"Import"*) = **[**VMX5(i) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT) SHX6(i) *# Share x6 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHX6(i) = **[**VX6(i) + TINY**]** / VGDPE ;

**COEFFICIENT** (**all**,i,SECT) SHZ02(i) *# Share z02 in GDPE #* ;
**FORMULA** (**all**,i,SECT) SHZ02(i) = **[**VZ02(i) + TINY**]** / VGDPE ;

*!----------------------------------------!*
*!  EQUATION  !*
*!----------------------------------------!*
*!----------Final Demand----------!*

```
EQUATION Total_demand #Total domestic demand#
(all,i,SECT) z01(i)
= sum(j,SECT,RX0(i,j,"Domestic") * x0(i,j,"Domestic"))
 + sum(j,SECT,RX1(i,j,"Domestic") *  x1(i,j,"Domestic"))
 + RX2(i,"Domestic") *  x2(i,"Domestic")
 + RX3(i,"Domestic") *  x3(i,"Domestic") + RX4(i) *  x4(i)
 + RX5(i,"Domestic") *  x5(i,"Domestic") + RX6(i) *  x6(i) ;

EQUATION Import_demand #Total import demand#
(all,i,SECT) z02(i) = sum(j,SECT,RX0(i,j,"Import") * x0(i,j,"Import"))
+ sum(j,SECT,RX1(i,j,"Import") *  x1(i,j,"Import"))
+ RX2(i,"Import") *  x2(i,"Import")
+ RX3(i,"Import") *  x3(i,"Import")
+ RX5(i,"Import") *  x5(i,"Import") ;

!----------Production Function----------!

EQUATION  Funcion_x0 #Sectoral produced input#
(all,i,SECT)(all,j,SECT)(all,s,SOURCE) x0(i,j,s) = z01(j) - 1 * (p0(i,s)
- SUM(r,SOURCE,SZX0(i,j,r) * p0(i,r))) ;

EQUATION Labor_demand # Labor demand # (all,j,SECT) x01(j)
= z01(j) - 1 * [p01(j) - ([SFAC1(j) * p01(j)] + [SFAC2(j) * p02(j)])] ;

EQUATION Capital_demand # Capital Demand # (all,j,SECT) x02(j)
= z01(j) - 1 * [p02(j) - ([SFAC1(j) * p01(j)] + [SFAC2(j) * p02(j)])] ;

EQUATION Indirect_taxes # Indirect taxes #
(all,j,SECT) x03(j) = p03(j) + p0(j,"Domestic") + z01(j) ;

!----------Market Clearing (Equilibrium)----------!
```

**EQUATION** Total_labor *# Total labor demand #*
va1 = **sum**(j,SECT,S01(j) * **[**p01(j) + x01(j)**]**) ;

**EQUATION** Total_Capital *# Total Capital #*
va2 = **sum**(j,SECT,S02(j) * **[**p02(j) + x02(j)**]**) ;

**EQUATION** Total_taxes *# Total indirect taxes #*
va3 = **sum**(j,SECT,S03(j) * **[**p03(j) + x03(j)**]**) ;

**EQUATION** Income_GDP *# Income GDP #*
gdpi = (H01 * va1) + (H02 * va2) + (H03 * va3);
*! Capital production SZX1 !*

**EQUATION** Subsitution_inv *# Substitution of investment #*
(**all**,i,SECT)(**all**,j,SECT)(**all**,s,SOURCE) x1(i,j,s)
= z1(j) -1* **[**p0(i,s) - **SUM**(r,SOURCE,SZX1(i,j,r) * p0(i,r))**]** ;

*! ---------- !*

**EQUATION** Subsitution_HH1 *#Substitution of Domestic HH#*
(**all**,i,SECT) (**all**,s,SOURCE) x2(i,s) = c2 - p0(i,s) ;

**EQUATION** Subsitution_Gov1 *#Subsitution of Government#*
(**all**,i,SECT) (**all**,s,SOURCE) x3(i,s) = c3 - p0(i,s) ;

**EQUATION** Export_dem *# Export demand #*

(**all**,i,SECT) pw1(i) = -GAM(i) * x4(i) + fx4(i) ;

**EQUATION** Inventory_Dem *#Inventory Demand#*
(**all**,i,SECT)(**all**,s,SOURCE) x5(i,s) = c2r ;

```
EQUATION Special_exp # Special Export #
(all,i,SECT) x6(i) = c2r ;

! Investment/Capital Accumulation !

Coefficient (All,j,SECT) DEP(j) # depreciation factors #;
Read DEP From File MDATA180 Header "DPRC";  ! numbers like 0.95 !

Coefficient (All,j,SECT) R_T(j) # investment/capital ratio #;
Read R_T From File MDATA180 Header "YBYK"; !  numbers like 0.08 !
Update (Change)  (All,j,SECT)
 R_T(j) =  R_T(j)*[z1(j)-k0(j)]/100;

Coefficient (INTEGER) T # number of years covered by simulation #;
Formula T = 5 ;
Set YEARS MAXIMUM SIZE 100 SIZE T;

Coefficient (all,y,YEARS) ORD(y) # = y for y = 1 to T #;
Read ORD From File MDATA180 Header "ORDY";

Coefficient (All,j,SECT) Z(j) # K(T)/K(0)#;
Formula (Initial) (All,j,SECT) Z(j) = 1;
Update (All,j,SECT) Z(j) = k0(j);

Coefficient (All,j,SECT) R_0(j) # Y(0)/K(0) ratio#;
Formula (Initial) (All,j,SECT) R_0(j) = R_T(j);

Coefficient (All,j,SECT) DEP_T(j) # DEP to the power of T #;
Formula (Initial) (All,j,SECT) DEP_T(j) = DEP(j)^T;
```

```
Coefficient (All,j,SECT) N_term(j) # useful constant #;
Formula (Initial) (All,j,SECT) N_term(j) =
   Sum(y,YEARS, DEP(j)^{T -ORD(y)} ); !note y takes values 1 to T!

Coefficient (All,j,SECT) M_term(j) # useful constant #;
Formula (Initial) (All,j,SECT) M_term(j) =
   Sum(y,YEARS,([ORD(y)-1]/T)*DEP(j)^{T -ORD(y)} );

Coefficient (All,j,SECT) K_TERM(j) # delFudge coefficient  #;
Formula (All,j,SECT) K_TERM(j) = 100 *[DEP_T(j) - 1 + R_0(j)*N_term(j)] /Z(j);

Equation k0_f # investment/capital accumulation #
(All,j,SECT) k0(j) = K_TERM(j)*delFudge + M_term(j)*R_T(j)*z1(j) + f_accum(j);

EQUATION Utilization_k # Capital utilization #
(all,j,SECT) x02(j) = k0(j) ;
!----------Commodity Price Equation----------!
EQUATION Price_p0 #Commodity price define#
(all,j,SECT) [p0(j,"Domestic")+ z01(j)]
 = SUM(i,SECT,HX0(i,j,"Domestic")*[p0(i,"Domestic") + x0(i,j,"Domestic")])
+ SUM(i,SECT,HX0(i,j,"Import") * [p0(i,"Import") + x0(i,j,"Import")])
+ [HX01(j) * (p01(j) + x01(j))] + [HX02(j) * (p02(j) + x02(j))]
+ [HX03(j) * (p03(j) + p0(j,"Domestic") + z01(j))] ;

EQUATION Export_price # Export price #
(all,i,SECT) p0(i,"Domestic") = pw1(i) + v1(i) + xr ;

EQUATION Import_price # Import price #
(all,i,SECT) p0(i,"Import") = pw2(i) + v2(i) + xr ;

! Cost of Capital SZX1 !
```

```
EQUATION Capital_Cost # Investment by sector #
(all,j,SECT) pz1(j) + z1(j)
= SUM(i,SECT,HZ1(i,j,"Domestic") *[p0(i,"Domestic") + x1(i,j,"Domestic")])
+ SUM(i,SECT,HZ1(i,j,"Import") *[p0(i,"Import") + x1(i,j,"Import")]) ;

EQUATION Capital_out # Capital output #
(all,j,SECT) z1(j) = c1 - pz1(j) + p02(j) ;

! --------------------------------- !

EQUATION Inv_price #Investment price index#
 cpi1 = SUM(j,SECT,SZ1(j) * pz1(j)) ;

EQUATION Cons_price #Consumer price index#
cpi2 = SUM(i,SECT,SX2(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SX2(i,"Import") * p0(i,"import")) ;

EQUATION Gov_price #Government price index#
cpi3 = SUM(i,SECT,SX3(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SX3(i,"Import") * p0(i,"Import")) ;

EQUATION Real_C1 #Real investment#
c1r = c1 - cpi1 ;
EQUATION Real_C2 #Real consumption#
c2r = c2 - cpi2 ;
EQUATION Real_C3 #Real goverment#
c3r = c3 - cpi3 ;

EQUATION Inv_total #Total investment consumption#
c1 = gdpe ;
 EQUATION HH_total #Total HH consumption#
```

```
c2 = gdpe ;
EQUATION Gov_total #Total government consumption#
c3 = gdpe ;

EQUATION Total_export #Total exports#
e= SUM(i,SECT,HX4(i)*[pw1(i) + x4(i)]) ;
EQUATION Total_import #Total imports#
m= SUM(i,SECT,HM(i)*[pw2(i) + z02(i)]) ;

!----------Numeraire (Reference)----------!

EQUATION Balance_Trade #Odinary Change in the Balance of Trade#
 100*delBT = (VE*e) - (VM*m) ;

EQUATION Debt_GDP #Debt-GDP#
 100*VGDPE*delDT = (VE*e) - (VM*m) - [(VE - VM)*gdpe] ;

EQUATION Real_wage # Real wage #
(all,j,SECT) rp01(j) = p01(j) - cpi2 ;

EQUATION Real_cap # Real capital Rent #
(all,j,SECT) rp02(j) = p02(j) - cpi2 ;

! Column Investment SZX1 !

EQUATION Col_x1 # Column domestic investment #
(all,i,SECT) cx1(i,"Domestic")
= sum(j,SECT,RCX1(i,j,"Domestic") * x1(i,j,"Domestic")) ;
```

```
EQUATION Invest_C2 #Column import investment#
(all,i,SECT) cx1(i,"Import")
= sum(j,SECT,RCX1(i,j,"Import") * x1(i,j,"Import")) ;

! ---------------------------------------------------------- !

EQUATION Identity_GDP # Identity GDP # gdpe =
SUM(i,SECT,SHZCX1(i,"Domestic") * [p0(i,"Domestic") + cx1(i,"Domestic")])
 + SUM(i,SECT,SHZCX1(i,"Import") * [p0(i,"Import") + cx1(i,"Import")])
+ SUM(i,SECT,SHX2(i,"Domestic") * [p0(i,"Domestic") + x2(i,"Domestic")])
 + SUM(i,SECT,SHX2(i,"Import") * [p0(i,"Import") + x2(i,"Import")])
 + SUM(i,SECT,SHX3(i,"Domestic") * [p0(i,"Domestic") + x3(i,"Domestic")])
 + SUM(i,SECT,SHX3(i,"Import") * [p0(i,"Import") + x3(i,"Import")])
 + SUM(i,SECT,SHX4(i) * [p0(i,"Domestic") + x4(i)])
 + SUM(i,SECT,SHX5(i,"Domestic") * [p0(i,"Domestic") + x5(i,"Domestic")])
 + SUM(i,SECT,SHX5(i,"Import") * [p0(i,"Import") + x5(i,"Import")])
 + SUM(i,SECT,SHX6(i) * [p0(i,"Domestic") + x6(i)])
 - SUM(i,SECT,SHZ02(i) * [p0(i,"Import") + z02(i)]) ;

EQUATION GDP_Def # GDP Deflator #
gdpdf = SUM(i,SECT,SHZCX1(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SHZCX1(i,"Import") * p0(i,"Import"))
 + SUM(i,SECT,SHX2(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SHX2(i,"Import") * p0(i,"Import"))
 + SUM(i,SECT,SHX3(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SHX3(i,"Import") * p0(i,"Import"))
 + SUM(i,SECT,SHX4(i) * p0(i,"Domestic"))
 + SUM(i,SECT,SHX5(i,"Domestic") * p0(i,"Domestic"))
 + SUM(i,SECT,SHX5(i,"Import") * p0(i,"Import"))
 + SUM(i,SECT,SHX6(i) * p0(i,"Domestic"))
 -  SUM(i,SECT,SHZ02(i) * p0(i,"Import")) ;
```

```
EQUATION Real_GDP # Real GDP #
gdpr = gdpe - gdpdf ;

!---  Cosmetics Equations (Linearized)  ----!
!--- Petroleum refinery (oil consumption) -----!

VARIABLE oil # Oil consumption (Quantity) # ;
VARIABLE oil_v # Oil consumption (Value) # ;

COEFFICIENT (all,i,SECT) VCOM(i) # Total commodity demand # ;
FORMULA (all,i,SECT) VCOM(i) = VZ01(i) + VZ02(i) ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) SCX0(i,j,s)
# Share X0 in total demand # ;
FORMULA (all,i,SECT)(all,j,SECT) SCX0(i,j,"Domestic")
= [VDINPUT(i,j)+TINY]/VCOM(i) ;
FORMULA (all,i,SECT)(all,j,SECT) SCX0(i,j,"Import")
= [VMINPUT(i,j)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT)(all,j,SECT)(all,s,SOURCE) SCX1(i,j,s)
# Share X1 in total demand # ;
FORMULA (all,i,SECT)(all,j,SECT) SCX1(i,j,"Domestic")
= [VDX1(i,j)+TINY]/VCOM(i) ;
FORMULA (all,i,SECT)(all,j,SECT) SCX1(i,j,"Import")
= [VMX1(i,j)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT)(all,s,SOURCE) SCX2(i,s)
# Share X2 in total demand # ;
FORMULA (all,i,SECT) SCX2(i,"Domestic")
= [VDX2(i)+TINY]/VCOM(i) ;
FORMULA (all,i,SECT) SCX2(i,"Import")
```

```
= [VMX2(i)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT)(all,s,SOURCE) SCX3(i,s)
# Share X3 in total demand # ;
FORMULA (all,i,SECT) SCX3(i,"Domestic")
= [VDX3(i)+TINY]/VCOM(i) ;
FORMULA (all,i,SECT) SCX3(i,"Import")
= [VMX3(i)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT) SCX4(i)
# Share X4 in total demand # ;
FORMULA (all,i,SECT) SCX4(i) = [VX4(i)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT)(all,s,SOURCE) SCX5(i,s)
# Share X5 in total demand # ;
FORMULA (all,i,SECT) SCX5(i,"Domestic")
= [VDX5(i)+TINY]/VCOM(i) ;
FORMULA (all,i,SECT) SCX5(i,"Import")
= [VMX5(i)+TINY]/VCOM(i) ;

COEFFICIENT (all,i,SECT) SCX6(i)
# Share X6 in total demand # ;
FORMULA (all,i,SECT) SCX6(i) = [VX6(i)+TINY]/VCOM(i) ;

EQUATION refinary # Oil consumption (Quantity) #
oil = sum(j,SECT,SCX0("s93",j,"Domestic")*x0("s93",j,"Domestic"))
+ sum(j,SECT,SCX0("s93",j,"Import")*x0("s93",j,"Import"))
+ sum(j,SECT,SCX1("s93",j,"Domestic")*x1("s93",j,"Domestic"))
+ sum(j,SECT,SCX1("s93",j,"Import")*x1("s93",j,"Import"))
+ SCX2("s93","Domestic")*x2("s93","Domestic")
+ SCX2("s93","Import")*x2("s93","Import")
```

```
+ SCX3("s93","Domestic")*x3("s93","Domestic")
+ SCX3("s93","Import")*x3("s93","Import")
+ SCX4("s93")*x4("s93")
+ SCX5("s93","Domestic")*x5("s93","Domestic")
+ SCX5("s93","Import")*x5("s93","Import")
+ SCX6("s93")*x6("s93") ;

EQUATION refiery_v # Oil consumption (Value) #
oil_v =
sum(j,SECT,SCX0("s93",j,"Domestic")*[p0("s93","Domestic")+x0("s93",j,"Domestic")])
+ sum(j,SECT,SCX0("s93",j,"Import")*[p0("s93","Import")+x0("s93",j,"Import")])
+
sum(j,SECT,SCX1("s93",j,"Domestic")*[p0("s93","Domestic")+x1("s93",j,"Domestic")])
+ sum(j,SECT,SCX1("s93",j,"Import")*[p0("s93","Import")+x1("s93",j,"Import")])
+ SCX2("s93","Domestic")*[p0("s93","Domestic")+x2("s93","Domestic")]
+ SCX2("s93","Import")*[p0("s93","Import")+x2("s93","Import")]
+ SCX3("s93","Domestic")*[p0("s93","Domestic")+x3("s93","Domestic")]
+ SCX3("s93","Import")*[p0("s93","Import")+x3("s93","Import")]
+ SCX4("s93")*[p0("s93","Domestic")+ x4("s93")]
+ SCX5("s93","Domestic")*[p0("s93","Domestic")+x5("s93","Domestic")]
+ SCX5("s93","Import")*[p0("s93","Import")+x5("s93","Import")]
+ SCX6("s93")*[p0("s93","Domestic")+x6("s93")] ;

!--- Oil consumption in Final Demand -----!
VARIABLE oil_fd # Oil consumption in Final Demand (Quantity) # ;
VARIABLE oil_fdv # Oil consumption in Final Demand (Value) # ;
```

**COEFFICIENT** (**all**,i,SECT) VFDD(i) *# Final Demand Domestic #* ;
**FORMULA** (**all**,i,SECT) VFDD(i) = **sum**(j,SECT,VDX1(i,j)) + VDX2(i) + VDX3(i) + VX4(i) + VDX5(i) + VX6(i) ;
**COEFFICIENT** (**all**,i,SECT) VFDM(i) *# Final Demand Import #* ;
**FORMULA** (**all**,i,SECT) VFDM(i) = **sum**(j,SECT,VMX1(i,j)) + VMX2(i) + VMX3(i)
+ VMX5(i) ;

**COEFFICIENT** (**all**,i,SECT) VFDT(i) *# Total Oil Final Demand #* ;
**FORMULA** (**all**,i,SECT) VFDT(i) = VFDD(i) + VFDM(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,j,SECT)(**all**,s,source) SFDX1(i,j,s)
*# Share X1 in Final Demand #* ;
**FORMULA** (**all**,i,SECT)(**all**,j,SECT) SFDX1(i,j,*"Domestic"*)
= **[**VDX1(i,j) + TINY**]**/VFDT(i) ;
**FORMULA** (**all**,i,SECT)(**all**,j,SECT) SFDX1(i,j,*"Import"*)
= **[**VMX1(i,j) + TINY**]**/VFDT(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,source) SFDX2(i,s)
*# Share X2 in Final Demand #* ;
**FORMULA** (**all**,i,SECT) SFDX2(i,*"Domestic"*)
= **[**VDX2(i) + TINY**]**/VFDT(i) ;
**FORMULA** (**all**,i,SECT) SFDX2(i,*"Import"*)
= **[**VMX2(i) + TINY**]**/VFDT(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,s,source) SFDX3(i,s)
*# Share X3 in Final Demand #* ;
**FORMULA** (**all**,i,SECT) SFDX3(i,*"Domestic"*)
= **[**VDX3(i) + TINY**]**/VFDT(i) ;
**FORMULA** (**all**,i,SECT) SFDX3(i,*"Import"*)
= **[**VMX3(i) + TINY**]**/VFDT(i) ;

```
COEFFICIENT (all,i,SECT) SFDX4(i)
# Share X4 in Final Demand # ;
FORMULA (all,i,SECT) SFDX4(i)
= [VX4(i) + TINY]/VFDT(i) ;

COEFFICIENT (all,i,SECT)(all,s,source) SFDX5(i,s)
# Share X5 in Final Demand # ;
FORMULA (all,i,SECT) SFDX5(i,"Domestic")
= [VDX5(i) + TINY]/VFDT(i) ;
FORMULA (all,i,SECT) SFDX5(i,"Import")
= [VMX5(i) + TINY]/VFDT(i) ;

COEFFICIENT (all,i,SECT) SFDX6(i)
# Share X6 in Final Demand # ;
FORMULA (all,i,SECT) SFDX6(i)
= [VX6(i) + TINY]/VFDT(i) ;

EQUATION refiery_fd # Oil consumption in final demand (Quantity) #
oil_fd = sum(j,SECT,SFDX1("s93",j,"Domestic")*x1("s93",j,"Domestic"))
+ sum(j,SECT,SFDX1("s93",j,"Import")*x1("s93",j,"Import"))
+ SFDX2("s93","Domestic")*x2("s93","Domestic")
+ SFDX2("s93","Import")*x2("s93","Import")
+ SFDX3("s93","Domestic")*x3("s93","Domestic")
+ SFDX3("s93","Import")*x3("s93","Import")
+ SFDX4("s93")*x4("s93")
+ SFDX5("s93","Domestic")*x5("s93","Domestic")
+ SFDX5("s93","Import")*x5("s93","Import")
+ SFDX6("s93")*x6("s93") ;
```

**EQUATION** refiery_fdv *# Oil consumption in final demand (Value) #*
oil_fdv =
**sum**(j,SECT,SFDX1(*"s93"*,j,*"Domestic"*)***[**p0(*"s93"*,*"Domestic"*)+x1(*"s93"*,j,*"Domestic"*)**]**)
+ **sum**(j,SECT,SFDX1(*"s93"*,j,*"Import"*)***[**p0(*"s93"*,*"Import"*)+x1(*"s93"*,j,*"Import"*)**]**)
+ SFDX2(*"s93"*,*"Domestic"*)***[**p0(*"s93"*,*"Domestic"*)+x2(*"s93"*,*"Domestic"*)**]**
+ SFDX2(*"s93"*,*"Import"*)***[**p0(*"s93"*,*"Import"*)+x2(*"s93"*,*"Import"*)**]**
+ SFDX3(*"s93"*,*"Domestic"*)***[**p0(*"s93"*,*"Domestic"*)+x3(*"s93"*,*"Domestic"*)**]**
+ SFDX3(*"s93"*,*"Import"*)***[**p0(*"s93"*,*"Import"*)+x3(*"s93"*,*"Import"*)**]**
+ SFDX4(*"s93"*)***[**p0(*"s93"*,*"Domestic"*)+ x4(*"s93"*)**]**
+ SFDX5(*"s93"*,*"Domestic"*)***[**p0(*"s93"*,*"Domestic"*)+x5(*"s93"*,*"Domestic"*)**]**
+ SFDX5(*"s93"*,*"Import"*)***[**p0(*"s93"*,*"Import"*)+x5(*"s93"*,*"Import"*)**]**
+ SFDX6(*"s93"*)***[**p0(*"s93"*,*"Domestic"*)+x6(*"s93"*)**]** ;

*!--- Oil consumption in intermediate -----!*

**VARIABLE** oil_int *# Oil consumption in intermediate (Quantity) #* ;
**VARIABLE** oil_intv *# Oil consumption in intermediate (Value) #* ;

**COEFFICIENT** (**all**,i,SECT) VIND(i) *# Domestic intermediate demand #* ;
**FORMULA** (**all**,i,SECT) VIND(i) = VZ01(i) -VFDD(i) ;
**COEFFICIENT** (**all**,i,SECT) VINI(i) *# Import intermediate demand #* ;
**FORMULA** (**all**,i,SECT) VINI(i) = VZ02(i) -VFDM(i) ;

**COEFFICIENT** (**all**,i,SECT) VINT(i) *# Total intermediate demand #* ;
**FORMULA** (**all**,i,SECT) VINT(i) = VIND(i) + VINI(i) ;

**COEFFICIENT** (**all**,i,SECT)(**all**,j,SECT)(**all**,s,SOURCE) SINX0(i,j,s)
*# Share X0 in intermediate demand #* ;
**FORMULA** (**all**,i,SECT)(**all**,j,SECT) SINX0(i,j,*"Domestic"*)
= **[**VDINPUT(i,j)+TINY**]**/VINT(i) ;

```
FORMULA (all,i,SECT)(all,j,SECT) SINX0(i,j,"Import")
= [VMINPUT(i,j)+TINY]/VINT(i) ;
EQUATION refinary_int # Oil consumption in intermediate (Quantity) #
oil_int = sum(j,SECT,SINX0("s93",j,"Domestic")*x0("s93",j,"Domestic"))
+ sum(j,SECT,SINX0("s93",j,"Import")*x0("s93",j,"Import")) ;

EQUATION refiery_intv # Oil consumption in intermediate (Value) #
oil_intv =
sum(j,SECT,SINX0("s93",j,"Domestic")*[p0("s93","Domestic")+x0("s93",j,"Domest
ic")])
+ sum(j,SECT,SINX0("s93",j,"Import")*[p0("s93","Import")+x0("s93",j,"Import")])
;

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# BIOGRAPHY

| | |
|---|---|
| **NAME** | Miss Chatsamee Chanitnan |
| **ACDEMIC BACKGROUD** | Bachelor's Degree with a major in Biochemistry Engineering from Rungsit university, Pathum Thani Province, Thailand in 1996 and a Master's Degree in Public Administration from National Institute Development Administration, Bangkok, Thailand in 2011. |
| **PRESENT POSITION** | 2004 - Present<br>CEO, THAI-HO Group (Thailand)<br>Bangkok, Thailand |