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Impacts of Taxation and Financial Development in Thailand: CGE and Econometric Analyses

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Abstract

The primary focus of this thesis is to investigate the impacts of tax reform, energy consumption and financial development on the growth and efficiency of the Thai economy. There are three main objectives, which are (i) to evaluate the impacts of reforms in value added tax (VAT) and corporate income tax (CIT) on the welfare and reallocation of resources across production sectors, (ii) to assess the impacts of personal income tax (PIT) reform on growth of production sectors and redistribution of income across households, and (iii) to measure impacts of financial development on growth and energy consumption and to re-examine the relationship between energy consumption, financial development and growth. These three chapters aim to contribute to our understanding of the Thai economy. The analysis is divided into three main parts to meet the objectives.

A static computable general equilibrium is used to study the impact of VAT and CIT in Thailand in first part. The analysis focuses on the change of VAT and CIT rates because these taxes are the first two biggest source of government revenue. In addition, there is no systematic study on such impacts in Thai context before. Interestingly, the changes in tax rates reveal contrasting results in term of the net welfare to households. While an increase in the VAT rate from the current level, 7 percent, generates higher net welfare to society, a reduction of the CIT rate from 30 percent to the lower end of the international range, 20 percent, is a more preferable policy on the basis of economy-wide welfare analysis. For the efficiency in reallocation of scarce resources, we study the impacts of these tax reforms on employment, capital, output, supply and price for each sector of the economy. Most positive impacts from reductions in VAT and CIT rates occur in the agriculture sector, textile sector and mining and quarrying sector as these reduce cost of inputs to producers. On the other hand, the paper industries and printing sector and trade and services sector show a negative impact that might have been protected due to higher taxes in the base scenario.

In examining the second objective, the **dynamic** computable general equilibrium approach is applied in order to evaluate the impacts of changes in personal income tax (PIT) rates on growth and redistribution for 25 periods of the Thai economy starting in 2011 using the latest Input-Output Table for the micro-consistent dataset. This study emphasises the impact of a reduction of PIT rate because this is the latest tax change in Thailand and any change in this tax rate will have a different distribution affect for

households in each income threshold. The results show that a reduction in PIT rate is helpful in decreasing disparity in the distribution of income and consumption in both the short and long-terms in Thailand. In particular, this tax policy benefited the poorest households throughout the study period, while the levels of income and consumption of the richest households declined, although the magnitude of changes are smaller from time to time. In addition, this PIT reform increases output, employment and capital stock in every sector, which results in a rise in all macroeconomic variables, especially the levels of investment and GDP. Under balanced budget assumption, the findings report that the drop in PIT revenue can be fully compensated by an increase in revenue from other taxes in a growing economy.

The third part of this thesis focuses on the third objective by utilising time series data with autoregressive distributed lag (ARDL) and the Toda-Yamamoto approach to investigate the long-run relationship and the direction of causality between energy consumption, financial development and economic growth. The findings reveal positive and significant short-term and long-term effects of energy consumption and gross fixed capital formation on economic growth, while population growth has negative impact on economic growth. Notably, the ARDL result report positive but insignificant impact of financial development on economic growth. Meanwhile, the Toda-Yamamoto causality test indicates a unidirectional causality running from economic growth to energy consumption. This finding supports the conservation hypothesis and implies that energy conservation policy can be implemented with little or no adverse effect on economic growth. In addition, the causality test reveals a unidirectional causality running from gross fixed capital formation and population growth to energy consumption, a unidirectional causality running from gross fixed capital formation and population growth to GDP. On the other hand, the test indicates the absence of causal relationship between financial development and energy consumption, and between financial development and economic growth thus indicating that these variables evolve independent of each other.

Above all, the findings indicate that tax reform and energy consumption play crucial roles in the growth of the Thai economy. These findings will hopefully encourage policymakers to carefully conduct policies related to taxation and energy. For instance, any tax policies proposed should not add an excess burden to taxpayers and potentially disturb the growth of consumption, production, trade, investment and saving. Regarding energy policy, the findings imply that the policymakers can implement a strong energy conservation policy to households and the business sectors without compromising economic growth. This can enable Thailand to become a low carbon society with inclusive growth as stated in the *Thailand 4.0* policy and the 20-year National Strategic Plan.

This study contributes to the existing literature in three aspects. First, this study is the first study that analyses the economy-wide impacts of changes in VAT and CIT rates on the allocation of labour and capital inputs, on output and supply as well as on prices and rental rates across sectors and on the levels of households' utility and public welfare in Thailand. Second, this study is the first study that presents the magnitude of the economic impacts from tax reforms taking account of complicated economy-wide income and substitution effects over 25 years of the Thai economy. Third, unlike the existing and growing literature on the energy-growth nexus, this study contributes to the literature in this topic by incorporating financial development in the production model and focus on only in the context of the Thai economy. The analytical framework of this study also allows us to investigate the presence of energy-led growth and finance-led growth hypotheses in Thailand.

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Chapter 1 : Introduction

1.1 Introduction

The primary focus of this thesis is to investigate the impacts of tax reform, energy consumption and financial development on the growth and efficiency of the Thai economy. The main contribution of this thesis is to measure the impacts of taxes on economic growth and to assess the cause effect relations between growth, energy consumption and financial development. It uses computable general equilibrium (CGE) and econometric methods. The static and dynamic computable general equilibrium models are used to evaluate the economy-wide impact of tax reform in Thailand. We focus our analysis on the reform of value added tax (VAT), corporate income tax (CIT), and personal income tax (PIT) because these taxes are subject to the latest tax reform in Thailand and account for the top three income sources of the Thai government in 2017; 41.85, 34.64, and 17.41 percent, respectively (Fiscal Information, 2018). The econometric method is applied to analyse the relationship between energy consumption, financial development and growth. Although there are many empirical studies in the literature on this issue, there are no studies to our knowledge that investigate the causality between energy consumption, financial development and economic growth in Thailand as a specific-country study. On top of that, the findings of a country-specific study can provide valuable insights to Thai policymakers.

Government has a role to stimulate growth through economic planning. It allocates limited resources according to priorities that best suit the country's conditions and needs. At the early stage of economic development, the government provides large investments in social and economic overheads such as roads, railways, ports, bridges, schools, hospitals, power, and utilities. Such investment facilitates economic activities and induces external economies - not only domestic private enterprises but also foreign investment in the field of agriculture and industry. This enables society to achieve higher productivity and welfare levels. For example, a transportation infrastructure provided by the government stimulates investment and trade, and improves the allocation of resources. In addition, the government has a role in setting up financial institutions to supply capital and money and provide financial inducements and subsidies to the business sector. For instance, the Government Saving Bank (GSB), The Bank for Agriculture and Agricultural Co-Operatives (BAACs), Export-Import Bank of Thailand, and Islamic Bank of Thailand have been established in Thailand to offer financial support to the agricultural, industrial and export sectors.

As the economy becomes more complex, the government can intervene in market forces to break a vicious circle and to prevent serious and prolonged recessions through several controls such as price control, exchange rate control and industrial licensing. Additionally, the government can interfere with the distribution of the output in an economy because total domestic output is simply a combination of private sector output and government output; an additional unit of government output may increase the total output by more than a unit, assuming no change in private sector output. Any additional unit of private output consumed by the government crowds out private consumption by a unit, assuming other things remain unchanged to retain social welfare. Therefore, the government plays a crucial role in promoting the economic growth of the country, not only acting as a producer but also as a consumer through public expenditure.

The amount of public spending is determined mainly by the level of taxes and revenue collection. The primary income source of the government comes from tax revenue. Any change in tax revenue affects government spending directly. Many countries experience problems with tax collection due to poor tax systems, including inadequate and ineffective taxpayer databases. Umar and Tusubira (2017) stated that poor taxpayer databases can negatively affect tax revenue generation, and so the authorities should ensure that all information about taxpayers is accurate and includes taxpayers outside of the tax net. In addition to the complexity of the tax system, the effectiveness of the audit and trust in the authorities are challenges for tax administration in developing countries, which create chances for tax avoidance and evasion. These can lessen government revenue.

Many countries use tax reforms to increase revenue and to raise the efficiency of tax collection, as well as to ensure equity in their tax systems with the belief that improving the tax system is a necessary and sustainable way to raise government revenue. Importantly, the government has to be aware that tax reform will not create an excess burden for the taxpayers nor create further distortions in the economy. In addition, the tax reform should not interrupt the growth of consumption, production, trade, investment and saving. Government should honour the four canons of taxation proposed by Adam Smith, which are (i) the canon of equality or ability, (ii) the canon of certainty, (iii) the canon of convenience, and (iv) the canon of economy. This study, therefore, analyses the impacts of recent tax reform in Thailand and investigates whether such reform would not deteriorate the growth of the nation and the welfare of Thai people.

The neo-classical theory of economic growth states the three essential factors of production for a growing economy are labour, capital and technology. It describes how the equilibrium and growth of the economy can be achieved by ensuring the right proportion of the three factors. However, it is widely accepted at present that energy is another key component of economic growth because it is an essential input in all production and consumption activities relating to industrialisation or urbanisation. Every production line uses energy as fuel to operate machines. For urbanisation as regards energy consumers, every person requires energy for heating their homes, cooking, lighting, washing and using electrical appliances. The causal relationship between energy consumption and economic growth was first introduced in the seminal work of Kraft and Kraft (1978). There have numerous papers on the subject in the energy economics literature since then. The empirical results on this topic have been varied and sometimes revealed to be conflicting and contradicting each other according to the difference in time periods, proxies of variables, econometric methodologies and country characteristics.

Apart from energy, Schumpeter (1911) posited that financial development promotes economic growth as it plays an important role in facilitating financial services for entrepreneurs. Nevertheless, the relationship between financial development and economic growth still stimulates curiosity among economists. Robinson (1952) and Kuznets (1955) claimed that financial development is caused by growth, while Patrick (1966) proposed that financial development and growth are mutually correlated and Lucas (1988) stated that financial development and economic growth are independent. Similarly, the large number of empirical studies on the finance-growth nexus have shown as ambiguous results as the findings on the energy-growth relationship. Subsequently, Karanfil (2009) suggested that energy demand could be affected by financial development as financial development is a source of funds for households and businesses. Hence, improving financial development is a crucial mechanism to increases economic activity through banking activities, foreign direct investment and stock market activity, consequently, affect energy demand and economic growth. This argument has been supported by Sadorsky (2010). Then, several studies have incorporated financial development into the energy-growth nexus, such as Shahbaz et al. (2013), Islam et al.

(2013), Mahalik and Mallick (2014) and Shahbaz et al. (2017). However, the direction of causality between energy consumption, financial development and growth remain elusive and controversial. Different causal relationships lead to different policy implications. Therefore, a proper understanding of the relationship between energy consumption, financial development and economic growth is essential, as it can provide a guideline for policymakers to design and implement appropriate energy and financial policies in the country.

In essence, the main sources of economic growth can be broadly attributed to activities of private and public sectors. Firstly, most of the economic agents come from the private sector but are subject to the guidance of the public sector. The private sector has millions of consumers as well as producers in the economy. Their decisions on optimal allocation of the resources available are influenced by the freedom obtained from the state. Therefore, actions of the private sector are under control of the law which is regulated by the government. In other words, government, households and firms are interlinked in the economy, they influence each other and are bound by the constitution and the rules and regulations regarding taxes, spending and investment and capital formation. These influence the living standards and welfare of an economy. How these relations work and the impacts of fiscal and financial policies on income, allocations, efficiency and welfare are the fundamental issues covered in this study.

While the objective of this thesis is to understand the impacts of fiscal and financial sector policies in Thailand, it is good to start this with a good understanding of the major features of the Thai economy. The next section summarises major stylised facts of the Thai economy. Section 3 presents a brief review of the *Thailand 4.0* policy followed by the research objectives, contributions and structure of the thesis.

1.2 Major Stylised Facts of the Thai Economy

During the last half-century, Thailand has enjoyed rapid economic growth and development and has transformed its industrial base from agriculture to export-oriented manufacturing. The country has a good track record of sound economic policies, high savings and investment, and low inflation. It has effectively reduced poverty and made remarkable progress in restructuring its society. This has transformed the country from a lower-middle income country to an upper-middle income country in the early 2010s.

This section provides an overview of major stylised facts of the Thai economy since 1960. It explains a historical review of the country's economic development. This is aimed at building a proper understanding of the background and socio-economic improvement in the Thai economy.

1.2.1 Growth of the Thai Economy

(1) The Pre-Boom Period: 1960 to 1986

During the pre-boom period of 1960-1986, the average annual GDP growth rate of the Thai economy was 7.05 percent (World Bank, 2019a). The agriculture sector was the major contributor to the high growth in that time. It accounted for 35.84, 25.92, and 23.24 percent of GDP in 1961, 1970, and 1980 respectively, as shown in Table 1.1. In 1961, the government launched the first National Plan emphasising infrastructure investment-including roads, railways and irrigations so farmers expanded their farmlands to meet the increase in export demand and obtain benefits from high prices in agricultural products from 1974 to 1979. The government also established the Stock Exchange of Thailand (SET) in 1975 to accumulate funds to support industrialisation and economic development. In 1977, the Investment Promotion Act was enacted with the aim of moving from import-substitution to export-promotion. However, the new investment policy was less effective due to the slowdown of the world economy, the over-valuation of the baht as well as the tight fiscal policy. Moreover, Thailand experienced crises in its financial institutions between 1979 and 1986 which led to the shutdown of 20 finance companies and one commercial bank; the central bank put 25 finance companies and 2 commercial banks under its rescue package (Jitsuchon, 2006).

Table 1.1: Thailand's Selected Macroeconomic Indicators

	Unit	**1961**	**1970**	**1980**	**1990**	**2000**	**2016**	**2017**
Population	Million	28.22	36.88	47.39	56.58	62.96	68.86	69.04
Annual GDP growth rate	Percent	5.36	11.41	5.17	11.17	4.46	3.28	3.91
GDP (constant 2010)	Million US$	16,478	34,269	66,513	141,610	217,712	407,014	422,940
Annual GDP per capita growth	Percent	2.27	8.21	3.01	9.62	3.37	2.97	3.65
GDP per capita (constant 2010)	US$	583.84	929.08	1,403.68	2,502.71	3,458.05	5,910.45	6,126.24
Agriculture, value added	% of GDP	35.84	25.92	23.24	12.50	8.50	8.50	8.65
Manufacturing, value added	% of GDP	12.99	15.94	21.51	27.20	28.59	27.39	27.09
Industry, value added	% of GDP	19.16	25.31	28.68	37.22	36.84	35.78	35.05
Services, value added	% of GDP	n/a	n/a	n/a	n/a	54.66	55.72	56.29
Exports of goods and services	% of GDP	17.34	15.02	24.11	34.13	64.84	68.47	68.17

Table 1.1: Thailand's Selected Macroeconomic Indicators, Continued

	Unit	1961	1970	1980	1990	2000	2016	2017
Imports of goods and services	% of GDP	17.11	19.38	30.37	41.51	56.46	53.70	54.63

Source: World Bank (2019a)

(2) The Economic Boom Period: 1986 to 1996

The prosperous time of the Thai economy occurred from 1986 to 1996. The average annual GDP growth rate in this period was 9.28 percent, with a peak of 13.3 percent in 1988 as shown in Figure 1.1. The country benefited from the 1985 Plaza accords, which led to the depreciation of the Thai baht as the US dollar had the highest weight in the basket system, combined with the lower oil prices which stimulated manufactured exports. The share of exports surged from 25.6 percent of GDP in 1986 to 41.53 percent of GDP in 1995 (World Bank, 2019a). Additionally, the weak currency induced numerous FDI from Japan, Taiwan and Hong Kong, whose currencies had appreciated and needed to find new production bases that had lower costs.

Growing export and investment demands, as well as the government's investment policy, stimulated manufacturing production, consequently transforming the economic structure from an agrarian economy to manufacturing society. As a result, the value added of agriculture sector continuously declined from 1970 and the manufacturing and industry sectors became a prominent sector in the economy from the 1980s. According to the poverty incidence, the boom also reduced the absolute poverty from 22 percent in 1988 to under 10 percent in 1994 (Warr, 1997).

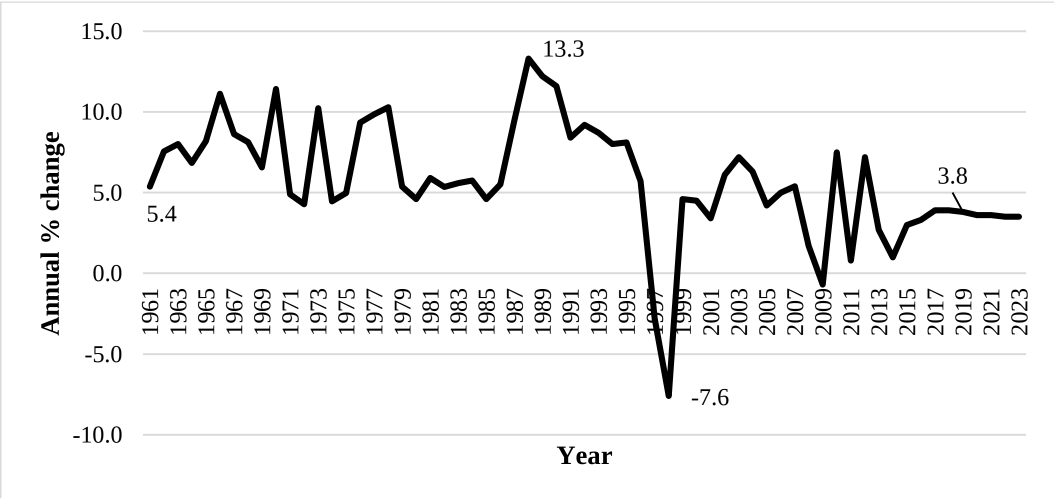

Figure 1.1: Real GDP Growth in Thailand

Source: World Bank (2019a): data for 1961-1979; and IMF (2018): data for 1980-2023

Note: Predicted value after 2016

The fiscal discipline in this period reflected the financial prudence in the public sector, while the double-digit growth rates and greater investment opportunities created the illusion of a bright economy condition in the private sector, in both real estate sector and the stock market. These attracted not only domestic investors but also foreign speculators, who rushed into real estate sector and the stock market with a lack of risk analysis. Subsequently, boom and speculation in real estate and the stock market occurred in 1988 and 1989, respectively. In 1991, there was a boom in investment, then in 1993 a flood of capital inflow to Thailand, especially in 1998 when the net inflow of FDI accounted for US$ 7,314 million or 6.43 percent of GDP as shown in Figure 1.2.

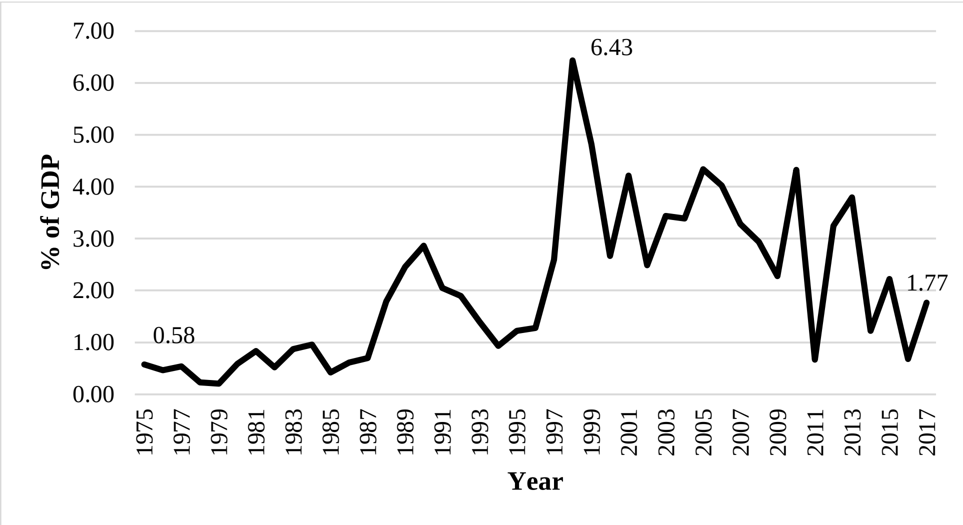

Figure 1.2: Net Inflows of Foreign Direct Investment in Thailand during 1975-2017

Source: World Bank (2019a)

(3) The Economic Crisis: 1997 to 1998

The boom period in Thailand came to an end in July, 1997 when the baht had to be devalued and the fixed adjusted exchange rate had been replaced by a floating exchange rate system. As a result, the value of the baht continuously declined since then, and reached the lowest ever level since Thailand started keeping records in 1960 at an average rate 41.37 baht per US$ in 1998 as shown in Figure 1.3. To be more precise, the lowest value of the baht was 53.81 baht per US$ in January 1998 (Bank of Thailand, 2019a). During 1997-1998, the country experienced a recession with an average annual GDP growth at -5.19 percent (World Bank, 2019a).

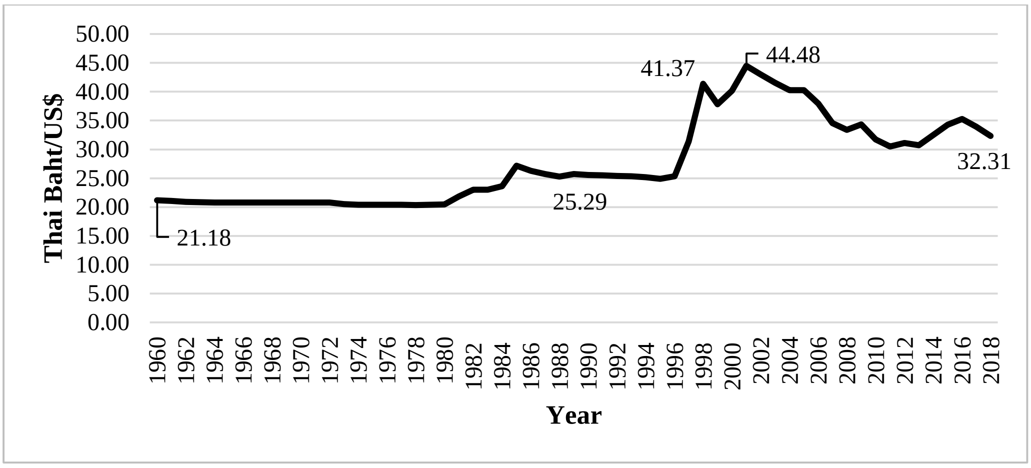

Figure 1.3: Exchange Rate of Thai Baht per US dollar during 1960-2018

Source: World Bank (2019a): data for 1960-1980; and Bank of Thailand (2019a) data for 1981-2018

(4) The Post-Crisis: 1999 to Present

After the Asian financial crisis, the Thai economy experienced many unexpected shocks not only internally but also related external impacts- including the 2008 to 2009 global financial crises, the 2011 massive flood, and the coups in 2006 and 2014. These shocks interrupted economic activities in key industries and affected investor confidence, resulting in the decline of GDP growth during that time. The average growth during 1999-2003 was 5.2 percent then decelerated to 3.5 percent during 2005-2017, with the lowest growth in 2009 below 0.7 percent (World Bank, 2019a). However, the growth has recovered in recent years because of an increase in electronics exports, tourist arrivals and public investment. The IMF (2018) estimated the real GDP growth to be 3.9 percent in 2018 with a slight drop to 3.8 percent in 2019 as shown in Figure 1.1. Meanwhile, the National Strategy 2036 set out a vision of a fast-growing economy, with a targeted growth rate of 5-6 percent per year and full achievement of the 2030 Sustainable Development Goals (SDGs). In May 2018 the National Economics and Social Development Board (NESDB, 2018) reported that the GDP growth in the first quarter stood at 4.8 percent, which was the highest level since 2013. This accelerated due to a high growth rate in exports of 9.9 percent combined with an increase in investment and consumption of both the private and public sector.

In addition, many international institutions have predicted a bright economic condition for the kingdom. According to The Nation (2018), the International Monetary Fund (IMF) estimated that the country's strong growth is expected to continue throughout 2018 and carry on to 2019. Thailand is the only country in Southeast Asia whose projected growth estimation was recently revised upwards by the Asian Development Bank (ADB). The production capacity utilisation rate, which represents the efficiency of an economy and the use of factors, in 2018 hit the highest rate for the past five years. It rose from around 63 percent in the first quarter of 2014 to 72.4 percent in the first quarter of 2018. The Bloomberg Misery Index has rated Thailand as "the world's happiest economy" for four years consecutively due to low inflation and unemployment rates. Furthermore, U.S. News and World Report have ranked Thailand number one for "best country to start a business" in 2016 and 2017 and Thailand was placed number eight for "best country to invest in".

1.2.2 Export and Import

During the pre-boom period of 1960 to 1986, Thailand had a trade deficit due to a large amount of imported capital goods in the 1960s and intermediate goods in the 1970s (Cuyvers et al., 1997). The trade deficit continued until 1997, then it turned to a trade surplus until 2017 as shown in Figure 1.4. The panellists of Focus Economics (2019) forecasted that the trade surplus in Thailand would be US$ 16.5 billion in 2019 and may decrease to US$ 14.4 billion in 2020.

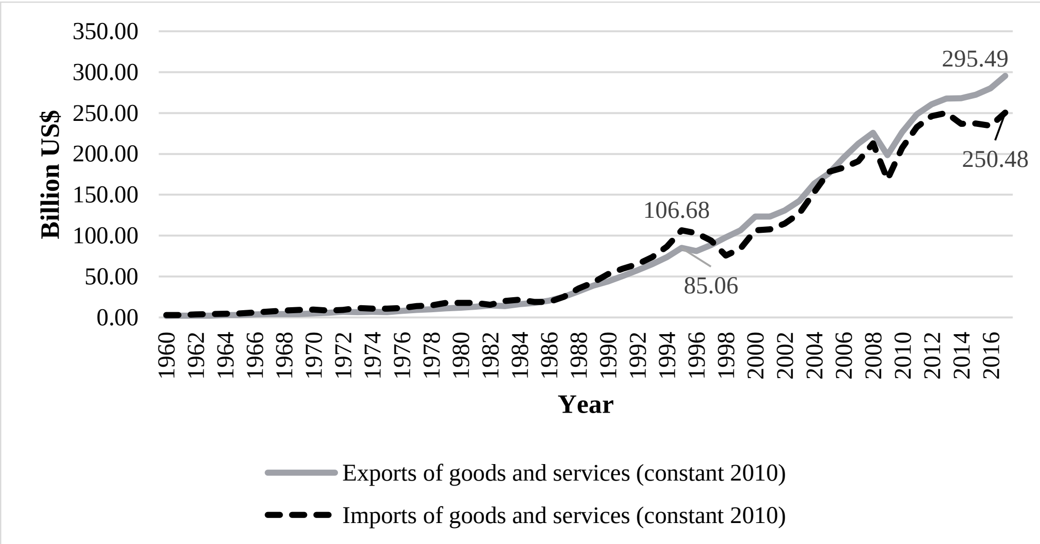

Figure 1.4: Value of Exports and Imports of Goods and Services (Constant 2010)

Source: World Bank (2019a)

From 1986 to 1996, the Thai economy shifted from import-substitution to export-oriented industrialisation. The country benefited from the 1985 Plaza accords, which led to the depreciation of Thai baht as the US dollar had the highest weight in the basket system, which combined with the lower oil prices stimulated manufactured exports. The share of exports surged from 25.6 percent of GDP in 1986 to 41.53 percent of GDP in 1995. As a result, in 1986 Thailand had a trade surplus for the first time ever, the surplus being US$ 1.72 billion. In addition, in 1988 Thailand reached its highest annual growth of exports and imports at 27.17 and 39.56 percent respectively, as shown in Figure 1.5.

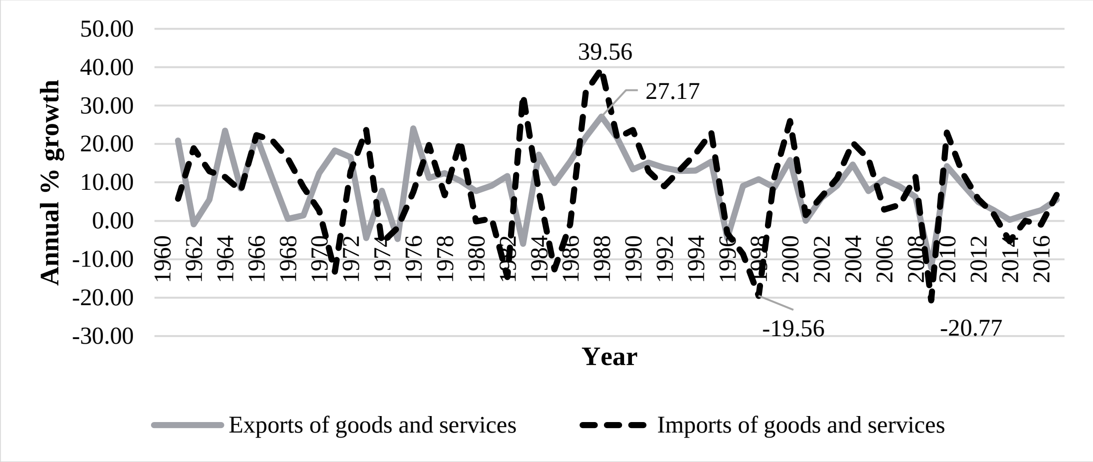

Figure 1.5: Growth of Exports and Imports of Goods and Services

Source: World Bank (2019a)

In 1996, export growth slowed from 22 percent of the previous year to less than 3 percent. Warr (1997) explained that a decrease in Thai exports was caused by a reduction in foreign demand, a real appreciation of the baht, and an increase in real wages in the country. The export growth sharply dropped again to -0.02 and -12.14 percent due to the Asian financial crisis and the global financial crisis, respectively. Since then Thailand's exports have been in a downward trend due to the slowdown of the world economy, which is in line with the import trend.

(1) Export Structure

The share of exported products from 1961 to 2018 reflected the transformation of the country's economic structure. As mentioned earlier, the share of agriculture in GDP declined from 35.8 percent in 1961 to 12.6 percent in 1991. This was in line with the decrease in the share of agricultural exports from 82.7 percent in 1961 to 15.1 percent in 1991. On the other hand, the manufacturing sector's share of GDP increased from 13 percent in 1961 to 28.2 percent in 1991. This is consistent with the rise of manufactured exports from 2.4 percent in 1961 to 76.2 percent in 1991. The OECD (2018) reported that the structural reforms, the trade and investment liberalisation, and business-friendly regulatory environment led Thailand to become an integral part of the global value chains (GVCs) in the Asia-Pacific region, especially for automobile and electronics products, and the share of these sectors in total manufacturing output increased from 10 percent in 1996 to 30 and 20 percent respectively. Table 1.2 shows that the manufacturing sector is the major sector behind Thailand's export performance.

Table 1.2: Share of Exports by Economic Sector, percent of total exports

	1961	1971	1981	1991	1995	2000	2005	2010	2018
Agriculture	82.7	62.2	47.7	15.1	11.1	6.7	6.9	8.7	7.2
Fishery	0.4	2.0	4.3	6.0	5.1	3.3	1.8	1.5	0.8
Forestry	3.3	1.5	0.1	0.12	0.2	0.2	0.3	0.4	0.6
Mining	6.6	13.7	7.7	1.0	0.5	1.2	1.5	0.6	0.5
Manufacturing	2.4	10.0	35.8	76.2	81.7	85.4	87.3	85.1	88.9
Other Exports*	4.7	3.3	4.3	1.5	1.5	3.1	2.2	3.7	2.0
Total Exports	100	100	100	100	100	100	100	100	100

Source: Cuyvers et al. (1997): data for 1961-1991; and Bank of Thailand (2019b): data for 1995-2018

Note: *Other exports included re-exports.

The Information and Communication Technology Center and the Customs Department (2019a) reported that Thailand's top-ten exported goods in 2018 were motor cars, parts and accessories (11.47 percent), automatic data processing machines and parts (7.82 percent), precious stones and jewellery (4.74 percent), rubber products (4.37 percent), polymers of ethylene, propylene in primary forms (4.09 percent), refined fuels (3.69 percent), chemical products (3.64 percent), electronic integrated circuits (3.30 percent), machinery and parts (3.25 percent) and iron and steel (2.35 percent). Although in 2017 Thailand was the second largest rice exporter in the world, accounting for 24.9 percent of total rice exports (Workman, 2019), the share of rice in Thailand's exports was quite low, only accounting for 2.19 percent in 2017 and increasing to 2.23 percent in 2018. The largest market for Thai exported goods in 2018 was China, followed by the US, Japan, Vietnam, Hong Kong, Malaysia, Australia, Indonesia, and Singapore (The Information and Communication Technology Center and the Customs Department, 2019b).

(2) Import Structure

From 1980 to 1990, capital goods were the main imported products. The share of capital goods rose from 34.48 percent to 51.98 percent in 1990 in response to expansion in the investment of infrastructure and manufacturing production. Later, the import structure changed to be dominated by the intermediate products and raw materials for manufactured exports as shown in Table 1.3.

Table 1.3: Share of Imports by Economic Category

	1980-1985	1985-1987	1990	1995	2000	2005	2010	2018
Consumer Goods	10.06	9.05	8.77	6.71	7.32	6.51	7.50	10.27
Intermediate Products and Raw Materials	26.92	34.42	23.76	54.27	65.56	64.56	61.42	56.23
Capital Goods	27.67	34.48	51.98	28.21	21.23	21.49	20.90	22.75
Other Imports	34.60	22.06	15.48	10.80	5.80	7.44	10.19	10.75
Total Imports	100	100	100	100	100	100	100	100

Source: Cuyvers et al. (1997): data for 1980-1990; and Bank of Thailand (2019b): data for 1995-2018

Thailand's top-ten imported products in 2018 were crude oil, which accounted for 11.16 percent of total imports, followed by machinery and parts (8.32 percent), electrical machinery and parts (7.68 percent), chemicals (6.71 percent), jewellery including silver bars (6.01 percent), iron, steel and products (5.39 percent), electronic integrated circuits (4.75 percent), vehicle parts and accessories (4.81 percent), other metal ores, metal waste scrap, and products (3.97 percent), and computers, parts and accessories (3.59 percent). The major suppliers of Thailand in 2018 were China, Japan, the US, Malaysia, United Arab Emirates, South Korea, Taiwan, and Indonesia (Information and Communication Technology Center and the Customs Department, 2019c and 2019d).

1.2.3 Gross Fixed Capital Formation

The World Bank (2019a) defines gross fixed capital formation as a gross domestic fixed investment that includes the value of land improvement, plant, machinery, and equipment purchases, and the construction of roads, railways and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

The annual gross fixed capital formation of Thailand has been varied for the past 50 years. According to Figure 1.6, the annual growth rate of gross fixed capital formation was more than 7 percent from 1961 to 2016 with the highest average growth at 15.15 percent during the boom period in the country from 1987 to 1996. At its peak in 1990, the annual gross fixed capital formation was 29.60 percent, whereas in 1998, gross fixed capital formation hit its lowest growth at -44.03 percent compared to the previous year as a result of the Asian financial crisis. The massive increase of gross fixed capital formation in Thailand at that time was due to the huge amount of investment, particularly foreign investment. Phongpaichit (1996) reported that the average annual net foreign direct investment inflow rose from THB 6.6 billion in 1980-1987 to THB 47.1 billion in 1988-1993. Coxhead

(1998) indicated that the key drivers of the Thai economy becoming an ideal host for foreign investment in the 1980s were low wages, reductions in trade restrictions, conservative economic management and a stable exchange rate. Hence, during the 1990s, Thailand had become the 9th largest exporter of computers and ranked 8th in terms of capital inflows among the developing countries, or 22nd in the world (Kunsabfueng, 2001).

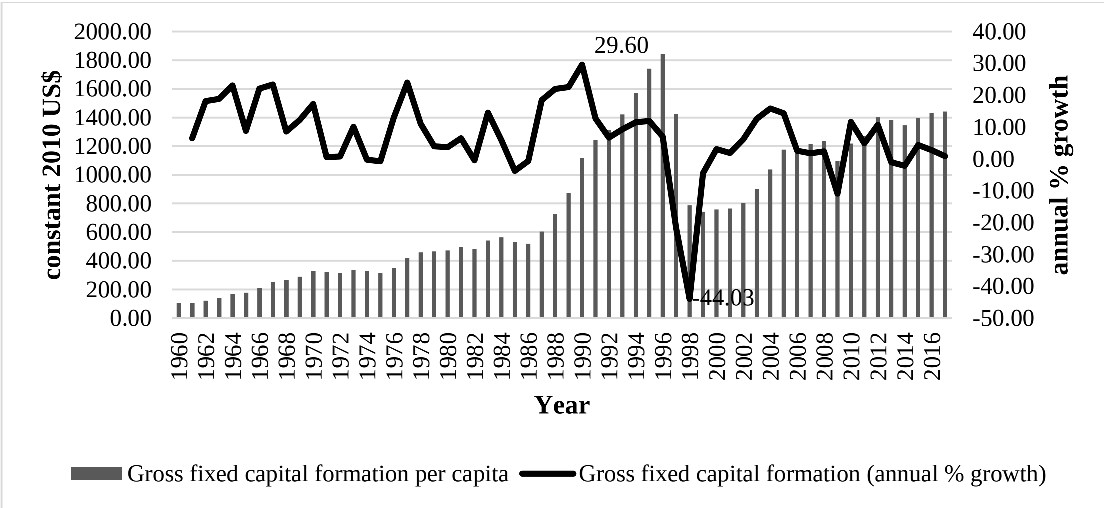

Figure 1.6: Gross Fixed Capital Formation in Thailand

Source: World Bank (2019a)

1.2.4 Financial Development

The deregulation of Thailand's financial market and capital account liberalisation combined with the recession in European countries and stagflation of the Japanese economy during the 1990s led to enormous amounts of capital inflow from aboard to Thailand. Substantially, they were prime years for domestic investment and the banking sector. During 1990-1996, Thailand's investment rate ranged from 39.94 to 41.73 percent of GDP, which was the highest in the region, whereas the GDP growth was 8.08 to 8.94 percent (Laplamwanit, 1999). In addition, more than 50 banks and non-bank financial institutions were established. The early 1990s was a golden era for Thailand's banks as the banks could charge up to 4 percentage points more interest than they paid on deposits. As a result, they were ranked among the world's most profitable banks. Table 1.4 shows that in 1997, the financial market in Thailand experienced its peak as domestic credit provided by the financial sector accounted for 178.42 percent of GDP and domestic credit to the private sector accounted for 166.50 percent of GDP. Consequently, the share of financial and insurance activities in GDP increased from 3.09 percent in 1980 to 6.38 percent in 1997. Unfortunately, a large amount of capital had been put into non-productive sectors, mainly real estate, and only a small portion of the capital inflow had been distributed into real sectors. Hence, the Thai economy faced a severe credit crunch problem that led to the financial crisis in 1997. The GDP growth hit its lowest rate, -7.63 percent, in 1998. This illustrates the crucial role of the banking sector in Thailand's financial transactions, which possibly has a strong relationship with economic growth.

Table 1.4: Selected Financial Indicators

	Unit	1970	1980	1990	1997	2000	2010	2016
Domestic Credit to Private Sector	% of GDP	19.32	40.81	83.37	166.50	105.12	115.75	146.37
Domestic Credit provided by Financial Sector	% of GDP	30.98	60.31	94.08	178.42	134.26	133.42	168.11
Value of Stocks Traded	% of GDP	n/a	2.14	18.44	11.76	15.29	65.21	78.93
Broad Money	% of GDP	32.04	42.01	76.16	99.87	111.21	108.98	125.86
Real Interest Rate	Percent	n/a	3.06	8.17	8.83	6.42	0.24	2.06
Interest Rate Spread	Percent	n/a	4.15	2.17	3.13	4.54	3.13	3.17
Lending Interest Rate	Percent	n/a	16.15	14.42	13.65	7.83	4.33	4.47
Deposit Interest Rate	Percent	n/a	12.00	12.25	10.52	3.29	1.20	1.30
Financial and Insurance Activities	% of GDP	2.53	3.09	5.53	6.38	3.81	5.37	7.71
Real Estate Activities	% of GDP	n/a	n/a	2.86	3.17	4.27	2.72	2.44

Source: World Bank (2019a), except the ratio of financial and insurance activities and real estate activities to GDP come from NESDB (2019).

Note: During 1951-1989, data for banking, insurance and real estate were combined together

1.2.5 Energy

(1) Energy Consumption

(1.1) Final energy consumption by Fuels

Final energy consumption in Thailand consists of commercial energy, renewable energy and traditional renewable energy[1]. Figure 1.7 indicates that Thailand's final energy consumption increased year by year from 2001 to 2016, in particular in commercial energy consumption, which accounted for 84 percent of final energy consumption. This energy type includes coal and its products, petroleum products, natural gas and electricity.

[1] Renewable energy includes solar, fuel wood, paddy husk, bagasse, agricultural waste, MSW and biogas, whereas the traditional renewable energy consumption includes fuel wood, charcoal, paddy husk and agricultural waste.

Petroleum products and electricity accounted for 65 and 20 percent of commercial energy consumption, respectively, during 2001-2016, whereas after 2014, natural gas became more dominant than coal and its products. Renewable energy and traditional renewable energy consumption accounted for 16 percent of the total final energy consumption, on average, during 2001-2016.

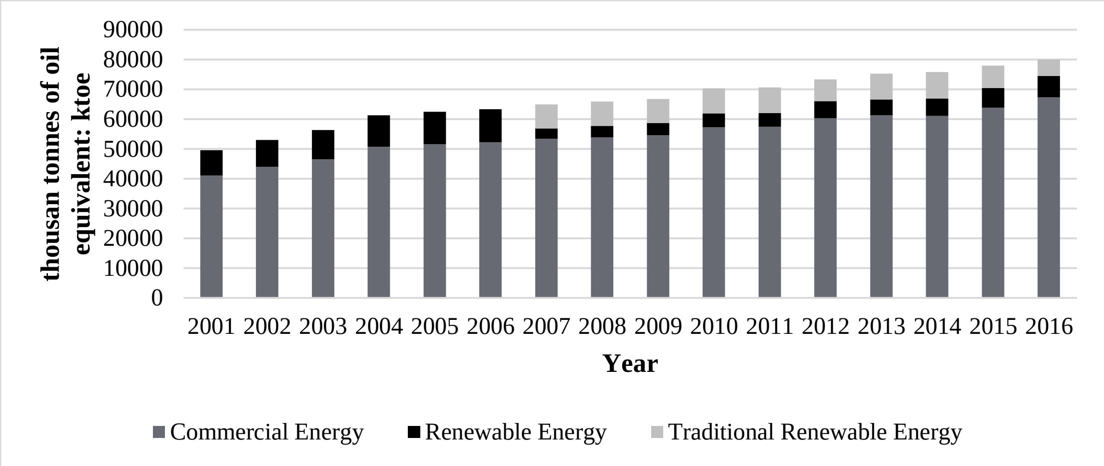

Figure 1.7: Final Energy Consumption by Fuels during 2001-2016

Source: Alternative Energy and Efficiency Information Center (2016)

Note: 2016 is preliminary data

In addition, the Alternative Energy and Efficiency Information Center reported that in 2016 final energy consumption in Thailand was 79,929 ktoe, which increased from the previous year by 2.6 percent. This happened because of the rise of final commercial energy and renewable energy consumption by 5.4 and 9.2 percent, respectively. Meanwhile, the consumption of traditional renewable energy decreased by 26.9 percent. In terms of fuel type, petroleum products had the greatest share at 49.7 percent of total final energy consumption, followed by electricity, renewable energy, natural gas, traditional renewable energy and coal and its products, which accounted for 20.3, 9, 7.6, 6.8 and 6.6 percent, respectively.

(1.2) Final Energy Consumption by Economic Sectors

The final energy consumption by economic sector covers all energy consumed in the seven sectors of agriculture, mining, manufacturing, construction, residential, commercial and transportation. Figure 1.8 shows that energy consumed by each economic sector varies every year. In addition, this figure shows that the major energy consumers during 1993-2016 were the manufacturing and transportation sectors, which was consistent with the increase in the number of firms and vehicles in Thailand at that time.

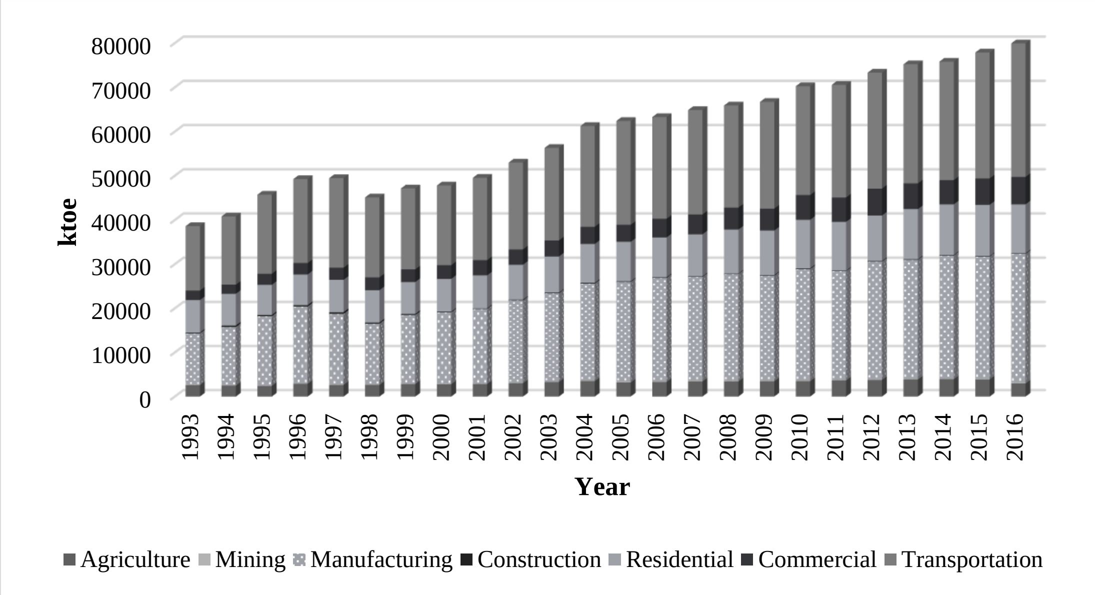

Figure 1.8: Final Energy Consumption by Economic Sectors during 2001-2016

Source: Department of Alternative Energy Development and Efficiency (2018)

In 2016, the final energy consumption in the agriculture sector was 2,987 ktoe which was a fall from the previous year of 23.23 percent. In addition, consumption in the mining and residential sectors decreased by 3.76 and 4.49 percent, respectively. On the other hand, the final energy consumption in construction, transportation, manufacturing and commercial sectors increased by 8.20, 5.93, 5.47 and 4.42 percent, respectively. In terms of the proportion of each economic sector, transportation had the greatest portion of the total energy consumption at 37.77 percent, followed by manufacturing, residential, commercial, agriculture, construction and mining, which each accounted for 36.54, 13.85, 7.78, 3.74, 0.17 and 0.16 percent, respectively.

(2) Value of Thailand's Energy Import

Although some energy needs in Thailand can be supplied by domestic production, more than half of the national energy demand was met by energy imports. As a result, Thailand has spent a lot of money on importing energy, particularly in 2012 the value of energy imported was THB 1,446 billion as shown in Figure 1.9. In terms of energy types, Figure 1.10 shows that the highest total value among Thailand's energy imports was crude oil, which sharply increased every year, except in 2009 when it plunged by 37.86 percent from the previous year due to the contraction of the world economy. In 2017, the value of crude oil import was THB 677.6 billion, or about US$ 19.97 billion (at 33.94 Baht per US dollar), which accounted for 66.70 percent of the total value of energy imported and increased from the previous year by 39.78 percent. The value of petroleum product imports accounted for the second largest share, 12.36 percent, which increased by 23.01 percent from the previous year. At the same time, the import shares of natural gas, coal and electricity were 11.76, 4.91, and 4.28 percent, respectively. Therefore, the overall value of imported energy was THB 1,015.9 billion (US$ 29.94 billion), which accounted for 13.31 percent of the total imports of the economy, or equivalent to 6.60 percent of the GDP.

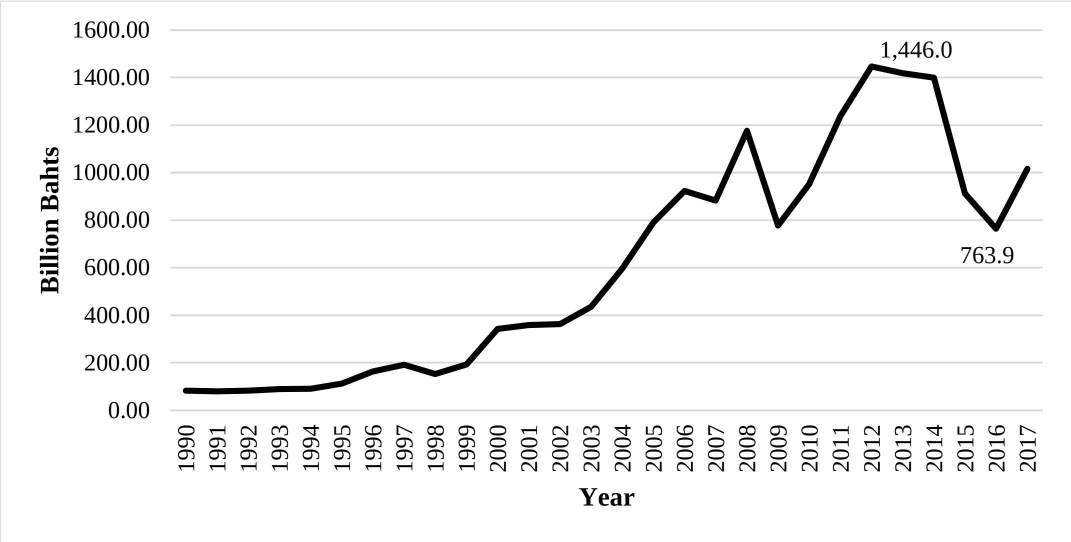

Figure 1.9: The Value of Energy Imported, Total

Source: Energy Policy and Planning Office of Thailand (2018)

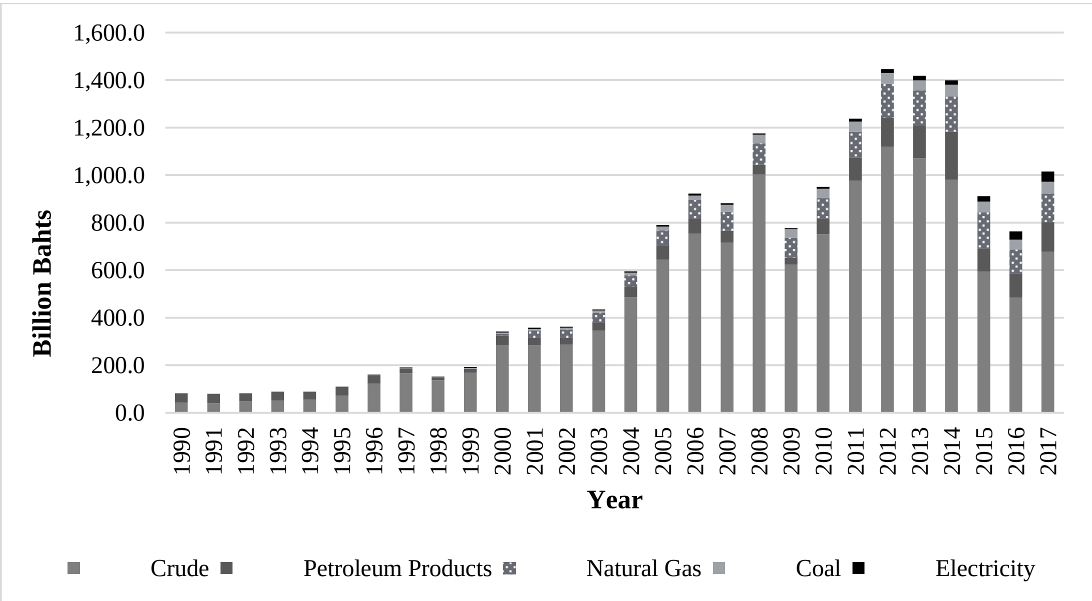

Figure 1.10: The Value of Energy Imported by Energy Types

Source: Energy Policy and Planning Office of Thailand (2018)

Note: Average exchange rate in 2017 was 33.94 Baht per US dollar (Bank of Thailand, 2019a)

(3) Energy Intensity

Energy intensity is the ratio of the amount of energy used to produce one unit of economic output with a lower ratio indicating that less energy is used to produce one unit of output. Figure 1.11 shows the ratio of energy supply to GDP measured at purchasing power parity; it shows that in 2014 Thailand's energy intensity was higher than the world average and many developed countries such as Japan, the European Union, OECD countries, United Kingdom and other high income economies. While the energy intensity of most countries on the list was declining, Thailand's energy intensity was increasing, and this may affect the economic competitiveness of Thailand in the future (World Bank, 2017). Furthermore, Figure 1.12 shows that energy intensity and energy use per capita in Thailand had increased substantially during 1990-2014, while GDP growth fluctuated over that period. This may indicate inefficiency in energy use in Thailand.

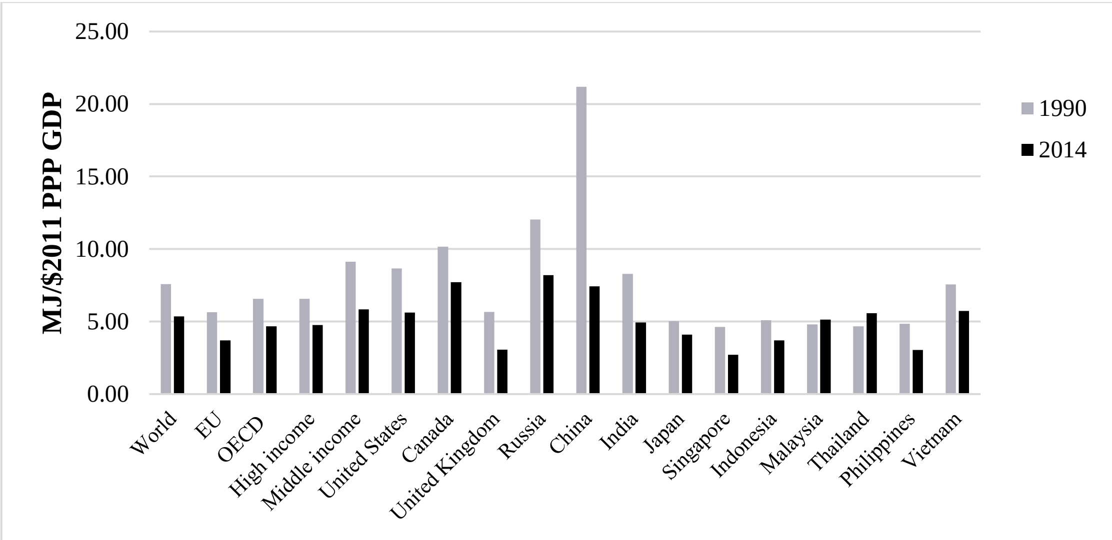

Figure 1.11: Energy Intensity Level of Primary Energy

Source: World Bank (2017)

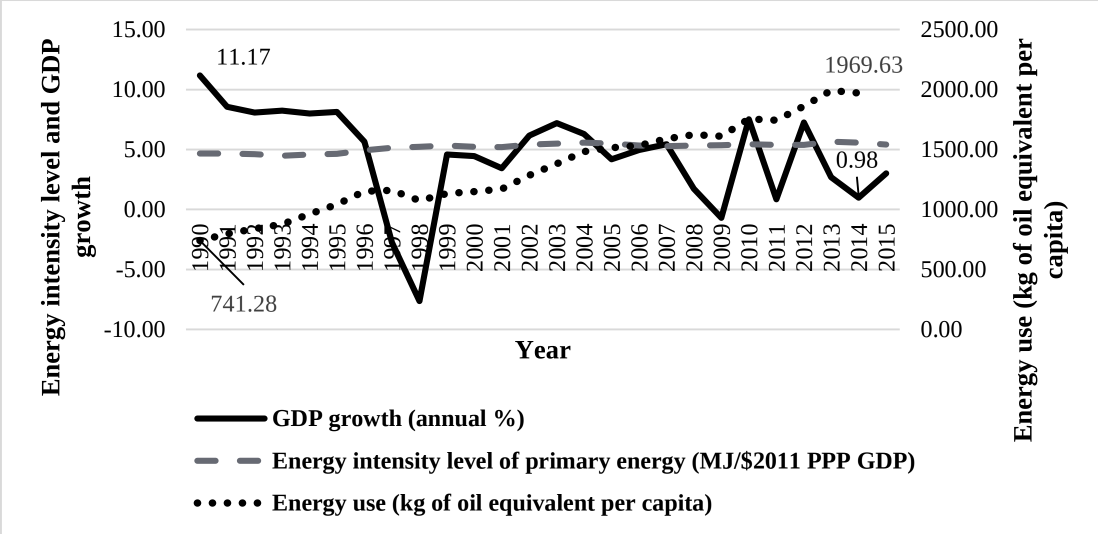

Figure 1.12: The Relationship between Thailand's Energy Intensity, Energy Use and GDP Growth

Source: World Bank (2019a)

(4) Major Energy Challenges

The Ministry of Energy (2015) predicted that energy demand in Thailand will continuously increase from 71,000 ktoe in 2010 to 151,000 ktoe in 2030, given the annual average growth rate of 3.9 percent and average energy elasticity at 0.93. In addition, the forecast for energy demand growth in each sector indicates that the commercial and industrial sectors have the highest rate of energy demand and this is higher than the GDP growth. Therefore, the increasing trend in energy demand as mentioned earlier may lead Thailand to face several crucial challenges including energy supply security due to an increase in energy cost and higher energy demand in the world, which may reduce amount of energy import of Thailand and subsequently harm terms of trade and competitiveness of the country. In addition, the nation needs to be aware of the climate change problems and energy security, which were addressed at the APEC Leaders' summit in 2007. The government leaders ratified the collaboration in energy conservation promotion to reduce energy intensity and final energy consumption to reach the agreed target.

1.2.6 Population

The population of Thailand was 69,183,175 as of 13 July 2018, based on the latest United Nations (2018). Its population is equivalent to 0.91 percent of the total world population and ranks twentieth in the list of countries by population size. During 1960-1982, the male population was greater than the female. Since then, the structure of the population has changed and the female population become greater than the male population until the estimated year in 2025, as shown in Figure 1.13. Thailand's population is expected to reach 69.68 million by 2025 and about half of these people will be living in Bangkok, which is not only the capital but also the most populous city. This is in line with the increasing share of the urban population which moved from 19.67 percent of the total population in 1960 to 49.20 percent in 2017. People in rural areas are migrating to the city in order to find jobs or live in better conditions.

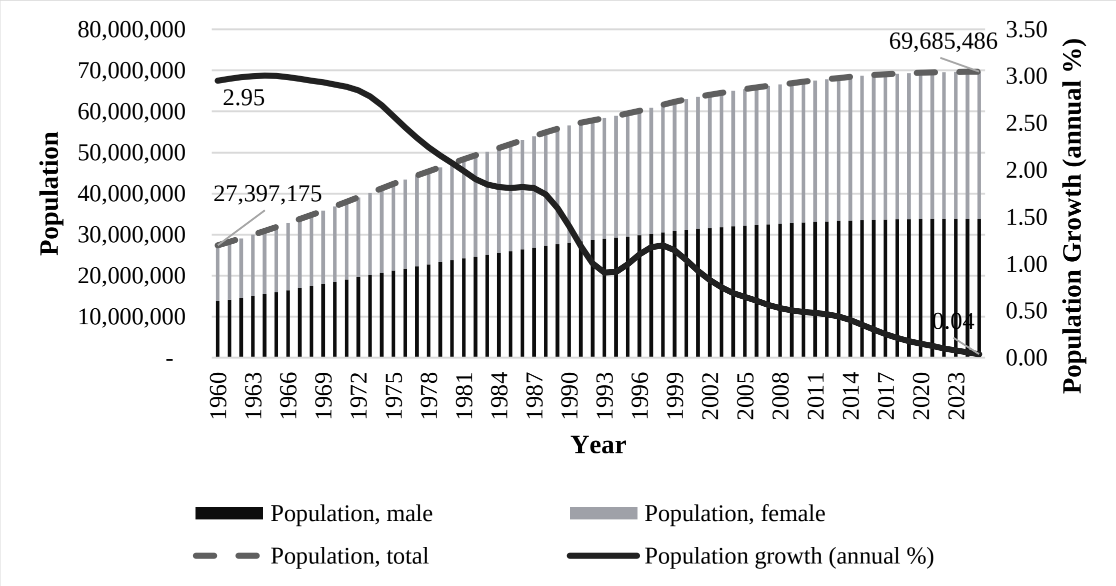

Figure 1.13: Thailand's Population during 1960-2025

Sources: World Bank (2019a): data from 1960-2017; and United Nations (2018): data from 2018-2025

The population density in Thailand has increased every year from 72.20 people per square kilometre in 1970 to 135.13 people per square kilometre in 2017 as shown in Table 1.5. However, the population growth in Thailand has been as fast as in China, Singapore, Taiwan and South Korea and consistent with the trend of lower population growth in Asia, which started in the early 1970s. That is, Thailand's population in 1970 grew by 2.91 percent: in 1990 the figure was 1.40 percent and in 2017 just 0.25 percent. The reason for the slowing of population growth in Thailand can be explained by a few factors. First, there has been a decline in the birth rates in Thailand over the years, according to the World Bank (2019a) which showed that the Thai birth rate dropped from around 42.74 per thousand people in 1960 to 19.22 per thousand people in 1990, then again to 10.58 per thousand people in 2015. This represents one of the most dramatic declines in birth rates in the world. Second, a growing number of people are not getting married or having children as they wish to be more independent. Third, the traditional role of women that ties them to the home has been changed; women study and have jobs. Finally, a smaller family is more compatible with working life and makes it easier to accommodate complex living conditions.

Table 1.5: Selected Population and Social Indicators in Thailand

	Unit	1960	1970	1980	1990	1995	2000	2017
1. Demographic Characteristics								
1.1 Total Population	Million	27.40	36.88	47.39	56.58	59.49	62.96	69.04
1.2 Annual Population Growth	Percent	2.95	2.91	2.07	1.40	1.00	1.04	0.25
1.3 Population Density	people per sq. km of land area	n/a	72.20	92.75	110.75	116.45	123.23	135.13
1.4 Urban Population	% of total	19.67	20.89	26.79	29.42	30.28	31.39	49.20
1.5 Rural Population	% of total	80.33	79.11	73.21	70.58	69.72	68.61	50.80
1.6 Population Ages 65 and above	% of total	3.31	3.50	3.75	4.52	5.47	6.54	11.37
1.7 Total Fertility Rate	births per woman	6.15	5.60	3.39	2.11	1.87	1.67	1.50[a]
1.8 Birth Rate	Per 1,000 people	42.74	37.85	26.45	19.22	16.91	14.53	10.58[a]
1.9 Total Life Expectancy at birth	years	54.70	59.39	64.43	70.25	70.19	70.62	75.10[a]
2. Social and Economic Characteristics								
2.1 Adult Literacy Rate	% of people ages 15 and above	n/a	n/a	87.98	n/a	n/a	92.65	92.87[a]
2.2 Total Labour Force	Million	n/a	n/a	n/a	29.90	32.38	35.14	39.14
2.3 Employment Ages 15 and above	% of population	n/a	n/a	n/a	n/a	73.80	71.68	67.82
-Employment in services	% of total employment	n/a	n/a	n/a	n/a	28.11	32.12	44.65
-Employment in industry	% of total employment	n/a	n/a	n/a	n/a	19.90	19.09	22.56
-Employment in agriculture	% of total employment	n/a	n/a	n/a	n/a	51.98	48.79	32.80
2.4 Unemployment Rate	% of total labour force	n/a	n/a	n/a	n/a	1.14	2.39	1.08
2.5 Elderly dependency ratio	% of working-age population	6.14	6.67	6.59	6.92	8.11	9.41	15.95

Source: World Bank (2019a)

Note: [a] is data from 2015

Apart from declining population growth, Thailand is now more concerned with the large number of old populations. According to the World Bank (2019a), the share of the population aged above 65 increased from 3.3 percent in 1960 to more than 11 percent in 2017. This is consistent with the World Bank (2016), which forecasted the elderly dependency ratio[2] in Thailand to increase threefold from 15 percent to 42 percent by 2040, subsequently people aged 65 years and older will account for more than a quarter of the total population. One of the major reasons for this could be the decline in fertility rate. As shown in Table 1.5, the total fertility rate per woman dropped from 6.15 in 1960 to only 1.5 in 2015. In addition, the rapidly ageing population was a result of advancement in medical technology and improvement in healthcare knowledge, meaning people are healthier and live longer. Thai life expectancy increased from 55 years old in 1960 to 75 years in 2015. As a result of this, Thailand is likely to become an ageing society before achieving high-income status.

For several years, the Thai government has been concerned about the declining population growth rate and ageing population because human capital is one of the most important factors for inclusive and sustainable growth of a growing economy. Therefore, the government has stressed these issues in the *Thailand 4.0* policy and the 20-year National Strategic Plan.

1.2.7 Income and Inequality

(1) Income

Over five decades, Thailand's GDP per capita has increased by more than ten times, from US$ 570 in 1960 to US$ 6,126 in 2017 as shown in Table 1.6. Between 1970 and 2017, Thailand's GDP growth per capita averaged 4.30 percent per year, with the highest average growth around 7.5 percent during the boom period of the Thai economy. The GDP growth per capita continued on an upward trend but slightly increased since the Asian financial crisis. In the early 2010s, the country has transformed from a lower-middle income country to an upper-middle income country status.

Poverty has been on the declining trend. As measured at 2011 international prices, only 7 percent of the population lived on less than US$ 5.50 a day in 2015, while in 1981 the figure was around 70 percent of the population, as shown in Table 1.6. Although the national poverty rates fell, the World Bank (2019b) revealed a rise in the poverty rate across regions in the nation. In particular, there was an increase in poverty rates from

[2] Elderly dependency ratio is the percentage of people age above 65 years old relative to the working age population (World Bank, 2016).

2015 to 2017 in the North and Northeast regions due to droughts that led to a sharp drop in agricultural production.

Table 1.6: Income and Poverty Indicators in Thailand

	Unit	1960	1970	1980	1990	1995	2000	2017
1. GDP (constant 2010)	Million US$	15,639	34,269	66,513	141,610	210,023	217,712	422,940
2. Annual GDP growth rate	Percent		11.41	5.17	11.17	8.12	4.46	3.91
3. GDP per capita (constant 2010)	US$	570.86	929.08	1,403.68	2,502.71	3,530.29	3,458.05	6,126.24
4. Annual GDP per capita growth	Percent		8.21	3.01	9.62	7.05	3.37	3.65
5. Gini index		n/a	n/a	45.2[a]	45.3	43.5	42.8	36.0[c]
6. Poverty Headcount Ratio at $5.50 a day (2011 PPP)	% of population	n/a	n/a	69.6[a]	64.7	45.4[b]	48.9	7.1[c]

Source: World Bank (2019a)

Note: [a] is the data in 1981, [b] is the data in 1996, and [c] is the data in 2015.

(2) Inequality

Thailand has effectively reduced poverty and made remarkable progress in restructuring its society. Income inequality, however, has not improved even slightly. In the late 1980s, the Thai economy took off on a rapid growth path with economic liberalisation and a shift of labour from agriculture to manufacturing and services. This raised income inequality even further. The Gini coefficient reached its highest value of 47.9 percent, particularly during the high growth period of 1988-1992 (World Bank, 2019a). Following redistribution programmes, the Gini coefficient consequently dropped to 36 percent in 2015 as shown in Table 1.6. However, less inclusive growth due to inequalities in household income and consumption can be seen throughout the lagging regions of Thailand (World Bank, 2018). As shown in Figure 1.14 households in Bangkok have the highest average monthly income, accounting for more than double the average monthly income of household in the Northeastern and the Northern regions.

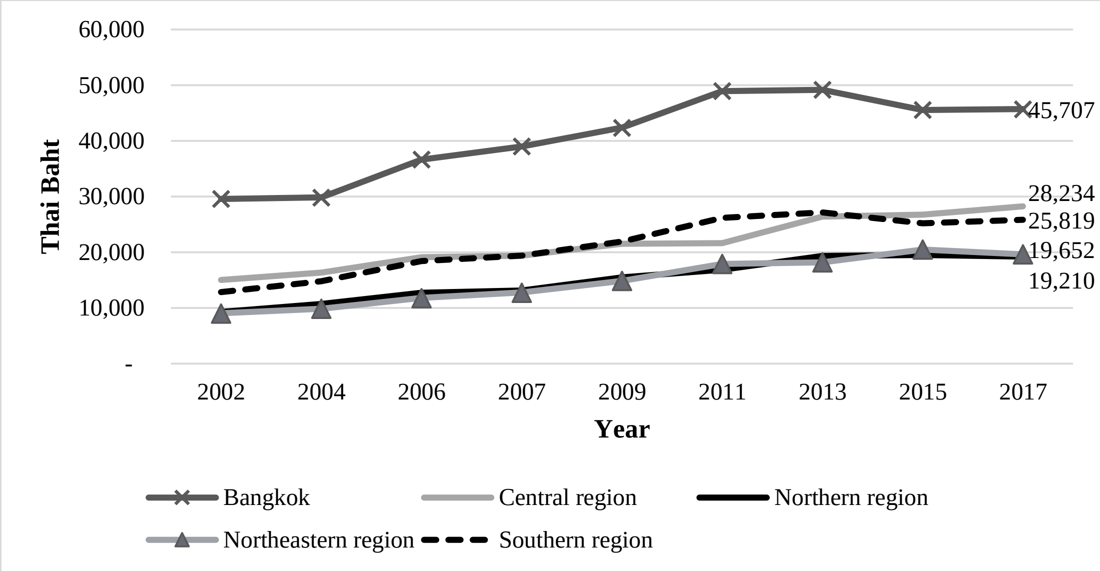

Figure 1.14: Average Monthly Income per Household by Region

Source: The Household Socio-Economic Survey, National Statistical Office, Ministry of Digital Economy and Society, Thailand (2019)

Note: Northeastern region excluding Bueng Kan which was established as a province in 2011. Average exchange rate in 2002-2017 was 35.50 Baht per US$ (Bank of Thailand, 2019a)

Income inequality and poverty have become a national priority issue for the Thai government because they can harm the levels of country development. Therefore, the government has highlighted the target for inclusive growth to unlock the country from an inequality trap by shifting society from the concentration of wealth into the distribution of wealth in the *Thailand 4.0* policy.

1.2.8 Government Budget

As mentioned above, government-led investment is the main factor for the success of any project which will allow Thailand to attain developed country status through broad reforms by 2036. Therefore, it is important to review the revenue status and the sources of Thai government revenue.

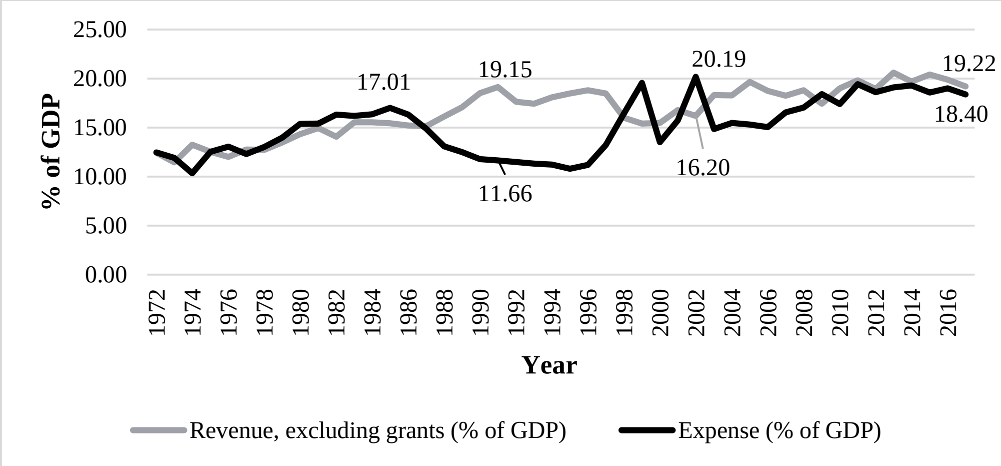

Figure 1.15: Revenue and Expense of Thai Government

Source: World Bank (2019a)

Figure 1.15 shows that the share of government spending as a percentage of GDP gradually increases from 1972 to 1985. The long-term trend is upwards, from an expenditure ratio between 11 percent in 1972 to a level of around 17 percent in 1985, with a slight drop in 1973-1974 due to the first oil crisis. During the growth boom of the 1990s, the expenditure ratio shrank and the ratio recovered to a level of around 18 percent in recent years. The revenue ratio also showed a similar trend at some periods. In the late 1970s the revenue ratio was around 12 percent of GDP, then it increased to a level of around 15 percent by the early 1980s. In the late 1980s and the 1990s the revenue ratio rose to around 19 percent of GDP as a result of the boom era of the Thai economy. The Asian financial crisis led to a decline in revenue ratio to around 15 percent between 1998 and 2001. However, the most recent years of revenue ratios show a recovery to around 19 percent of GDP.

The balance between the expenditure ratio and revenue ratio during the 1970s and the first half of the 1980s showed a small deficit. In the late 1980s to 1996, the government's balance was in surplus due to the sharp fall of the expenditure ratio and the huge increase in the revenue ratio, which came from foreign capital inflows during the economic boom period. This fiscal surplus was interrupted by the Asian crisis in 1996 and 1997, resulting in fiscal deficit until 2002, but since 2003 the fiscal balance has been restored to a small surplus. For the 2019 fiscal year, the government budget has been in deficit of THB 450,000 million or 2.3 percent of GDP, which is lower than the 2018 fiscal year, when the estimated revenue was THB 2,550,000 million or 14.5 percent of GDP (World Bank, 2019b). Public debt is estimated to increase from 41.5 percent of GDP in 2018 to 43.3

percent of GDP in 2019, which is still far below the fiscal prudential maximum limit of 60 percent of GDP (Fiscal Policy Office, 2018).

(1) Government Expenditure

The share of government budget as a percentage of GDP slightly increased from 1989 to 2018. The long-term trend is upwards, ranging between 16 to 20 percent of GDP. As shown in Figure 1.16, more than half of the budget is allocated to current expenditure, especially personal administration in the public sector. From 1990 to 1997, the government increased spending on capital expenditure to stimulate the expansion of the economy in this boom period. In particular, the share of capital expenditure reached its highest point at 41.45 percent of the total budget in 1997. But since 1998 the share of capital spending in the total budget declined due to the jointed investment from the private sector, the public-private partnerships (PPPs), while the share of current expenditure increased to more than two-thirds of the total budget.

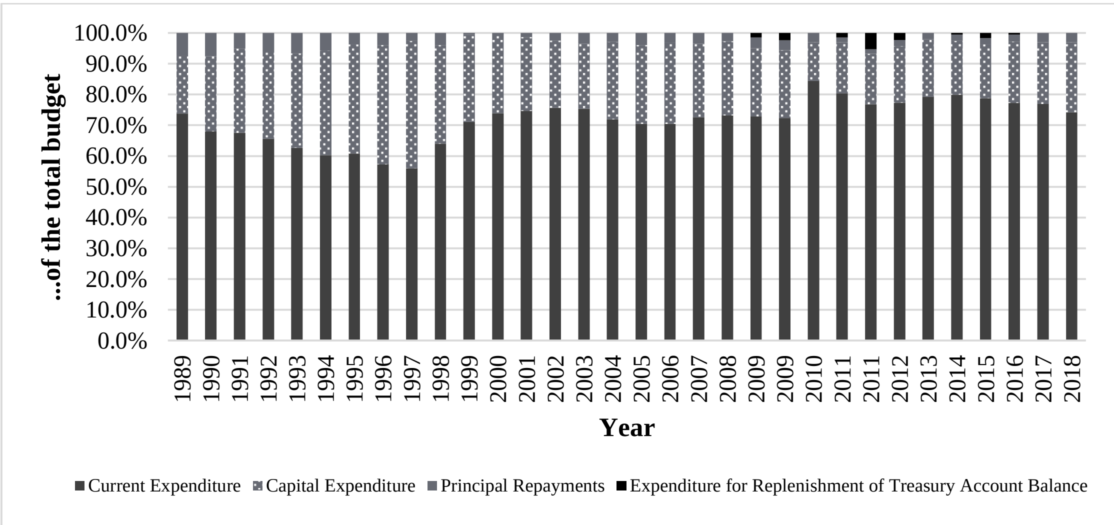

Figure 1.16: Thailand's Budget Expenditure from 1989 to 2018

Source: Fiscal Policy Bureau, Fiscal Policy Office (2019)

(2) Government Revenue

The main source of government revenue is tax revenue. As shown in Figure 1.17, tax revenue accounted for more than 88 percent of the total government revenue. During 2011-2015, Thailand's total government revenues and tax collections averaged 21.4 and 17.7 percent of GDP, respectively. Despite this being widely consistent with regional comparators, it is much lower than the OECD average (41.9 percent). As a result, the government realises that it is necessary to boost revenues to achieve the target of tax collection totalling 20 percent of GDP by 2020. In doing so, the OECD (2018) proposed that the Thai government should encourage people to work in the formal economy and increase the efficiency of the tax system by improving ease of compliance through technological innovation, promoting financial incentives to stimulate tax compliance and strengthening tax enforcement.

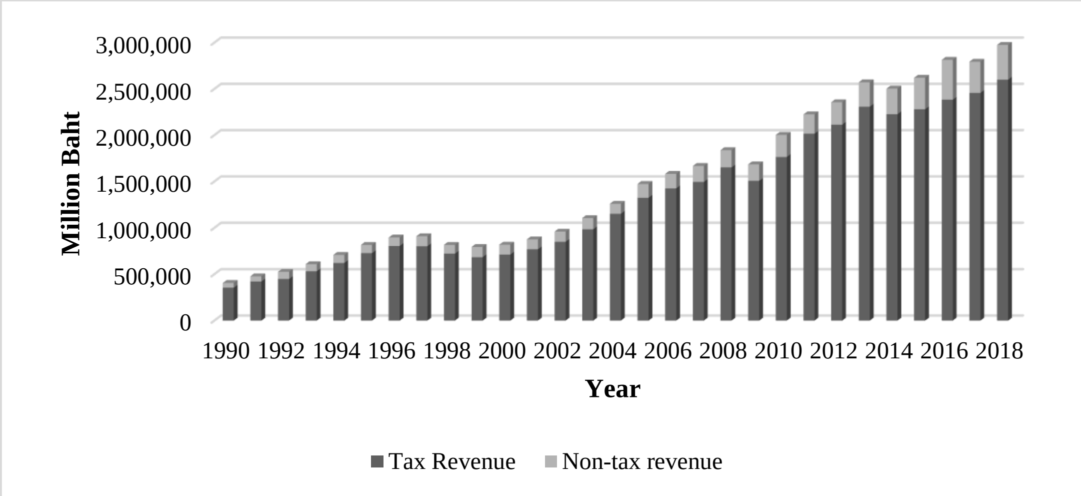

Figure 1.17: Revenue Collection Classified by Revenue Base

Source: Revenue Policy Division, Fiscal Policy Bureau, Fiscal Policy Office (2018)

The OECD (2018) stated that direct and indirect taxes in Thailand accounted, respectively, for 41 percent and 59 percent of total tax revenues in 2016. Before this, there had been reform in direct taxes, particularly in personal income and corporate income taxes. Personal income tax (PIT) is levied at a progressive rate ranging from 5 to 37 percent and includes an exemption threshold of up to THB 150,000 (around US$ 4,500). But in the tax year 2017, there was a reform to personal income tax that cut the top rate from 37 to 35 percent and increased the thresholds and deductibles. This tax cut would gradually reduce informality as only one-fifth of the working-age population (15-64 years old) pay any income tax, and to ensure people enjoy better social protection.

In addition, the corporate income tax (CIT) rate which is the largest source of direct tax revenue, accounting for 4.6 percent of GDP, was reduced from 23 to 20 percent in 2013, down to the lower end of the international range. This led to a decline in corporate income tax revenue. The OECD (2018) suggested that Thailand should consider other issues to improve competitiveness and avoid a lower further corporate income tax rate. For indirect taxes, VAT is the main source of public revenue as it accounts for the largest proportion of total tax revenue. The VAT in Thailand has been set at 7 percent since 1999, despite the statutory VAT rate being 10 percent. This is one of the lowest rates in the world.

Hence the estimated VAT revenue ratio is 38 percent in Thailand, lower than the OECD average of 56 percent. The OECD (2018) proposed that Thailand can raise VAT revenue by steadily expanding the scope of VAT and increasing its rate. Additionally, encouraging people to participate in the formal economy and raising the efficiency of the tax system might also help increase revenue.

Although Thailand has a good record of fiscal prudence over the past 10 years, the efficiency of the tax system still needs improvement in order to raise revenue and overcome informality and inequality. Therefore, studying the impact of tax reform, particularly PIT, CIT, and VAT, on welfare and the reallocation of resources across sectors and Thai households will ensure that these recent reforms benefit the Thai people and society has social protection and a sustainable fiscal safeguard.

To sum up, the major stylised facts of the Thai economy above show that Thailand has enjoyed rapid economic growth and development, and has transformed its industrial base from agriculture to export-oriented manufacturing within the last half-century. The country has a good track record of sound economic policies, high savings and investment, and low inflation. It has effectively reduced poverty and made remarkable progress in restructuring its society. This transformed the country from lower-middle income country status to upper-middle income country status in the early 2010s. The OECD (2018) declared that the welfare of the Thai people has been enhanced along multiple dimensions with the expansion and improvement of education and health services.

However, the country still faces several economic challenges caused by the previous three economic development models. The first model, *Thailand 1.0,* focused on the agricultural sector, which led to an industrial revolution within the nation. In the second model, *Thailand 2.0*, the emphasis was placed on light industry such as food processing and textiles, and the nation had a comparative advantage from low wages. This policy transferred the country's economy from low-income to middle-income status. The third model, *Thailand 3.0,* spotlighted heavy industry, such as petrochemicals and steel. Advanced machinery was used in production. The nation emphasised foreign direct investment and export promotion. Although the Thai economy became stronger from the previous economic policies, particularly *Thailand 2.0* and *3.0,* which integrated the economy into the globalised world, it could not unlock Thailand from the middle-income trap, the inequality trap and the imbalanced trap which was caused by the *Thailand 3.0* economic model as shown in Figure 1.18. Therefore, in 2016 the Thai government introduced a new economic model called *"Thailand 4.0"* with the aim of releasing the nation from the aforementioned traps and developing the country into a value-based economy.

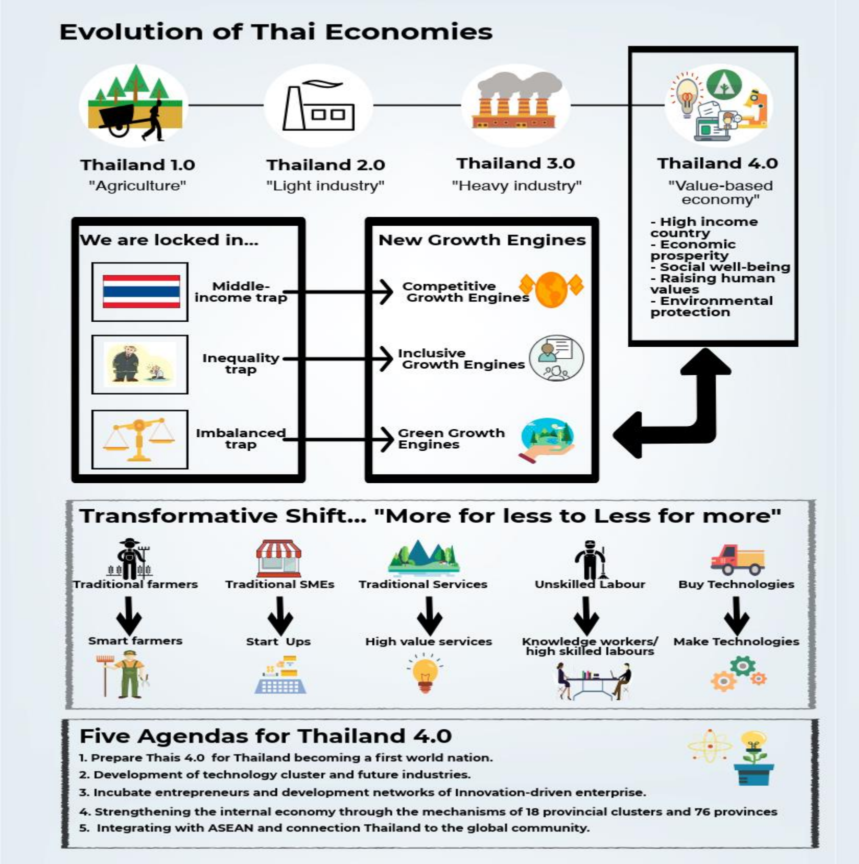

Figure 1.18: Evolution of Thai Economies and Thailand 4.0 Policy

Source: Author summaries from Thailand 4.0 Policy, Royal Thai Embassy-Washington, D.C. (2018)

The next section summarises the *Thailand 4.0* economic model which complied with the Twelfth National Economic and Social Development Plan (2017-2021), the 20-year National Strategy Plan (2017-2036), and the country's Sustainable Development Goals (SDGs). This plan proposes development directions and strategies in order to improve human capital, society and environment to achieve the objectives of prosperity, security, and sustainability, so that the country will have inclusive growth and become a high-income country by 2036.

1.3 Thailand 4.0 Economic Model: Growth with Redistribution

The *Thailand 4.0* economic model is consistent with globalisation 4.0 highlights a value-based or technology driven economy. It presents a desired future economic model for a more innovative, inclusive and sustainable economy. This economic policy deals effectively with disparities and the imbalance between the environment and society to achieve four objectives stated on the website of the Royal Thai Embassy in Washington, D.C. (2018). The first of these is *"Economic Prosperity"*, which aims to create a value-based economy that is driven by innovation, technology and creativity; the model aims to increase national income per capita from US$5,410 in 2014 to US$15,000 by 2032, to increase the economic growth rate from 3-4 percent to a full capacity rate of 5-6 percent within five years, to increase GNP growth from 1.3 percent in 2013 to greater than 5 percent continuing within 10 years, and to increase research and development expenditure to 4 percent of GDP. The second is *"Social Well-being"*, which looks to create a society that moves forward without leaving anyone behind (an inclusive society) through the realisation of the full potential of all members of society. Society should have economic and social security, rebuilding reconciliation and solidarity. This objective aims to reduce social inequality from 0.465 percent of Gini coefficient in 2013 to 0.2-0.4 percent in 2032, to completely change to the social welfare system within 20 years, to upgrade at least 20,000 traditional farmers to Smart Farmer within five years, and to develop at least 100,000 traditional SMEs into "Smart SMEs and Startups" within five years. Thirdly, is *"Raising Human Values"*, which aims to transform Thais into "Competent human beings in the 21st Century" and "Thais 4.0 in the first world"; the aims are to improve the PISA score from 47th to the top 20 within 20 years, to raise the Thailand Human Development Index (HDI) from 0.722 in 2013 to 0.8 or into the top 50 countries within 10 years, to develop at least 500,000 skilled labour workers to meet industrial demand and national strategies, and to promote at least five Thai universities to rank amongst the world's top 100 higher education institutions within 20 years. Lastly, is *"Environmental Protection"*, which looks to make Thailand a liveable society with an economic system that can adjust to climate change and develop into low carbon society; the goals are to promote at least 10 cities into the world's most liveable cities within five years, and have at least five completely smart cities within 10 years.

From Plans to Actions

In order to fulfil Thailand's ambitions to become a high-income country by 2036, the Multidimensional Country Reviews (OECD, 2018) suggested that the core of Thailand's development strategies should focus on reducing informality and inequality, enhancing productivity, improving management of natural resources and restructuring institutions to ensure a sustainable development path for the country and prosperity is shared more equally across the nation. This is consistent with the three new growth engines that are mentioned in the *Thailand 4.0* economic model (Division of Research Administration and Educational Quality Assurance, 2016). Firstly, the *"Competitive Growth Engine"* intends to unlock the country from the middle-income trap to become a high-income country driven by innovation, technology and creativity and transform the country from "more for less to less for more". Secondly, the *"Inclusive Growth Engine"* aims to solve the inequality problem in the nation by transforming it from a "concentration of wealth into distribution of wealth society". Finally, the *"Green Growth Engine"* targets overcoming the imbalance trap by considering the environmental aspect of economic development that leads to balanced development.

In June 2016, the Cabinet approved the Eastern Economic Corridor Development Plan to force *Thailand 4.0* into action through area-based development. The Eastern Economic Corridor (EEC) is expected to be a new growth hub for investment, trade and regional transportation, and a strategic gateway to Asia. The EEC includes ten key industries divided into two groups. The First S-Curve[3] industries comprise of the next generation automotive industry, the intelligent electronics industry, advanced agriculture and biotechnology, the food processing industry, and the high wealth and medical tourism industries. The Second S-Curve industries include the digital industry, the robotics and automation industry, the aviation and logistics industry, the comprehensive medical and healthcare industry, and biofuel and biochemical industries (Sangsubhan, 2018). In addition, Thailand's Transport Infrastructure Development Strategy (2015-2022) is continuing to be implemented as planned to increase Thailand's productivity and competitiveness and to support sustainable economic growth and social development (ADB, 2017). Several projects are also included in the agendas for *Thailand 4.0* such as the establishment of Special Border Economic Zones in 10 provinces, an Innovation Hub at a regional level, and reform of Thai research and education systems. The EEC project is expected to require approximately combined public and private investments of at least Baht 1.7 trillion (US$ 49.9 billion) in the first five years between 2017 to 2021 as shown in Figure 1.19 (Sangsubhan, 2018). These key strategies require large government-led investment in infrastructure with support from public-private partnerships (PPPs) or *Pracharath*, in particular the dual tracking of railways and local infrastructure improvement projects. The World Bank (2019b) expected that public investment in the fiscal year 2019 increase to 6.2 percent from 5 percent in the previous fiscal year.

[3] S-curve is a measure of the speed of adoption of an innovation (Jones and Paitoon, 2017).

Therefore, government revenue is a crucial factor in determining government investment and the success of projects.

Figure 1.19: Combined Public and Private Investment in ECC Project

Source: Sangsubhan (2018)

The research undertaken in this study should be understood and interpreted in the context of the above major features of the Thai economy. How far the fiscal and financial sectors have influenced the growth, efficiency and redistribution are the main points of investigation.

1.4 Research Objectives

The main objectives of this research are

(i) to evaluate the impacts of reforms in the value added tax (VAT) and corporate income tax (CIT) on welfare and the reallocation of resources across various sectors in the Thai economy.

(ii) to assess the impacts of a reduction of personal income tax (PIT) rate on growth and redistribution in the Thai economy.

(iii) to re-examine the relationship between energy consumption, financial development and the growth of GDP in Thailand.

General equilibrium models will be employed to capture the economy-wide income and substitution effects that impact on investment, capital accumulation and the growth of the Thai economy. Then, dynamic computable general equilibrium models will be applied to find the most efficient path of economic growth in order to enhance the wellbeing of Thai households over the next 25 years. Finally, the econometrics method is used to estimate some basic parameters relating to the central ratios of the Thai economy. Specifically, we will study the following questions:

(i) What are the impacts of VAT and CIT reform? Which tax policy is preferable?

(ii) Does a reduction in personal income tax rates improve inequality in Thailand?

(iii) Is there any relationship between energy consumption, financial development and the growth of GDP in Thailand?

1.5 Contributions

This study contributes to the existing literature in three aspects.

(i) This study contributes to existing studies as it evaluates the economy-wide income and substitution effects and how they impact on the growth of the Thai economy resulting from the changes in the rates of VAT and CIT on output, prices, welfare and sectoral allocation of capital and labour inputs in production.

(ii) This study is the first study to present the magnitude of the economic impacts from a reduction in personal income tax rates on complicated economy-wide income and substitution effects over 25 years of the Thai economy from 2011 to 2036.

(iii) Unlike the existing and growing literature on the energy-growth nexus, this study contributes to the literature on this topic by incorporating financial development in the production function and focusing only on the context of the Thai economy. The analytical framework of this study also allows us to investigate the presence of energy-led growth and finance-led growth hypotheses in Thailand.

1.6 Structure of the Thesis

The remainder of the thesis is divided into four chapters. The next chapter examines the economy-wide impacts of tax reform, particularly the changes in VAT and CIT rates. This chapter provides literature reviews of fiscal policy that apply partial and general equilibrium techniques and summarises the structure of tax reform in Thailand. We simulate the change in tax rates in order to assess the economy-wide impact of that reform on its welfare by employing the static computable general equilibrium (CGE) approach. In addition, we compare the results with the baseline simulation and the findings of each scenario to evaluate which scenario is preferable in terms of net welfare. In Chapter 3, we apply the dynamic CGE model to analyse the impacts of changes in personal income tax rates on growth and redistribution over 25 years of the Thai economy. Furthermore, this chapter provides the effects of alternative tax policies as a guideline for policymakers to implement appropriate tax reform to meet their fiscal target. Chapter 4 contains a review of the empirical literatures on the relationship between energy consumption, financial development and growth. From the existing empirical studies, we find that there is a lack of this type of study on Thailand context. Therefore, this chapter examines the association among those variables in Thailand and discusses some policy implications. In the final chapter of the thesis, we summarise the findings and results of the research, also proposing some areas for further research.

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Chapter 2 : General Equilibrium Impacts of VAT and Corporate Income Tax in Thailand

In the previous chapter, it was explained that the Thai government would require a large amount of money to create sustainable economic growth and social development. Government revenue, particularly tax collection, is a crucial source of that money, apart from private investment. Among the tax revenues, the VAT and CIT are the biggest sources. However, the government revenue from those taxes are still low as the estimated VAT revenue ratio in Thailand is lower than the OECD average, while the CIT rate is down towards the lower end of the international range. This might have adverse impacts on the revenue and Thai economy.

Therefore, the aim of this chapter is to evaluate the impacts of taxation, more specifically of changes in VAT and CIT rates on the welfare and reallocation of resources across sectors in the Thai economy by applying the difference rates of those taxes. In order to analyse that impacts of such policy, a computable general equilibrium (CGE) model is more appropriate than the econometric method because this approach can illustrate how an adjustment in the system of relative prices balances supply and demand across various markets in an economy. Therefore, this approach can clearly explain the economy-wide impacts of tax reforms on all agents in the economy. Furthermore, this method doesn't suffer from endogeneity problem, although depends on specific form adopted.

The findings show that an increase in the VAT rate from the current level, 7 percent, to 10 percent generates higher net welfare to society, while a reduction of the CIT rate from 30 percent to 20 percent is a more preferable policy on the basis of economy-wide welfare analysis. For the efficiency in reallocation of scarce resources, we study the impacts of these tax reforms on employment, capital, output, supply and price for each sector of the economy. Most positive impacts from reductions in VAT and CIT rates occur in the agriculture sector, textile sector and mining and quarrying sector as these reduce cost of inputs to producers. On the other hand, the paper industries and printing sector and trade and services sector show a negative impact that might have been protected due to higher taxes in the base scenario.

This chapter begins with the introduction section and follows with literature review of previous studies that used CGE models to analyse the impacts of tax policy in developed and developing countries. Then next section presents the overview of taxation in Thailand. It explains main source of taxes and the reforms in tax system. The model structure and highlights on the structure of production and data description are described in section four. The fifth section reports the analysis of the impacts of these taxes, while the sixth section draws the conclusion from this study.

2.1 Introduction

The public sector plays a crucial role in the Thai economy as government spending accounted for 22 percent of GDP in 2015 (IMF, 2016). The share of government in the Thai economy has been slowly rising since 2003 as presented in Figure 2.1. Fiscal policy, which includes both government spending and taxation, is one of the key instruments that the government uses in order to achieve stability and growth in the economy. The Thai Government derives revenue predominantly from taxes, the most important of which include income tax, value added tax, excise tax, and import duties (Sujjapongse, 2005). The vulnerability in the world economy and economic potentials in Thailand motivated the Thai government to embark on an ambitious programme of reforms to increase its long-term growth and to achieve high-income status. However, these reforms cannot be realised if the government decreases its expenditure, and tax revenue is the most significant source of a government's income. Therefore, any tax reform will affect tax revenue, subsequently will has impact on government spending and also the whole economy.

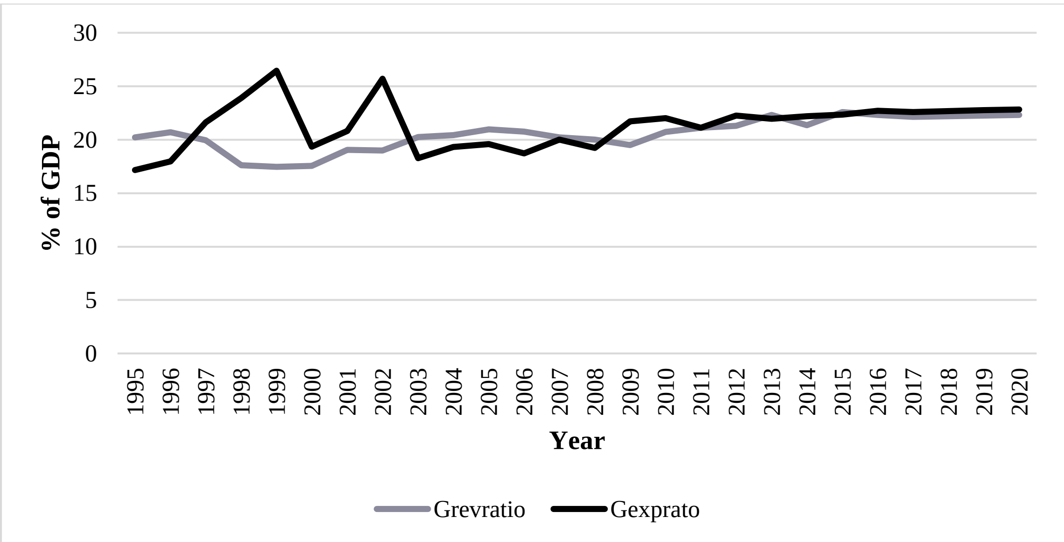

Figure 2.1: Share of Government in the Thai Economy

Source: International Monetary Fund, WEO (2016)

Tax reform occurs by changes either in tax administration, or changes in the tax base, or by changes in tax rates. Many countries use tax reforms to increase revenue and to raise the efficiency of tax collection and to ensure equity by their tax systems with the belief that improving the tax system is a necessary and sustainable way to raise government revenue. Importantly, the government has to be aware that tax reform will not create an excess burden for the taxpayers nor create further distortions in the economy. In addition, the tax reform should not interrupt the growth of consumption, production, trade, investment and saving. Government should honour the four canons of taxation proposed by Adam Smith, which are (i) the canon of equality or ability, (ii) the canon of certainty, (iii) the canon of convenience, and (iv) the canon of economy.

Thai government has implemented a number of tax reform policies to improve the tax system in order to achieve its social and economic goals. One of these key instruments is the implementation of some tax reduction policies, particularly the reduction of VAT rate in 1999 and the CIT rates in 2012 and 2013 which will be discuss more details in the next section. Accordingly, this study aims to assess the impacts of these two tax policies on Thai economy by using the computable general equilibrium (CGE) model. This approach is more applicable than the econometric method because it can illustrate how an adjustment in the system of relative prices balances supply and demand across various markets in an economy. Therefore, it can evaluate the economy-wide income and substitution effects and how they impact on growth of the Thai economy resulting from the changes in the rates of VAT and CIT on output, prices, welfare and sectoral allocation of capital and labour inputs in production. Furthermore, this method doesn’t suffer from endogeneity problem, although depends on specific form adopted.

2.2 Literature Review

Many previous empirical studies have tried to examine the impacts of tax reforms on an economy, for instance, Lee and Gordon (2005), Onwuchekwa and Aruwa (2014), McNabb and LeMay-Boucher (2014), Arnold et al. (2011), Barrell and Weale (2009) and Blundell (2009), however these works failed to analyse the full impacts of taxation policy as they only applied partial equilibrium approaches. Therefore, a gap exists for a more comprehensive approach that can explain the interrelationships between all the agents in the economy who are affected by changes in the tax policy, as well as the impacts on reallocation of welfare and resources across sectors which influenced by changes in the relative prices. Such analysis can be study by using a computable general equilibrium (CGE) as stated by Pereira and Shoven (1988) that the CGE methodology allows the study of differential impacts across sectors of production and across consumer groups. In addition, this approach allows a consideration of the interactions among different sectors and agents, so the policy evaluation is not biased by ceteris paribus assumptions. Despite, the modellers should be aware of applying CGE approach because it is a big model with many assumptions, hence, it might not very transparent.

CGE models have been used widely to analyse the impacts of tax and other policies and other external shocks on all sectors of the economy for almost four decades, as stated by Bhattarai (2003). For example, Fan et al. (2002) apply a computable general equilibrium (CGE) model to illustrate the impact of tax reform on the Chinese economy. The findings indicated that an increase in VAT rates reduces gross output, demand for goods and investment. In contrast, a VAT rebate on investment goods increases sectoral investment and GDP. Bhattarai (2007) uses the CGE approach to forecast the impact of tax distortion on the level of capital accumulation and welfare across households in Hull and the Humber Region. His findings are consistent with his later work (Bhattarai, 2011), wherein higher rates of energy and environmental taxes can slow down the growth rates of output across all sectors and reduce the level of households welfare. Bergman (1990) uses a CGE model to examine the impacts of environmental constraints on the Swedish economy. The results revealed that the environmental constraints lower the GNP and reallocate the factor incomes from the owners of capital, labour and forest to the owners of hydro and nuclear power capacity and holders of SO_x and NO_x emission permits. Amir et al. (2013) use the CGE model to explain how, in case of Indonesia, reductions in personal income tax (PIT) and corporate income tax (CIT) affected economic growth and income inequality under both a balanced budget and non-balanced budget assumption. The findings revealed that under both assumptions, the reduction in PIT and CIT reduces the poverty level in Indonesia, but the CIT policy has no impact on income inequality. For sectoral impacts, the reduction in PIT and CIT under a balanced budget assumption lead to a decline in price in all sectors, whereas the outputs in all sectors, except in government administration sector, increased. Under the non-balanced budget scenario, the reduction in PIT and CIT increased the prices in all sectors while the output in some sectors (other crops, forestry, coal, other mining, textiles, woods, papers, chemicals, constructions, hotel, and transportation support services and warehouse) decreased. In the case of Malaysia, Al-Amin et al. (2008) use a CGE model to analyse the impacts of environmental taxation policies and concluded that carbon tax policy caused a reduction in nominal GDP and exports, a higher percentage of carbon emission reduction, and a larger decrease in nominal GDP and exports. Recently, Llambi et al. (2016) employ CGE with microsimulation to analyse the impacts of tax reform on aggregate economic activity, employment, poverty and inequality in Uruguay. They concluded that the effects of the full implementation of the tax reforms are robust to the alternative assumptions about government closure. Particularly, the reform generates the most positive effects in relation to economic activity, poverty and inequality when the government budget is held fixed and additional reductions of the VAT rate are allowed.

For Thailand, there are some previous studies that applied CGE models for policy analyses. Puttanapong et al. (2015) use this technique to study impacts of carbon-tax policies on the Thai economy. The findings indicated that the higher carbon tax rate imposed on the producer of each sector will lead to higher price level, lower aggegate output, employment, household’s income and consumption, resulting in a greater degree of economic contraction. On the other hand, the carbon tax policies increase the government’s revenue and reduce the CO_2 emissions. Winyuchakrit et al. (2011) develop a CGE model to analyse the possibility of Thailand becoming a low-carbon society (LCS) by using the 2005 input-output table and socio-economic data. They revealed that the climate change mitigation measures would decrease CO_2 emissions in Thailand by 28.4 percent compared to the 2030 BAU scenario. Wianwiwat and Asafu-Adjaye (2013) use a static CGE model to investigate impacts of biofuel-promoting measures contained in the Thai government’s 10-year alternative energy development plan. They found adverse effect of biofuel-promoting policy on real output in the short-run, whilst this policy increases aggregate investment, sectoral output and real GDP in the long-run. In addition, Field and Wongwatanasin (2007) apply a CGE model to assess the effects of alternative tax and transfer policies on output, trade flows and income distribution for specific industries and on the Thai economy as a whole. They concluded that in the early 1980s export subsidies created the largest effect on the quantity of intermediate output and capital goods industries. The subsidisation of industrial institution loans stimulated the second largest effect on the output of intermediate and capital goods industries. While the output levels of secondary agricultural industries increased due to the reduction of the import protection policy, the outward-oriented industrial policy during the 1980s also raised income inequality, although, it slightly improved during 1981-1985.

Although those previous studies can explain some economy-wide impacts of tax policies, we find no specific analysis on the impact of value added taxes (VAT) and corporate income tax (CIT) on the Thai economy. Therefore, this study aims to fill this gap in the literature. The main objective here is to construct a computable general equilibrium (CGE) model of the Thai economy in order to assess the impacts on it of changes in fiscal policy, especially in tax policies. In addition, this study aims to investigate whether such reform would not deteriorate the growth of the country and the welfare of Thai people. This model contributes to the existing studies as it evaluates the economy-wide income and substitution effects and how they impact on growth of the Thai economy resulting from the changes in the rates of VAT and CIT on output, prices, welfare and sectoral allocation of capital and labour inputs in production. Apparently, no such systematic study exists, to our knowledge, that assesses the impacts of reforms of these taxes in Thailand. More specifically, we will study the following questions:

(i) What are the impacts of changes in VAT rates?
(ii) What are the impacts of changes in CIT rates?
(iii) Which tax policy is preferable?

Before starting the analysis, it is important to summarise the tax situation in Thailand. Therefore, the next section presents the overview of taxation, particularly VAT and CIT, in Thailand.

2.3 Overview of Taxation in Thailand

The Ministry of Finance is authorised to collect taxes through the Department of Revenue, the Department of Excise, and the Department of Customs. The Department of Revenue is in charge of collection of taxes based on income and domestic consumption as provided under the Revenue Code and related laws on personal income tax, corporate income tax, petroleum income tax, value added tax, stamp duties, and bird's nest concession. Department of Excise collects tax from 11 types of domestic and import goods and services: namely, spirit, tobacco, playing cards, beverages, electrical lamps and air conditioners, crystal wares and glasses, petroleum products, passenger cars, yachts and luxury boats, perfumes, and race courses. Lastly, the Department of Customs raises revenue from import and export tariffs. Furthermore, other departments in other ministries are empowered to levy other related charges or fees. For example, the Department of Land collects registration fees on transfer of land ownership. Other revenue sources are profit remittances from state enterprises, privatisation, and income of government properties, etc. Figure 2.2 shows that the biggest source of government revenue in 1992 and 2017 came from the Revenue Department which accounted for 49 percent and 64 percent of total revenue, respectively.

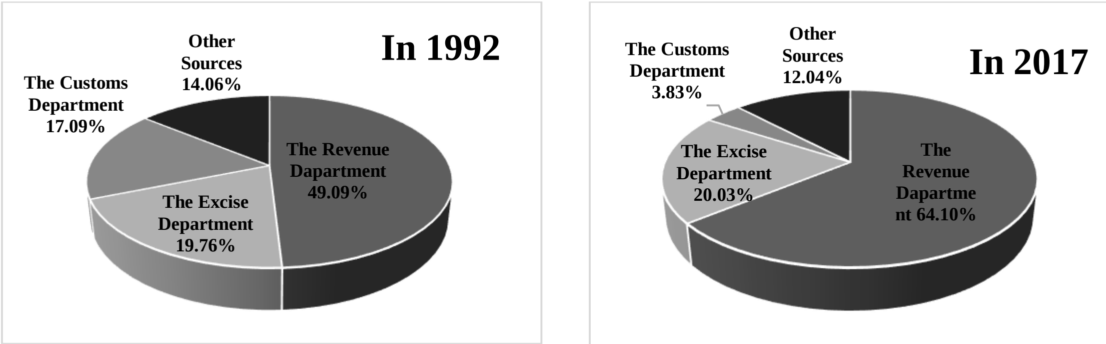

Figure 2.2: Composition of Government Revenues, total

Source: Fiscal Information (2018)

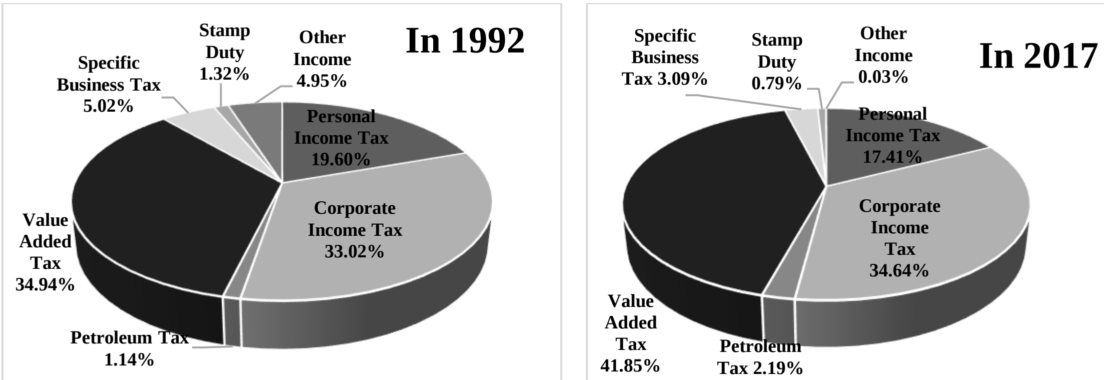

Figure 2.3: Composition of Revenues collected by the Revenue Department

Source: Fiscal Information (2018)

In term of tax types, Figure 2.3 explains that the biggest source of tax revenue collected by the Revenue Department in 1992 and 2017 was value added tax which accounted for 35 percent and 42 percent of total tax revenue, respectively. It is followed by corporate income tax, personal income tax, specific business tax, petroleum tax, stamp duty and other incomes.

The value added tax (VAT) was introduced in Thailand on 1 January 1992 to replace the business tax (Sujjapongse, 2005). At that time, the Thai economy was in a rapid growth phase led by a reform of its fiscal and financial sectors. The Thai government applied VAT on the amount of the sale invoice at a 10 percent rate. However, in 1997 there was a financial crisis in Thailand and the Thai economy was in a weak situation. Therefore, the Thai government reduced VAT from 10 percent to the current level of 7 percent on 1 April 1999 in order to stimulate the economy. It was a temporary measure that was expected to expire in two years, but the government decided to extend it until 30 September 2017.

Recently, the Thai cabinet decided to keep VAT at 7 percent for another year from 1 October 2018 to 30 September 2019 (Bangkok Post, 2018) in order to maintain people's purchasing power and build public confidence in the Thai economic growth. Despite that, the National Legislative Assembly (NLA) proposed the cabinet should raise VAT to 8 percent, believing that it can boost the government revenue by up to 70 billion Baht a year. This is consistent with Sujjapongse (2005), who revealed that an increase of 1 percent in VAT results in 30 billion Baht in additional government revenue, though it might cause a 0.95 percent reduction in the growth rate of GDP. Table 2.1 depicts that the VAT rate in Thailand, which is the same as the goods and services tax (GST) rate in Singapore, is still lower than the ASEAN average rate (9 percent).

Table 2.1: Value added tax and corporate income tax rate adjustments in Thailand and some ASEAN countries

	VAT or GST (%)		**Corporate income tax (%)**	
	Old rate (in 1992)	**Current rate (in 2017)**	**Old rate (in 2009)**	**Current rate (in 2017)**
Thailand	10	7	30	20
Singapore	3[a]	7	18	17
Malaysia	6[a]	6	25	24
Vietnam	10[a]	10	25	20
ASEAN average	8. 6[b]	9[b]	26 [c]	22.17[c]

Source: KPMG (2017), Avalara VATLive (2016) and Mok (2017)

Note: [a] denotes initial VAT or GST rates implemented in Singapore, Malaysia and Vietnam in 1993, 2015, and 1999, respectively.

[b] denotes ASEAN (Association of Southeast Asian Nations) average VAT or GST rate in eight ASEAN countries, excluding Myanmar and Brunei due to data limitation.

[c] denotes ASEAN average CIT rate in nine ASEAN countries, excluding Laos due to data limitation.

Furthermore, Figure 2.3 also showed that the second largest source of government revenue in Thailand is corporate income tax (CIT). It is a direct tax imposed on a juristic company[4] or partnership carrying on business in Thailand or not carrying on business in Thailand but deriving certain types of income from Thailand. In 2009, the CIT rate in Thailand was 30 percent on net profit, which was relatively high compared to those in other ASEAN countries, as shown in Table 2.2. In 2012 the Thai government lowered the CIT rate to 23 percent and to 20 percent in 2013. The purpose of these reductions was not only to lower the cost of Thai firms but also to increase their competitiveness in the world market. At first, the government expected to apply a CIT rate at 20 percent until the end of 2015 and planned to employ a 30 percent rate after that. However, Jatusripitak (2015) cited in Dailynews (2015) announced that the Thai government decided to retain CIT at a 20 percent rate on net profit as a permanent measurement. Although this policy will reduce the government revenue by 179,000 million Baht annually, it will not affect foreign investment and also benefits to Thai companies. Furthermore, the reduction of the CIT rate is consistent with policies in other neighbouring countries, such as Malaysia (24 percent) and Vietnam (20 percent).

Table 2.2: Corporate Income Tax Rate by Country (Percent)

	2009	**2010**	**2011**	**2012**	**2013**	**2015**	**2016**	**2017**
Brunei Darussalam								18.50
Cambodia		20.00	20.00	20.00	20.00	20.00	20.00	20.00
Indonesia	28.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Malaysia	25.00	25.00	25.00	25.00	25.00	24.00	24.00	24.00
Myanmar								25.00
Philippines	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Singapore	18.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Thailand	**30.00**	**30.00**	**30.00**	**23.00**	**20.00**	**20.00**	**20.00**	**20.00**
Vietnam	25.00	25.00	25.00	25.00	25.00	22.00	22.00	20.00
China	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Japan	40.69	40.69	40.69	38.01	38.01	33.86	30.86	30.86
UK	28.00	28.00	26.00	24.00	23.00	20.00	20.00	19.00
ASEAN Avarage	26.00	24.57	24.57	23.57	23.14	22.57	22.57	22.39
Asia Average	25.73	23.96	23.10	22.89	22.05	21.78	21.46	21.40
EU Average	23.11	22.93	22.70	22.51	22.75	22.20	22.09	21.51
OECD Average	25.64	25.70	25.40	25.15	25.32	24.84	24.81	24.27
Global Average	25.38	24.69	24.50	24.40	24.09	23.52	23.47	24.26

Source: KPMG (2017)

Note: ASEAN average corporate income tax excluding Laos due to data limitation.

[4] A juristic company under Thai law consists of limited company, public company limited, limited partnership and registered partnership (The Revenue Department, 2018).

2.4 Model Structure

As mentioned that general equilibrium model is useful to analyses the economy-wide impact of a tax policy on all agents in the economy. Therefore, this section first explains the definition of the model. Then it presents the structure of the model used in this study and follows with the data description. Finally, this study includes the flow chart of implementation of model structure in GAMS.

A general equilibrium model illustrates how an adjustment in the system of relative prices balances supply and demand across various markets in an economy. On the supply side, this model can be applied to evaluate the impacts of changes in economic policy on output, investment, employment, and capital across sectors. Likewise, the effects of changes in the demand side can also explain by changes in preferences of consumer groups across commodities. This theory explains the mechanism by which the choices of economic agents are coordinated across all markets.

The general equilibrium model in this study builds on Bhattarai (2008a). It makes some modifications to it to capture the characteristics of the Thai economy. This model includes a representative household, eighteen producers, a government sector and the rest of the world. A general equilibrium is the micro foundation model where a representative household supplies capital and labour in factor markets and acts as a consumer aiming to maximise utility under a budget constraint. The production side is more decentralised in the model. The main purpose for each of these producers is to maximise profit (or minimise cost) conditional on competitive markets with the constant elasticity of substitution (CES) or Cobb-Douglas type production technologies; they produce under the constant return to scale conditions. While government collects revenue from various taxes and uses that revenue to provide public services or transfer to household in lump sum form.

2.4.1 Structure of Production

In this model, we have nested functions for consumption, production and trade, as is common with many CGE models. Capital and labour inputs are used to generate value added. Then, intermediate input is combined with value added by a Leontief production technology. In each tradable sector, gross domestic supply is either sold in the domestic market or exported to the rest of the world according to a constant elasticity of transformation (CET) function. Total supply of goods in tradable sectors of the economy is a CES composite of differentiated domestic and imported Armington commodities as shown in Figure 2.4.

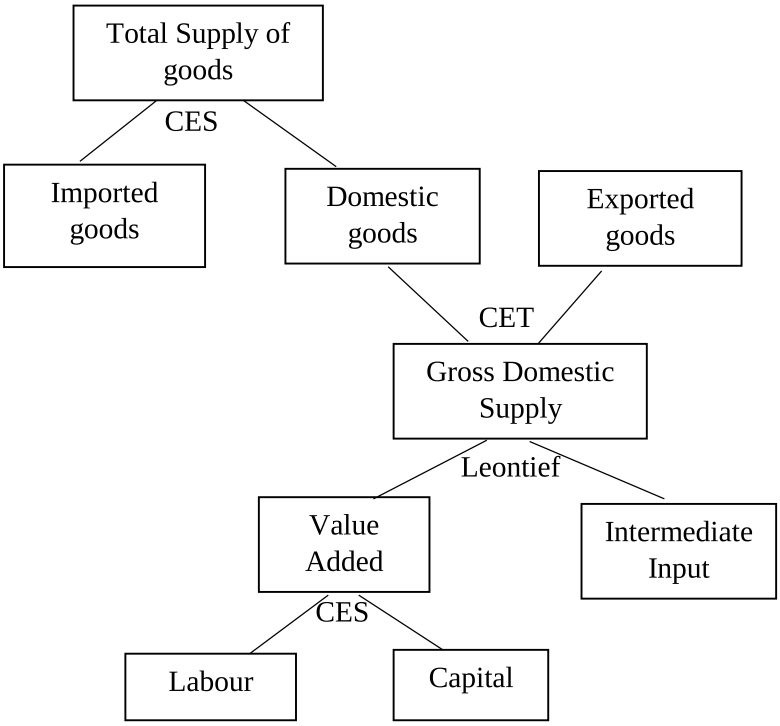

Figure 2.4: Structure of Production

(1) Total Supply of Output

The aggregate supply of output in the economy must be equal to the sum of the values of domestic products and imports and is given by a CES Armington function as

$$A_i = \Omega_{A_i} \left[\delta_i^d D_i^{\sigma_{A_i}-1/\sigma_{A_i}} + (1-\delta_i^d) M_i^{\sigma_{A_i}-1/\sigma_{A_i}} \right]^{\sigma_{A_i}/\sigma_{A_i}-1} \quad ....(2.1)$$

where for each i sector in economy, A_i is the CES aggregate supply composite of domestic output (D_i) and imported commodities (M_i); δ_i^d is the share of domestic supplies for good i; and σ_{A_i} is the elasticity of substitution between domestic goods and imports; and Ω_{A_i} is the shift parameter of the aggregate supply function. In addition, the value of total supply of output can be written as

$$PA_i A_i = PD_i D_i + PM_i M_i \quad ....(2.2)$$

where PA_i is the price of aggregate supply in sector i; PD_i is the price of domestic output; and PM_i is the price of imported commodities. Overall market clearing in the product market implies that

$$A_i = C_i + I_i + G_i \quad ....(2.3)$$

where C_i is the composite consumption by household; and I_i and G_i refer to composite consumption by investment and government, respectively.

(2) Gross Domestic Supply

The aggregate domestic products in the economy are equal to the sum of the values of domestic products and exports commodities given by a constant elasticity transformation function.

$$Y_i = \Omega_{Y_i}\left[(1 - \delta_i^e)D_i^{\sigma_{y_i}-1/\sigma_{y_i}} + \delta_i^e X_i^{\sigma_{y_i}-1/\sigma_{y_i}}\right]^{\sigma_{y_i}/\sigma_{y_i}-1} \quad ....(2.4)$$

where Y_i is aggregate domestic production; D_i is domestic supplies; X_i is export products; δ_i^e is the share of export for good i; and σ_{y_i} is the elasticity of substitution in domestic sales and exports from total production. Ω_{Y_i} is the shift parameter in the production function.

The value of aggregate domestic product is

$$PY_iY_i = PD_iD_i + PX_iX_i \quad ....(2.5)$$

where PY_i is the price of aggregate domestic product in sector i; PD_i is the price of domestic output; and PX_i is the price of exported commodities.

(3) Value Added

Producers use labour and capital in each of i sectors to generate value added.

$$VA_i = \Omega_{VA_i}[(1 - \delta_i^L)(K_i)^{\gamma_i} + \delta_i^L(L_i)^{\gamma_i}]^{1/\gamma_i} \quad ....(2.6)$$

where VA_i is the CES aggregate value added of sector i; Ω_{VA_i} is the shift parameter of the value added production function; K_i is capital and L_i is labour used in sector i; δ_i^L is the share parameter of labour; and γ_i is the elasticity of substitution between labour and capital.

The gross output of each sector (Y_i) contains value added (VA_i) and intermediate inputs. We allow substitution between domestic and imported intermediate inputs, and between value added and intermediate inputs.

$$PY_iY_i = PV_iVA_i + \sum_i PA_i(1 + t_i^d)DI_i + \sum_i PM_i(1 + t_i^m)MI_i \quad ....(2.7)$$

where DI_i is the demand for domestic intermediate input and MI_i is demand for imported intermediate inputs, PV_i is the composite price of value added, and VA_i is the value added component of gross output, t_i^d and t_i^m are taxes on domestic and imported intermediate demands, respectively.

At any set of prices, producers in each sector maximise profits subject to their technology constraint.

$$\pi_i = PY_i Y_i - wL_i - \sum_i r_i K_i - \sum_i PM_i(1 + t_i^m)MI_i - \sum_i PA_i(1 + t_i^d)DI_i \qquad \text{….(2.8)}$$

where π_i is the profit of sector i. In equilibrium, factor demands by sectors are determined where the value of the marginal product of factors equal factor prices, and there are no positive profits for producers.

(4) Demand

In this model, we assumed the utility of a representative household to be given by a CES function of composite consumption subject to a budget constraint.

$$U = \sum_{i=1}^{N} \left(\delta_i C_i^{\sigma_u - 1/\sigma_u} \right)^{\sigma_u/\sigma_u - 1} + U(GOV_i) \qquad \text{….(2.9)}$$

where U is the utility of household; C_i is the composite consumption; δ_i is the share of income that household spent on consumption which is equal to $\frac{C_i}{NI}$; and σ_u is the elasticity parameter in the utility function, the elasticity of substitution between goods. GOV_i is the composite consumption of government which is generate later in Equation (2.15).

(5) Household Income

Household in this model supplies capital and labour in factor market. Net income of household comes from capital income, labour income and money transfer from government:

$$NI = \sum_i ((1 - t_r)rK_i + (1 - t_w)wL_i) + TR \qquad \text{....(2.10)}$$

where NI is net income of household; K_i is capital and L_i is labour; r is rental or return on capital; and w is wage rate and TR transfer money from government to households. Tax rate on labour income and capital income are t_w and t_r, respectively.

(6) Investment and Saving

Total investment is the sum of investment in all sectors of the economy. Saving is the rest of net income after consumption:

$$TIV = \sum_i IV_i \quad ....(2.11)$$

$$S = NI - \sum_i P_i C_i \quad ....(2.12)$$

where TIV is total investment; IV_i is investment and S is saving

(7) Government Revenues

Government receives the revenue from three tax sources: income tax from labour, capital income (corporate income tax) and value added tax (VAT) on consumption.

$$GREV = \sum_i (t_w w L_i) + \sum_i (t_r r K_i) + \sum_i (t_v C_i) \quad ....(2.13)$$

where $GREV$ is total government revenue; w is wage rate and r is capital income; C_i is consumption composite; tax rate on labour income and capital income are t_w and t_r, respectively; and t_v is value added tax on final product and i is the sector in economy.

Tax revenues are either used to finance public consumption or to make transfer to household.

$$GREV = GOV_i + TR \quad ....(2.14)$$

where GOV_i is government spending and TR is transfer money to household.

(8) Government Spending

Government spends revenue to consume domestic goods and services and to purchases imported goods as given by:

$$GOV_i = \sum_i PA_i GD_i + \sum_i PA_i GM_i \quad ....(2.15)$$

where GOV_i is government spending; GD_i is government consumption of domestic goods and GM_i is government consumption of imported goods. Like households, government choose between domestic and imported good for its consumption on the basis of their relative prices.

(9) Budget Balance

In this model, government has a balanced budget, which is the difference between revenue and spending of the government:

$$BBAL = GREV - \sum_i GOV_i \quad ....(2.16)$$

where $BBAL$ is a budget balance; $GREV$ is total government revenue; and GOV_i is government spending in i sector.

(10) Resource Balance

$$RE = S - TIV + BBAL \quad \text{….(2.17)}$$

where RE is resource balance.

(11) International Trade

This model has a small open economy structure for Thailand. It assumes a competitive global economy where Thailand exports goods produced at home and imports commodities from the rest of the world. Therefore, the net export of the country is the difference between the volumes of exports and imports. The summation of the net export generates trade deficit.

$$NX_i = P_iX_i - P_iM_i \quad \text{….(2.18)}$$

$$TNX = \sum_i NX_i \quad \text{….(2.19)}$$

where NX_i is net export; P_iX_i is value of export; P_iM_i is value of import; and TNX is total trade deficit.

In equilibrium, the value of exports is equal to the value of imports

$$\sum_i PX_iX_i = \sum_i PM_iM_i \quad \text{….(2.20)}$$

2.4.2 Description of Data

This model uses the latest economic data from the 180 sectors input-output table of the year 2010 obtained from the Office of the National Economics and Social Development Board (2016) to construct a micro-consistent dataset for Thailand as given in Appendix 2A. These data were restructured into 18 production sectors as shown in Table 2.3. Then, these data were used for calibration of the parameters of the model. The general algebraic modelling system (GAMS, 2017) was applied to compute the model.

Table 2.3: Sectors Classification of Thai Economy in the Model

Sector	I-O Code	Code
1. Agriculture	001-029	Agric
2. Mining and Quarrying	032-041	Mining
3. Food Manufacturing	042-066	FoodManu
4. Textile Industry	067-074	Textile
5. Saw Mills and Wood Products	078-080	SawMill
6. Paper Industries and Printing	081-083	Paper
7. Rubber and Chemical Industries	084-092, 095-098	Rubber

Table 2.3: Sectors Classification of Thai Economy in the Model, Continued

Sector	I-O Code	Code
8. Non-metallic Products	099-104	NonMetal
9. Metal, Metal Products and Machinery	105-128	Metal
10.Other Manufacturing and Unclassified	075-077, 129-134, 137 and 180	OthManu
11. Construction	138-144	Const
12. Trade and Services	145-148, 160-178	Trade
13. Transportation and Communication	149-159	Trans
14. Coal and Lignite	030	Coal
15. Petroleum and Natural Gas	031	Petro
16. Petroleum Refineries	093	PetroRefin
17. Other Petroleum Product	094	OthPetro
18. Electricity	135	Electri

Source: National Economics and Social Development Board (2016)

The advantage of an input-output table is that it represents a snapshot of the economy at one point in time. Then, with calibrated parameters, the Thai CGE model can be used to evaluate the changes in the economy or to assess the impacts of policy as with Bergman (1990), Semboja (1994), Bhattarai (2007, 2016, 2017), and Ruamsuke et al. (2015). While input-output tables have two main assumptions, fixed technical coefficients and fixed input proportions, the CGE model accommodates more behavioural analysis. Although the input-output table can be used to conduct backward and forward linkages in the economy to explain the current situation and to make short-term predictions about the economy, CGE model based results show the outcome of optimisations by households and firms given their resource constraints.

2.4.3 Requirement for a Micro Consistent Data Set for the Model

The benchmark data require three imperative conditions of a general equilibrium model to be satisfied, which are a zero profit condition, market clearing and income balance as stated by Bhattarai (2008b). The zero profit condition for producers in the benchmark data is met for various sectors of the economy when aggregate output equals the gross tax payments to labour and capital services and intermediate inputs. This basically means that firms are just breaking even while producing goods and services and supplying them to markets. The market clearing condition for each sector implies that the total supply or output equals the aggregate demand for goods of that sector. The total supply of goods in the market comprises domestic output and imports, while aggregate demand is the sum of intermediate and final demands. The income balance condition implies that the expenditure of households and government is equal to their income or revenues gross of saving, the economy wide trade balance condition holds, and the volume of savings equals the volume of investment in the economy.

The original data from input-output table were not perfect as some of the accounts were not balanced. Allowance for capital depreciation or subsidies vary by sectors. Some of them not includes in input-output table – leaving adjustment factors. We modified the labour and capital in each sector, adding 300 and 200, respectively, to balance the account and to avoid a situation where tax rates could exceed 100 percent. That modification was enough to remove the imbalance in demand and supply in order to fulfil the vital condition of a general equilibrium model and to reach into the optimal solutions of the model.

Table 2.4: Factor Inputs, Tax Rates and Output in Thailand, 2010: Benchmark reproduced data.

	Factor inputs (Billion Baht)		**Capital Tax revenues (Billion Baht)**		**Tax Rates/ Subsidy (-) (%)**			**(Billion Baht)**
	Labour	**Capital**	**Ktax**	**Import**	**K_tax**	**Ltax**	**VAT**	**Output**
Agric	610.363	957.903	-493.029	605.348	-46.800	-1.700	7.000	1787.359
Mining	310.887	224.329	11.758	220.231	7.000	0.400	7.000	72.031
FoodManu	444.956	488.742	-36.499	410.086	3.400	11.300	7.000	2381.237
Textile	373.989	302.877	-28.446	149.343	1.700	3.200	7.000	771.757
SawMill	325.655	236.599	9.211	18.301	7.600	0.900	7.000	199.232
Paper	321.402	239.188	-44.470	124.547	-14.200	1.200	7.000	256.167
Rubber	421.392	403.069	-41.723	457.122	4.700	5.700	7.000	1578.832
NonMetal	333.343	257.593	-2.921	51.127	7.800	1.900	7.000	399.582
Metal	591.218	764.760	-605.041	2834.137	-55.100	24.100	7.000	5875.674
OthManu	412.092	336.224	62.147	324.392	34.800	5.300	7.000	1323.773
Const	367.580	286.724	30.118	150.000	25.700	2.700	7.000	915.144
Trade	2153.481	2543.785	-1948.928	1977.208	-49.600	15.400	7.000	7443.186
Trans	520.995	454.953	-158.388	65.532	27.000	6.000	7.000	1672.218
Coal	302.722	207.705	-2.987	3.151	-1.200	0.100	7.000	17.421
Petro	377.390	321.559	-163.313	-61.434	-24.900	12.700	7.000	789.809
PetroRefin	312.124	225.043	7.209	1028.813	9.900	1.700	7.000	1210.326
OthPetro	312.122	222.240	-7.738	50.264	-0.500	2.000	7.000	115.311
Electri	406.382	290.878	7.097	139.584	30.200	2.700	7.000	705.733
Total	8898.093	8764.171						27514.793

Source: Author's calculations for the CGE model of Thailand using data from the National Economics and Social Development Board (2016)

Note: Numbers of labour and capital are net of tax. Ktax is the total tax revenue from inputs including depreciation. K_tax is tax rates on capital. Ltax is tax rates on labour income.

Table 2.4 depicts the benchmark reproduced dataset before calibrate the model. The trade and services sector were the largest users of labour and capital, which accounted for THB 2,153.481 and 2,543.785 billion or equivalent to 24 and 29 percent of total labour and capital, respectively. It was followed by the agriculture sector, metal, metal products and machinery sector, transportation and communication sector, and food manufacturing sector. For energy sectors, labour accounted for the highest level in the electricity sector, while the petroleum and natural gas sector was the most capital intensive. At the same time, the coal sector used the least amount of labour and capital input. In this benchmark case, VAT equals 7 percent across all sectors.

The 18 sectors input-output coefficient table of Thailand in Table 2.5 explains the details about forward and backward linkages between the model sectors in the Thai economy. For instance, activities in the agriculture sector will have strong forward (35 percent) and backward linkages (8 percent) to food manufacturing sector and agriculture sector, respectively. As the agriculture sector supplies raw materials, such as beans and nuts, vegetables and fruits, cassava, meat, and seafood for the food manufacturing industry. On the other hand, the agriculture sector itself also uses inputs from agriculture industry: for example, uses maize to feed animals. In addition, the agriculture sector has strong backward linkage to trade and service sector (8 percent) as it uses inputs from trade and services sector to produce agriculture products. Interestingly, activities in the food manufacturing sector will have strong backward linkage (35 percent) to agriculture sector. This implies that the food manufacturing sector is determined by agricultural inputs. On the other hand, food manufacturing sector has strong forward linkage to itself (11.3 percent). This means the food manufacturing sector supplies raw materials for the food manufacturing industry. For instance, food manufacturing sector provides flour, sugar, dairy products to produce bakery products and confectionery. It is also worth noting that trade and services sector will have strong forward linkage to paper industries and printing sector (16.8 percent), saw mills and wood products sector (14.9 percent), and other manufacturing and unclassified sector (13.9 percent). In spite of this, trade and services sector will have strong backward linkage to itself (11.9 percent).

For the energy sector, the petroleum and natural gas sector has strong backward and forward linkages (38 percent) to itself. Meanwhile, the petroleum refineries industry has strong backward (7 percent) and forward linkage (20 percent) to the petroleum and natural gas production and transportation and communication sectors, respectively. As the petroleum refineries industry uses inputs from petroleum and natural gas sector. On the other hand, it supplies gasoline, jet oil, LPG, diesel and fuel oil to transportation and communication sector.

The forward and backward inter-sectoral linkages obtained from the input-output table are important for the multi-sectoral analysis of our model. These linkages not only show how much intermediate inputs a sector provides, it also presents information on final demand.

Table 2.5: A 18 Sectors Input-Output Coefficient Table of Thailand, 2010

	Agric	Mining	Food Manu	Textile	Saw Mill	Paper	Rubber	Non Metal	Metal	Oth Manu	Const	Trade	Trans	Coal	Petro	Petro Refin	Oth Petro	Electri
Agric	0.082	0.002	0.345	0.005	0.093	0.015	0.087	0.002	0.000	0.009	0.005	0.014	0.001	0.000	0.000	0.000	0.000	0.001
Mining	0.000	0.001	0.001	0.000	0.000	0.000	0.003	0.122	0.002	0.014	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FoodManu	0.057	0.000	0.113	0.001	0.001	0.008	0.007	0.003	0.000	0.021	0.000	0.025	0.003	0.000	0.000	0.000	0.001	0.002
Textile	0.001	0.001	0.001	0.261	0.004	0.001	0.006	0.002	0.001	0.016	0.001	0.004	0.002	0.000	0.000	0.000	0.000	0.000
SawMill	0.001	0.003	0.000	0.000	0.078	0.001	0.001	0.001	0.002	0.003	0.017	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Paper	0.000	0.001	0.003	0.004	0.007	0.079	0.004	0.005	0.003	0.007	0.001	0.013	0.003	0.001	0.000	0.000	0.000	0.001
Rubber	0.033	0.029	0.008	0.067	0.055	0.032	0.127	0.023	0.028	0.035	0.012	0.018	0.013	0.000	0.001	0.000	0.010	0.000
NonMetal	0.001	0.000	0.004	0.000	0.003	0.000	0.001	0.106	0.005	0.007	0.194	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Metal	0.015	0.126	0.009	0.008	0.022	0.015	0.011	0.030	0.206	0.032	0.071	0.014	0.091	0.026	0.013	0.001	0.002	0.012
OthManu	0.002	0.003	0.007	0.020	0.012	0.011	0.006	0.013	0.006	0.120	0.002	0.012	0.005	0.001	0.004	0.000	0.001	0.002
Const	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.000	0.000	0.001
Trade	0.082	0.069	0.079	0.106	0.149	0.168	0.114	0.110	0.118	0.139	0.126	0.119	0.119	0.027	0.108	0.010	0.047	0.067
Trans	0.012	0.054	0.019	0.017	0.032	0.031	0.027	0.043	0.017	0.032	0.080	0.031	0.122	0.172	0.006	0.003	0.004	0.009
Coal	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Petro	0.000	0.005	0.001	0.001	0.000	0.001	0.014	0.013	0.001	0.002	0.000	0.002	0.001	0.000	0.382	0.073	0.000	0.190
PetroRefin	0.027	0.060	0.007	0.010	0.005	0.007	0.035	0.038	0.008	0.005	0.011	0.011	0.196	0.109	0.046	0.005	0.031	0.075
OthPetro	0.003	0.023	0.000	0.001	0.001	0.001	0.002	0.005	0.003	0.001	0.006	0.001	0.018	0.000	0.007	0.000	0.122	0.000
Electri	0.003	0.026	0.020	0.053	0.027	0.021	0.030	0.060	0.018	0.019	0.007	0.028	0.014	0.009	0.008	0.003	0.003	0.022

Table 2.6: Composition of Total Demand and Final Demand in Billion Baht

	Composition of Total Demand			Composition of Final Demand			
	Intermediate Demand (%)	Final Demand (%)	Total Demand (%)	Consumption (%)	Government Expenditure (%)	Investment (%)	Export (%)
Agric	1256.445	530.914	1787.359	344.108	4.146	29.161	153.498
	(11.082)	(3.282)	(6.496)	(7.074)	(0.245)	(1.174)	(2.151)
Mining	125.694	-53.663	72.031	0.000	0.000	-71.799	18.137
	(1.109)	(-0.332)	(0.262)	(0.000)	(0.000)	(-2.891)	(0.254)
FoodManu	608.235	1773.002	2381.237	879.139	11.199	125.911	756.753
	(5.365)	(10.960)	(8.654)	(18.073)	(0.662)	(5.070)	(10.604)
Textile	276.191	495.566	771.757	199.434	2.987	-9.056	302.200
	(2.436)	(3.063)	(2.805)	(4.100)	(0.176)	(-0.365)	(4.235)
SawMill	59.113	140.119	199.232	41.253	4.500	47.085	47.281
	(0.521)	(0.866)	(0.724)	(0.848)	(0.266)	(1.896)	(0.663)
Paper	170.300	85.867	256.167	16.749	25.278	-9.814	53.655
	(1.502)	(0.531)	(0.931)	(0.344)	(1.493)	(-0.395)	(0.752)
Rubber	735.473	843.359	1578.832	100.043	7.271	-98.348	834.393
	(6.487)	(5.213)	(5.738)	(2.057)	(0.430)	(-3.960)	(11.692)
NonMetal	271.937	127.646	399.582	14.788	1.661	52.098	59.098
	(2.398)	(0.789)	(1.452)	(0.304)	(0.098)	(2.098)	(0.828)
Metal	1697.874	4177.800	5875.674	302.057	52.602	1098.102	2725.039
	(14.975)	(25.826)	(21.355)	(6.209)	(3.108)	(44.220)	(38.185)
OthManu	353.516	970.256	1323.773	280.528	41.516	64.091	584.122
	(3.118)	(5.998)	(4.811)	(5.767)	(2.453)	(2.581)	(8.185)
Const	40.019	875.126	915.144	8.684	8.308	858.034	0.100
	(0.353)	(5.410)	(3.326)	(0.179)	(0.491)	(34.553)	(0.001)
Trade	2944.681	4498.505	7443.186	1989.480	1425.840	232.673	850.512
	(25.972)	(27.808)	(27.052)	(40.898)	(84.241)	(9.370)	(11.918)
Trans	822.786	849.431	1672.218	360.448	37.456	30.643	420.884
	(7.257)	(5.251)	(6.078)	(7.410)	(2.213)	(1.234)	(5.898)
Coal	4.726	12.695	17.421	0.000	0.000	12.280	0.415
	(0.042)	(0.078)	(0.063)	(0.000)	(0.000)	(0.495)	(0.006)
Petro	582.931	206.878	789.809	55.548	2.027	106.218	43.085
	(5.141)	(1.279)	(2.870)	(1.142)	(0.120)	(4.277)	(0.604)
PetroRefin	726.181	484.145	1210.326	155.707	36.326	42.982	249.131
	(6.405)	(2.993)	(4.399)	(3.201)	(2.146)	(1.731)	(3.491)
OthPetro	91.396	23.914	115.311	13.101	4.279	-26.985	33.519
	(0.806)	(0.148)	(0.419)	(0.269)	(0.253)	(-1.087)	(0.470)
Electri	570.553	135.180	705.733	103.381	27.175	0.000	4.623
	(5.032)	(0.836)	(2.565)	(2.125)	(1.606)	(0.000)	(0.065)
Total	11338.053	16176.741	27514.793	4864.450	1692.571	2483.275	7136.445
	(100.000)	(100.000)	(100.000)	(100.000)	(100.000)	(100.000)	(100.000)
(% of Total Demand)	(41.207)	(58.793)	(100.000)				
(% of Final Demand)				(30.071)	(10.463)	(15.351)	(44.115)

Source: Author's calculations based on input-output table of the year 2010

The data in Table 2.6 explains the composition of total demand which consists of intermediate demand and final demand for the 18 sectors. It indicates that trade and services sector is the most important sector of total demand which accounts for THB 7,443.186 billion or 27.052 percent of the total demand, while coal and lignite sector is the smallest sector of total demand which comprises only THB 17.421 billion or 0.063 percent of the total demand. This is consistent with the amount of labour and capital in trade and services sector and coal and lignite sector that presented in Table 2.4. This implies that trade and services sector is the key sector in Thai economy, follows by metal, metal products and machinery sector.

Total intermediate demand accounts for 41 percent of the total demand, whereas the residual 59 percent is sold to final users. Table 2.6 clarifies that the demand structure of intermediate demand varies significantly across sectors. Trade and services sector has the biggest amount of THB 2,944.681 billion or 25.972% of total intermediate demand. In addition, metal, metal products and machinery sector and agriculture sector are the main sectors of intermediate demand because outputs of these sectors were used as major inputs for final demand.

The composition of final demand shows that 44 percent of final sales is exported abroad, while domestic consumption accounts for nearly 30 percent. The investment demand takes about 15 percent of the final demand, leaving 11 percent to fulfil government expenditure. The final demand composition indicates that trade and services sector is the largest component of private consumption and government expenditure account for 40.898 and 84.241 percent of total consumption of private and government sector, respectively. Metal, metal products and machinery sector is the major elements of investment in Thailand, accounts for 44.22 percent of total investment. It is worth noting that the investment amount of mining and quarrying sector, textile sector, paper industries and printing sector, rubber and chemical industries, and other petroleum product are negative, due to the decrease in inventories of these sectors and the decline of purchasing order. For export, Metal, metal products and machinery sector is the predominant sector in export structure as this sector produces many major Thailand’s exported goods which are electrical machinery, motors vehicles and repairing, industrial machinery, fabricated metal products and iron and steel.

In the general equilibrium model, the elasticity parameters, which represent the flexibility of markets, play a very crucial role in determining the model results. These influence the magnitude of welfare changes and the marginal excess burden of taxes across model scenarios. The values of elasticity used in this model are based on values generally accepted in the literature, as shown in Table 2.7.

Table 2.7: Elasticity Parameters of the Model

Parameters	**Values**
Elasticity of Substitution between Labour and Capital (σ_{LK})	2
Armington Elasticity[5] (σ_A)	2
Elasticity of Utility (σ_U)	2
Elasticity of Capital (σ_K)	2

In addition to information on the benchmark dataset and elasticity parameters, this model also adjusts quantities so that the benchmark price is 1 for goods as well as for labour and capital inputs.

The CGE model has several advantages over more macro-oriented aggregate models or analytical partial equilibrium analysis as stated by Pereira and Shoven (1988). Firstly, the CGE approach allows the study of differential effects across consumer groups and across sectors of production. Secondly, the policy evaluation is not biased by ceteris paribus assumptions because this model allows a consideration of the interactions among different sectors and agents. Lastly, the CGE modeller does not have to be confined to small changes in parameters. In addition, Asafu-Adjaye and Wianwiwat (2012) stated that the CGE methodology requires only one year's macroeconomic data such as input-output table, social accounting matrix (SAM), national accounts tables and trade statistics which contrary to standard econometric models that need time series data to estimate parameters with sufficient degrees of freedom. On the other hand, this model also has some drawbacks including it has many assumptions with big model and not very transparent. Therefore, this study checks the robustness of the model by using sensitivity analysis. We highlight the sensitivity analysis on two key elasticity parameters which are the elasticity of substitution between labour and capital (σ_{LK}) and the Armington elasticity (σ_A) by setting the elasticity from low sc1 to the highest sc10 to see the changes of output across sectors.

[5] Armington elasticity is the elasticity of substitution between goods from different countries.

2.4.4 Implementing the Model Structure in GAMS

The early general equilibrium tax models typically used Scarf's algorithm for their solution and were solved with codes written in FORTRAN. After the development of GAMS/MPSGE software, a large scale of general equilibrium modelling has become much easier and broader apply among economists and policymakers.

The model in this study uses the GAMS/MPSGE and MCP solver (Rutherford, 1995) to solve the CGE model of Thailand. According to Bhattarai (2008b), technically there are five steps in the numerical implementation of the model: benchmarking, model declaration, benchmark replication, counterfactual solution and report writing. First, model dimensions (sets) are declared and all base year data are read in tabular, parameter or scalar form in the base year model. Second, markets, production activities and budget constraints for each agent in the model are specified. This part consists of blocks of equations for production technology, household preferences, revenues and income constraints. Third, a model is calibrated when the base year data is reproduced by the model as its solution. This step is known a benchmark replication. Fourth, policies or various taxed are changed in order to assess the efficiency and allocation effects of proposed changes in policies or tax rates. Finally, model solutions are printed for review in the reporting stage. Figure 2.5 presents the flow chart of implementation of model structure in GAMS.

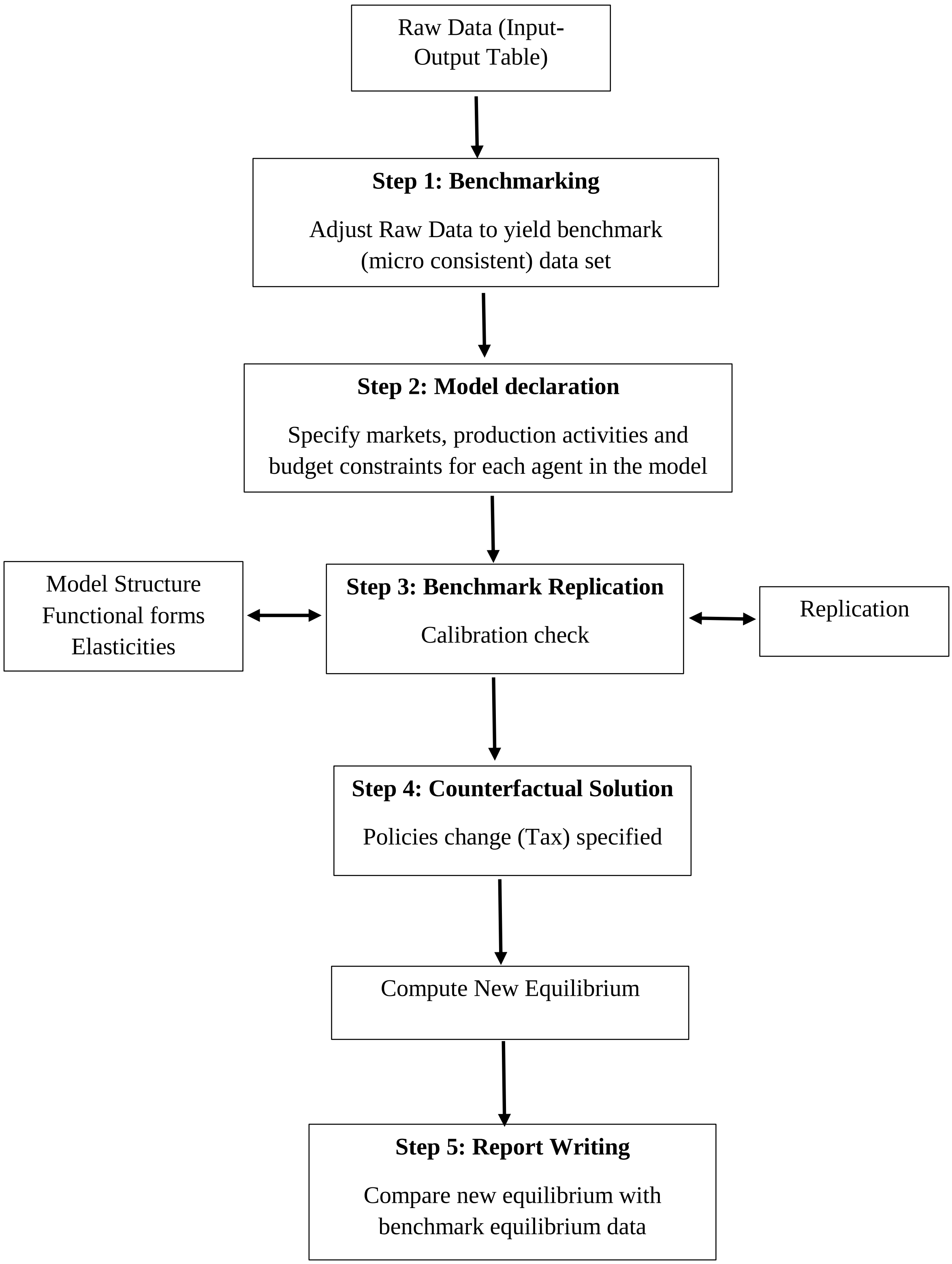

Figure 2.5: Flow Chart of Implementing the Model Structure in GAMS

Source: Author adapted from Bhattarai (2008b)

2.5 Analysis of Model Results

As mentioned above, the main objective in this chapter is to evaluate the impacts of reforms in the overall and sectoral tax structure in the Thai economy. The analysis focuses on the reform of VAT and CIT on output, prices, welfare and sectoral allocation of capital and labour inputs in production.

We consider six scenarios to assess impacts of taxes in this study. These are (i) baseline case where VAT is 7 percent, (ii) the impact of an increase in VAT from 7 to 10 percent and change in capital tax rate in food manufacturing and petroleum refineries sectors to 10 percent, (iii) the impact of a decrease in VAT to 0 percent and setting capital tax rate in petroleum refineries to 0 percent, (iv) baseline case when CIT rate is 30 percent, (v) the impact of a decrease in CIT rate from 30 to 23 percent, and (vi) the impact of a decrease in the CIT rate from 30 to 20 percent. The assumptions of capital tax rate in case (ii) and (iii) are necessary to remove the imbalance in demand and supply and to reach into the optimal solutions of the model.

2.5.1 Macroeconomic Impacts of 7 Percent VAT, by sector

The benchmark replication result, step 3 in Figure 2.5, where the VAT equals 7 percent are presented in Table 2.8. It shows that trade and services sector is the predominant sector with the highest levels in labour, capital, output, and supply. The mining and quarrying sector is the smallest amount in these terms. Consequently, output in this sector has the highest price. In addition, there is numeraire in the price of metal, metal products and machinery sector. It is worth noting that the number of benchmark data in Table 2.8 are different from the reproduced data in Table 2.4 because of the adjustment to fulfill equilibrium condition. In addition, data in Table 2.4 are net of tax, while data in Table 2.8 are gross of tax data.

Among the energy sectors, electricity sector has the highest level in labour and output while coal and lignite sector has the smallest amount in labour, capital, output, and supply. In terms of price, the petroleum refineries sector has the highest price, followed by electricity sector.

Table 2.8: Benchmark with 7 Percent VAT Rate

	Labour	Capital	Output	Supply	Price	Rental
Agric	832.958	1194.195	2016.593	2809.816	1.0230	1.012
Mining	4.893	3.225	8.506	11.839	1.0250	1.012
FoodManu	794.386	797.100	2832.77	3530.874	0.9810	1.012
Textile	345.396	255.531	717.049	849.52	0.9600	1.012
SawMill	111.876	74.253	208.313	214.359	0.9820	1.012
Paper	120.736	82.082	208.272	253.46	1.0020	1.012
Rubber	355.51	310.645	615.646	984.422	0.9500	1.012
NonMetal	120.419	85.008	271.669	289.404	0.9910	1.012
Metal	660.635	780.653	728.993	3793.855	1.0000	1.012
OthManu	471.413	351.363	975.449	1329.548	0.9590	1.012
Const	255.972	182.399	836.083	936.015	1.0080	1.012
Trade	3206.943	3460.585	6877.737	9725.767	1.0140	1.012
Trans	638.764	509.557	1946.45	2023.103	0.9770	1.012
Coal	10.244	6.421	16.763	16.865	0.9860	1.012
Petro	298.056	231.999	786.201	739.341	0.9700	1.012
PetroRefin	274.608	180.872	361.217	1231.335	1.0640	1.012
OthPetro	53.481	34.787	86.736	95.035	0.9910	1.012
Electri	341.802	223.496	846.446	958.893	1.0070	1.012

Source: Author’s calculations based on the CGE model of Thailand

Note: Numbers of labour and capital are gross of tax

After the replication of the benchmark economy, we evaluate the taxes change, step 4 in Figure 2.5, then report the impact of these changes by computing the percentage change in macroeconomic variables, step 5 in Figure 2.5. The results of our counterfactual simulation are as follow in next section.

2.5.2 Macroeconomic Impacts of Increasing VAT from 7 to 10 Percent

The simulation results of increase the VAT rate from 7 percent to initial rate 10 percent in order to rise government revenue indicate significant changes in all macroeconomic variables, as shown in Table 2.9. This policy benefits the producers and consumers in the textile industry sector, the rubber and chemical industries sector, the other manufacturing and unclassified sector, and the transportation and communication sector. When the producers in these sectors increase their production and the use of labour and capital inputs, consumers benefit from reduction of prices in these sectors. This means such change in VAT triggers reallocation of resources. On the other hand, the agriculture sector, the food manufacturing sector, and the metal, metal products and machinery sector are adversely affected by a VAT policy because the producers in these sectors reduce the use of labour and capital. Consequently, the prices of these products increase in response to the reduction in outputs. In contrast, an increase in the prices in the mining and quarrying sector, the paper industries and printing sector, the trade and services sector, and the construction sector stimulate the production, employment, and the use of capital in these sectors as these sectors are linked more to exporting sectors.

Table 2.9: Percentage Change in Macroeconomic Variables of Increasing in VAT from 7 to 10 Percent (Unit: Percentage)

	Labour	Capital	Output	Supply	Price	Rental
Agric	-3.3400	-3.2000	-3.2800	-3.2800	1.1700	-0.4000
Mining	2.4100	2.5700	2.4900	2.4900	1.2700	-0.4000
FoodManu	-3.3800	-3.2400	-3.4400	-3.4400	1.0200	-0.4000
Textile	1.2200	1.3700	1.2900	1.2900	-1.7700	-0.4000
SawMill	-0.1000	0.0400	-0.0400	-0.0400	-0.6100	-0.4000
Paper	2.5300	2.6800	2.5900	2.5900	0.3000	-0.4000
Rubber	1.0200	1.1700	1.0900	1.0900	-2.3200	-0.4000
NonMetal	-0.2600	-0.1200	-0.2000	-0.2000	-0.2000	-0.4000
Metal	-0.4200	-0.2700	-0.3700	-0.3700	0.3000	-0.4000
OthManu	1.8700	2.0200	1.9500	1.9500	-1.8800	-0.4000
Const	0.1000	0.2500	0.1700	0.1700	0.5000	-0.4000
Trade	1.2800	1.4300	1.3400	1.3400	0.8900	-0.4000
Trans	0.3400	0.4900	0.4200	0.4200	-1.0200	-0.4000
Coal	-0.1900	-0.0300	-0.1300	-0.1200	-0.3000	-0.4000
Petro	-0.1800	-0.0300	-0.1300	-0.1300	-1.1300	-0.4000
PetroRefin	-1.6900	-1.5500	-1.6300	-1.6300	2.9100	-0.4000
OthPetro	0.2500	0.4000	0.3100	0.3100	-0.2000	-0.4000
Electri	-0.1200	0.0300	-0.0500	-0.0500	0.5000	-0.4000

Source: Author’s calculations based on the CGE model of Thailand

For the energy sectors, employment, capital, output, and supply decline in the coal and lignite sectors with the same magnitude as the petroleum and natural gas sectors. We also observe the same size decrease by 1.63 percent in output and supply value in the petroleum refineries sector, which reflects the biggest influence of the VAT policy. Subsequently, labour and capital use decrease in response to the reduction in productions. For the electricity sector, even though there are moderate decreases in output and supply, there is a substitution effect from labour to capital. Interestingly, the other petroleum product sector is the only energy sector where the labour, capital, output and supply increases from the change in VAT rate from 7 to 10 percent. In term of price, the increase in VAT rate from 7 to 10 percent increases the price of petroleum refineries and electricity sectors as the VAT rate rises the cost of production. Producers in these sectors can put this burden on consumers because electricity and petroleum products, such as diesel, gasoline, gasohol, are necessary products for all economic sectors. On the other hand, the prices of coal and lignite sector, petroleum and natural gas sector and other petroleum sector slightly decrease as these sectors are the inputs of petroleum refineries and electricity sectors. This reflects the price distortion among the energy sectors.

Furthermore, there is a decrease in rental rates of 0.4 percent in all sectors as VAT raises the cost of production in them. So that, the producers reduce the production and the use of capital input. This is consistent with the assumption that the prices of capital are the same in all sectors of the economy.

From these results, we can conclude that the increase in the VAT rate from 7 to 10 percent leads to an increase in prices and a decrease in output from the agriculture and food manufacturing sectors, which are necessary products for every economic agent. Similarly, an increase in the costs in the petroleum refineries and electricity sectors lead to a decline in output of these sectors. These results are intuitively correct.

2.5.3 Macroeconomic Impacts of Decreasing VAT from 7 to 0 Percent

There are significant changes in many sectors when the VAT rate is set to 0 percent in comparison to 7 percent at the benchmark, as shown in Table 2.10. Interestingly, this policy has favourable effects on consumers who can buy agriculture products, mining and quarrying products, and metal, metal products and machinery products at lower prices, as a result of increases in output, supply, capital and labour in these sectors. On the other hand, the rise in prices in the other manufacturing and unclassified sector results in a decrease in output, capital and employment by 0.53 percent. Furthermore, this policy not only increases the prices in the food manufacturing sector, textile industry sector, saw mills and wood products sector, rubber and chemical industries sector, non-metallic products sector, and transportation and communication sector but also raise the employment level, capital and output in these sectors. For the remaining sectors, paper industries and printing sector, construction sector and trade and services sector, this policy leads to a reduction in prices, employment, capital and output. Therefore, it is worth noting that the reduction in VAT rate from 7 to 0 percent leads to different effects on price of each sector, price distortions are higher for some sectors than others. Consumer goods are more distorted than producer goods.

For the energy sectors, the petroleum refineries sector shows the biggest increases in employment, capital and output. It is followed by the petroleum and natural gas sector, other petroleum product sector, electricity sector, and coal and lignite sector. Moreover, this policy benefits the producer in the petroleum and natural gas sector, coal and lignite sector, and other petroleum product sector as it increases the prices of these products. At the same time, this policy favours the consumers in the sense that it lowers the prices in the petroleum refineries and electricity product sectors by 5.17 and 0.60 percent, respectively.

Lastly, we find that rental rate in the zero percent VAT case increases by 0.59 percent in all sectors as there is more return to capital. This result corresponds well to our assumption of equal price of capital input in all sectors.

Table 2.10: Percentage Change in Macroeconomic Variables of Reducing VAT from 7 to 0 Percent (Unit: Percentage)

	Labour	Capital	Output	Supply	Price	Rental
Agric	3.6900	3.6900	3.6900	3.6900	-1.4700	0.5900
Mining	1.5700	1.5800	1.5600	1.5700	-1.6600	0.5900
FoodManu	0.8700	0.8700	0.7300	0.7300	2.9600	0.5900
Textile	1.9100	1.9100	1.9100	1.9100	2.1900	0.5900
SawMill	1.9000	1.9000	1.9000	1.9000	0.9200	0.5900
Paper	-5.0500	-5.0500	-5.0500	-5.0500	-0.4000	0.5900
Rubber	0.2000	0.2000	0.2000	0.2000	2.8400	0.5900
NonMetal	0.6900	0.6900	0.6900	0.6900	0.3000	0.5900
Metal	1.5400	1.5400	1.5400	1.5400	-0.3000	0.5900
OthManu	-0.5300	-0.5300	-0.5300	-0.5300	2.5000	0.5900
Const	-0.3100	-0.3100	-0.3100	-0.3100	-0.6000	0.5900
Trade	-2.5200	-2.5200	-2.5200	-2.5200	-1.0800	0.5900
Trans	1.6000	1.6000	1.6000	1.6000	1.0200	0.5900
Coal	0.2400	0.2500	0.2400	0.2500	0.5100	0.5900
Petro	2.0000	2.0000	2.0000	2.0000	1.3400	0.5900
PetroRefin	4.7200	4.7200	4.9400	4.9400	-5.1700	0.5900
OthPetro	1.3000	1.3000	1.3000	1.3000	0.3000	0.5900
Electri	0.6500	0.6500	0.6500	0.6500	-0.6000	0.5900

Source: Author’s calculations based on the CGE model of Thailand

Overall, our counterfactual results reveal that the change in VAT rates affect each sector differently. This is due to the adjustment of the relative price mechanism to balances supply and demand across various markets in an economy. Effect of VAT depends on composition of consumption of households.

2.5.4 Macroeconomic Impacts of 30 Percent Corporate Income Tax

This section presents the findings of impact of a reduction in CIT rates on labour, capital, output, supply, price and rental in each sector. Our simulation scenarios inspired by real situation of CIT policy in Thailand. It starts from benchmark replication case with the initial CIT rate at 30 percent, then follows by the counterfactual scenarios where the CIT rate reduces to 23 and 20 percent, respectively.

Table 2.11: Benchmark with 30 Percent CIT Rate

	Labour	Capital	Output	Supply	Price	Rental
Agric	721.6660	1035.5620	1747.1770	2434.4260	1.0780	1.0040
Mining	4.8120	3.1750	8.3690	11.6490	1.0830	1.0040
FoodManu	694.3900	697.3850	2483.2840	3095.2610	0.9980	1.0040
Textile	323.4370	239.4990	672.1870	796.3700	0.9350	1.0040
SawMill	108.4200	72.0230	201.9960	207.8580	0.9760	1.0040
Paper	142.3110	96.8360	245.6340	298.9290	1.0330	1.0040
Rubber	351.5690	307.4750	609.8480	975.1510	0.9180	1.0040
NonMetal	118.7490	83.9030	268.1150	285.6180	1.0050	1.0040
Metal	665.1400	786.6790	737.3770	3657.3370	1.1020	1.0040
OthManu	468.6370	349.6050	971.2590	1323.8380	0.9400	1.0040
Const	258.7960	184.5760	846.1830	947.3220	1.0530	1.0040
Trade	3490.9800	3770.4540	7511.230	10621.5900	1.1150	1.0040
Trans	609.9730	487.0240	1861.9860	1935.3130	0.9880	1.0040
Coal	10.2210	6.4120	16.7320	16.8340	0.9810	1.0040
Petro	277.0520	215.8430	732.870	689.1890	1.0170	1.0040
PetroRefin	257.2740	169.6060	338.670	1154.4780	1.1930	1.0040
OthPetro	53.0340	34.5270	86.0800	94.3160	1.0030	1.0040
Electri	341.6340	223.5860	846.8820	959.3860	1.0540	1.0040

Source: Author’s calculations based on the CGE model of Thailand

Note: Numbers of labour and capital are gross of tax

The findings in Table 2.11 present the benchmark replication result when the CIT rate equals 30 percent. The trade and services sector has the highest levels in labour, capital, output, and supply while the mining and quarrying sector has the smallest amount in these terms. For the energy sectors, electricity has the highest levels in labour, capital, and output while coal and lignite sector has the smallest amount in labour, capital, output, and supply. These results are similar to the results in the benchmark case of 7 percent VAT rate explained earlier.

2.5.5 Macroeconomic Impacts of Decreasing CIT from 30 to 23 Percent

In 2012, Thai government decided to reduce the CIT rate from 30 percent to 23 percent. This led to adjustment of demand and supply in the economy through the relative prices. By comparison, decreasing the CIT rate from 30 to 23 percent reduces the employment, capital, output and supplies in the paper industries and printing sector, metal, metal products and machinery sector, construction sector, trade and services sector and also in the coal and lignite sectors. At the same time, this policy boosts the use of factors and output in many important sectors in Thailand such as the agriculture sector, rubber and chemical industries, textile industry, and the other manufacturing and unclassified sector. Income effect is greater than substitution effect in this case as demand increases due to tax rebates result in a rise of the prices in all sectors, in particular, in the food manufacturing sector which has increased in price by 1.90 percent as shown in Table 2.12. This is consistent with the Thai economy in 2010, that the prices of commodities products excluding fuel in that year rose by 21.4 percent on a yearly average basis and the Thai economy expanded by 7.8 percent (Bank of Thailand, 2011).

Table 2.12: Percentage Change in Macroeconomic Variables of Decreasing in CIT from 30 to 23 Percent (Unit: Percentage)

	Labour	Capital	Output	Supply	Price	Rental
Agric	2.5100	2.6600	2.5800	2.5800	0.0900	0.0000
Mining	3.2600	3.4000	3.3300	3.3300	0.0900	0.0000
FoodManu	1.6500	1.7900	1.5800	1.5800	1.9000	0.0000
Textile	4.9800	5.1300	5.0500	5.0500	0.0000	0.0000
SawMill	2.2500	2.4000	2.3100	2.3100	0.0000	0.0000
Paper	-2.7400	-2.6000	-2.6900	-2.6900	0.1000	0.0000
Rubber	1.5900	1.7300	1.6600	1.6600	0.1100	0.0000
NonMetal	0.4100	0.5500	0.4700	0.4700	0.0000	0.0000
Metal	-1.8200	-1.6800	-1.7800	0.0000	0.0000	0.0000
OthManu	2.5800	2.7200	2.6500	2.6500	0.1100	0.0000
Const	-0.2700	-0.1300	-0.2100	-0.2100	0.0900	0.0000
Trade	-2.0300	-1.8900	-1.9800	-1.9800	0.0900	0.0000
Trans	2.0700	2.2200	2.1500	2.1500	0.1000	0.0000
Coal	-0.2200	-0.0800	-0.1700	-0.1600	0.0000	0.0000
Petro	1.6600	1.8000	1.7100	1.7100	0.1000	0.0000

Table 2.12: Percentage Change in Macroeconomic Variables of Decreasing in CIT from 30 to 23 Percent (Unit: Percentage), Continued

	Labour	Capital	Output	Supply	Price	Rental
PetroRefin	1.0600	1.2000	1.1200	1.1200	0.0800	0.0000
OthPetro	1.3100	1.4500	1.3600	1.3600	0.0000	0.0000
Electri	0.1400	0.2800	0.2000	0.2000	0.0000	0.0000

Source: Author's calculations based on the CGE model of Thailand

For the energy sector, this policy stimulates production and employment in every energy sector except the coal and lignite sectors. The highest increase in employment, capital, output and supply occur in the petroleum and natural gas industry, followed by the other petroleum product sector, petroleum refineries sector, and electricity sector, respectively. However, only the prices in the petroleum and natural gas industry and petroleum refineries sector increase slightly, while those of the other sectors remained unchanged.

2.5.6 Macroeconomic Impacts of Decreasing CIT from 30 to 20 Percent

Later in 2013, the government lowered the CIT rate again from 23 percent to 20 percent. This further reduction of CIT rate affected not only tax revenue but only the composition of production and consumption in economy. Our analysis compares the impact of CIT rate change from 30 percent to 20 percent because the government expected to apply a CIT rate at 20 percent until the end of 2015 and planned to employ a 30 percent rate after that.

The results of reducing the CIT rate from 30 to 20 percent show similar results as lowering the CIT rate to 23 percent. However, the magnitude of changes in every sector are different. For instance, output in the food manufacturing sector increases by 1.58 percent when the CIT rate is 23 percent and increase to 3.45 percent when the CIT rate is 20 percent. This means a further reduction of CIT rate to 20 percent promote a production in food manufacturing sector. Furthermore, a remarkable change happens in metal, metal products and machinery industry as supply and the prices of this sector decreases after the reduction of CIT rate to 20 percent compared to the benchmark case. In addition, this policy also decreases the prices in the transportation and communication sector, petroleum refineries sector, and electricity sector, as illustrated in Table 2.13. Overall, the reduction of CIT rate benefits to most sectors in economy as most sectors increase their production, while few industries are adversely affected. This shows that such change in

CIT rate causes reallocation of resources among sectors. The relative price mechanism adjusts quantity of demand and supply in the economy.

Table 2.13: Percentage Change in Macroeconomic Variables of Decreasing in CIT from 30 to 20 Percent (Unit: Percentage)

	Labour	Capital	Output	Supply	Price	Rental
Agric	4.2600	4.4600	4.3500	4.3500	0.0000	0.0000
Mining	4.2400	4.4400	4.3400	4.3400	0.0000	0.0000
FoodManu	3.4900	3.6900	3.4500	3.4500	1.8000	0.0000
Textile	7.0700	7.2800	7.1600	7.1600	0.0000	0.0000
SawMill	3.1200	3.3200	3.2000	3.2000	0.0000	0.0000
Paper	-4.3000	-4.1100	-4.2300	-4.2300	0.1000	0.0000
Rubber	2.2500	2.4500	2.3400	2.3400	0.0000	0.0000
NonMetal	0.5800	0.7700	0.6600	0.6600	0.0000	0.0000
Metal	-2.9000	-2.7100	-2.8400	-0.1300	-0.0900	0.0000
OthManu	3.5800	3.7800	3.6800	3.6800	0.0000	0.0000
Const	-0.4200	-0.2300	-0.3300	-0.3300	0.0000	0.0000
Trade	-3.2400	-3.0500	-3.1800	-3.1800	0.0000	0.0000
Trans	3.2200	3.4300	3.3200	3.3200	-0.3000	0.0000
Coal	-0.3200	-0.1200	-0.2500	-0.2500	0.0000	0.0000
Petro	2.4600	2.6600	2.5300	2.5300	0.0000	0.0000
PetroRefin	1.9800	2.1700	2.2700	2.2700	-1.3400	0.0000
OthPetro	1.8000	2.0000	1.8800	1.8800	0.0000	0.0000
Electri	0.1000	0.2900	0.1900	0.1900	-0.0900	0.0000

Source: Author's calculations based on the CGE model of Thailand

Under non-balanced budget Amir et al. (2013) found that a decrease in Indonesian CIT rate caused the reduction in output in some sectors while the prices in all sectors increase. In case of balanced budget, they reported that all outputs increase, except government administration sector, while all prices decrease. In contrast with similar CIT reduction under the balanced budget scenario in our model, we find that output increases in 13 sectors and marginally decreases in five sectors on one hand, with almost no effect on prices of products on the other. This might happen because of the differences in model structure and assumptions.

2.5.7 Aggregate Impacts of Tax Reforms on Macroeconomic Variables

The aggregate effects of tax reforms on macroeconomic variables are reported in Table 2.14. Under increasing VAT from 7 to 10 percent leads to a decrease in output by 2.53 percent. This might happen because of a reduction in household consumption and employment. This finding is in line with the results of Fan et al. (2002) and Sujjapongse

(2005), who reported an increase in the VAT rate decreases GDP and demand for goods. On the other hand, the government expenditure increases by 3.04 percent because of the rise in VAT revenue. Consequently, investment expands by 0.43 percent due to rises in government services. This investment also stimulates imports which can be input factors, then re-exporting the products afterwards, so that exports increase. In contrast, the reduction of the VAT rate from 7 to 0 percent leads to increases in output, household consumption and employment by 3.76, 7.0, and 4.95 percent, respectively. This is in line with the results from Llambi et al. (2016), who found that a reduction of the VAT increases private consumption and employment in Uruguay. Notably, the removal of VAT rate leads to a reduction of export by 6.91 percent. This is plausible because some export products might be used for domestic consumption as households increase their consumption regarding cheaper prices. The elimination of VAT means the government has no revenue from this type of tax; hence, government consumption decreases by 6.31 percent. The reduction in government expenditure not only decreases investment but also lowers imports.

Table 2.14: Percentage Change in Aggregate Level of Macroeconomic Variables in Comparison with the Benchmark Case (Unit: Percentage)

Macro variables	VAT 10%	VAT 0%	CIT 23%	CIT 20%
Output	-2.5286	3.7613	0.6006	0.5972
Household consumption	-2.7273	7.0000	5.6911	8.3333
Investment	0.4252	-0.3297	0.1355	0.0375
Employment	-3.6013	4.9529	0.3133	0.0844
Government Consumption	3.0360	-6.3107	-2.8784	-4.5436
Export	5.4731	-6.9115	0.0529	-0.0296
Import	5.4731	-6.9115	0.0528	-0.0296

Source: Author’s calculations based on the CGE model of Thailand

Under a reduction in corporate income tax (CIT) rate, in both cases lead to a decline in government consumption because government revenues from this tax decrease. On the other hand, this policy increases the disposable income of the society. The household consumption increases and can compensate for the reduction in the public sector; hence, stimulating the investment and employment in the economy results in an expansion in output. This is in line with the results by Amir et al. (2013), who concluded that a reduction in CIT rate raises economic growth under a balanced budget assumption in Indonesia. It is interesting to note that the reduction of CIT rate from 30 to 23 and 20 percent yields contrasting results for exports and imports. That is, the 23 percent CIT rate leads to increases in exports and imports, while the 20 percent CIT rate lessens exports and imports. This may happen due to the increase in other macroeconomic variables where in the 20 percent CIT rate case cannot compensate for the decrease in government consumption, hence, imports decrease. On the other hand, the rise in domestic consumption and investment decrease exports. This is plausible because a reduction in CIT rate increases disposable income of people, stimulate domestic consumption and investment, thereby less products available for exports.

2.5.8 Welfare Analysis of Tax Reforms

In addition, this CGE model can explain the change in the utility levels of households and public welfare by using Equation 2.9. The results in Table 2.15 show that an increase in the VAT rate reduces a household's utility by 3.146 percent while increasing public welfare by 42.705 percent, compared to the benchmark case. If this welfare is weighted by the respective sizes of private and public sectors at 0.78 and 0.22 percent. Thus, the net welfare in this case equals 6.941 percent. This means the public sector can compensate private loss through public services or transfer to households.

Table 2.15: Welfare Analysis: Utility from Private and Public Goods and Net-Gains

	Households utility	Change in utility (%)	Public Utility	Change in public utility (%)	Net gain[6] (%)
VAT 7%	2.734		0.562		
VAT 10%	2.648	-3.146	0.802	42.705	6.941
VAT 0%	2.920	6.803	0.043	-92.349	-15.010
CIT 30%	4.999		2.204		
CIT 23%	5.261	5.241	1.910	-13.339	1.153
CIT 20%	5.400	8.022	1.757	-20.281	1.795

Source: Author's calculations based on the CGE model of Thailand

On the other hand, the removal of VAT accelerates the household's utility by 6.803 percent but reduces public welfare by 92.349 percent. Consequently, there is a net loss to the social welfare of 15.010 percent. Therefore, aggregate changes in the net welfare effect of a 10 percent VAT rate are better than the zero percent VAT rate because utility from the public services for the households more than compensate for their loss of utility

[6] In 2010, government expenditure accounted for 22.02% of GDP. So, government weight is 0.22 while private weight is 0.78. Net gain = 0.78(-3.146) + 0.22(42.705) = 6.941.

due to the higher tax rate. Therefore, increasing the VAT rate from 7 to 10 percent becomes a desirable policy action on the basis of economy-wide welfare analysis because the net gain of 10 percent VAT rate is higher than 0 percent VAT rate. This result is in line with the report by OECD (2018), which stated that Thailand should consider gradually broadening the scope of its VAT and increasing its rate to boost tax revenue because the statutory rate of VAT was 10 percent.

Moreover, the welfare impact of the change in the CIT rate indicates that a decrease in the CIT rate from 30 to 23 percent not only leads to an increase in household's utility by 5.241 percent, but also this policy decreases public welfare by 13.339 percent. In addition, the permanent CIT rate of 20 percent raises household's utility level by 8.022 percent but lessens public welfare by 20.281 percent, compared to the benchmark case. Although the reduction of the CIT rate increase household's welfare in both cases, the magnitude of changes are less than the decrease in public welfare. Therefore, the increase of private utility cannot compensate for the loss of public welfare due to the lower CIT rate. Accordingly, the net gain of 20 percent CIT rate is slightly higher than the 23 percent CIT rate. Thus, decreasing the CIT rate from 30 to 20 percent is a preferable policy tool as the overall change in the net welfare effect of 20 percent is better than that of the 23 percent rate.

2.5.9 Sensitivity Analysis

In CGE modeling, the parametrisation and the choice of parameter values may have a distinct influence on the model results. This study therefore checks the robustness of the model results outlined above by using sensitivity analysis. We highlight the sensitivity analysis on two key elasticity parameters which are the elasticity of substitution between labour and capital (σ_{LK}) and the Armington elasticity (σ_A) by setting the elasticity from low sc1 to the highest sc10, holding tax structure fixed as in the benchmark, to see the changes of output across sectors. The variations are done separately by vary one elasticity at the time and leave the others unchanged at their benchmark values.

The robustness of this model is illustrated as the variation in output across sectors. The results of the robustness in Appendix 2B, 2C, 2D and 2E were confirmed with all other computations as the output in each sector varies within a small range. The sectoral effects are different depending on the elasticity that is varied.

2.6 Conclusions

This chapter has constructed a computable general equilibrium (CGE) model of the Thai economy by utilising the micro-consistent data contained in the Input-Output Table 2010 published by the Office of National Economics and Social Development Board (NESDB) with some restructuring into 18 sectors. This chapter contributes to the existing literature by examining for the first time the economy-wide impacts of changes in VAT and CIT rates on the allocation of labour and capital inputs, on output and supply as well as on prices and rental rates across sectors and on the levels of household's utility and public welfare in Thailand.

Results reveal that an increase in the VAT rate from 7 to 10 percent generates an increase in public welfare with a decrease in household's utility from the consumption of private goods. This result occurs because the higher VAT rate raises prices and lowers outputs in many sectors, especially in the agriculture and food manufacturing sectors. On the other hand, this policy has favorable effect to producers in some sectors leading to rises in both output and prices such as in the mining and quarrying sector, and trade and services sector. For the energy sectors, output only increases in the other petroleum product sector, whereas prices rise in the petroleum refineries and electricity sectors. These reallocation affects caused by the relative price mechanism, resulting in the changes of output, capital, employment and price across sectors.

The elimination of VAT boosts output in most sectors. However, the increase in household's utility from private consumption cannot compensate enough for reduction in utility from public consumption as evidenced by negative net gain. Thus, VAT can have a positive impact on welfare when revenues are used prudently for providing public services. In comparison, increasing the VAT rate from 7 to 10 percent becomes a desirable policy action on the basis of economy-wide welfare analysis because utility from the public services for households more than compensates for their loss of utility due to higher tax rates. On the other hand, removing VAT rate becomes more favourable policy in term of economic growth targeted because this policy induces output, household consumption and employment at aggregate level by comparison to increasing VAT rate to 10 percent policy. Therefore, policymakers should be aware of implementing any tax policies according to the policy targeted and the efficiency of economic agents in the country. If public sector is the main sector in economy and reallocate resources efficiently, increasing VAT rate to 10 percent would create more benefit to the nation. If most of economic activities run by private sector, eliminating VAT policy might more suitable to implement.

In the case of reduction in the CIT rate, the findings are similar to the VAT results, but the magnitude of the changes across sectors are different. Although these policies increase household's welfare in both cases, the changes are less than the size of decrease in public welfare. In comparison, decreasing the CIT rate from 30 to 20 percent is a preferable policy as the overall net changes in welfare of the 20 percent CIT rate are slightly better than those of the 23 percent CIT rate. In term of aggregate level, implementing CIT rate at 23 percent seems to be more appropriate than 20 percent CIT rate because the findings reveal greater positive impact on macroeconomic indicators.

We note that while the above results based on our CGE model of the Thai economy are robust within the model structure but they are influenced by the structure of the model. On one hand, the results coming from the comparative static analysis can at best be said to represent a steady state behavior in the model economy. Full impact analysis requires a full scale dynamic model. Another point is that while this model includes heterogeneity of firms but still contains only a representative household. As public policy like this is likely to have different impacts on different households, such a model should have a multiplicity of households in it. This efficiency analysis presented here, in itself, is a unique contribution to the current literature on the impacts of VAT and CIT in the Thai economy.

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Appendix 2A: Thailand's Eighteen Sectors Input-Output Table (in Billion Baht)

	Agric	Mining	FoodManu	Textile	SawMill	Paper	Rubber	NonMetal	Metal
Agric	146.936	0.162	822.034	4.025	18.605	3.909	137.866	0.750	0.140
Mining	0.143	0.082	1.440	0.044	0.031	0.127	4.649	48.633	13.349
FoodManu	102.010	0.000	269.182	0.415	0.261	2.081	11.451	1.073	0.051
Textile	1.585	0.039	1.394	201.711	0.775	0.228	9.288	0.755	6.611
SawMill	2.200	0.202	1.136	0.081	15.501	0.131	1.685	0.581	10.720
Paper	0.583	0.104	6.698	2.850	1.349	20.357	6.597	1.915	17.999
Rubber	58.153	2.059	18.133	51.817	11.004	8.130	199.724	9.190	163.006
NonMetal	1.012	0.020	8.915	0.027	0.574	0.037	1.466	42.354	27.276
Metal	27.678	9.082	21.560	5.866	4.307	3.900	17.854	12.126	1210.232
OthManu	2.773	0.243	15.786	15.451	2.362	2.731	9.662	5.278	35.237
Const	1.280	0.163	1.233	0.701	0.162	0.336	1.789	0.716	6.015
Trade	146.698	4.988	188.929	81.859	29.747	42.925	180.283	44.028	692.234
Trans	21.826	3.909	44.501	12.784	6.279	8.001	42.944	17.283	100.387
Coal	0.000	0.000	0.381	0.053	0.000	0.399	0.201	0.202	2.317
Petro	0.086	0.335	2.700	1.030	0.051	0.373	22.629	5.239	8.772
PetroRefin	48.846	4.306	16.957	7.707	0.992	1.767	55.998	15.158	48.409
OthPetro	5.453	1.662	0.857	0.882	0.261	0.272	3.127	2.014	15.798
Electri	5.701	1.844	48.553	41.217	5.379	5.442	46.812	24.026	106.107

Appendix 2A: Thailand's Eighteen Sectors Input-Output Table (in Billion Baht), Continued

	OthManu	Const	Trade	Trans	Coal	Petro	PetroRefin	OthPetro	Electri
Agric	11.982	4.756	102.911	1.979	0.000	0.000	0.000	0.000	0.388
Mining	18.094	38.873	0.021	0.023	0.000	0.159	0.001	0.001	0.024
FoodManu	27.884	0.000	186.584	5.774	0.000	0.000	0.131	0.134	1.204
Textile	21.409	0.478	28.623	3.157	0.001	0.000	0.000	0.008	0.130
SawMill	3.367	15.668	6.499	1.233	0.000	0.009	0.045	0.002	0.053
Paper	8.814	0.522	96.625	4.900	0.017	0.264	0.141	0.030	0.535
Rubber	46.650	10.596	133.484	21.071	0.001	0.517	0.526	1.096	0.316
NonMetal	9.545	177.534	3.153	0.024	0.000	0.000	0.000	0.000	0.000
Metal	42.252	65.265	105.729	151.373	0.457	10.240	1.183	0.211	8.558
OthManu	158.360	2.130	89.572	9.020	0.013	2.934	0.385	0.124	1.454
Const	1.438	0.890	22.472	1.343	0.010	0.418	0.022	0.030	1.001
Trade	184.458	115.071	883.853	198.948	0.475	85.276	12.210	5.450	47.248
Trans	41.753	73.307	227.319	204.257	2.994	4.510	4.053	0.494	6.185
Coal	0.217	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.956
Petro	3.047	0.432	11.377	2.194	0.000	302.030	88.660	0.032	133.944
PetroRefin	6.672	9.897	80.593	327.701	1.892	36.593	6.280	3.622	52.790
OthPetro	1.939	5.270	4.433	29.602	0.007	5.611	0.077	14.070	0.059
Electri	24.519	6.268	205.634	23.747	0.155	6.360	3.122	0.352	15.316

Appendix 2B: Sensitivity of Output by Sectors to the Elasticity of Substitution between Capital and Labour in VAT scenario (Increment is 0.5 from sc1 to sc10)

	sc1	sc2	sc3	sc4	sc5	sc6	sc7	sc8	sc9	sc10
Agric	2129.17	2133.048	2134.97	2136.118	2136.881	2137.424	2137.831	2138.147	2138.4	2138.607
Mining	4.212399	4.250369	4.269743	4.281489	4.289369	4.295023	4.299276	4.302592	4.305249	4.307427
FoodManu	2781.706	2788.15	2791.348	2793.259	2794.531	2795.437	2796.116	2796.644	2797.065	2797.41
Textile	703.3966	703.5179	703.574	703.6062	703.6271	703.6418	703.6526	703.661	703.6676	703.6729
SawMill	215.9179	215.8878	215.8721	215.8625	215.8559	215.8513	215.8477	215.845	215.8427	215.8409
Paper	221.4893	221.7701	221.9083	221.9905	222.045	222.0838	222.1129	222.1354	222.1534	222.1681
Rubber	615.5973	617.2878	618.1281	618.6306	618.965	619.2034	619.3821	619.521	619.632	619.7228
NonMetal	281.6356	282.024	282.217	282.3324	282.4091	282.4639	282.5049	282.5367	282.5622	282.5831
Metal	600.4551	594.8798	592.1255	590.4837	589.3937	588.6173	588.0361	587.5849	587.2243	586.9296
OthManu	968.414	973.3762	975.8486	977.3291	978.3148	979.0183	979.5456	979.9555	980.2833	980.5514
Const	891.7932	894.4385	895.7516	896.5365	897.0584	897.4305	897.7093	897.9259	898.0991	898.2407
Trade	7004.761	7003.683	7003.124	7002.782	7002.552	7002.386	7002.261	7002.163	7002.085	7002.021
Trans	1891.056	1893.273	1894.371	1895.027	1895.463	1895.773	1896.006	1896.187	1896.331	1896.449
Coal	17.97357	17.95362	17.94369	17.93774	17.93377	17.93095	17.92883	17.92718	17.92586	17.92479
Petro	771.6984	770.4524	769.8344	769.4652	769.2198	769.0448	768.9138	768.812	768.7306	768.6641
PetroRefin	420.9033	421.7871	422.2228	422.4823	422.6544	422.777	422.8687	422.9399	422.9967	423.0432
OthPetro	84.04971	83.98426	83.95188	83.93256	83.91973	83.91059	83.90374	83.89843	83.89418	83.89071
Electri	851.7081	851.9215	852.0258	852.0876	852.1285	852.1576	852.1794	852.1962	852.2097	852.2207

Appendix 2C: Sensitivity of Output by Sectors to the Armington Elasticity in VAT scenario (Increment is 0.2 from sc1 to sc10)

	sc1	sc2	sc3	sc4	sc5	sc6	sc7	sc8	sc9	sc10
Agric	2249.596	2260.517	2271.339	2282.063	2292.689	2303.216	2313.646	2323.978	2334.212	2344.348
Mining	5.643933	5.568047	5.492907	5.418504	5.344839	5.271918	5.199753	5.128356	5.057742	4.987928
FoodManu	2872.858	2878.317	2883.722	2889.073	2894.367	2899.602	2904.778	2909.893	2914.949	2919.943
Textile	778.8867	780.5019	782.0979	783.6733	785.2271	786.7585	788.2672	789.7528	791.2152	792.6543
SawMill	230.0685	229.971	229.8748	229.7798	229.6858	229.5928	229.5007	229.4096	229.3194	229.2301
Paper	223.4705	223.6963	223.9154	224.128	224.3342	224.5341	224.728	224.9159	225.098	225.2744
Rubber	636.8662	639.0075	641.1201	643.2038	645.2585	647.2841	649.2808	651.2487	653.188	655.0989
NonMetal	280.8896	280.7828	280.677	280.572	280.4681	280.3652	280.2634	280.1627	280.0632	279.965
Metal	547.729	537.3141	527.0441	516.9194	506.9403	497.1069	487.4191	477.8766	468.4791	459.2263
OthManu	1014.431	1017.034	1019.607	1022.149	1024.659	1027.136	1029.58	1031.99	1034.367	1036.709
Const	875.1559	875.7451	876.3247	876.895	877.4561	878.0082	878.5515	879.0862	879.6124	880.1302
Trade	6753.839	6747.921	6741.922	6735.847	6729.698	6723.479	6717.191	6710.837	6704.417	6697.934
Trans	1923.58	1922.744	1921.922	1921.113	1920.316	1919.529	1918.751	1917.983	1917.224	1916.474
Coal	17.16046	17.12648	17.09295	17.05986	17.02721	16.995	16.96323	16.9319	16.90101	16.87056
Petro	766.0456	767.2016	768.3638	769.5317	770.7049	771.8832	773.0662	774.2538	775.4455	776.6414
PetroRefin	432.1553	436.8271	441.4928	446.1524	450.8055	455.4517	460.0905	464.7215	469.344	473.9577
OthPetro	89.70086	89.60363	89.5075	89.41249	89.31861	89.22588	89.13433	89.04396	88.95481	88.8669
Electri	859.7277	859.279	858.8297	858.3801	857.9306	857.4815	857.0332	856.5857	856.1395	855.6946

Appendix 2D: Sensitivity of Output by Sectors to the Elasticity of Substitution between Capital and Labour in CIT scenario (Increment is 0.5 from sc1 to sc10)

	sc1	sc2	sc3	sc4	sc5	sc6	sc7	sc8	sc9	sc10
Agric	1870.062	1873.842	1875.717	1876.837	1877.581	1878.112	1878.509	1878.818	1879.065	1879.267
Mining	3.379783	3.417235	3.436336	3.447914	3.455681	3.461253	3.465444	3.468711	3.47133	3.473476
FoodManu	2424.003	2430.013	2432.998	2434.782	2435.969	2436.816	2437.45	2437.943	2438.337	2438.659
Textile	604.9473	605.1446	605.2394	605.295	605.3316	605.3575	605.3767	605.3916	605.4035	605.4132
SawMill	201.5612	201.5607	201.5598	201.5591	201.5585	201.558	201.5577	201.5574	201.5571	201.5569
Paper	252.2938	252.546	252.67	252.7437	252.7926	252.8274	252.8534	252.8736	252.8897	252.9029
Rubber	591.6732	593.3845	594.2352	594.744	595.0826	595.3241	595.505	595.6456	595.758	595.85
NonMetal	276.6772	277.092	277.2981	277.4213	277.5033	277.5618	277.6056	277.6396	277.6668	277.6891
Metal	623.1693	617.7457	615.0646	613.4658	612.4041	611.6477	611.0816	610.6419	610.2906	610.0034
OthManu	910.2744	914.988	917.3374	918.7446	919.6816	920.3504	920.8517	921.2415	921.5531	921.8081
Const	900.8883	903.613	904.9659	905.7746	906.3125	906.696	906.9833	907.2066	907.3851	907.531
Trade	7699.655	7698.684	7698.177	7697.866	7697.655	7697.504	7697.389	7697.3	7697.228	7697.169
Trans	1777.885	1779.882	1780.871	1781.462	1781.854	1782.134	1782.343	1782.506	1782.636	1782.742
Coal	17.98719	17.96835	17.95896	17.95333	17.94959	17.94691	17.94491	17.94335	17.94211	17.94109
Petro	733.2469	732.2304	731.7262	731.4251	731.2249	731.0822	730.9753	730.8922	730.8258	730.7716
PetroRefin	408.6439	409.6335	410.1222	410.4135	410.6069	410.7447	410.8477	410.9278	410.9917	411.044
OthPetro	80.66189	80.60316	80.57409	80.55676	80.54524	80.53703	80.53089	80.52612	80.52231	80.51919
Electri	849.7024	849.924	850.0324	850.0966	850.1392	850.1694	850.192	850.2095	850.2235	850.2349

Appendix 2E: Sensitivity of Output by Sectors to the Armington Elasticity in CIT scenario (Increment is 0.2 from sc1 to sc10)

	sc1	sc2	sc3	sc4	sc5	sc6	sc7	sc8	sc9	sc10
Agric	1971.715	1981.642	1991.475	2001.219	2010.873	2020.439	2029.918	2039.311	2048.618	2057.839
Mining	4.727281	4.642783	4.559906	4.478452	4.39828	4.319286	4.241394	4.16455	4.088713	4.013856
FoodManu	2505.423	2510.089	2514.766	2519.441	2524.105	2528.751	2533.372	2537.964	2542.525	2547.05
Textile	671.2301	672.4188	673.6269	674.8464	676.071	677.2961	678.5182	679.7345	680.9428	682.1414
SawMill	212.8988	212.7858	212.6769	212.5713	212.4685	212.3682	212.27	212.1737	212.0792	211.9862
Paper	254.1495	254.4777	254.7967	255.107	255.409	255.7029	255.9891	256.2677	256.539	256.8033
Rubber	612.6053	614.639	616.6576	618.6585	620.6397	622.5999	624.5381	626.4535	628.3457	630.2142
NonMetal	275.2458	275.148	275.0511	274.9549	274.8596	274.7652	274.6716	274.5789	274.4871	274.3964
Metal	574.2486	564.0749	554.0216	544.0912	534.286	524.6072	515.056	505.6332	496.3392	487.1743
OthManu	952.5885	954.8654	957.1554	959.4495	961.7408	964.0242	966.2957	968.5522	970.7912	973.011
Const	884.3665	885.0175	885.6561	886.283	886.8989	887.5043	888.0995	888.6849	889.2609	889.8277
Trade	7485.837	7481.53	7477.052	7472.423	7467.66	7462.773	7457.774	7452.669	7447.464	7442.166
Trans	1806.262	1805.25	1804.283	1803.353	1802.455	1801.584	1800.737	1799.91	1799.102	1798.312
Coal	17.17252	17.13895	17.10583	17.07314	17.04088	17.00904	16.97762	16.94662	16.91603	16.88585
Petro	729.1874	730.3126	731.4485	732.5938	733.7475	734.9086	736.0766	737.2508	738.4307	739.6158
PetroRefin	418.8737	423.6097	428.3322	433.0433	437.7442	442.4356	447.1182	451.7921	456.4574	461.1142
OthPetro	85.5147	85.41312	85.313	85.21424	85.11678	85.02059	84.92564	84.83191	84.7394	84.64811
Electri	855.9259	855.563	855.1947	854.8221	854.446	854.0671	853.6862	853.3037	852.9202	852.5358

Chapter 3 : Growth and Redistribution Impacts in the Thai Economy: A Dynamic CGE Model

The last chapter focused on the impacts of reforms in VAT and CIT on allocation of output and supply, labour and capital input, and prices and rental across sectors as well as on the levels of household's utility and public welfare in Thailand at an aggregate level by using a static computable general equilibrium (CGE) with one representative household. The findings of this technique can only explain how the economic indicators and welfare are affected by those policies, but it cannot describe the reallocation path of economic indicators and welfare overtime. However, this problem can be overcome by applying a multi-household and multi-sector dynamic CGE model of Thailand.

This chapter will construct a dynamic CGE to assess the impacts of a reduction of personal income tax (PIT) on growth and redistribution over 25 years in Thailand. It includes multi-households in the model to reveal the impact of such changes of tax rates at disaggregate household level. This chapter emphasises the impact of a reduction of PIT rate because this is the latest tax change in Thailand. This tax has a progressive rate and taxes the income of a person directly, any change in the tax rate will have a different distribution affect for households in each income threshold.

The results show that a reduction in PIT rate benefited the poorest households throughout the study period, while the levels of income and consumption of the richest households declined, although the magnitude of changes are smaller from time to time. This implies that a reduction in PIT rate is helpful in decreasing disparity in the distribution of income and consumption in both the short and long-terms in Thailand. In addition, this policy increases output, employment and capital stock in every sector, which results in a rise in all macroeconomic variables, especially the levels of investment and GDP. Under balanced budget assumption, the findings report that the drop in PIT revenue can be fully compensated by an increase in revenue from other taxes in a growing economy.

This chapter starts with the introduction, then section 2 briefly discusses previous literatures related to applying a CGE model. Section 3 gives some information on the change of PIT in Thailand. The dynamic CGE model of Thailand, together with model calibration and parameter specification, is formulated in detail in section 4. The simulation results on the growth and reallocation from that policy are reported in section 5. Section 6 presents the conclusion of the Thai DCGE and outlines the scope for future research.

3.1 Introduction

In the 1980s, Thailand was one of the widely cited development success stories with sustained strong growth and impressive poverty reduction. In addition, it had made remarkable progress in social and economic development, moving from a lower-middle income country to an upper-middle income country status in less than a generation. Income inequality, however, had not improved even slightly. In the late 1980s, the Thai economy took off on a rapid growth path with economic liberalisation and a shift of labour from agriculture to manufacturing and services. This raised income inequality even further. The Gini coefficient reached a highest value of 47.9 percent, particularly during the high growth period of 1988-1992. Following redistribution programmes, the Gini coefficient consequently dropped to the current level of 37.8 percent in 2013, as shown in Figure 3.1. Vanitcharearnthum (2017) suggests that this is consistent with the Kuznets hypothesis, which claims that income inequality worsens in the early stages of economic development before it gradually improves later. A wide gap between the average income of households in top quintile and the bottom quintile in Thailand is more than is acceptable. In 2011, the average income of households in the top quintile was approximately 7.49 times that of the households at the bottom quintile (National Statistical Office, 2012). In addition, Figure 3.2 illustrates that the distribution of disposable income of Thailand was more unequal than other neighbouring countries such as Indonesia, India and Vietnam.

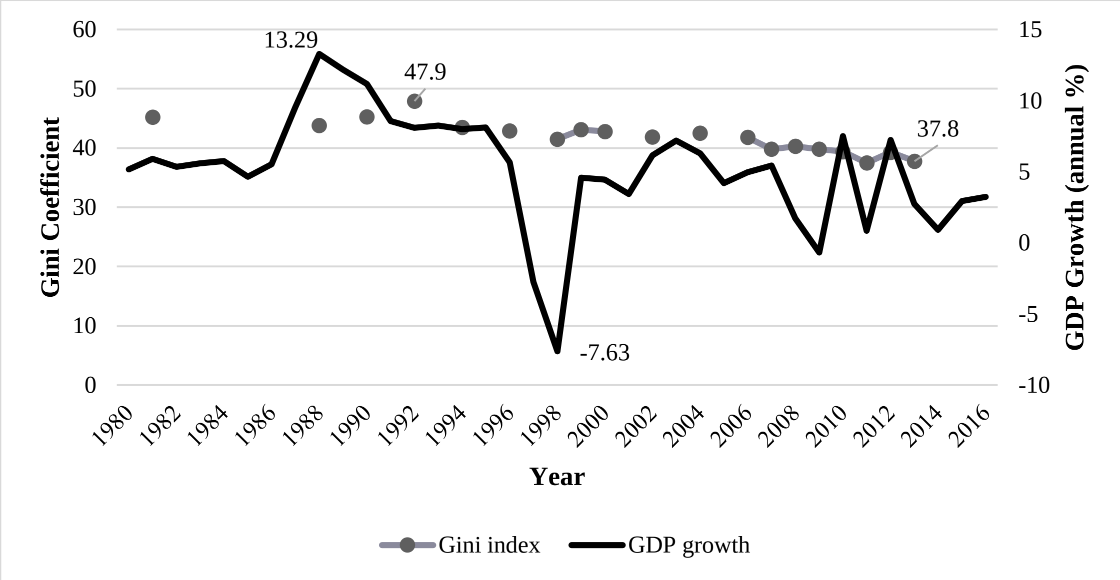

Figure 3.1: Gini Index and GDP Growth in Thailand

Source: World Development Indicator, World Bank (2017)

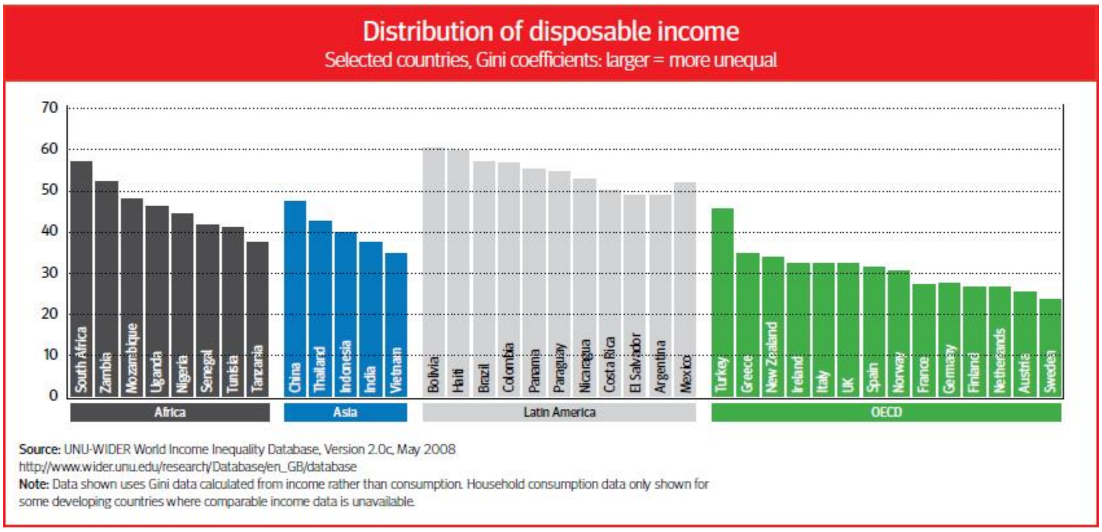

Figure 3.2: Distribution of Disposable Income

Source: Carter and Matthews (2012)

Carter and Matthews (2012) point out that the post-tax income distribution can be more equal through tax policy because tax policy is a vital tool for raising government revenues to finance public spending that benefit low-income families through transfers, education and health. Aside from this, tax policy can improve social equity via growth-facilitating infrastructure. Their view was also supported by the OECD's experts, who claimed that governments can use progressive income tax as one of the key approaches to redistribute incomes.

However, there are concerns in many countries about the potential trade-offs between meeting both economic growth and equity objectives. Effects of income tax on the distribution of income need to be considered in this context. This means the overall effects of any reform of taxation policies should be analysed as a whole for the economy, particularly the effects of tax on different categories of households and production sectors in the economy. According to Bhattarai (2017), the most appropriate techniques for evaluating such impacts of taxes are the dynamic computable general equilibrium models (DCGE). This tool is superior even when compared to static CGE because it provides deep intuitions on the intertemporal behaviour of households and firms and of their economic activities including consumption, investment, exports and imports. His previous work (Bhattarai, 2008) also proposed that the explicit dynamic specification of demand and supply of commodities and factors of production allows the transition paths of output, employment and capital formation in various sectors to be assessed in response to a certain policy change that causes reallocation of resources through changes in factor and commodity prices. The transitional effects of tax reform may differ significantly across sectors even when long-run impacts are similar. The sector-specific impacts of tax changes both in the short and in the long-run can be evaluated by a dynamic model through adjustment of price mechanism. This had been supported by Radulescu and Stimmelmayr (2010), who stated that the short-run and long-run impacts of policy proposals can be distinguished by the dynamic CGE model. Apart from aforementioned advantages of dynamic CGE method, this approach has some drawbacks on the transparency of the model because it is a big model with many assumptions. Hence, the modellers should have good economics knowledge and great skill of software packages to ensure that the constructed model is correct and suitable to evaluate consider policy.

A dynamic CGE models have been used extensively for measuring the impacts of taxes policies in developed and developing countries (e.g., Wendner, 2001; Giesecke and Nhi, 2010; Radulescu and Stimmelmayr, 2010; Bretschger et al., 2011; Xu et al., 2015; Bhattarai, 2017; Bhattarai et al., 2017; Tang et al., 2017). However, to our knowledge, there is no evidence of dynamic CGE model that try to investigate the impacts of fiscal policy on the Thai economy. There were few studies in literature that tried to apply difference versions of the static CGE models including Puttanapong et al. (2015), Winyuchakrit et al. (2011), and Wianwiwat and Asafu-Adjaye (2013), Wattanakuljarus and Coxhead (2008) and Field and Wongwatanasin (2007). Most of these researchers focus on evaluating impacts of energy and trade policies on Thai economy. Interestingly, Ponjan and Thirawat (2016) could be seen as the latest dynamic CGE study that provided empirical evidence of the impact of Thailand's tourism tax cut policy in response to the floods in 2011.

Therefore, the objective of this study, in terms of methodology, is to develop a multi-household dynamic CGE model of Thailand in order to address the question of whether the reduction of personal income tax (PIT) can lower the inequality in the distribution of income and consumption of Thai households. This study would contribute to previous general equilibrium models of Thailand using a standard dataset obtained from the OECD input-output table of Thailand that provides reliable results of model simulation for policy analysis. Our dynamic CGE model will examine how changes in tax rates will affect key macroeconomic variables through relative price mechanism of commodities and the allocation of resources among sectors and households.

3.2 Literature Review

There are some empirical studies that use a dynamic CGE model to analyse the impacts of tax policies on an economy. For instance, Wendner (2001) uses a dynamic computable general equilibrium model to examine usage of revenue from CO_2 taxation to partially finance the pension system in Austria. His findings reveal that pension policy is the most favourable policy in terms of growth, consumption, private investment and demand of labour compared to transfer policy and labour cost policy. So, the CO_2 reduction and pension policy might harmonise otherwise conflicting policy objectives. By including endogenous growth theory into the DCGE model, Bretschger et al. (2011) find that carbon tax moderately decreases welfare and consumption in Switzerland, but this policy has a positive effect on the growth rates of all non-energy sectors. For a regional perspective, Xu et al. (2015) develop the dynamic CGE model across multi-regions and multi-sectors to evaluate the impact of China's coal resource tax reform on regional resource curse. Their finding shows that the change of coal resource tax rate affects resource curse differently among different regions of China. This policy increases revenues in resource-rich regions but hinders development of other regions. Also, Tang et al. (2017) construct a multi-sectoral dynamic CGE model to evaluate the impacts of coal resource tax reform on the environment of the Chinese economy. The results show negative effect of tax reform policy on real GDP, consumption, investment, export, and income of rural and urban households, but this policy can effectively help China to achieve its emissions reduction target.

In terms of VAT policy, Giesecke and Nhi (2010) apply a dynamic CGE model to evaluate the macroeconomic, industrial and distributional effects of simplifying Vietnam's complex VAT system. In case of a single VAT rate, this policy could create an aggregate consumption gain of the order of 0.25 percent, but with adverse distributional effects to the rural poor. In addition, they simulate the alternative policy which excludes paddy and rice from an otherwise general policy of VAT simplification, concluding that this alternative policy increases real consumption, with little impact on Gini-measured inequality. Claus (2013) also uses a dynamic general equilibrium model to evaluate the usefulness of value added tax (VAT) as a macroeconomic stabilisation instrument for New Zealand. He finds that a variable VAT rate is a less effective stabilisation tool than an interest rate because a variable VAT rate generates greater welfare losses and larger fluctuations in the real economy and inflation. In addition, a variable VAT rate would affect saving and investment decisions over time, whereas a change in the interest rate influences only this period's saving and investment decisions. Furthermore, the dynamic CGE has been applied to analyse the impact of capital and input tax reform, such as Radulescu and Stimmelmayr (2010), who conclude that the 2008 tax reform in Germany reduces corporate firm's activities, while the non-corporate firms are almost unaffected by the tax reform. This leads to a decrease in overall GDP as the increase in the non-corporate sector's activity cannot compensate for the fall in corporate firms' activity. In addition, this policy has a negative impact on overall households' welfare even though the consumption level increases in the long-run. This result contrasts with the finding by Bhattarai (2017), who reveals that capital and labour input taxes reform enhance real output, household's consumption and household's welfare in the Chinese economy.

By incorporating multi-household and distribution effects, Bhattarai et al. (2015) find that tax reforms only increase households' welfare in all household deciles in the short-run, whereas it has a limited impact in reducing the inequality in the distribution of income over the long-term. Additionally, Bhattarai et al. (2017) conclude that reductions in the corporate income tax in the US economy demonstrate significant positive impacts on output, investment, capital formation, and employment. However, this policy has an adverse effect on the poorest households because it reduces their wellbeing and consumption levels. Recent work by Bhattarai et al. (2018) use DCGE to estimate the macroeconomic impacts, particularly on efficiency and revenue, from the Trump and Clinton tax proposals. The reduction in tax and corporate tax for middle-class Americans, which was proposed and enacted by Trump, reduces the tax burden of all households but favours the richest decile more. Therefore, this proposal increases income inequality and reduces total tax revenues. However, the reduction in the corporate tax rate encourages investment and increases capital stock. Consequently, it increases real GDP due to dynamic scoring effects. On the other hand, the Clinton personal income tax hikes proposal, if implemented, would have increased US federal tax revenue, but lowered real GDP.

Existing empirical studies mentioned above were developed with multi-sectoral and multi-household settings to study the impact of various policies on growth and redistribution but obviously not to consider the impact of fiscal policy, especially the reduction of personal income tax, on income distribution. In addition, there is no evidence of dynamic CGE model that try to investigate the impacts of fiscal policy on the Thai economy, although there are only few studies that employ a computable general equilibrium (CGE) model to investigate the impact of energy and trade policies in Thailand. Those are Puttanapong et al. (2015), Winyuchakrit et al. (2011), and Wianwiwat and Asafu-Adjaye (2013), who examine the effects of energy policy on the Thai economy. Meanwhile, Field and Wongwatanasin (2007) employ CGE to assess the impacts on output, trade flows, income distribution and welfare from industrial policies. Apart from this, Wattanakuljarus and Coxhead (2008) use applied general equilibrium models to evaluate the use of tax revenues to finance tourism promotions campaigns. They conclude that a 10 percent rise in inbound tourism creates real GDP growth, real household consumption, total domestic absorption and prices index but worsens the real exchange rate, trade and household distribution. Hence, this policy has favourable effects on high-income non-agricultural households, whilst the low-income agricultural classes benefit less from it.

The recent work of Ponjan and Thirawat (2016) could be seen as the latest dynamic CGE study that provided empirical evidence of the impact of Thailand’s tourism tax cut policy in response to the floods in 2011. This dynamic framework of TRAVELTHAI is not only based on the dynamic features of a Monash-style Applied General Equilibrium model for Malaysia (MyAGE) and MONASH but also incorporating three types of tourism sector including domestic, inbound, and outbound. The model is calibrated with the Thai Tourism Satellite Accounts for the year 2000 with 40 industries, 40 commodities, 40 investors, three primary factors of production, one representative household, one central government, and an international trade with net foreign liabilities. Their results show that the inbound tourism tax cut policy generated most benefit to direct-tourism industries, particularly in the short-run, whilst its long-term effects on the whole economy were found to be negligible. However, this study does not consider the redistribution impact of each household and neglect other long-term incentives such as tax refunds and/or transfers.

Hence, the main contribution of this chapter is to develop and apply a multi- household dynamic CGE model of Thailand to evaluate the effects of tax policy on the Thai economy. To be more precise, this study aims to examine the impact of a reduction of PIT on key macroeconomic variables such as GDP, employment, and investment, as well as the level and distribution of household welfare and consumption in each quintile over 25 years from 2011 to 2036. There are two main reasons that we focus our analysis on PIT. Firstly, this tax was the latest item of the recent tax reform process in Thailand. Secondly, PIT is the third biggest tax revenue of the Thai government after value added tax and corporate income tax. Although the analysis of the impacts of tax policy over 25 years seem to be too far in future, earlier dynamic applied general equilibrium literatures used this method to evaluate the impact of policy changes for longer period than our model. For instance, Bretschger et al. (2011) assess the effects of carbon policies on consumption, welfare, and sectoral development from 2010 to 2050. Additionally, Bhattarai (2017) uses dynamic CGE model to analyse the impact of fiscal and financial policy on Chinese economy for 34 years from 2006 to 2040. Bhattarai et al. (2017) evaluates the effects of changes in corporate income taxes on the US economy from 2017-2050.

The next section briefly gives some information on PIT in Thailand.

3.3 Personal Income Tax in Thailand

The Revenue Department of Thailand defines personal income tax as a direct tax levied on income of a person who is resident and non-resident in Thailand. A resident is a person who lives in Thailand for a period or aggregate period of more than 180 days in any tax calendar year and receives income from sources in Thailand as well as on a portion of income from foreign sources brought into Thailand. For non-residents only pay tax on income from sources in Thailand.

As stated above, the PIT is the third biggest tax revenue of the Thai government after VAT and CIT. Table 3.1 illustrates that government revenue from PIT increased gradually from 2010 to 2016, except in 2014, due to the slowdown of economic growth and a reduction in PIT rate which affected the tax years 2013 and 2014. However, the expansion of wages and employment along with the growth in bank deposits and interest rates raised the PIT revenue in the following years.

Table 3.1: Taxes revenues (Unit: Million Baht)

Tax types	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY2016
Personal Income Tax	208,368	236,483	266,203	299,067	281,008	302,491	319,116
Corporate Income Tax	454,630	574,152	544,591	592,346	570,127	566,150	604,929
Petroleum Tax	67,599	81,444	94,097	113,291	102,165	83,522	46,297
Value Added Tax	502,260	577,725	659,804	698,033	711,523	708,905	716,384
Specific Business Tax	22,989	35,714	41,057	48,773	53,127	54,175	56,249
Stamp Duty	8,757	10,313	11,180	12,741	11,692	13,572	14,498
Other Income	243	279	362	290	339	388	469
Total	1,264,845	1,516,110	1,617,293	1,764,541	1,729,980	1,729,203	1,757,942

Source: The Revenue Department, Thailand (2018). Average exchange rate during 2010-2016 was 32.29 Baht per US dollars.

In term of PIT rates, Figure 3.3 shows that the PIT rate in Thailand ranged from 0 to 35 percent, which is similar to Vietnam and other countries in ASEAN, and not much different from other developed countries. However, there is a huge difference between the income of taxpayers in OECD countries and Thailand. The taxpayers in Thailand should have income at least 1.2 times of GDP per capita, whilst most of the taxpayers in OECD countries have to pay tax even when their income is less than the GDP per capita (Pitidol, 2017).

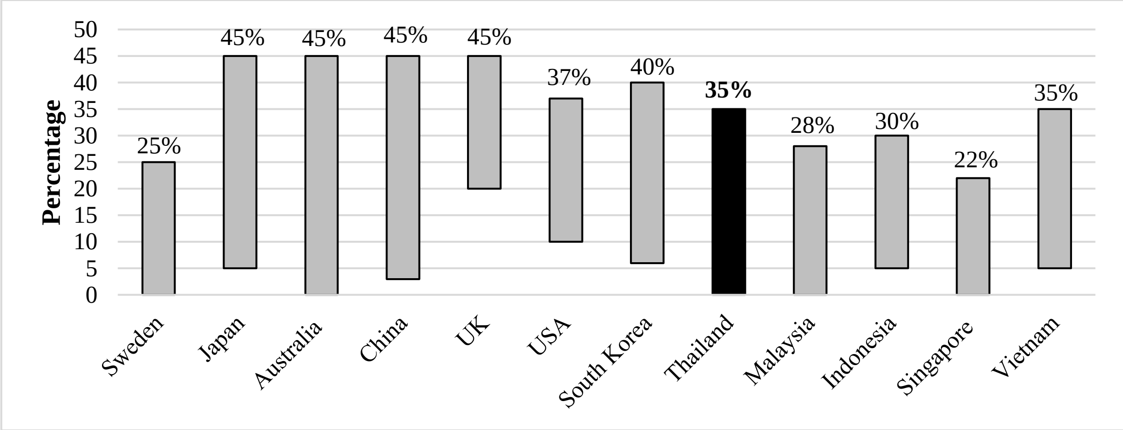

Figure 3.3: Highest and Lowest Personal Income Tax Rates of Selected Countries in 2018

Source: PWC (2018)

The latest tax reform in Thailand is the reduction of PIT. The Thai Cabinet agreed a proposal by the Ministry of Finance to revise the Personal Income Tax law on 19 April 2016. Then, the Department of Revenue announced this proposal to the public the next day and stated that this proposal would apply from the tax year 2017 onwards. The purpose of this tax change was not only to increase the efficiency of tax collection but also to reduce the burden on taxpayers by making it more consistent with the economic situation and living standards in Thai society. The key reforms are concerned with (i) increasing the minimum income threshold for filing tax returns from THB 50,000 to THB 100,000 for single person and from THB 100,000 to THB 200,000 for married; (ii) increasing deductible expenses for some types of income such as income derived from employment and hire of service and income derived from copyrights, goodwill, patents or other IP rights from a maximum 40% or THB 60,000 to a maximum 50% or THB 100,000 (whatever is lower); (iii) increasing the allowances for taxpayers and spouse from THB 30,000 to 60,000 and child allowance from THB 15,000 to THB 30,000 per child[7]; and (iv) increasing the minimum income for the last progression level (35 percent PIT rate) from THB 4,000,001 to 5,000,001 (Lorenz & Partners Co Ltd, 2016). The details of personal income tax reform are shown in Table 3.2.

[7] Maximum child allowance is three plus THB 2,000 education support per child.

Table 3.2: Progressive Personal Income Tax Rate in Thailand

Net Income (Baht)	Before Tax Year 2014	Tax Year 2014	Net Income (Baht)	Tax Year 2017
0-150,000	Exempt	Exempt	0-150,000	Exempt
150,001-300,000	10%	5%	150,001-300,000	5%
300,001-500,000	10%	10%	300,001-500,000	10%
500,001-750,000	20%	15%	500,001-750,000	15%
750,001-1,000,000	20%	20%	750,001-1,000,000	20%
1,000,001-2,000,000	30%	25%	1,000,001-2,000,000	25%
2,000,001-4,000,000	30%	30%	**2,000,001-5,000,000**	30%
Over 4,000,001	37%	35%	**Over 5,000,001**	35%

Source: Revenue Department News, Thailand (2016). Average exchange rate during 2014-2017 was 34 Baht per US dollars.

Since government revenue is the main source of government spending and tax revenue is the most significant source of government income, any changes in tax rates will affect tax revenue and spending simultaneously. Furthermore, the change in PIT rate also has impact on household income and welfare because this tax is a direct tax levied on a person’s income. Hence, the change in PIT, especially the tax rate by income bracket, will affect households in each income threshold differently. These impacts can be analysed by dynamic computable general equilibrium approach with multi-households to investigate such effects in the short and long-term.

3.4 Model

A general equilibrium model provides rich insight on interactions of demand and supply in the various markets in an economy. It helps to find out the optimal quantities and prices in goods and factors markets. In addition, it includes governments that induce market outcomes by altering prices through transfers and taxes. The general equilibrium is reached when demand and supply are balanced in each market for each period, with zero excess demand in each of them. Fixed point theorems guarantee the existence of a general equilibrium. They are unique and stable when preferences and technologies are well defined.

The model in this chapter is an advance from the comparative static general equilibrium analysis because it is able to capture the wide-ranging income and substitution effects of changes in relative prices regarding the changes in tax policies. To be more precise, the process of growth, investment and income redistribution can be assessed using this technique. This dynamic CGE model assumed the constrained inter-temporal optimisation by households with standard constant elasticity of substitution (CES) preferences and intertemporal maximisation of profits by firms with CES technologies and constant elasticity of transformation (CET) functions for tradable commodities as given in Bhattarai (2017) and Bhattarai et al. (2015, 2017). In addition, households in this model also make optimal choices consistent with the Ramsey problem, which states that economic agents use labour and capital to produce output then distribute these products between consumption and capital accumulation (Heer and Maussner, 2009). The details of the model are described clearly in the next section, which was developed from Bhattarai (2008) and Bhattarai et al. (2015, 2017). However, this model differs from those previous studies in term of structure, model dimensionality and flexibility of model application to various policy issues.

3.4.1 The Model Structure

(1) Preference

In this model, all Thai families are classified in one of the five quintiles and indexed by $h = 1, 2, 3, 4, and\ 5,$ ranked from the lowest to the highest income levels. A composite consumption good for each household is produced from 33 domestic products and imports. Infinitely-lived households allocate lifetime income to maximise lifetime utility, which derives from the consumption of goods and services $(C_{i,t}^h)$ and leisure $\left(L_t^h\right)$ as shown in equations (3.1) and (3.2), respectively.

$$LU^h = \sum_{t=0}^{\infty} \beta^t \frac{U_t^{h,1-\sigma_{lu}^h} - 1}{1-\sigma_{lu}^h} \quad \text{…. (3.1)}$$

where LU^h is lifetime utility of household h; β^t is the discount factor and shows the strength of time preference; U_t^h is its instantaneous utility function; and σ_{lu}^h is the elasticity of the intertemporal substitution for household h.

$$U\left(C_{i,t}^h, L_t^h\right) = \left[\alpha_c^h C_{i,t}^{h\ \frac{\sigma_u^h - 1}{\sigma_u^h}} + (1-\alpha_c^h) L_t^{h\ \frac{\sigma_u^h - 1}{\sigma_u^h}}\right]^{\frac{\sigma_u^h}{\sigma_u^h - 1}} \quad \text{…. (3.2)}$$

where $C_{i,t}^h = \sum_{i=1}^{N} C_{i,t}^{h\ \frac{\sigma_i^h - 1}{\sigma_i^h}}$ is the composite consumption of good i by household h in period t; L_t^h is leisure of household h in period t; α_c^h denotes the consumption share of household h; and σ_u^h is the elasticity of substitution between consumption and leisure of household h.

The representative household in each quintile is subject to an intertemporal budget constraint where the present value of its consumption and leisure in all periods is less than or equal to the present value of infinite lifetime full income. Households pay consumption tax, value added tax, and labour income tax to the government. At the same time, they receive transfer money from the government. Therefore, it can be stated as

$$\left[\sum_{t=0}^{\infty}\mu(t)(P_{i,t}\left(1+tv_i^h\right)C_{i,t}^h + w_{i,t}^h(1-tw_i^h)L_t^h\right] \leq \left[\sum_{t=0}^{\infty}\left(1-tw_i^h\right)w_{i,t}^h\bar{L}_t^h + \left(1-tk_i^h\right)r_{i,t}K_{i,t}^h + TR_t^h\right] \quad \text{.... (3.3)}$$

where $\mu(t) = \Pi_{s=0}^{t-1}\frac{1}{(1+r_s)}$ is a discount factor; r_s is the real interest rate on assets at time s; $P_{i,t}$ is the composite price of consumption in sector i at period t; tv_i^h is the value added tax on final consumption in sector i by household h; $w_{i,t}^h$ is the wage rate from sector i for household h; tw_i^h is the labour income tax rate paid by household h; $\bar{L}_t^h$ is labour endowment; tk_i is the tax rate of capital inputs; $r_{i,t}$ is the rental or return on capital in sector i; $K_{i,t}^h$ is the capital stock of sector i owned by household h; and TR_t^h is the transfer money from government to household h.

(2) Production Function

The production function for each of the 33 industries in each period comprises a composite labour supply function from five quintiles of households and a sector-specific capital accumulation which generates to a value added function. Then, the value added is summed up with intermediate inputs by a Leontief function. Gross output is distributed either to domestic supply or exported to the rest of the world by a constant elasticity of transformation (CET). Total supply of goods in an economy is defined by a constant elasticity of substitution (CES) function between domestic and imported commodities.

The production technology constraint of each firm can be expressed as

$$Y_{i,t} = \Omega_{i,t}\left[(1-\omega_i)K_{i,t}^{\frac{\sigma_{lk}-1}{\sigma_{lk}}} + \omega_i L_{i,t}^{\frac{\sigma_{lk}-1}{\sigma_{lk}}}\right]^{\frac{\sigma_{lk}}{\sigma_{lk}-1}} \quad \text{.... (3.4)}$$

where $Y_{i,t}$ is the gross value added of sector i; $\Omega_{i,t}$ is a shift parameter in the production function; ω_i is the share parameter of labour in the production; $K_{i,t}$ is the amount of capital used in sector i; $L_{i,t}$ is the amount of labour used in sector i; and σ_{lk} is an elasticity of substitution between capital and labour.

Each firm in the model aims to maximise the present value of profits subject to production technology constraints, whereby a firm's profit is the difference between the revenue from sales and the cost of production. It can be written in dual form as:

$$\pi_{j,t}^{y} = \left[\left((1-\varphi_j^{ex})PD_{j,t}^{\frac{\sigma_y-1}{\sigma_y}} + \varphi_j^{ex}PE_{j,t}^{\frac{\sigma_y-1}{\sigma_y}}\right)\right]^{\frac{1}{\sigma_y}} - \theta_j^{va}PY_{j,t}^{va} - \theta_j^{do}\sum_i \alpha_{i,j}^{do}P_{i,t} \quad \text{.... (3.5)}$$

where $\pi_{j,t}^{y}$ is a unit profit of activity in sector j; $PD_{j,t}$ is the domestic price of good j; $PE_{j,t}$ is the export price of good j; $PY_{j,t}$is the price of value added per unit of output in activity j; $P_{i,t}$ is the price of final goods used as intermediate goods; φ_j^{ex} is the share parameter for exports in total production; θ_j^{va} is the share of costs paid to labour and capital; θ_j^{do} is the share of cost for the domestic intermediate inputs; σ_y is an elasticity of transformation between domestic supplies and export products; and $\alpha_{i,j}^{do}$ are input-output coefficients for domestic supply of intermediate goods.

(3) Labour Supply

The labour supply for each household is defined by the difference between the household labour endowment and the demand for leisure.

$$LS_t^h = \bar{L}_t^h - L_t^h \quad \text{.... (3.6)}$$

where LS_t^h is labour supply for each household h; $\bar{L}_t^h$ is the labour endowment; and L_t^h is leisure demand for each household.

(4) Investment

The net investment for sector i in period t is given by the difference between the capital accumulation and the capital stock of period t net of depreciation, as follow:

$$I_{i,t} = K_{i,t} - (1-\delta_i)K_{i,t-1} \quad \text{.... (3.7)}$$

where $I_{i,t}$ is the net investment for sector i in period t; $K_{i,t}$ is the capital stock for sector i in period t; $K_{i,t-1}$ is the capital stock for sector i in period $t-1$; and δ_i is the rate of depreciation for sector i.

On the balanced growth path, where all prices are steady and all real economic variables grow at a constant rate, capital stocks must grow at a fast enough rate to sustain growth. This condition can be described as:

$$I_{i,T} = K_{i,T}(g_i + \delta_i) \quad \text{…. (3.8)}$$

Where T represents the terminal period of the model, and g_i is the growth rate for sector i in the steady state and is assumed constant across sectors for the benchmark economy.

(5) Government Sector

The government collects revenues from four parts which are value added tax (VAT) revenues, personal income tax (PIT) revenues, labour input tax revenues and capital input tax revenues.

$$RV_t = \sum_{h=1}^{H}\sum_{i=1}^{N} tv_i^h P_{i,t} C_{i,t}^h + \sum_{h=1}^{H}\sum_{i=1}^{N} tw_i^h w_{i,t}^h LS_t^h + \sum_{i=1}^{N} tk_i^h r_{i,t} K_{i,t}^h + \sum_{h=1}^{H} tp^h J_t^h$$

…. (3.9)

where RV_t is total government revenue in period t; tv_i^h is the value added tax on final consumption by household h; tw_i^h is a tax rate on labour income of household h from sector i; tk_i^h is a composite tax rate on capital income of household h from sector i; tp^h is personal income tax rate of household h; and $J^h = \sum_{t=0}^{\infty}\left(1 - t_l^h\right) w_t^h \bar{L}_t^h + \left(1 - t_{i,k}\right) r_{i,t} K_{i,t}^h + TR_t^h$ is disposable income of household h in period t.

In this model, tax revenues can be used either to finance public consumption or to distribute to households as a money transfer, which can be stated as

$$RV_t = G_t + TR_t \quad \text{…. (3.10)}$$

where G_t is composite consumption by the government.

(6) Foreign Sector

In an open economy of applied general equilibrium models, consumers have a variety of goods to consume as total supply of goods consists of domestic and imported products. This is consistent with the Armington aggregation function, which explains that products are differentiated across country regarding to the location of production. Therefore, intra-industry trade can happen because domestic and foreign produced products within a product category are qualitatively different and are not fully substitutes. This can be stated as follows:

$$A_{i,t} = \Phi_{i,t}\left(\gamma_i^d D_{i,t}^{\frac{\sigma_m-1}{\sigma_m}} + \gamma_i^{im} M_{i,t}^{\frac{\sigma_m-1}{\sigma_m}}\right)^{\frac{\sigma_m}{\sigma_m-1}} \qquad \text{…. (3.11)}$$

where $A_{i,t}$ is the Armington CES aggregate of domestic supplies; $D_{i,t}$ is the supply of domestic goods for each sector; $M_{i,t}$ is import supplies for each sector; γ_i^d is the share of good i domestic production; γ_i^{im} is the share of good i in imports; σ_m is the elasticity of substitution between domestic products and imports from the rest of the world; and $\Phi_{i,t}$ is the shift parameter of the aggregate supply function.

Therefore, the total supply value in the economy must be equal to the aggregate of the values of domestic products and imports.

$$PA_{i,t}A_{i,t} = PD_{i,t}D_{i,t} + PM_{i,t}M_{i,t} \qquad \text{…. (3.12)}$$

where $PA_{i,t}$ is the gross price of composite commodity i; $PD_{i,t}$ is the gross price of domestic supplies and tariffs; and $PM_{i,t}$ is the gross price of imported products.

Apart from domestic sales, the rest of gross output is exported to the rest of the world, according to a CET function, as stated below.

$$GI_{i,t} = \phi_{i,t}\left((1-\varphi_i^{ex})D_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} + \varphi_i^{ex} E_{i,t}^{\frac{\sigma_y-1}{\sigma_y}}\right)^{\frac{\sigma_y}{\sigma_y-1}} \qquad \text{…. (3.13)}$$

where $GI_{i,t}$ is output in term of gross of intermediate inputs; $E_{i,t}$ is exports; $\varphi_i^{ex}$is the share of export goods; σ_y is the elasticity of transformation in total supply; and $\phi_{i,t}$ is the shift parameter in the transformation function.

Therefore, the total supply's value in the economy must be equal to the aggregate of the values of domestic products and exports.

$$P_{i,t}GI_{i,t} = PD_{i,t}D_{i,t} + PE_{i,t}E_{i,t} \qquad \text{…. (3.14)}$$

where $PD_{i,t}$ is the gross price of domestic supplies; and $PE_{i,t}$ is the gross price of exported products and export taxes.

(7) General Equilibrium in Economy

General equilibrium in the economy occurs when the demand and supply sides balance each other in the goods, labour and capital markets, which can be stated as below.

Goods market clearing:

$$A_{i,t} = C_{i,t} + G_{i,t} + I_{i,t} + \sum_j DI_{i,j,t} + \sum_j MI_{i,j,t} \qquad \text{…. (3.15)}$$

where $C_{i,t}$ is composite consumption of domestic products and imports by households; $G_{i,t}$ is composite consumption by the government; $I_{i,t}$ is investment; $DI_{i,j,t}$ is demand for domestic intermediate input; and $MI_{i,j,t}$ is demand for imported intermediate inputs.

Labour market clearing:

$$\bar{L}_t^h = LS_t^h + L_t^h; \; LS_t^h = \sum_{h=1}^{H} LS_{i,t}^h \quad \text{…. (3.16)}$$

where $\bar{L}_t^h$ is the labour endowment; LS_t^h is labour supply for each household h; and L_t^h is the leisure demand for each household.

Capital market clearing:

$$K_t = \sum_{i=1}^{N} K_{i,t} = \sum_{i=1}^{N} \left[(1-\delta_i) K_{i,t-1} + I_{i,t} \right] \quad \text{…. (3.17)}$$

3.4.2 Specification of Thai Dynamic CGE Model

This model uses the latest economic data from the 2011 Input-Output Table obtained from the Organisation for Economic Co-operation and Development (OECD, 2018) to construct micro-consistent data for Thailand. These data consist of 33 production sectors, as shown in Table 3.3.

Table 3.3: Production Sectors in the Thai Dynamic CGE

Sector	Code	Sector	Code
1. agriculture, hunting, forestry and fishing	Agric	18. manufacturing nec; recycling	Manufac
2. mining and quarrying	Mining	19. electricity, gas and water supply	Electric
3. food products, beverages and tobacco	Food	20. construction	Const
4. textiles, textile products, leather and footwear	Textile	21. wholesale and retail trade; repairs	Wholsal
5. wood and products of wood and cork	Wood	22. hotels and restaurants	Hotel
6. pulp, paper, paper products, printing and publishing	Pulp	23. transport and storage	Transpt
7. coke, refined petroleum products and nuclear fuel	Coke	24. post and telecommunications	PostTel
8. chemicals and chemical products	Chemical	25. financial intermediation	Finance
9. rubber and plastics products	Rubber	26. real estate activities	RealEst
10. other non-metallic mineral products	OthNonme	27. renting of machinery and equipment	RentMac
11. basic metals	BasMetal	28. computer and related activities	ComRlAct
12. fabricated metal products	Fabric	29. R&D and other business activities	RnD
13. machinery and equipment, nec	Machine	30. public administration and defence; compulsory social security	PubAdmin

Table 3.3: Production Sectors in the Thai Dynamic CGE, Continued

Sector	Code	Sector	Code
14. computer, electronic and optical equipment	Comput	31. education	Edu
15. electrical machinery and apparatus, nec	Elecal	32. health and social work	Health
16. motor vehicles, trailers and semi-trailers	Motor	33. other community, social and personal services	OthCommu
17. other transport equipment	OthTran		

Source: OECD (2018)

In addition, this model utilised a share of household current income by five quintile groups from the National Statistical Office (2012) of Thailand to calculate the income share of each household. Then these data were used for calibration of the parameters of the model as shown in Appendix 3A, 3B, 3C and 3D. After that, the general algebraic modelling system (GAMS, 2017) was applied to compute the model in order to evaluate the changes in economy or to assess the impacts of tax policy over a horizon of 25 years from 2011 to 2036.

The values of elasticity used in this study are based on values widely accepted in the literature, whereas other values of parameters were obtained from the World Development Indicator (World Bank, 2017). Income tax rate and value added tax data were collected from the Revenue Department (2018), Thailand as shown in Table 3.4.

Table 3.4: Key Parameters of the DCGE Model of Thailand

Parameters	Values
Elasticity of substitution in consumption and leisure (σ_u^h)	2.95
Elasticity of substitution in intertemporal choices (σ_{lu}^h)	0.99
Elasticity of substitution between capital and labour (σ_{lk})	1.5
VAT rate (tv_i)	0.07
Personal Income Tax rate (tp^h)	0, 0.1.0.2, 0.3, 0.37
Growth rate of output $(g_{i,t})$	0.06
Rate of depreciation in section i $(\delta_{i,t})$	0.04
Interest rate (r)	0.10

As aforementioned that the main objective of this study is to examine the impact of the reduction of PIT rate on the level and distribution of household welfare and consumption in each quintile, hence, we classified each net income threshold into five groups of households as shown in Table 3.5. Households in each quintile were represented by H1, H2, H3, H4 and H5. Then, we calculated the average PIT rate of each quintile. These average 2014 PIT rates in each quintile will be used as benchmark PIT rates, while the average 2017 PIT rates in each quintile will used as counterfactual scenarios. We started our analysis by calibrating benchmark scenario then simulated model by using new average PIT rates to evaluate the effects of PIT reduction on the Thai economy in the short and long-term.

Table 3.5: Progressive Personal Income Tax Rate in Thailand classified by each quintile

Quintile	Net Income (Baht)	Before Tax Year 2014	Average rate (Bench mark)	Net Income (Baht)	Tax Year 2017	Average rate (Couter factual)
H1	0-150,000	Exempt	**0%**	0-150,000	Exempt	**0%**
H2	150,001-300,000	10%	**10%**	150,001-300,000	5%	**7.5%**
	300,001-500,000	10%		300,001-500,000	10%	
H3	500,001-750,000	20%	**20%**	500,001-750,000	15%	**17.5%**
	750,001-1,000,000	20%		750,001-1,000,000	20%	
H4	1,000,001-2,000,000	30%	**30%**	1,000,001-2,000,000	25%	**27.5%**
	2,000,001-4,000,000	30%		2,000,001-5,000,000	30%	
H5	Over 4,000,001	37%	**37%**	Over 5,000,001	35%	**35%**

Source: The Revenue Department, Thailand (2018); Average exchange rate during 2014-2017 was 34 Baht per US dollars.

3.5 Results of the Thai DCGE with Personal Income Tax Reform

The results of the Thai DCGE explain the impact of PIT reform, a reduction of PIT rates, on distribution of households' welfare and consumption in each quintile. They also show impacts on macroeconomic variables such as GDP, employment, investment and the microeconomic variables including sectoral production. In addition, this study describes the macro impacts of alternative tax policies as a guideline for policymakers.

3.5.1 Impacts of PIT Reform on Utility and Consumption Distribution

The result in Table 3.6 reveals that tax reform affects the wellbeing of each household's quintile differently, and such effects increase gradually when the economy evolves over time. Utility levels in 2036 will be about 4.29 times the current figure, with similar distribution patterns of utility in 2011. After the reforms, the utility levels of households in 2036 will be 4.34 times greater than that in 2011. This indicates that the reform has slightly improved the wellbeing of the families. The finding also shows that this tax reform has the most favourable effect on the poorest households (H1) as their share of utility has increased from 14.66 percent in 2011 to 15.93 percent in 2036. In addition, this reform also enhances the utility levels of families in quintiles 2 and 3. For households in the fourth and fifth quintile, at the beginning of the reform those families were worse off from the reform as shown in the decreases in utility levels. However, the redistribution effects in the long-run will improve the utility level of households in quintiles 4 and 5.

Table 3.6: Redistribution of Households' utility before and after Tax Reforms, 2011 and 2036 (Unit: Million US Dollars)

Quintiles	Households utility in 2011			Households utility in 2036		
	Benchmark	Reformed system	Percentage change	Benchmark	Reformed system	Percentage change
H1	19,165.71	21,975.80	14.66	82,256.73	95,360.32	15.93
H2	29,961.32	33,085.94	10.43	128,590.12	143,611.87	11.68
H3	39,444.38	41,383.54	4.92	169,290.18	179,666.02	6.13
H4	53,264.75	52,741.85	-0.98	228,605.41	229,029.74	0.19
H5	126,457.33	119,353.72	-5.62	542,738.51	518,365.61	-4.49

Source: Author's calculations based on the Thai DCGE model

The paths of utility level for the richest (H5) and the poorest (H1) households in Figure 3.4 show clearly that this tax reform benefits the poorest households throughout the study period. At the same time, the richest households are worse off but the magnitude of changes is smaller from time to time. This finding is consistent with the purpose of the tax reform proposal, to reduce the burden of taxpayers and help people in the first three taxpayer brackets to have more disposable income for consumption and investment.

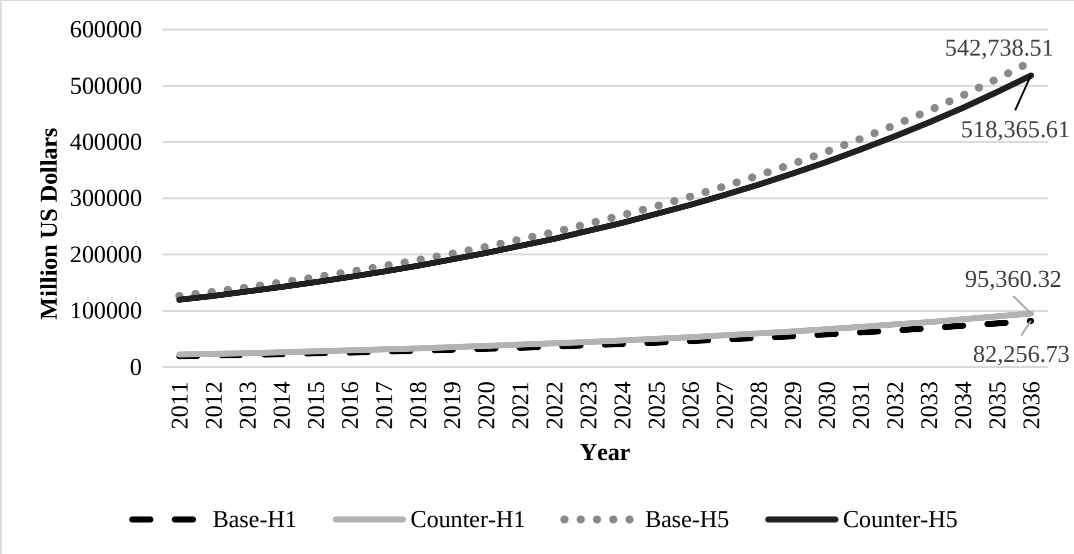

Figure 3.4: The path of utility level of the richest (H5) and the poorest (H1) households

Source: Author's calculations based on the Thai DCGE model

Table 3.7: Redistribution of Households Consumption before and after Tax Reforms, 2011 and 2036 (Unit: Million US Dollars)

Quintiles	Households consumption in 2011			Households consumption in 2036		
	Benchmark	Reformed system	Percentage change	Benchmark	Reformed system	Percentage change
H1	12,983.50	14,675.43	13.03	55,723.49	64,205.12	15.22
H2	20,973.34	23,415.91	11.65	90,014.87	102,386.96	13.74
H3	28,563.69	30,353.00	6.26	122,591.68	132,664.27	8.22
H4	39,949.22	40,141.54	0.48	171,456.89	175,368.67	2.28
H5	97,276.35	92,826.76	-4.57	417,497.53	405,419.90	-2.89

Source: Author's calculations based on the Thai DCGE model

The reduction of personal income tax rate not only raise the utility of households, but also increase household consumption as shown in Table 3.7. The consumption level of each household category rises after tax reform except households in quintile 5. In the benchmark case, the reformed benefits to the poorest households as their consumption increased more than that of any others quintiles. That is followed by household in quintiles 2 and 3. This policy yields greater favour effect to households in all quintiles in the long-run because the magnitude of changes in the long-run are higher than the percentage change of consumption in the short-run. Although the richest households (H5) seem to worse off after the reform as evidenced by a reduction of consumption, that reduction in consumption is still less than the reduction of consumption in the short-run. This result is in line with the utility effect explained earlier from Table 3.6. In addition, this result accords with the findings by Bhattarai (2017), who reveals that China's tax reforms enhance household consumption and household welfare. Radulescu and Stimmelmayr (2010) have also concluded that the 2008 tax reform in Germany increases the consumption level in the long-run.

3.5.2 Impacts of PIT Reform on Macroeconomic Variables

There are significant impacts on macroeconomic variables due to the reductions in personal income tax rates. This reform increases household real disposable income so that private consumption rises relative to the benchmark case, initially by 0.83 percent and ultimately to 2.65 percent in 2036. This increase in private consumption also boosts investment and imports. Consequently, it leads to an expansion in labour market, capital stock and export products. Finally, GDP increases gradually, from 1.05 percent in 2011 to 2.94 percent in 2036, as shown in Table 3.8. These findings are consistent with the results of Bhattarai et al. (2017), who conclude that a reduction in the corporate income tax on the US economy has significant positive impacts on output, investment, capital formation, and employment.

Table 3.8: Percentage Change of Key Macroeconomics Variables in Response to a Decrease in Personal Income Tax Rate

	2011	**2016**	**2021**	**2026**	**2031**	**2036**
GDP	1.0563	1.5533	1.9568	2.3129	2.6358	2.9411
Investment	1.4206	1.9482	2.3619	2.7475	3.1265	3.5263
Employment	2.4781	2.6633	2.7498	2.8304	2.9095	2.9929
Capital stock	0.0000	0.6578	1.2343	1.7416	2.1995	2.6291
Consumption	0.8343	1.3358	1.7542	2.1077	2.4054	2.6550
Export	0.9942	1.3787	1.7512	2.0810	2.3816	2.6680
Import	1.0393	1.4412	1.8307	2.1754	2.4896	2.7889

Source: Author's calculations based on the Thai DCGE model

3.5.3 Impacts of PIT Reform on Sectoral

The reduction of personal income tax rates affects economic activities unevenly across various industries. Table 3.9 shows that every sector grows faster with PIT reforms than without them, especially the output, employment and capital stock. The most positive effects are observed in various sectors, such as food products sector, textiles sector, hotel sector, finance and wholesale sector. Growth rates in these industries derive mainly from the expansion of capital stock, employment and investment across sectors. In addition, there are significant increases in investment in numerous manufacturing industries: for instance, the basic metals sector, electrical machinery sector, and motors sector. This is consistent with the growth of the Thai economy and the expansion of household income. Despite the investment in public administration and education sectors increasing after the reforms, this could not compensate for the decline of capital stock, employment and output in these sectors in the long-run. This might have been caused by the decrease in real government consumption.

Table 3.9: Percentage Changes by Sector in Response to a Decrease in Personal Income Tax Rate

	Output		**Employment**		**Investment**		**Capital Stock**	
Year	**2011**	**2036**	**2011**	**2036**	**2011**	**2036**	**2011**	**2036**
Period	**1**	**25**	**1**	**25**	**1**	**25**	**1**	**25**
Agric	1.0921	4.0840	4.0444	4.9949	6.7820	4.6288	0.0000	3.5618
Mining	1.1398	2.9179	3.4746	3.8564	1.3431	3.2865	0.0000	2.4388
Food	1.1195	3.3272	2.8640	4.0473	0.0010	3.5287	0.0000	2.6271
Textile	1.2330	3.3509	3.3407	4.1946	1.5300	3.6612	0.0000	2.7723
Wood	0.9824	2.2722	2.6738	3.1778	-2.7878	2.4994	0.0000	1.7694
Pulp	0.9577	2.8959	3.4736	3.7537	1.7624	3.1366	0.0000	2.3375
Coke	1.0631	2.8709	2.6989	3.6923	-1.7615	3.1334	0.0000	2.2769
Chemical	1.1184	3.0609	3.3063	3.7829	0.8741	3.1957	0.0000	2.3663
Rubber	1.0841	2.9425	2.8407	3.6806	-0.5852	3.1056	0.0000	2.2654
OthNonme	0.7892	1.8478	2.9938	2.9237	-1.1887	2.1347	0.0000	1.5188
BasMetal	0.9749	2.2649	3.0111	3.3520	-1.1451	2.6841	0.0000	1.9413
Fabric	0.8665	2.2265	3.0381	3.3077	-0.5741	2.6071	0.0000	1.8976
Machine	0.7109	1.6764	2.8551	2.8781	-1.6806	2.0763	0.0000	1.4739
Comput	0.9945	2.5299	3.1065	3.5698	-0.1486	2.9391	0.0000	2.1561
Elecal	0.7816	2.0543	3.2166	3.2536	-0.0192	2.5217	0.0000	1.8442
Motor	0.7724	1.7111	2.4838	2.8660	-3.7555	2.1060	0.0000	1.4619
OthTran	0.8856	1.7903	2.9588	3.4714	-1.8285	2.8638	0.0000	2.0590
Manufac	1.1797	3.0047	2.9545	3.7699	-0.9915	3.1944	0.0000	2.3535
Electric	1.1729	3.1639	3.0281	4.0274	-0.2882	3.5486	0.0000	2.6074
Const	0.2426	0.4361	0.6605	1.3046	-11.0534	0.2639	0.0000	-0.0781
Wholsal	1.0709	3.4915	3.6737	4.3068	3.7349	3.8188	0.0000	2.8830
Hotel	1.1257	3.3122	3.2115	4.0928	1.0822	3.5489	0.0000	2.6720
Transpt	1.1420	2.8149	2.9060	3.6139	-1.6304	3.0186	0.0000	2.1996
PostTel	1.1319	3.7739	3.7862	4.7016	4.8014	4.3136	0.0000	3.2724
Finance	1.3778	3.8439	3.5915	4.7054	3.7368	4.3519	0.0000	3.2763
RealEst	0.6553	4.1479	3.7464	5.3038	6.3973	5.0194	0.0000	3.8664
RentMac	1.3403	2.6715	1.8298	2.9060	-13.9105	2.4934	0.0000	1.5014

Table 3.9: Percentage Changes by Sector in Response to a Decrease in Personal Income Tax Rate, Continued

	Output		Employment		Investment		Capital Stock	
Year	**2011**	**2036**	**2011**	**2036**	**2011**	**2036**	**2011**	**2036**
Period	**1**	**25**	**1**	**25**	**1**	**25**	**1**	**25**
ComRlAct	0.7733	1.7079	0.8407	1.7819	-23.6347	1.2954	0.0000	0.3926
RnD	1.1099	2.8284	2.5043	3.5709	-3.7105	3.0732	0.0000	2.1572
PubAdmin	1.1932	0.9748	1.2883	1.0766	-18.9718	0.1790	0.0000	-0.3030
Edu	0.3399	0.2395	0.3530	0.2897	-27.9075	-0.5732	0.0000	-1.0792
Health	0.3935	0.9207	0.7569	1.5221	-19.7875	0.8085	0.0000	0.1363
OthCommu	1.3021	3.1236	2.5261	3.7619	-3.9958	3.3088	0.0000	2.3456

Source: Author's calculations based on the Thai DCGE model

3.5.4 Impacts of PIT Reform on Government Revenue

The reform of the personal income tax rate of every quintile has a major impact on revenues as shown in Table 3.10. Government revenue from PIT decrease year by year in both the short and long-term around 5.5 percent. However, higher economic activities from consumption, production, investment and trade stimulate revenues from other taxes, particularly labour input tax and value added tax. Revenue from capital input tax increases only slightly in the short-term. Conversely, in the long-term this revenue exceeds the revenue from value added tax as the Thai economy will become more capital intensive. Although, PIT reform changes revenues in each tax type, the total revenue of the government remains at the same level. This means growth in other tax revenues can compensate for the drop in personal income tax revenue.

Table 3.10: Percentage Change of Government Revenue in Response to a Decrease in Personal Income Tax Rate

Revenue	**2011**	**2016**	**2021**	**2026**	**2031**	**2036**
Labour input tax	1.0407	1.2455	1.2623	1.2922	1.3414	1.4186
Capital input tax	0.0155	0.3173	0.4754	0.6270	0.7826	0.9550
Personal income tax	-5.4637	-5.4108	-5.4710	-5.5099	-5.5249	-5.5110
Value added tax	0.1290	0.3080	0.4008	0.4810	0.5513	0.6146
Total revenue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Author's calculations based on the Thai DCGE model

3.5.5 Impacts of Alternative Tax Policies on Macroeconomic Variable

In addition to the reduction of the PIT rate, we also simulated five alternative tax policies that the government can use to achieve target policy. These five scenarios include; (i) apply only 10 percent VAT rate, (ii) apply only 5 percent capital input tax, (iii) apply only

5 percent labour input tax, (iv) apply both PIT reform and 10 percent VAT rate, and (v) apply all taxes.

The effect of macroeconomic variables from alternative tax policies are presented in Figures 3.5 to 3.9. As we can see from Figures 3.5 to 3.7, the alternative tax policies that government can use to stimulate GDP, investment, and capital stock include labour input tax, which has the highest magnitude of percentage changes in both the short and long-term. On the other hand, the policymaker should avoid applying capital input tax because this tax leads to decreases in GDP, investment and capital stock.

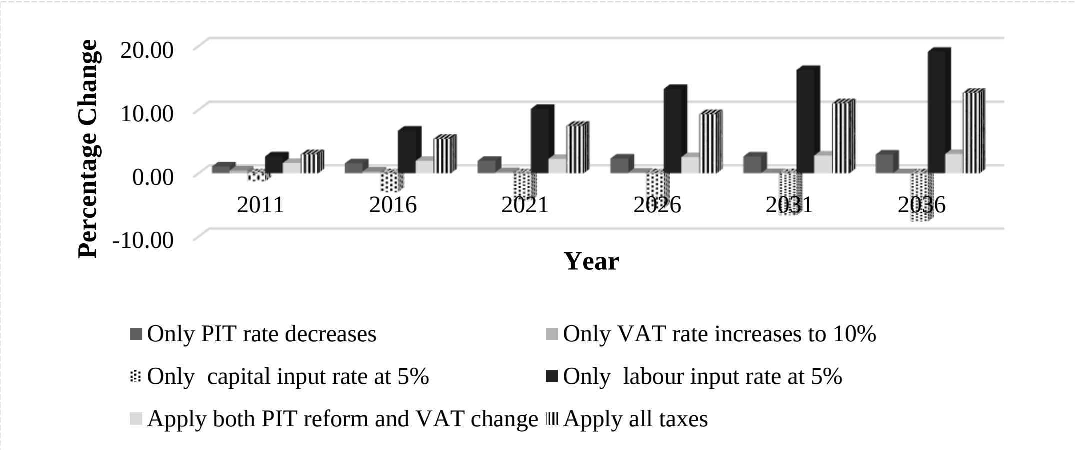

Figure 3.5: Percentage Change of GDP in Response to Alternative Tax Reform

Source: Author's calculations based on the Thai DCGE model

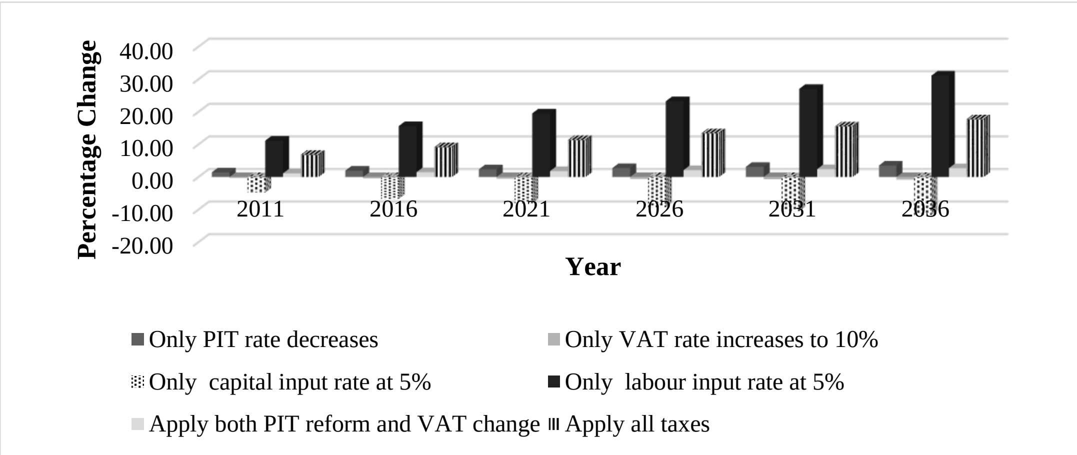

Figure 3.6: Percentage Change of Investment in Response to Alternative Tax Reform

Source: Author's calculations based on the Thai DCGE model

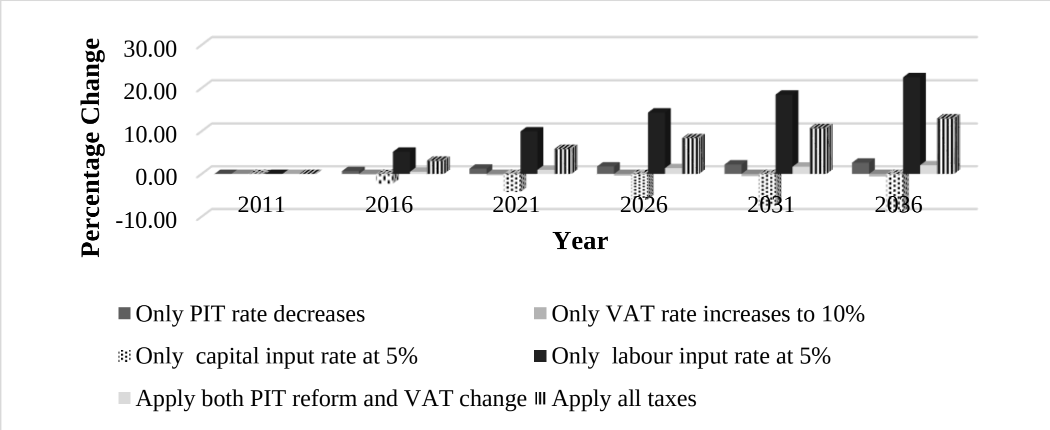

Figure 3.7: Percentage Change of Capital Stock in Response to Alternative Tax Reform

Source: Author’s calculations based on the Thai DCGE model

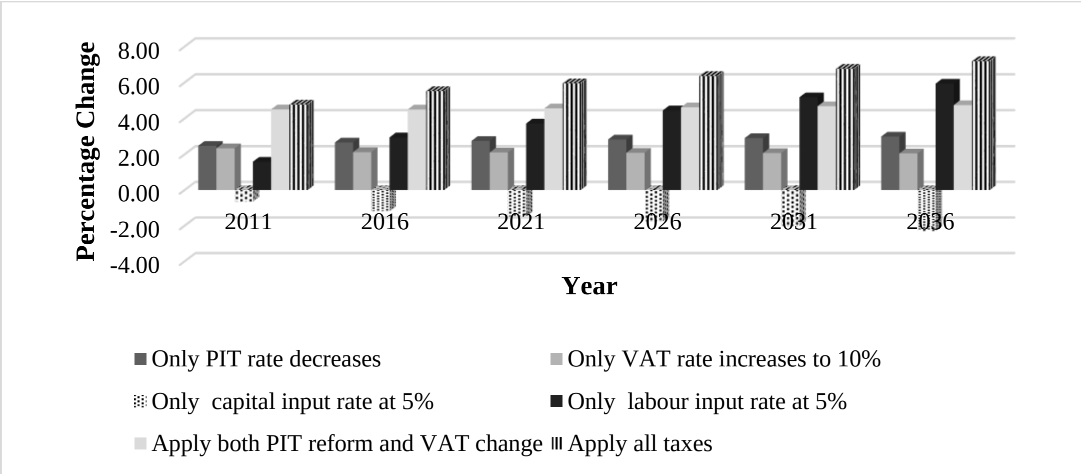

Figure 3.8: Percentage Change of Employment in Response to Alternative Tax Reform

Source: Author’s calculations based on the Thai DCGE model

Another interesting conclusion can be made from the simulation results where all tax policies were applied. This policy would effectively increase employment both in the short and long-term in Thailand, as shown in Figure 3.8. In particular, employment increases from 4 percent in 2011 to 7.2 percent in 2036. Instead of applying all taxes, the policymaker would implement PIT reform and a VAT rate policy in the short-term while in the long-term applying labour input tax. As illustrated in Figure 3.8 that in short-term PIT reform and VAT rate policy stimulate higher employment than labour input tax, but conversely not in the long-term.

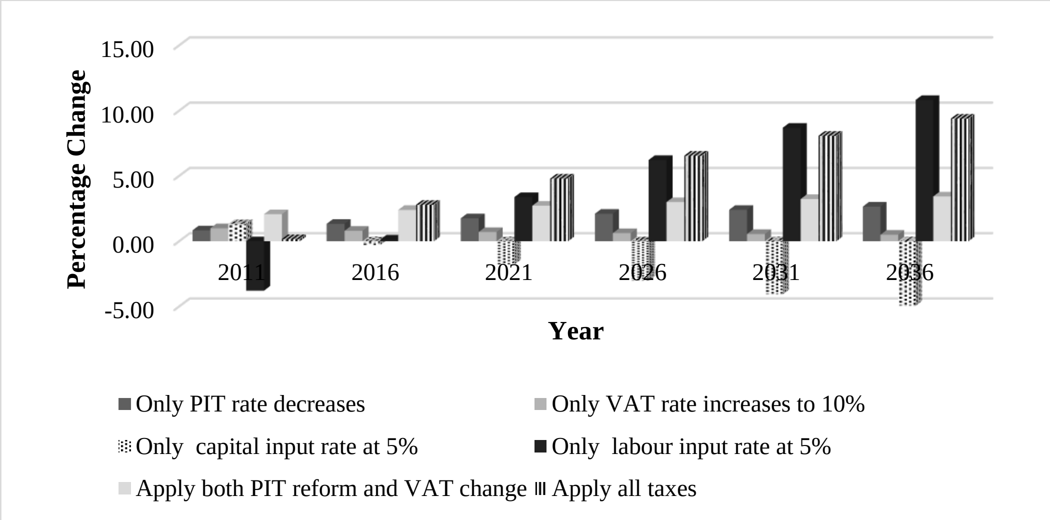

Figure 3.9: Percentage Change of Consumption in Response to Alternative Tax Reform

Source: Author's calculations based on the Thai DCGE model

It is noteworthy that labour input tax should be implemented with awareness to promote consumption because this policy decreases consumption at the beginning of the reform, before becoming more effective afterwards, as it enhances consumption more than any other alternative tax policies. This is the reverse of the impact of applying capital input tax, as illustrated in Figure 3.9 that this policy boosts consumption in 2011, before the positive effect gradually decline and eventually becomes negative in long-term.

3.6 Conclusion

This chapter exemplifies how a dynamic CGE model can be used to evaluate the impact of PIT reform in Thailand. The model was calibrated from the input-output table for 2011 obtained from OECD and household data from National Statistical Office of Thailand.

The results reveal that PIT reform is helpful in reducing inequality in the distribution of income and consumption not only in the short-term but also in the long-term. In addition, this reform boosts private consumption as households' disposable income increase. Consequently, investments, employment, capital stock, exports, imports and GDP rise. In terms of sectoral effect, the reduction of PIT rate affects economic activities unevenly across various industries. Findings show that every sector grows faster with the reforms in the personal income tax than without reforms, except in public administration and education sectors that output, employment and capital stock slightly decrease in the long-term.

Government revenue from PIT decreases year by year in both the short and long-term due to the reduction in PIT rates. Greater economic activity from consumption, production, investment and trade stimulates revenues from other taxes, particularly labour input tax and value added tax. This means an increase in other tax revenue can compensate for the drop in personal income tax revenue, so that the total revenue of the government remains at the same level. However, the government can increase their revenue from personal income tax by increasing the tax base and inducting people into the tax system because in the tax year 2014, only 15 percent of Thais filled in the tax form and only 6 percent paid tax. In addition, Pawin (2016) cited in Pitidol (2017) stated that more than 28 million people were not included in the tax system. In addition, the government should provide incentives to discourage tax avoidance and informality, and strengthening enforcement on tax evasion in order to increase efficiency of tax collection and also offer opportunities to increase public revenue. This will reduce disparity in society because the government can use revenue to finance public spending that benefit low-income families through transfers money, improves infrastructure, enhances education and healthcare services.

Although the findings of this study show a positive impact from the reduction in personal income tax rate, the policymaker still has to consider the limitations of this study. Due to lack of the data, this study applied some parameter values from existing studies that might not reflect the real circumstances in Thailand. On the other hand, this is the first paper that presents the magnitude of the economic impacts from tax reforms on complicated economy-wide income and substitution effects over 25 periods of the Thai economy. The model could be further applied to other tax policies or even other fiscal or financial policies such as pensions or health care policy, with some modifications to suit that scopes. Another possibility for further study is to classify labours into skilled and unskilled labours because different abilities and productivities of labours affect the capacity to reduce inequality differently.

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Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars)

	1.Agric	2.Mining	3.Food	4.Textile	5.Wood	6.Pulp	7.Coke	8.Chemical	9.Rubber	10.OthNonme	11.BasMetal	12.Fabric	13.Machine
1.Agric	5933.4000	8.4000	23242.9000	1007.9000	1132.0000	224.0000	0.3000	610.7000	5040.7000	33.2000	2.0000	1.0000	0.5000
2.Mining	12.7000	805.1000	73.8000	8.6000	2.5000	62.5000	26625.9000	1206.9000	19.9000	2926.0000	1098.4000	29.1000	80.3000
3.Food	5564.7000	0.6000	11959.3000	347.4000	4.5000	90.1000	10.5000	458.6000	22.1000	36.4000	2.1000	1.5000	5.6000
4.Textile	152.4000	1.6000	59.8000	17429.2000	115.4000	28.5000	2.4000	604.5000	514.3000	49.9000	10.3000	8.5000	48.5000
5.Wood	138.2000	4.9000	18.2000	7.5000	2228.2000	5.3000	1.1000	51.4000	13.9000	28.7000	6.2000	70.2000	82.3000
6.Pulp	18.1000	3.3000	159.2000	89.2000	30.2000	2399.8000	3.4000	157.0000	25.8000	51.1000	18.2000	13.4000	57.4000
7.Coke	2923.7000	1593.1000	662.4000	295.8000	65.2000	130.2000	1170.2000	1047.8000	341.6000	558.9000	401.6000	131.9000	571.3000
8.Chemical	3657.6000	47.5000	546.0000	1260.8000	217.1000	734.7000	102.5000	7092.3000	3062.3000	646.1000	188.5000	188.7000	907.6000
9.Rubber	513.3000	12.2000	595.6000	603.5000	200.3000	149.5000	6.9000	374.6000	1676.8000	45.7000	21.1000	116.4000	871.8000
10.OthNonme	56.9000	1.1000	418.5000	4.8000	38.6000	2.5000	1.9000	123.8000	4.1000	1105.2000	19.1000	27.7000	304.4000
11.BasMetal	9.6000	7.2000	76.5000	6.8000	47.7000	18.6000	226.5000	29.9000	30.0000	384.3000	7517.9000	5460.7000	6025.0000
12.Fabric	813.9000	57.0000	1591.5000	144.4000	163.2000	81.0000	12.1000	173.4000	111.9000	41.9000	81.1000	377.7000	1219.8000
13.Machine	375.7000	210.6000	369.0000	179.8000	85.2000	171.6000	55.5000	259.4000	109.6000	141.2000	102.9000	51.7000	19570.0000
14.Comput	6.9000	9.4000	5.4000	6.9000	0.7000	2.3000	16.1000	11.8000	4.2000	3.0000	2.9000	1.9000	1121.9000
15.Elecal	16.9000	12.4000	7.0000	4.8000	2.0000	0.9000	2.1000	4.0000	2.3000	9.2000	8.5000	7.6000	1003.4000
16.Motor	5.7000	1.4000	9.6000	9.8000	1.1000	1.7000	4.0000	5.2000	3.4000	1.8000	2.1000	1.8000	127.0000
17.OthTran	112.6000	12.5000	1.2000	0.9000	0.2000	0.2000	0.6000	0.6000	0.4000	0.3000	1.0000	0.8000	8.8000
18.Manufac	28.1000	7.6000	29.6000	1165.6000	36.1000	22.5000	4.5000	84.0000	49.9000	22.9000	20.8000	10.1000	340.1000
19.Electric	153.6000	125.2000	1172.4000	1462.9000	225.3000	262.4000	58.1000	1527.9000	744.3000	752.6000	695.5000	130.8000	645.3000
20.Const	50.0000	13.9000	32.7000	28.9000	6.9000	18.8000	5.9000	44.7000	23.7000	29.2000	14.0000	5.3000	78.9000
21.Wholsal	2899.9000	618.4000	4876.7000	4912.0000	467.3000	574.6000	4630.7000	2204.9000	1521.1000	954.2000	1073.5000	717.2000	3232.1000
22.Hotel	73.7000	26.3000	65.9000	145.4000	17.0000	55.7000	4.9000	67.4000	36.6000	21.5000	16.3000	10.9000	70.9000
23.Transpt	1115.9000	828.8000	1906.0000	1467.7000	272.1000	379.6000	1120.4000	1153.1000	570.2000	456.8000	338.3000	279.7000	1314.9000
24.PostTel	106.7000	16.9000	109.4000	81.2000	18.3000	67.5000	17.9000	134.6000	60.2000	67.0000	26.6000	25.9000	185.0000
25.Finance	3123.0000	213.8000	1671.6000	1187.9000	434.0000	399.2000	79.5000	1300.1000	533.2000	678.9000	570.0000	276.6000	657.5000
26.RealEst	118.7000	56.9000	160.6000	145.6000	30.3000	30.1000	9.7000	162.2000	39.5000	23.3000	20.2000	45.9000	184.4000
27.RentMac	32.2000	3.3000	13.3000	1.2000	3.8000	23.5000	1.7000	16.2000	8.3000	4.9000	4.4000	8.5000	13.2000
28.ComRlAct	4.3000	1.5000	11.0000	5.8000	1.6000	55.7000	4.9000	30.0000	7.2000	4.2000	7.6000	17.7000	35.5000

Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars), Continued

	1.Agric	2.Mining	3.Food	4.Textile	5.Wood	6.Pulp	7.Coke	8.Chemical	9.Rubber	10.OthNonme	11.BasMetal	12.Fabric	13.Machine
29.RnD	80.7000	1621.8000	779.0000	295.4000	80.4000	302.9000	25.6000	439.3000	167.9000	238.2000	41.2000	48.5000	258.3000
30.PubAdmin	4.1000	1.1000	5.7000	3.7000	0.7000	2.7000	1.4000	3.8000	2.2000	1.2000	0.8000	0.6000	2.8000
31.Edu	0.2000	0.1000	0.3000	0.2000	0.1000	0.5000	0.1000	0.3000	0.2000	0.1000	0.1000	0.1000	0.2000
32.Health	1.1000	0.1000	1.0000	0.9000	0.1000	0.5000	0.4000	1.6000	0.8000	0.3000	0.2000	0.1000	0.8000
33.OthCommu	142.6000	14.5000	275.2000	209.4000	16.5000	51.7000	13.2000	78.5000	39.2000	75.6000	36.3000	14.0000	131.0000

Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars), Continued

	14.Comput	15.Elecal	16.Motor	17.OthTran	18.Manufac	19.Electric	20.Const	21.Wholsal	22.Hotel	23.Transpt	24.PostTel	25.Finance	26.RealEst
1.Agric	0.4000	0.3000	0.4000	3.2000	35.5000	6.6000	133.1000	1.4000	3644.9000	52.3000	0.1000	23.3000	25.6000
2.Mining	16.7000	15.3000	129.1000	12.2000	370.6000	7408.1000	3462.5000	1.8000	0.6000	2.6000	0.0000	0.1000	0.0000
3.Food	3.8000	4.0000	3.7000	0.8000	159.7000	1.4000	3.7000	134.3000	6938.9000	288.1000	0.1000	42.5000	2.5000
4.Textile	29.9000	102.5000	131.1000	97.4000	795.9000	5.3000	35.8000	740.5000	338.5000	250.9000	0.3000	243.5000	11.2000
5.Wood	86.4000	53.1000	84.1000	61.7000	131.3000	0.5000	1053.6000	110.2000	15.2000	45.1000	0.0000	16.5000	0.6000
6.Pulp	71.6000	47.1000	85.2000	2.0000	84.2000	8.5000	15.7000	125.5000	24.1000	56.3000	9.7000	389.9000	3.6000
7.Coke	186.2000	215.2000	234.7000	86.9000	91.9000	1055.9000	620.2000	522.2000	391.1000	12709.7000	56.3000	170.2000	56.8000
8.Chemical	478.5000	331.0000	652.0000	75.7000	385.4000	43.1000	360.2000	122.4000	116.2000	50.8000	1.8000	71.3000	2.9000
9.Rubber	1038.1000	533.5000	1150.4000	58.0000	250.8000	11.5000	364.0000	919.0000	62.9000	564.7000	2.7000	18.3000	7.1000
10.OthNonme	702.0000	944.7000	212.2000	35.9000	67.4000	1.5000	7605.4000	48.7000	71.5000	2.0000	0.0000	6.0000	10.1000
11.BasMetal	1736.3000	1814.3000	6054.7000	567.3000	4022.5000	62.0000	4040.5000	398.7000	1.1000	8.8000	0.1000	0.3000	0.6000
12.Fabric	418.1000	563.2000	855.4000	168.0000	100.3000	29.6000	1407.8000	116.8000	49.3000	64.6000	8.3000	8.9000	11.0000
13.Machine	312.3000	157.7000	3260.1000	287.0000	65.1000	103.9000	270.8000	465.0000	37.9000	153.7000	96.5000	123.6000	14.1000
14.Comput	14236.6000	82.5000	170.1000	4.2000	20.8000	8.4000	13.6000	70.2000	1.6000	7.6000	16.5000	0.9000	0.6000
15.Elecal	582.6000	6821.4000	1159.6000	78.1000	10.2000	279.8000	1796.3000	432.6000	129.8000	45.6000	26.3000	57.5000	17.1000
16.Motor	23.1000	13.6000	10574.3000	6.8000	22.2000	2.4000	8.3000	896.7000	2.0000	179.9000	0.3000	1.0000	2.4000
17.OthTran	8.3000	2.2000	3.7000	675.5000	1.8000	0.3000	2.2000	0.5000	0.3000	299.0000	0.0000	0.1000	0.0000
18.Manufac	133.1000	38.8000	53.2000	11.2000	4590.9000	13.3000	44.0000	86.5000	23.9000	70.5000	8.5000	114.3000	4.8000

Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars), Continued

	14.Comput	15.Elecal	16.Motor	17.OthTran	18.Manufac	19.Electric	20.Const	21.Wholsal	22.Hotel	23.Transpt	24.PostTel	25.Finance	26.RealEst
19.Electric	541.6000	307.3000	548.7000	78.6000	170.5000	2057.3000	229.3000	1179.0000	1688.2000	486.9000	259.7000	369.2000	553.8000
20.Const	60.0000	12.7000	41.1000	3.5000	15.3000	22.7000	29.7000	39.3000	66.7000	21.7000	10.5000	79.6000	134.4000
21.Wholsal	3538.6000	1239.4000	2566.0000	216.4000	1981.0000	1420.7000	2626.1000	788.7000	1658.5000	5169.5000	87.3000	446.8000	50.3000
22.Hotel	85.9000	27.4000	38.9000	9.6000	40.1000	23.1000	195.1000	1357.3000	39.9000	426.4000	35.0000	230.1000	24.7000
23.Transpt	1681.5000	406.6000	958.8000	133.9000	747.7000	423.3000	5461.1000	2889.7000	491.1000	11596.1000	454.9000	756.7000	70.8000
24.PostTel	223.7000	20.1000	149.8000	14.0000	110.2000	29.5000	40.6000	560.6000	293.3000	296.6000	1154.5000	673.8000	15.1000
25.Finance	779.9000	259.2000	835.1000	185.4000	456.9000	1319.5000	935.3000	4921.4000	705.6000	2262.6000	881.1000	4018.3000	1950.7000
26.RealEst	102.2000	90.5000	72.6000	17.3000	66.7000	15.3000	195.6000	610.3000	298.0000	695.5000	68.7000	434.6000	110.4000
27.RentMac	20.6000	7.8000	17.0000	1.6000	3.3000	8.4000	50.2000	29.4000	4.2000	64.1000	5.8000	23.2000	1.9000
28.ComRlAct	66.4000	17.6000	36.1000	6.7000	5.7000	5.5000	6.9000	32.0000	3.0000	73.8000	49.0000	117.5000	14.1000
29.RnD	333.5000	115.4000	304.3000	55.0000	114.8000	59.9000	389.7000	336.6000	239.0000	1027.5000	252.1000	609.3000	266.1000
30.PubAdmin	3.0000	0.9000	1.9000	0.3000	4.2000	1.3000	6.3000	4.1000	1.5000	8.2000	0.6000	2.1000	0.6000
31.Edu	0.4000	0.1000	0.2000	0.0000	0.2000	0.1000	0.3000	0.2000	0.1000	0.4000	0.0000	0.1000	0.0000
32.Health	1.0000	0.3000	0.5000	0.1000	0.6000	0.2000	0.8000	0.3000	0.3000	0.8000	0.0000	9.5000	0.0000
33.OthCommu	166.1000	41.9000	276.7000	37.9000	28.7000	137.4000	70.4000	616.2000	144.4000	200.8000	183.3000	299.8000	129.9000

Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars), Continued

	27.RentMac	28.ComRlAct	29.RnD	30.PubAdmin	31.Edu	32.Health	33.OthCommu
1.Agric	0.3000	0.2000	27.2000	0.0000	187.9000	446.4000	398.8000
2.Mining	0.6000	3.6000	0.1000	0.0000	0.5000	1.6000	99.2000
3.Food	0.0000	0.0000	2.7000	0.0000	323.2000	287.0000	816.3000
4.Textile	0.7000	1.3000	19.9000	0.0000	18.3000	173.0000	593.6000
5.Wood	0.5000	0.6000	48.6000	0.0000	27.4000	9.0000	63.4000
6.Pulp	3.8000	8.7000	991.2000	0.0000	499.5000	64.4000	121.1000
7.Coke	27.0000	23.5000	448.1000	0.0000	519.5000	149.7000	264.1000
8.Chemical	0.1000	1.2000	40.7000	0.0000	58.7000	2251.2000	290.3000
9.Rubber	0.0000	0.3000	72.2000	0.0000	11.3000	108.5000	258.1000

Appendix 3A: Thailand's Thirty-three Sectors Input-Output Table (Unit: Million US Dollars), Continued

	27.RentMac	28.ComRlAct	29.RnD	30.PubAdmin	31.Edu	32.Health	33.OthCommu
10.OthNonme	0.0000	0.0000	3.1000	0.0000	4.7000	5.8000	228.8000
11.BasMetal	0.0000	0.1000	12.8000	0.0000	0.6000	8.1000	235.7000
12.Fabric	0.9000	2.9000	11.3000	0.0000	19.3000	86.0000	262.9000
13.Machine	0.1000	0.5000	144.4000	0.0000	56.5000	9.4000	285.9000
14.Comput	1.2000	32.1000	40.2000	0.0000	19.0000	73.8000	105.3000
15.Elecal	0.2000	5.3000	5.1000	0.0000	6.4000	25.4000	213.8000
16.Motor	0.1000	0.0000	1.2000	0.0000	1.4000	1.5000	4.5000
17.OthTran	0.0000	0.0000	0.1000	0.0000	0.2000	0.2000	0.6000
18.Manufac	1.7000	1.4000	120.5000	0.0000	254.0000	34.4000	671.5000
19.Electric	10.9000	13.7000	165.6000	0.0000	581.3000	665.5000	440.4000
20.Const	20.1000	29.4000	60.6000	0.0000	34.7000	15.8000	69.7000
21.Wholsal	61.9000	15.8000	298.7000	0.0000	436.0000	706.6000	968.0000
22.Hotel	1.9000	7.3000	211.6000	0.0000	147.4000	66.6000	96.7000
23.Transpt	12.1000	65.5000	475.3000	0.0000	436.1000	383.4000	1256.1000
24.PostTel	8.7000	23.5000	402.2000	0.0000	100.2000	60.1000	665.3000
25.Finance	518.9000	135.1000	366.6000	0.0000	303.1000	122.7000	644.4000
26.RealEst	95.8000	103.7000	217.3000	0.0000	54.2000	13.5000	340.3000
27.RentMac	315.2000	22.7000	11.4000	0.0000	6.7000	27.0000	31.7000
28.ComRlAct	2.4000	630.2000	158.6000	0.0000	35.2000	75.0000	45.4000
29.RnD	335.1000	170.3000	257.6000	0.0000	122.1000	164.6000	283.7000
30.PubAdmin	6.9000	5.2000	1.5000	0.0000	1.0000	1.1000	2.0000
31.Edu	2.3000	93.7000	0.2000	0.0000	0.1000	0.1000	0.1000
32.Health	0.0000	0.0000	0.2000	0.0000	0.1000	1.2000	0.3000
33.OthCommu	8.6000	40.0000	4875.1000	0.0000	142.8000	78.2000	1924.4000

Appendix 3B: Benchmark data set by sectors (Unit: Million US Dollars)

	Consumption	Investment	Government	Export	Import	Labour wage	Capital return
1.Agric	16369.2000	1565.3000	142.6000	12344.0000	2698.1000	10562.8780	31104.5220
2.Mining	13.3000	1931.1000	0.3000	1538.4000	29598.7000	2848.8820	7707.7180
3.Food	26105.3000	867.0000	539.0000	22913.3000	5790.9000	4828.7380	12102.0620
4.Textile	19265.9000	1531.9000	67.3000	6304.5000	2766.7000	5007.3740	9075.4260
5.Wood	1625.4000	1873.6000	169.7000	1627.3000	478.7000	1229.1145	2062.7855
6.Pulp	606.9000	112.1000	626.4000	6066.4000	3836.0000	697.6730	2093.8270
7.Coke	6449.0000	521.7000	1415.0000	9361.3000	3760.3000	918.0515	3823.1485
8.Chemical	3912.4000	317.1000	205.4000	18359.7000	18077.0000	2846.2700	6262.4300
9.Rubber	1321.9000	332.4000	3.9000	10037.1000	3816.9000	1274.6810	2367.8190
10.OthNonme	781.8000	726.5000	130.7000	1944.9000	1377.1000	1273.1635	3533.2365
11.BasMetal	11.4000	1063.2000	0.7000	9371.3000	33459.2000	1138.7935	2266.5065
12.Fabric	674.1000	3133.1000	37.3000	4441.1000	6159.4000	910.2825	2158.3175
13.Machine	1173.6000	20361.2000	86.7000	16013.5000	14972.9000	2784.6145	7920.0855
14.Comput	834.1000	3695.2000	109.0000	34512.3000	22602.1000	1495.2590	3307.4410
15.Elecal	1162.7000	4724.8000	62.0000	8287.2000	8252.5000	1100.3105	3296.0895
16.Motor	4625.4000	14413.2000	17.4000	16076.8000	8434.9000	1800.6420	4702.8580
17.OthTran	5.2000	3097.0000	9.6000	4407.1000	4188.9000	597.7320	854.5680
18.Manufac	5949.7000	679.7000	268.4000	6903.8000	2489.3000	1617.8315	2629.9685
19.Electric	4585.4000	67.0000	1492.3000	410.5000	299.7000	3419.8110	5938.9890
20.Const	31.6000	38278.3000	643.5000	989.0000	343.2000	3341.4555	5521.8445
21.Wholsal	15618.3000	6293.1000	1656.2000	27434.8000	31938.6000	12080.7650	38998.3350
22.Hotel	15175.1000	5.2000	708.5000	9043.7000	20.6000	2832.6170	6991.2830
23.Transpt	24429.4000	1532.5000	2276.7000	21063.2000	33046.2000	7513.2575	11276.0425

Appendix 3B: Benchmark data set by sectors (Unit: Million US Dollars), Continued

	Consumption	Investment	Government	Export	Import	Labour wage	Capital return
24.PostTel	2122.0000	7.7000	630.0000	1146.3000	578.5000	1534.5365	3811.5635
25.Finance	5749.9000	90.5000	254.6000	949.9000	9391.0000	7015.3315	12571.7685
26.RealEst	15818.6000	13.1000	385.4000	754.0000	52.0000	1505.0210	14370.6790
27.RentMac	28.3000	1.9000	0.5000	1379.7000	29.1000	672.6155	5.4845
28.ComRlAct	46.5000	617.3000	7.2000	108.8000	180.0000	672.6155	5.4845
29.RnD	240.6000	41.6000	1660.4000	2719.3000	168.0000	1981.1340	2493.8660
30.PubAdmin	4397.2000	4.7000	18689.8000	0.0000	105.4000	21374.2355	1695.4645
31.Edu	1083.6000	1.4000	17519.0000	4.0000	7.1000	14038.8480	606.9520
32.Health	2690.9000	3.4000	7852.0000	1013.5000	19.4000	3374.4180	2000.5820
33.OthCommu	3773.9000	50.4000	747.8000	2787.3000	70.4000	2525.5935	2683.5065

Appendix 3C: Source of Income to the households (Unit: Million US Dollars)

	H1	H2	H3	H4	H5
intr	14055.6425	22705.2687	30922.4135	43248.1308	105309.1985
Wage	8242.9455	13315.5273	18134.4801	25362.9092	61758.6839
Conshh	12134.1090	19601.2530	26695.0398	37335.7200	90912.4782
Leisure	6182.2091	9986.6455	13600.8601	19022.1819	46319.0129

Appendix 3D: Source of Income to the households, by sector (Unit: Million US Dollars)

	1.Agric	2.Mining	3.Food	4.Textile	5.Wood	6.Pulp	7.Coke	8.Chemical	9.Rubber	10.OthNonme	11.BasMetal
H1	1063.9980	0.8645	1696.8445	1252.2835	105.6510	39.4485	419.1850	254.3060	85.9235	50.8170	0.7410
H2	1718.7660	1.3965	2741.0565	2022.9195	170.6670	63.7245	677.1450	410.8020	138.7995	82.0890	1.1970
H3	2340.7956	1.9019	3733.0579	2755.0237	232.4322	86.7867	922.2070	559.4732	189.0317	111.7974	1.6302
H4	3273.8400	2.6600	5221.0600	3853.1800	325.0800	121.3800	1289.8000	782.4800	264.3800	156.3600	2.2800
H5	7971.8004	6.4771	12713.2811	9382.4933	791.5698	295.5603	3140.6630	1905.3388	643.7653	380.7366	5.5518

Appendix 3D: Source of Income to the households, by sector (Unit: Million US Dollars), Continued

	12.Fabric	13.Machine	14.Comput	15.Elecal	16.Motor	17.OthTran	18.Manufac	19.Electric	20.Const	21.Wholsal	22.Hotel
H1	43.8165	76.2840	54.2165	75.5755	300.6510	0.3380	386.7305	298.0510	2.0540	1015.1895	986.3815
H2	70.7805	123.2280	87.5805	122.0835	485.6670	0.5460	624.7185	481.4670	3.3180	1639.9215	1593.3855
H3	96.3963	167.8248	119.2763	166.2661	661.4322	0.7436	850.8071	655.7122	4.5188	2233.4169	2170.0393
H4	134.8200	234.7200	166.8200	232.5400	925.0800	1.0400	1189.9400	917.0800	6.3200	3123.6600	3035.0200
H5	328.2867	571.5432	406.2067	566.2349	2252.5698	2.5324	2897.5039	2233.0898	15.3892	7606.1121	7390.2737

Appendix 3D: Source of Income to the households, by sector (Unit: Million US Dollars), Continued

	23.Transpt	24.PostTel	25.Finance	26.RealEst	27.RentMac	28.ComRlAct	29.RnD	30.PubAdmin	31.Edu	32.Health	33.OthCommu
H1	1587.9110	137.9300	373.7435	1028.2090	1.8395	3.0225	15.6390	285.8180	70.4340	174.9085	245.3035
H2	2565.0870	222.8100	603.7395	1660.9530	2.9715	4.8825	25.2630	461.7060	113.7780	282.5445	396.2595
H3	3493.4042	303.4460	822.2357	2262.0598	4.0469	6.6495	34.4058	628.7996	154.9548	384.7987	539.6677
H4	4885.8800	424.4000	1149.9800	3163.7200	5.6600	9.3000	48.1200	879.4400	216.7200	538.1800	754.7800
H5	11897.1178	1033.4140	2800.2013	7703.6582	13.7821	22.6455	117.1722	2141.4364	527.7132	1310.4683	1837.8893

Chapter 4 : Energy Consumption, Financial Development and Economic Growth in Thailand

Previous two chapters showed that any change in tax policies has an impact on growth and other economic indicators. Having argued in the first chapter that economic growth can be determined by other variables as stated in the Neo-Classical theory of economic growth, many empirical studies have extended this theory by incorporating energy consumption and financial development into the model.

Financial development is an important factor for energy consumption and economic growth because it can increase the economic efficiency of a country's financial system and this can influence economic activity and the demand for energy. Therefore, it is crucial to investigate the validity of the link between economic growth, energy consumption, financial development, capital and labour. In particular no study, to our knowledge, has considered this association in the Thailand context. The precise knowledge of the relationship among considered variables is valuable for policymakers to implement appropriate policies that will not deteriorate economic growth.

The results suggest that there is evidence on the long-run and causal relationship between economic growth, energy consumption, gross fixed capital formation and population growth. The Toda-Yamamoto causality test indicates a unidirectional causality running from economic growth to energy consumption, implying that conservation energy policy may be implemented with little or no adverse effect on economic growth. In addition, the test reveals a unidirectional causality running from gross fixed capital formation and population growth to energy consumption; a unidirectional causality running from gross fixed capital formation and population growth to economic growth. On the other hand, there is absence (neutrality) of any causality between financial development and energy consumption as well as between financial development and economic growth.

This chapter will start with the introduction section which also includes contributions and its main objectives. Section 2 provides a review of existing literature related to this topic. Section 3 describes a brief overview of the variables used in this study. Section 4 explains the data and methodology used while section 5 reports the empirical results. The conclusion and policy implications are presented in section 6.

4.1 Introduction

In the past 40 years, from 1972 to 2014, energy consumption in Thailand continuously increased at an annual average rate of 5.58 percent. Particularly, during the boom period of Thai economy in 1986-1996, energy consumption was at the annual average rate of 9.85 percent, which was in line with the growth of Thai economy in that period at an annual average rate of 9.28 percent. In 2014, energy consumption was 9.38 times the amount it was in 1972, whereas the GDP growth had decreased from 10.24 percent in 1972 to 3.02 percent in 2014 (World Bank, 2019). This had raised the question whether the relationship is present between the energy consumption and economic growth in Thailand as it seem to be either energy consumption caused economic growth or economic growth created energy consumption through domestic production and investment in the boom period, but recent data in 2014 showed opposite connection or unexplainable relationship between energy consumption and economic growth.

Although the nexus of energy-growth has been extensively studied in the literature for more than four decades since the seminal work of Kraft and Kraft (1978), the empirical results indicate the direction of the causality between energy consumption and economic growth has been ambiguous and distinct from country to country. Furthermore, the differences in methodologies used, the time period under consideration and different proxies for energy consumption can generate different results (Shahbaz et al., 2017). Basically, the empirical studies reveal four hypotheses of the relationship between energy use and economic growth. First, the growth hypothesis is indicated when there exists only a unidirectional causality running from energy consumption to economic growth (e.g., Ghosh and Kanjilal, 2014; Odhiambo, 2009; Masih and Masih, 1998; Tang et al., 2016). Second, the conservation hypothesis holds when there exists only a unidirectional causality running from economic growth to energy consumption (e.g., Lise and Van Montfort, 2007; Ang, 2008; Zhang and Cheng, 2009; Chang, 2010; Bartleet and Gounder, 2010; Fang and Chang, 2016). Third, the feedback hypothesis is supported when there exists a bidirectional causality between energy consumption and economic growth (e.g., Erdal et al., 2008; Loganathan and Subramaniam, 2010; Dagher and Yacoubian, 2012; Kyophilavong et al., 2015). Fourth, the neutrality hypothesis holds when there exists no causality between the two variables (e.g., Jobert and Karanfil, 2007; Halicioglu, 2009; Jafari et al., 2012).

Apart from the energy-growth nexus, many academic researchers have also tried to identify the relationships between financial development and economic growth. The theoretical foundation of this relationship can be drawn as far back to the work of Schumpeter (1911), who highlighted the positive role of financial development on economic growth. He stated that financial intermediaries not only reduce transaction costs but also facilitate pool saving and managing the risks. Hence, the growth of a country depends on the performance of its financial system. In other words, financial development leads to economic growth. Although Schumpeter's view had been supported by the study of McKinnon (1973) and Shaw (1973), Robinson (1952) and Kuznets (1955) later argued that financial development follows economic growth. Moreover, Patrick (1966) posited that financial development and economic growth share a feedback causal relationship, whereas Lucas (1988) stated that financial development and economic growth are independent and not causally related. To date, there have been voluminous empirical studies investigating the relationship between financial development and economic growth but there is no consensus view yet on the direction of causality.

The aforementioned evidence suggests that there is a link between energy consumption, financial development and economic growth. Therefore, the estimated results of the energy-growth nexus might be biased if the financial development variable is omitted from the model. This is supported by Karanfil (2009), who suggests adding financial development variables into the energy-growth framework because finance could potentially impact the demand for energy. An empirical study by Sadorsky (2010) points out that financial development is crucial to the demand for energy because it increases the economic efficiency of the financial system in the country by reducing financial risk and lending costs, promoting transparency between debtors and creditors, accessing to more financial capital, increasing investment flow and therefore enhances energy use and economic growth. Similarly, Magazzino (2018) also states that financial development is important because it can increase the economic efficiency of a country's financial system and this can affect economic activity and the demand for energy. Financial development helps industrial growth, creates demand for new infrastructure and, thus, positively impacts energy use.

To date, the debate regarding a causal relationship between energy consumption, financial development and economic growth has generated much literature in both developed and developing countries (e.g., Shahbaz and Lean, 2012: Shahbaz et al., 2013a; Islam et al., 2013; Mahalik and Mallick, 2014; Shahbaz et al., 2017). However, the energy-finance-growth nexus is very limited in the Thai context. Two limitations were observed from the literature survey. First, previous studies that incorporated financial development into the energy-growth nexus utilised panel data and included Thailand in their sample countries (Sadorsky, 2010; Al-mulali and Sab, 2012; Chang, 2015). Therefore, results of those studies cannot satisfactorily address the country-specific findings. To the best of our knowledge, the empirical paper by Kyophilavong et al. (2015) appears to be the only published work that examined the energy-growth nexus in Thailand as a countrywide study. However, this study does not take into consideration of the role of financial development, nor does it focus on how trade openness could affect energy consumption and economic growth. On the other hand, Majid (2007) is the only research that investigated the finance-growth nexus in Thailand as country-specific study but this study uses dataset only after 1997 financial crisis. Therefore, his result about the role of financial development on Thai economy might be overstated. Second, the direction of causality between energy consumption, financial development and economic growth for Thailand remains controversial. Being one of the most widely cited development success stories, with sustained strong growth and impressive poverty reduction country in the Southeast Asia region, Thailand is an interesting case study as it faces crucial challenges on energy security and financial intermediaries are the main drivers of economic growth as sources of funds for investment in Thailand.

The objective of this chapter is to investigate the impacts of energy consumption on the economic growth as well as the role of financial development on the economic growth of Thailand over the period of 1971 to 2014. Specifically, this study attempts to answer these following questions.

(1) What kind of effect, positive or negative, has energy consumption and financial development applied on economic growth?
(2) What type of causality exists in energy-growth and finance-growth nexus?
(3) Should Thai households and government adopt energy saving methods or will these measures have adverse impacts on economic growth?
(4) Was development of the financial sector helpful for growth of the economy or is it a by-product of the growth process?

This study contributes to the existing literature in three ways. Firstly, this study uses time series data to study Thailand as a specific country. Secondly, this study applies multivariate framework by incorporates gross fixed capital formation, population as well as financial development to investigate the long-run relationship among considered variables in the energy-growth framework as widely discussed in the economic literature that financial development enhances economic growth and energy consumption. Lastly, this study employs the Autoregressive Distributed Lag (ARDL) bounds testing to test for long-run relation and applies the Toda-Yamamoto causality test to investigate the dynamic causality among the variables. The knowledge of the precise relationship among considered variables is valuable for policymakers for an energy-dependent economy such as Thailand. The policies might change in response to the causal relationship among energy consumption and economic growth. That is when the causality runs from economic growth to energy consumption or no causality between these two variables, energy conservation policies, which proposed in the Thailand 4.0 economic model and the Thailand 20-year energy efficiency development plan, can be rational policy for the government to apply without restricting the growth of the economy. On the other hand, the bidirectional causality or unidirectional causality from energy consumption to economic growth implies a shortage of energy will negatively affect income and thereby be harmful on economic growth. It is also important to investigate the relationship between financial development and economic growth because if financial development Granger causes economic growth, any restrictions in domestic credit to private sector may lower potential growth of the economy. Therefore, the policymakers can use the findings of this research as a guideline to implement appropriate policies that will not deteriorate economic growth.

Thus, the flow of analysis in this chapter will begin with a review of existing studies on the nexus between energy consumption and economic growth followed by the previous studies on financial development and economic growth, then sum up with the existing empirical studies on the relationship between energy consumption, financial development and economic growth that based on econometric approaches as shown in Figure 4.1;

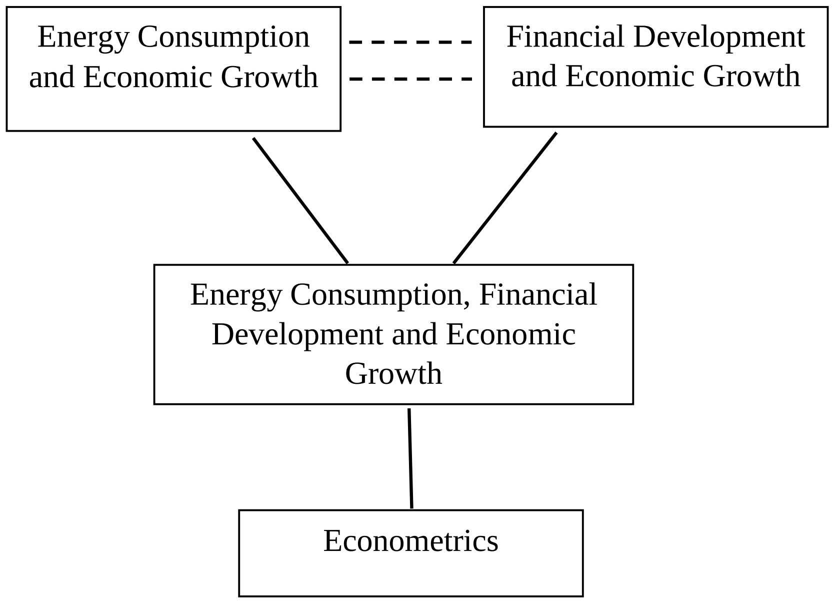

Figure 4.1: The Analytical Framework

4.2 Literature Review

There are several existing literatures that focus on the nexus between economic growth and energy consumption as well as economic growth and financial development. Therefore, this chapter reviews existing studies under three subsections: starting from an assessment of studies on economic growth and energy consumption in section 4.2.1 followed by that on economic growth and financial development in section 4.2.2 and finally examining connections among three variables economic growth, energy consumption and financial development in section 4.2.3.

4.2.1 The Economic Growth and Energy Consumption Nexus

Since the original study by Kraft and Kraft (1978) on the relationship of economic growth with energy, a flood of empirical papers has emerged on this topic investigating the causality between energy consumption and economic growth in various geographical areas as summarised by Ozturk (2010) and Omri (2014). Interestingly, the existing empirical studies on this topic have come up with different results, depending on the features of the specific economy or region corresponding to four hypotheses about the energy-growth nexus, as follows.

(1) "The growth hypothesis: energy-led growth"

The growth hypothesis describes causality running from energy consumption to economic growth, representing the view of an energy dependent economy. This hypothesis highlights the vital role of energy consumption for economic growth. It implies that a rise in energy consumption may lead to economic growth, while the restrictions on the use of energy may negatively affect the growth of an economy. The single-country empirical studies that support the growth hypothesis include studies such as Odhiambo (2009), who applies a bivariate model to test for causal link between energy consumption and economic growth in Tanzania. His findings indicate that energy consumption spurs economic growth. Ghosh and Kanjilal (2014) use a trivariate model by including urban population to test the causality of energy use and economic growth in India. The Toda-Yamamoto causality tests support the growth hypothesis. Using a multivariate model incorporating capital and labour into an energy-growth framework, similar results have been found by Stern (2000) and Bowden and Payne (2009) in case of the US, and Wang et al. (2011) in case of China. The findings of Alshehry and Belloumi (2015) for Saudi Arabia and Tang et al. (2016) for Vietnam are also in line with the growth hypothesis, although the former added energy prices and carbon emissions and the latter incorporated real domestic investment and foreign direct investment in the model. In addition, there are numerous multi-country studies that concur to these findings. For instance, Masih and Masih (1998) find causality exists from energy consumption to income in Thailand and Sri Lanka. Asafu-Adjaye (2000) brings energy prices into the model and finds a unidirectional causality running from energy consumption to economic growth in India and Indonesia. His discovery of an energy-growth nexus in Indonesia has been confirmed by Chiou-Wei et al. (2008). Narayan and Smyth (2008) also find a causality relationship running from energy consumption to economic growth in G7 countries. The study of Akkemik and Goksal (2012) also support this view for 6 countries out of 79 countries. By including human capital to the panel cointegration model, the findings of Fang and Chang (2016) support this view in the case of Korea, Pakistan and Taiwan out of 16 countries in the Asia Pacific region.

(2) "The conservation hypothesis: growth-led energy"

The conservation hypothesis explains the unidirectional causality running from economic growth to energy consumption. Increasing consumption of energy is a consequence of economic growth but the growth itself is not constrained by the level of energy consumption, this means an economy is less dependent on energy. In contrast from the energy-led growth hypothesis, this energy conservation hypothesis assumes that policies such as phasing out energy subsidies may not have much impact on economic growth. Several studies provide empirical support for this view. A notable contribution by Kraft and Kraft (1978) utilises a VAR model to study causal relationship between energy consumption and GNP growth in the US from 1947 to 1974. Their finding supported the conservation hypothesis. In addition, the findings by Lise and Van Montfort (2007) for Turkey, Ang (2008) for Malaysia, Zhang and Cheng (2009) for China, Chang (2010) for China, and Bartleet and Gounder (2010) for New Zealand are also consistent with this view. Similar results have been found not only in country-specific studies but also in multi-country studies such as Chiou-Wei et al. (2008) in case of the Philippines and Singapore. For panel analysis, the finding of Akkemik and Goksal (2012) is also in line with this view in 9 countries out of 79 countries. Yildirim et al. (2014), looking at ASEAN, show unidirectional causality from economic growth to energy consumption in Indonesia, Malaysia, the Philippines and Thailand. The findings by Azam et al. (2015) for the ASEAN-5 also confirm the conservation hypothesis in case of Malaysia but not for Indonesia, the Philippines and Thailand. Fang and Chang (2016) extend conservation analysis to 16 countries in the Asia Pacific region showing causality from GDP to energy consumption.

(3) "The feedback hypothesis: interdependence of energy and growth"

The feedback hypothesis indicates a bidirectional causality between energy consumption and economic growth. It is short of combination of energy-led growth and growth-led energy consumption. An increase in energy consumption stimulates economic growth, and higher economic growth results in more energy consumption and so on. This view has been widely supported by studies such as Erdal et al. (2008), who apply a bivariate model with Pair-wise Granger causality test and find a feedback effect of energy consumption and economic growth in Turkey. Similar results of bivariate models are also reported by Loganathan and Subramaniam (2010) for Malaysia, and Dagher and Yacoubian (2012) for Lebanon. By incorporating gross fixed capital formation and population, Paul and Bhattacharya (2004) point out bidirectional causality between energy consumption and economic growth in India. Similar results in India has been found by Ahmad et al. (2016), who include carbon emissions and employ ARDL to the data over the period 1971-2014. By incorporating trade openness, the Granger causality test reveals a feedback relationship between energy consumption and economic growth in Thailand (Kyophilavong et al., 2015). Similarly, there are several multi-country studies consistent with this view. For instance, Asafu-Adjaye (2000), who examines the causal link between energy consumption and economic growth by incorporating energy prices in 4 countries, and finds bidirectional causality in the Philippines and Thailand. For panel cointegration, Akkemik and Goksal (2012) reveal a feedback hypothesis in 57 out of 79 countries in their samples. Kahsai et al. (2012) report long-run bidirectional causality in 40 sub-Saharan countries. Uniform results are also found by Nasreen and Anwar (2014) in the case of 15 Asian countries including Thailand, and Fang and Chang (2016) in the case of India out of his 16 countries sample.

(4) "The neutrality hypothesis"

The neutrality hypothesis discloses no causality between energy consumption and economic growth. It implies that neither conservative nor expansive energy policies have any influence on economic growth. This view has been supported by several studies such as Jobert and Karanfil (2007) and Halicioglu (2009) for Turkey. Although the former applied a bivariate model with the Granger causality test, the latter employed a multivariate model with ARDL and the Granger causality test. Similar results for single country studies are also found by Payne (2009) for the US, Liu (2009) for China, Alam et al. (2011) for India, and Jafari et al. (2012) for Indonesia. Meanwhile, Chiou-Wei et al. (2008), Akkemik and Goksal (2012), Yildirim et al. (2014) and Azam et al. (2015) are the multi-country studies that support this hypothesis. More details of recent selected empirical studies on the energy-growth nexus are presented in Table 4.1.

Table 4.1: Summary of Empirical Studies on Energy Consumption-Growth Nexus during 2000-2016

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
Country-specific studies					
1. Stern (2000)	US	1948-1994	Cointegration, Granger causality	Capital, labour	EC $\rightarrow$ GDP
2. Paul and Bhattacharya (2004)	India	1950-1996	Cointegration, and Granger causality	Gross fixed capital formation and population	EC $\leftrightarrow$ GDP
3. Jobert and Karanfil (2007)	Turkey	1960-2003	Cointegration and Granger causality		GDP $\neq$ EC
4. Lise and Van Montfort (2007)	Turkey	1970-2003	Cointegration, VECM and Granger causality	Population	GDP $\rightarrow$ EC
5. Erdal et al. (2008)	Turkey	1970-2006	Johansen cointegration test, and Pair-wise Granger causality test		EC $\leftrightarrow$ GDP
6. Ang (2008)	Malaysia	1971-1999	Cointegration and VECM	Carbon emissions	GDP $\rightarrow$ EC
7. Bowden and Payne (2009)	US	1949-2006	Toda-Yamamoto causality test	Capital, labour	EC $\rightarrow$ GDP
8. Payne (2009)	US	1949-2006	Toda-Yamamoto causality test	Capital, labour	GDP $\neq$ EC
9. Halicioglu (2009)	Turkey	1960-2005	ARDL and Granger causality	Carbon emissions and openness ratio	GDP $\neq$ EC
10. Odhiambo (2009)	Tanzania	1971-2006	ARDL and ECM		EC $\rightarrow$ GDP
11. Zhang and Cheng (2009)	China	1960-2007	Granger causality	Capital, urban population, carbon emissions	GDP $\rightarrow$ EC
12. Liu (2009)	China	1978-2008	ARDL and ECM	Population and urbanization level	GDP $\neq$ EC
13. Chang (2010)	China	1981-2006	Cointegration and VECM	Carbon emissions	GDP $\rightarrow$ EC
14. Bartleet and Gounder (2010)	New Zealand	1960-2004	Bounds test and Granger causality	Employment	GDP $\rightarrow$ EC

Table 4.1: Summary of Empirical Studies on Energy Consumption-Growth Nexus during 2000-2016, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
15. Loganathan and Subramaniam (2010)	Malaysia	1971-2008	ARDL and ECM		EC ↔ GDP
16. Alam et al. (2011)	India	1971-2006	Granger causality	Carbon emissions, gross fixed capital formation and labour force	GDP ≠ EC
17. Wang et al. (2011)	China	1972-2006	Cointegration and ARDL	Capital, labour	EC → GDP
18. Dagher and Yacoubian (2012)	Lebanon	1980-2009	Hsiao's Granger causality, Toda-Yamamoto and VECM		EC ↔ GDP
19. Jafari et al. (2012)	Indonesia	1971-2007	Toda-Yamamoto causality test	Carbon emissions, capital stock and urban population	GDP ≠ EC
20. Zhang and Xu (2012)	China	1995-2008	Cointegration and Granger causality	Price index and per capita sectoral value added	EC ↔ GDP
21. Ghosh and Kanjilal (2014)	India	1971-2008	ARDL, threshold cointegration and Toda-Yamamoto test	Urban population	EC → GDP
22. Kyophilavong et al. (2015)	Thailand	1971-2012	Cointegration, VECM and Granger causality	Trade openness	EC ↔ GDP
23. Alshehry and Belloumi (2015)	Saudi Arabia	1971-2010	Johansen Cointegration, and Granger causality	Energy price and carbon emissions	EC → GDP
24. Ahmad et al. (2016)	India	1971-2014	ARDL and VECM	Carbon emissions	EC ↔ GDP
25. Tang et al. (2016)	Vietnam	1971-2011	Toda-Yamamoto causality test	Real domestic investment and FDI	EC → GDP
Multi-country studies that included Thailand					
1. Masih and Masih (1998)	Thailand, Sri Lanka	1955-1991	Cointegration and VECM	Prices (CPI)	EC → GDP
2. Asafu-Adjaye (2000)	India, Indonesia, Philippines, Thailand	1973-1995 1971-1995	Cointegration and Granger causality	Energy price	EC → GDP EC ↔ GDP

Table 4.1: Summary of Empirical Studies on Energy Consumption-Growth Nexus during 2000-2016, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
3. Chiou-Wei et al. (2008)	Asian newly industrialised countries, including Thailand and the US	1954-2006	Granger causality		GDP $\neq$ EC (US, Thailand, South Korea) GDP $\rightarrow$ EC (Philippines and Singapore) EC $\rightarrow$ GDP (Taiwan, Hong Kong, Malaysia and Indonesia)
4. Lee and Chang (2008)	16 Asian countries, including Thailand	1971-2002	Panel cointegration and ECM	Real gross fixed capital formation and labour force	EC $\rightarrow$ GDP
5. Narayan and Smyth (2008)	G7 countries	1972–2002	Panel cointegration and Granger causality test	Real gross fixed capital formation	EC $\rightarrow$ GDP
6. Akkemik and Goksal (2012)	79 countries, including Thailand	1980-2007	Panel cointegration and Granger causality test	Gross fixed capital formation and labour force	EC $\leftrightarrow$ GDP (57 countries including Thailand) GDP $\neq$ EC (7 countries) EC $\rightarrow$ GDP (6 countries) GDP $\rightarrow$ EC (9 countries)
7. Kahsai et al. (2012)	40 Sub-Saharan countries	1980-2007	Panel cointegration and ECM	Energy price	GDP $\neq$ EC (in short-run) EC $\leftrightarrow$ GDP (in long-run)
8. Nasreen and Anwar (2014)	15 Asian countries, including Thailand	1980-2011	Panel cointegration, FMOLS, DOLS and panel VECM causality	Trade openness and energy price	EC $\leftrightarrow$ GDP

Table 4.1: Summary of Empirical Studies on Energy Consumption-Growth Nexus during 2000-2016, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
9. Yildirim et al. (2014)	Indonesia, Malaysia, the Philippines, Singapore and Thailand	1971-2009	Bootstrap corrected panel, Toda–Yamamoto and the Hacker–Hatemi-J causality test	Gross capital formation and total labour force	GDP → EC (Indonesia, Malaysia, Philippines, Thailand) GDP ≠ EC (Singapore)
10. Azam et al. (2015)	Indonesia, Malaysia, the Philippines, Singapore and Thailand	1980-2012	Cointegration and Granger causality	Gross fixed capital formation and exports	GDP → EC (Malaysia) GDP ≠ EC (Indonesia, Philippines, Singapore, Thailand)
11. Fang and Chang (2016)	16 countries in Asia Pacific region, including Thailand	1970-2011	Panel cointegration, FMOLS and bootstrap panel Granger causality test	Human capital, labour and physical capital	GDP → EC (in the region) GDP → EC (Australia, Philippines) EC ↔ GDP (India) EC → GDP (Korea, Pakistan, Taiwan)

Note: Abbreviations are defined as follows:

1. EC = Energy Consumption and GDP = Economic Growth.
2. EC ↔ GDP denotes bi-directional causality exists between energy consumption and growth.
3. GDP ≠ EC denotes no causality exists between growth and energy consumption.
4. EC → GDP denotes causality runs from energy consumption to growth.
5. GDP → EC denotes causality runs from economic growth to energy consumption.

In addition to the studies outlined in Table 4.1 on the causal relationship between energy consumption and growth, there are some other studies on the energy- growth nexus which apply difference methodologies and analyse different aspects of linkage between energy consumption and economic growth, such as Fallahi (2011), Kocaaslan (2013), Aslan et al. (2014), and Menegaki and Tugcu (2016). By applying Markov-switching vector autoregressive (MS-VAR) models to US data for the period 1960-2005, Fallahi (2011) concludes that there is a bidirectional Granger causality between GDP and energy use in the first regime, whilst there is no evidence of Granger causality between the variables in the second regime. The finding of Fallahi (2011) has been supported partially by Kocaaslan (2013), who uses a similar technique and finds unidirectional causality running from energy consumption to output growth in a recession period of the US economy. However, his findings differ from Fallahi (2011) as his results reveal different significant causality relationships among the related variables across different regimes. For sub-Saharan countries, Menegaki and Tugcu (2016) reinvestigate the relationship between energy use and economic growth by using the index of sustainable economic welfare growth (ISEW) as a proxy for sustainable income instead of GDP for the period of 1985-2013. The results show the evidence of the feedback hypothesis when the ISEW is used in place of GDP, while the neutrality hypothesis is found when the GDP is used as an indicator of income. Apart from these surveys, many recent studies have extended the attention from the energy-growth nexus to different types of energy, including electricity consumption, renewable energy consumption and nuclear consumption. For example, Yoo (2006) uses the Hsiao Granger-causality test to investigate the causal relationship between electricity consumption and economic growth in Indonesia, Malaysia, Singapore and Thailand during 1971-2002 data span. His findings reveal the feedback relationship between the series in Malaysia and Singapore, while there is unidirectional causality running from economic growth to electricity consumption in Thailand and Indonesia. Contrastingly, Chen et al. (2007) find no evidence of causality in Thailand and Singapore. Wolde-Rufael (2010) uses bounds testing and Toda and Yamamoto approach to test the existence of causality between nuclear energy consumption and economic growth in India. His results indicate a significant unidirectional causality running from nuclear energy consumption to economic growth. The relationship between natural gas consumption and economic development in China and Japan was studied by Furuoka (2016). The VECM results show unidirectional causality running from natural gas consumption to economic development in China, while there is feedback causality in Japan.

Overall, the review of existing previous studies on the relationship between energy consumption and economic growth illustrate inconsistent results as regards to the methods used and the period under investigation. In addition, the differences in results can also come from the different measures of energy consumption, such as oil, electricity or fossil fuel consumption. Aforementioned literatures show that several researches have included Thailand in their panel analyses, though Kyophilavong et al. (2015) is the only time series empirical paper on this topic which reveals conflicting result with the panel estimations. To illuminate these unclear findings, we re-examine the direction of the relationship between energy consumption and economic growth as a specific country study. However, this study differs from Kyophilavong et al. (2015) as we incorporating financial development in the extended Cobb-Douglas production function, while Kyophilavong et al. (2015) apply trade openness. In this chapter, we will use overall energy consumption measured by kilogram (kg) of oil equivalent per capita to neutralise the effect of different proxies of energy consumption and examine the direction, as well as the role of energy consumption on economic growth following Kyophilavong et al. (2015), and Shahbaz et al. (2017).

4.2.2 The Economic Growth and Financial Development Nexus

Although there are numerous existing studies on the relationship between financial development and economic growth for many specific countries or country groups, the direction of causality is still inconclusive. The findings in economic literature have categorised the causality between financial development and economic growth into four different hypotheses, as concluded by Nyasha and Odhiambo (2018). These are (i) the finance-led growth hypothesis, financial deepening and economic growth or the supply-leading hypothesis, (ii) the growth-led finance hypothesis or the demand-following hypothesis, (iii) the feedback hypothesis or the bi-directional causality view, and (iv) the neutrality hypothesis. The details of these hypotheses and empirical studies are summarised below and in Table 4.2.

(1) The "finance-led growth hypothesis, financial deepening and economic growth or the supply-leading hypothesis"

This view states that financial development promotes economic growth by acting as a productive input. Financial development increases savings and facilitates capital accumulation so that the investment and growth expand. This view was first proposed by

Schumpeter (1911), who posits that the basic services of financial systems play a vital role in encouraging technological innovation and economic growth. This argument was supported by McKinnon (1973) and Shaw (1973), who point out that any government restrictions on financial systems not only hamper financial development but also lessen the growth of output. Samargandi et al. (2014) state that this view has been supported theoretically and empirically by plenty of studies. For instance, King and Levine (1993) reveal that financial development is a good predictor of economic growth in 80 selected countries. Arestis et al. (2001) disclose that banking system development is more powerful than the stock market in terms of promoting economic growth in France, Germany and Japan, while in the US and the United Kingdom find no long-run causality runs from banking system development and real GDP. Christopoulos and Tsionas (2004) also indicate significant long-run causality running from financial development to economic growth in 10 developing countries. However, this study incorporates only capital formation as a growth determinant variable in the model. Additional support for this view can also be found in the empirical study by Abu-Bader and Abu-Qarn (2008), who apply the vector autoregressive methodology of Toda and Yamamoto to assess the Granger causality between financial development and economic growth for 6 Middle Eastern and North African (MENA) countries. The authors employ four different measures of financial development: the ratio of money stock (M2) to nominal GDP; the ratio of M2 minus currency to GDP; the ratio of bank credit to the private sector to nominal GDP; and the ratio of credit issued to nonfinancial private firms to total domestic credit (excluding credit to banks). The empirical results strongly support the finance led growth hypothesis in five out of the six countries. Moreover, there are several empirical studies which are consistent with this view, includes studies such as Fase and Abma (2003) of 9 emerging countries including Thailand, Habibullah and Eng (2006) for 13 Asian countries including Thailand, Bittencourt (2012) for 4 Latin American countries, Hsueh et al. (2013) for Malaysia, Indonesia, Korea, Singapore, Thailand, Taiwan and China, and Bhattarai (2015) for advanced and emerging economies. Similar results also found in single country studies by Kargbo and Adamu (2009) for Sierra Leone, Masih et al. (2009) for Saudi Arabia and Sehrawat and Giri (2015) for India.

(2) The "growth-led finance hypothesis or the demand-following hypothesis"

This argument was explained by Robinson (1952) and Kuznets (1955), who said that economic growth stimulates financial development. This implies that expansion in the real sector of the economy generates demand for financial services and thereby more financial instruments and financial institutions emerge in the market in response to higher demand for financial services. This view has been supported by Boulila and Trabelsi (2004), who utilise cointegration and Granger causality to examine the causality between financial development and economic growth in 16 MENA countries during 1960-2002. The results indicate the causality runs from the real sector to the financial sector. Hassan et al. (2011) find the causality runs from growth to finance in East Asia and the Pacific and sub-Saharan Africa. In addition, empirical support for this view can be found in the country specific studies by Liang and Jian-Zhou (2006), who examine the association between financial development and economic growth in China. They utilise the multivariate vector autoregressive (VAR) approach and find a unidirectional relationship going from economic growth to financial development. Ang and McKibbin (2007) apply the multivariate cointegration technique to study the finance-growth association by incorporating the real interest rate and financial repression into the model. The authors conclude that economic growth leads to higher financial development in the long-run in Malaysia. The studies of Odhiambo (2008, 2010), and Akinci et al. (2014) also provide an empirical support of this view.

(3) The "feedback hypothesis or the bi-directional causalities"

The feedback hypothesis explains that there is a mutual or two-way causal relationship between financial development and economic growth. One of the earliest contributions to this view is Patrick (1966), who points out that the stages of the development process identified the causal relationship between financial development and economic growth. That is, a supply-leading financial pattern prevails in the early stage of economic development as the causality runs from financial development to economic growth, whereas a demand-following financial pattern prevails in the later stages as the reversed direction of causality. This implies that both financial and real sectors correspond to each other. This view has been supported by Al-Yousif (2002), who employs the Granger-causality test to examine the relationship between financial development and economic growth in 30 developing countries. He concludes that there is strong support for bidirectional causality between financial development and economic growth from both time-series and panel data analysis. Chuah et al. (2004) examine the causal relationship between financial development and economic growth in the six countries of the Gulf Cooperation Council (GCC). They utilise ECM and the VAR framework and find a bidirectional relationship in five countries. In addition, this view has also been empirically confirmed by time series studies on a selection of countries, such as Majid (2007), who utilises the ARDL and VECM technique to examine the short- and long-run relationships between financial development and economic growth in Thailand in aftermath of the 1997 financial crisis. His finding reveals the bidirectional causality between financial development and economic growth. Wolde-Rufael (2009), who applies the quadvariate vector autoregressive (VAR) framework and Granger causality technique to the Toda Yamamoto test with four proxies of financial development. His finding indicates evidence in Kenya of a bidirectional causality between economic growth and three proxies of financial development: domestic credit provided by the banking sector; total domestic credit provided by the banking sector; and liquid liabilities. Al-Malkawi et al. (2012) investigate the causality between economic growth and two proxies of financial development: broad money supply (M2) to GDP; and the ratio of credit provided to private sector by financial intermediaries as a percentage of GDP. Their results reveal only a bidirectional linkage between the broad money supply (M2) to GDP and economic growth in UAE. Moreover, there are several empirical studies which are consistent with this view, including studies such as Apergis et al. (2007) of 15 OECD and 50 non-OECD countries, Bangake and Eggoh (2011) in 71 developed and developing countries, Abduh and Azmi Omar (2012) in Indonesia, and Shahbaz and Rahman (2012) in Pakistan.

(4) The "neutrality hypothesis"

This hypothesis postulates that there is no causal relationship between financial development and economic growth. Hence, financial development and economic growth are independent and not causally related. This view was originally proposed by Lucas (1988), who explains that the importance of financial factors in activating economic growth is overstressed. In addition, Chandavarkar (1992) cited in Majid (2007) notes that "none of the pioneers of the development economics…even list finance as a factor of development". Empirically, this view has been supported by Shan and Morris (2002), who state that no clear correlation exists between financial development and economic growth or between financial development and investment and productivity growth in 19 OECD countries. Similar results have been found by Menyah et al. (2014), who examine the causal relationship between financial development and economic growth in 21 African countries. They develop four proxies of financial development and employ the panel bootstrap technique to Granger causality. The findings indicate no evidence of causality between financial development and economic growth in 16 out of 21 countries. Additional supported for this view can be found in the single-country studies by Duarte et al. (2017), who utilise the ARDL model and the ECM Granger causality technique to examine the short- and long-run relationship between foreign direct investment, economic growth and financial development in Cabo Verde during 1987-2014. The results indicate that even though domestic credit to the private sector has a negative relationship with economic growth in the long-run, there is no causality that exists between these two variables.

Overall, the review of existing previous studies on the relationship between financial development and economic growth reveal conflicting results due to the methods used and the period under investigation. In addition, the differences in results can also come from the different proxies of financial development, such as ratio of total bank deposits liabilities to nominal GDP, ratio of liquid liabilities to GDP (M3/GDP), ratio of deposit money bank assets to GDP, ratio of private domestic credit to GDP or ratio of broad money (M2) to nominal GDP. In this chapter, we will use domestic credit to the private sector as a share of GDP as a proxy of financial development to investigate the effect and direction of the relationship between financial development and economic growth following Arestis et al. (2001), Apergis et al. (2007), Kargbo and Adamu (2009), and Bangake and Eggoh (2011).

The above existing literatures show that there is a lack of country-specific study on the finance-growth relationship in context of Thailand. Majid (2007) is the only research that investigated the finance-growth nexus in Thailand as country-specific study but this study uses dataset only after 1997 financial crisis. So, his result about the role of financial development on Thai economy might be overstated. Therefore, it is of interest to examine the type of causality exist in finance-growth nexus because the accurate knowledge about the relationship of financial development and economic growth can be a guideline for policymakers to launch a sound financial policy that will not hamper economic growth of the nation.

Table 4.2: Summary of Empirical Studies on Finance-Growth Nexus during 2000-2017

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
Country-specific studies					
1. Liang and Jian-Zhou (2006)	China	1952-2001	Multivariate VAR	Real per capital fixed capital formation, real interest rate, trade ratio (2 proxies of financial development)	GDP $\rightarrow$ FD
2. Ang and McKibbin (2007)	Malaysia	1960-2001	Cointegration, causality tests, VECM	Real interest rate, financial repression (3 proxies of financial development)	GDP $\rightarrow$ FD
3. Majid (2007)	Thailand	1998:1 -2006:4	ARDL, Granger causality tests, VECM	Share of investment, inflation	FD $\leftrightarrow$ GDP
4. Odhiambo (2008)	Kenya	1969-2005	Cointegration, Granger causality tests, ECM	Savings	GDP $\rightarrow$ FD
5. Kargbo and Adamu (2009)	Sierra Leone	1970-2008	ARDL, causality test	Ratio of gross fixed capital formation to nominal GDP, real deposit rate (3 proxies of financial development)	FD $\rightarrow$ GDP
6. Masih et al. (2009)	Saudi Arabia	1985-2004	Long-run structural modelling, VECM	Real interest rate, export	FD $\rightarrow$ GDP
7.Wolde-Rufael (2009)	Kenya	1966-2005	VAR, Toda-Yamamoto causality test	Real export, real import (4 proxies of financial development)	FD $\leftrightarrow$ GDP
8. Odhiambo (2010)	South Africa	1969-2006	ARDL bound testing and Granger causality	Ratio of private investment to GDP (3 proxies of financial development)	GDP $\rightarrow$ FD
9. Abduh and Azmi Omar (2012)	Indonesia	2003:1-2010:2	ARDL, ECM	Gross fixed capital formation	FD $\leftrightarrow$ GDP
10. Al-Malkawi et al. (2012)	United Arab Emirates	1974-2008	ARDL, VECM	Inflation, trade openness, government expenditure (2 proxies of financial development)	FD $\leftrightarrow$ GDP

Table 4.2: Summary of Empirical Studies on Finance-Growth Nexus during 2000-2017, Continued

Author/Year	**Countries**	**Time Period**	**Methods**	**Extra variables**	**Findings**
11. Shahbaz and Rahman (2012)	Pakistan	1990:1-2008:4	ARDL bound testing, VECM	Real FDI, real import	FD ↔ GDP
12. Sehrawat and Giri (2015)	India	1982-2012	ARDL and cointegration	Trade openness, call money rate, CPI	FD → GDP
13. Faisal et al. (2016)	China	1999:1-2015:1	ARDL, VECM	Stock prices, FDI	GDP ≠ FD
14. Duarte et al. (2017)	Cabo Verde	1987-2014	ARDL, ECM	FDI inflow, inflation (2 proxies of financial development)	GDP ≠ FD
Multi-country studies					
1. Arestis et al. (2001)	5 developed economies	Germany: 1973:1-1997:4 The US: 1972:2-1998:1 Japan: 1974:2-1998:1 United Kingdom: 1968:2-1997:4 France: 1974:1-1998:1	VAR and VECM	Ratio of stock market value to GDP, the stock market volatility	FD → GDP (France, Germany and Japan) GDP ≠ FD (US and UK)
2. Al-Yousif (2002)	30 developing countries, include Thailand	1970-1999	Granger-causality test and ECM	(2 proxies of financial development)	FD ↔ GDP
3. Fase and Abma (2003)	9 emerging countries, include Thailand	1978-1999	Granger-Sims causality test, ECM	Capital investment	FD → GDP
4. Boulila and Trabelsi (2004)	16 MENA countries	1960-2002	Cointegration and Granger causality	(3 proxies of financial development)	GDP → FD
5. Christopoulos and Tsionas (2004)	10 developing countries, include Thailand	1970-2000	Panel cointegration, VECM and FMOLS	Gross fixed capital formation, inflation	FD → GDP

Table 4.2: Summary of Empirical Studies on Finance-Growth Nexus during 2000-2017, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
6. Chuah et al. (2004)	6 GCC countries	1973-2002	VAR and ECM	(2 proxies of financial development and 5 proxies of economic growth)	FD → GDP (Qatar) FD ↔ GDP (5 countries)
7. Habibullah and Eng (2006)	13 Asian countries, include Thailand	1990-1998	GMM		FD → GDP
8. Apergis et al. (2007)	15 OECD and 50 non-OECD, include Thailand	1975-2000	Panel cointegration and pooled mean group	Human capital, gross capital formation, government expenditure, trade openness (3 proxies of financial development)	FD ↔ GDP
9. Abu-Bader and Abu-Qarn (2008)	6 MENA countries	1960-2004	VAR and Toda-Yamamoto causality test	Share of gross fixed capital formation in GDP, share of government expenditures in GDP (4 proxies of financial development)	FD → GDP (Algeria, Egypt, Morocco, Syria, Tunisia) GDP → FD (Israel)
10. Bangake and Eggoh (2011)	71 developed and developing countries, include Thailand	1960-2004	Panel cointegration, dynamic OLS and VECM	Government expenditure, trade openness (3 proxies of financial development)	FD ↔ GDP
11. Hassan et al. (2011)	6 regions and High-income OECD and non-OECD countries	1980-2007	VAR and Toda-Yamamoto causality	Government expenditure, ratio of trade to GDP, inflation (4 proxies of financial development)	FD ↔ GDP (all regions except Sub-Saharan Africa and East Asia & Pacific) GDP → FD (East Asia & Pacific, Sub-Saharan Africa)
12. Bittencourt (2012)	4 Latin America	1980-2007	Fixed effects with instrumental variables and pooled estimators	Government's share in real GDP, ratio of exports and imports to real GDP, ratio of investment to real GDP, macroeconomic instability (4 proxies of financial development)	FD → GDP

Table 4.2: Summary of Empirical Studies on Finance-Growth Nexus during 2000-2017, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
13. Hsueh et al. (2013)	10 Asian countries	1980-2007	Bootstrap panel Granger causality	(4 proxies of financial development)	FD $\rightarrow$ GDP (Malaysia, Indonesia, Korea, Singapore, Thailand, Taiwan, China) GDP $\neq$ FD (the Philippines, India, Japan)
14. Akinci et al. (2014)	OECD countries	1980-2011	Pedroni and Kao cointegration and Granger causality	(4 proxies of financial development)	GDP $\rightarrow$ FD
15. Menyah et al. (2014)	21 SSA countries	1965-2008	Bootstrap panel causality	Trade openness (4 proxies of financial development)	FD $\rightarrow$ GDP (Benin, Sierra Leone, South Africa) GDP $\rightarrow$ FD (Nigeria) FD $\leftrightarrow$ GDP (Zambia) GDP $\neq$ FD (16 countries)
16. Omri et al. (2015)	12 MENA countries	1990-2011	Panel cointegration and GMM	Carbon emissions, gross fixed capital formation, total trade to GDP, urban population, FDI and CPI	FD $\leftrightarrow$ GDP (Algeria, Egypt, Iran, Jordan, Morocco, Tunisia) GDP $\neq$ FD (Bahrain, Kuwait, Oman, Syria) GDP $\rightarrow$ FD (Saudi Arabia, Qatar)

Note: Abbreviations are defined as follows:

1. FD = Financial Development and GDP = Economic Growth.
2. FD $\leftrightarrow$ GDP denotes bi-directional causality exists between financial development and growth.
3. GDP $\neq$ FD denotes no causality exists between growth and financial development.
4. FD $\rightarrow$ GDP denotes causality runs from financial development to growth.
5. GDP $\rightarrow$ FD denotes causality runs from economic growth to financial development.

4.2.3 The Economic Growth, Energy Consumption and Financial Development Nexus

In recent years, several existing literatures have appeared incorporating financial development indicators into the energy-growth nexus. These try to identify the direction of causality between these variables. As presented in Table 4.3, the findings of these studies contradict to each other. There is no consensus either on the existence or the direction of causality among these variables. For instance, in the case of country-specific studies, Chtioui (2012) studies the causal link between energy consumption, financial development and growth in Tunisia by employing Johansen cointegration and VECM techniques to the model for the period of 1972-2010. The findings suggest a bidirectional relationship between energy consumption and growth as well as unidirectional causality running from energy consumption to financial development, while there is absence of any causality between financial development and economic growth. However, Shahbaz and Lean (2012) apply ARDL bound testing and the VECM method with Tunisian data for the period of 1971-2008. They detect a unidirectional causality from energy consumption and financial development to growth but only in the short-run. Also, the researchers find a feedback effect between financial development and energy consumption. Islam et al. (2013) and Tang and Tan (2014) use bound testing and VECM framework to Malaysian economy. They detect not only a bidirectional causality between energy use and economic growth but also a unidirectional causality existing from financial development to economic growth in the long-run. While Islam et al. (2013) report a unidirectional causality from financial development to energy consumption in the short-run and converse causality in the long-run, Tang and Tan (2014) find a bidirectional relationship between financial development and energy consumption. These contrasting results might be due to use of different additional variables in their regression. Additional studies on this topic also found by Shahbaz et al. (2013a) for China, Shahbaz et al. (2013b) for Indonesia, Boutabba (2014) for India, Destek (2015) for Turkey, Kumar et al. (2015) for South Africa, Sehrawat et al. (2015) for India, Magazzino (2018) for Italy, and Ouyang and Li (2018) for China. Moreover, Pao and Tsai (2011), and Al-mulali and Sab (2012) are the multi-country studies that provide evidences of a causality relationship between these variables.

In addition to the existing studies presented in Table 4.3 on the causality between energy consumption, financial development and economic growth, there are some other research papers on this issue, such as Jalil and Feridun (2011) on China, Mahalik and Mallick

(2014) on India, Chang (2015) on non-high income, high-income and higher income countries, Komal and Abbas (2015) on Pakistan, Rafindadi and Ozturk (2016) on post-Fukushima Japan, and Shahbaz et al. (2017) on India, which apply different methodologies and analyse different aspects of the relationship between energy use, financial development and economic growth. For instance, Komal and Abbas (2015) use the GMM technique to detect the indirect effect of financial development on energy consumption through economic growth channels in Pakistan during 1972-2012. They explore the impact among the series but do not test for any causality. The results not only find a positive and significant impact of economic growth on energy consumption, but also positively and significantly effects of financial development on economic growth and energy consumption. Shahbaz et al. (2017) using multivariate nonlinear autoregressive distributed lag (ARDL) bounds testing to capture the cointegration and use the asymmetric causality test developed by Hatemi-J (2012) to analyse the direction of the asymmetric causal relationship between energy consumption and economic growth in India. They have incorporated financial development into a production function and use quarterly data from 1960 to 2015. The findings indicate only negative shocks to energy consumption have impacts on economic growth and only negative shocks to financial development have impacts on economic growth.

For a multi-country study, Chang (2015) examines the nonlinear impacts of financial development and income on energy consumption for a panel of 53 countries over the period 1999-2008. He includes energy prices in a multivariate framework, uses 5 proxy for financial development indicators and applies a panel threshold regression approach. The findings report that energy consumption increases with financial development when both private and domestic credits are used as financial development indicators in the non-high income regime. However, in high-income countries, energy consumption marginally decreases with financial development when the value of traded stocks and stock market turnover are used as proxies of financial development, but it increases in the higher income countries of emerging market and developing countries.

Table 4.3: Summary of Empirical Studies Incorporating Financial Development to the Energy-Growth Nexus

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
Country-specific studies					
1. Chtioui (2012)	Tunisia	1972-2010	Johansen cointegration, VECM	Carbon dioxide emissions	EC $\leftrightarrow$ GDP (in long-run) FD $\neq$ GDP (in long-run) EC $\rightarrow$ FD (in long-run)
2. Shahbaz and Lean (2012)	Tunisia	1971-2008	ARDL bound testing, VECM	Industrial value added as share of GDP, ratio of urban population to total population	EC $\rightarrow$ GDP (in short-run) FD $\rightarrow$ GDP (in short-run) FD $\leftrightarrow$ EC
3. Islam et al. (2013)	Malaysia	1971-2009	ARDL bound testing, VECM	Total population	EC $\leftrightarrow$ GDP FD $\rightarrow$ GDP (in long-run) FD $\rightarrow$ EC (in short-run) EC $\rightarrow$ FD (in long-run)
4. Shahbaz et al. (2013a)	China	1971-2011	ARDL bound testing, VECM	Real export, real import, real capital use	EC $\rightarrow$ GDP FD $\leftrightarrow$ GDP FD $\leftrightarrow$ EC
5. Shahbaz et al. (2013b)	Indonesia	1975:1-2011:4	ARDL bound testing, VECM	Trade openness	EC $\leftrightarrow$ GDP FD $\rightarrow$ GDP (in short-run) FD $\neq$ EC
6. Boutabba (2014)	India	1971-2008	ARDL bound testing, VECM	Carbon emissions, trade openness	GDP $\rightarrow$ EC FD $\neq$ GDP FD $\rightarrow$ EC
7. Tang and Tan (2014)	Malaysia	1972-2009	Johansen cointegration, Bound testing and ECM	Relative price of energy to non-energy goods, per capita real FDI	EC $\leftrightarrow$ GDP FD $\rightarrow$ GDP FD $\leftrightarrow$ EC
8. Destek (2015)	Turkey	1960-2011	Maki cointegration, FMOLS, VECM	Energy price, trade openness	EC $\leftrightarrow$ GDP (in long-run) FD $\rightarrow$ GDP (in short-run) FD $\rightarrow$ EC (in short-run)
9. Kumar et al. (2015)	South Africa	1971-2011	ARDL bound testing, Bayer and Hanck cointegration, Toda-Yamamoto causality test	Trade openness, gross fixed capital formation	EC $\rightarrow$ GDP FD $\neq$ GDP FD $\neq$ EC

Table 4.3: Summary of Empirical Studies Incorporating Financial Development to the Energy-Growth Nexus, Continued

Author/Year	Countries	Time Period	Methods	Extra variables	Findings
10. Sehrawat et al. (2015)	India	1971-2011	ARDL bound testing, VECM	Per capita carbon dioxide emissions, percentage of urban population of total population, trade openness	EC $\neq$ GDP FD $\rightarrow$ GDP FD $\neq$ EC
11. Magazzino (2018)	Italy	1960-2014	ARDL bound testing, Toda and Yamamoto causality tests and Granger causality tests	Oil price	GDP $\rightarrow$ EC FD $\rightarrow$ EC No test on FD and GDP
12. Ouyang and Li (2018)	China (eastern region, central region, and western region)	1996:1-2015:4	GMM panel VAR, Granger causality test		EC $\rightarrow$ GDP (central and eastern) EC $\leftrightarrow$ GDP (western) GDP $\rightarrow$ FD (eastern and western) FD $\rightarrow$ GDP (central) EC $\rightarrow$ FD (central) FD $\leftrightarrow$ EC (eastern) FD $\neq$ EC (western)
Multi-country studies					
1. Pao and Tsai (2011)	BRIC countries; Brazil, Russian Federation, India, and China	1980-2007, except for Russia (1992-2007)	1. Panel cointegration: Pedroni, Kao and Fisher tests 2. VECM	Per capita carbon dioxide emissions	EC $\rightarrow$ GDP GDP $\rightarrow$ FD EC $\rightarrow$ FD
2. Al-mulali and Sab (2012)	19 countries, include Thailand	1980-2008	1. Panel cointegration: Pedroni 2. VECM	Per capita carbon dioxide emissions	EC $\rightarrow$ GDP EC $\rightarrow$ FD No test on FD and GDP

Note: Abbreviations are defined as follows:

1. EC = Energy Consumption, FD = Financial Development and GDP = Economic Growth.
2. EC $\leftrightarrow$ GDP denotes bi-directional causality exists between energy consumption and growth.
3. EC $\neq$ GDP denotes no causality exists between energy consumption and growth.
4. EC $\rightarrow$ GDP denotes causality runs from energy consumption to growth.
5. GDP $\rightarrow$ EC denotes causality runs from economic growth to energy consumption.

6. FD $\longleftrightarrow$ GDP denotes bi-directional causality exists between financial development and growth.
7. FD $\neq$ GDP denotes no causality exists between financial development and growth.
8. FD $\longrightarrow$ GDP denotes causality runs from financial development to growth.
9. GDP $\longrightarrow$ FD denotes causality runs from economic growth to financial development.
10. FD $\longleftrightarrow$ EC denotes bi-directional causality exist between financial development and energy consumption.
11. FD $\neq$ EC denotes no causality exists between financial development and energy consumption.
12. FD $\longrightarrow$ EC denotes causality runs from financial development to energy consumption.
13. EC $\longrightarrow$ FD denotes causality runs from energy consumption to financial development.

Obviously, the aforementioned studies do not fully represent the large body of literature on the energy-growth nexus and financial-growth nexus, but this review evidences that the results of existing studies diverge from one country to another, from one period to another and from one technique to another.

There are many concerns in the existing literature regarding the drawback in cross-sectional and panel data studies. Apergis et al. (2007) point out that the key weakness in the cross-sectional analysis is the lack of ability to discuss the integration and cointegration properties of the data. In addition, Levine and Zervos (1998), Arestis and Demetriades (1997), and Demetriades and Hussien (1996) as cited in Bangake and Eggoh (2011) also state that the issue of causality cannot be solved by cross country regressions. For the panel data framework, although it incorporates other determinants of growth to avoid potential biases regarding omitted variables, the conclusion of the long-run equilibrium might be misleading because panel data studies ignore the integration properties of their data. Hence, it is not clear whether the estimated panel models represent a long-run equilibrium relationship or a spurious one. This supports by Luintel and Khan (2004), who posit that the broad conclusions from panel results may present incorrect interpretation for many countries, industries or firms of the set of sample panel. Additionally, Luintel et al. (2008) state that panel and cross-section analyses disregard cross-country heterogeneity, which may limit the policy implications for some countries in the panel estimation. The time series studies are superior to the aforementioned analysis as they are able to identify the direction of causality and the nature of the $I(1)$ variables. However, academics still have to consider the reliability of standard tests and results from time series analysis due to the limitation of the small samples in the data sets. Although this is a drawback of time series studies, it is still crucial to investigate the relationship between energy consumption, financial development and economic growth on a country case basis. As the understanding of the finance-growth nexus and energy-growth nexus have significantly different implications for a country's development policy.

4.3 Overview of the variables

Before re-examines the relationship between energy consumption, financial development and economic growth in Thailand, this section summarises the overview of variables used in this chapter.

4.3.1 Gross Domestic Product (GDP)

Thailand is one of the most widely cited development success stories, with sustained strong growth and impressive reduction of poverty, particularly in the 1980s the growth rates were strong, averaging between 6 and 8 percent. In particular, between 1988 and 1990, as illustrated in Figure 4.2, Thailand experienced the peak of 12 percent growth annually (World Bank, 2017). This remarkable growth was made possible by several factors such as abundant natural resources, a large amount of labour, prudent fiscal policy and open policy for foreign investment. Consequently, this shifted the national economy from agriculture to export-oriented manufacturing and attracted much foreign direct investment. Therefore, Thailand was on its way to become a fifth tiger in the late 1980s after South Korea, Taiwan, Hong Kong and Singapore. Although there was a recession in the early 1990s and severe flooding in November 1995 decelerated the economy, Thailand was classified as a member of the Newly Industrialising Economies (NIEs) by the mid-1990s, according to the list of top computer and electronic parts exporters. However, the fast growth was interrupted by the Asian financial crisis of 1997-1998, followed by the effect of the global financial crisis of 2008-2009, the massive flooding in 2011 and the coups in 2006 and 2014, which resulted in a slowdown of average real GDP growth rate to 2.5 percent over 2011-2014 (ADB, 2015).

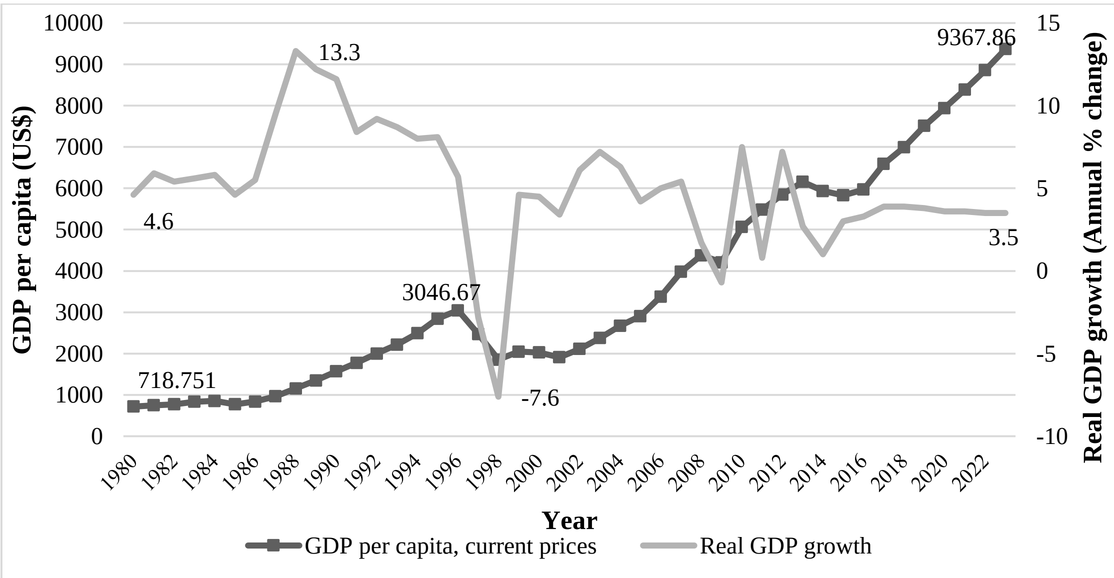

Figure 4.2: GDP per Capita and Real GDP Growth in Thailand

Source: IMF (2018)

Note: Predicted value after 2016

Over half a century, Thailand has made remarkable progress in social and economic development, transforming from a lower-middle income country to an upper-middle income country status in less than a generation. Thailand is now the second largest economy in the ASEAN following Indonesia and has the fourth highest GDP per capita in 2015 at US$ 5,775.14 following Malaysia (US$ 10,878.39), Brunei Darussalam (US$ 32,226.10) and Singapore (US$ 51,855.08) (World Bank, 2017). The rapid growth of the economy has led to a transformation from agriculture to the manufacturing and industry sectors. As presented in Figure 4.3, the share of agriculture in GDP has decreased from 23.92 percent in 1971 to 8.34 percent in 2016, while the contribution of industry and the service sectors in GDP has increased promptly from 27.05 and 49.02 percent in 1960 to 35.82 and 55.83 percent in 2016, respectively (World Bank, 2017). As a result, the volume of energy consumption has risen more than fivefold during 1971 to 2015 leading Thailand to face challenges concerning energy security, energy cost and the environment as Thailand is highly dependent on imported energy.

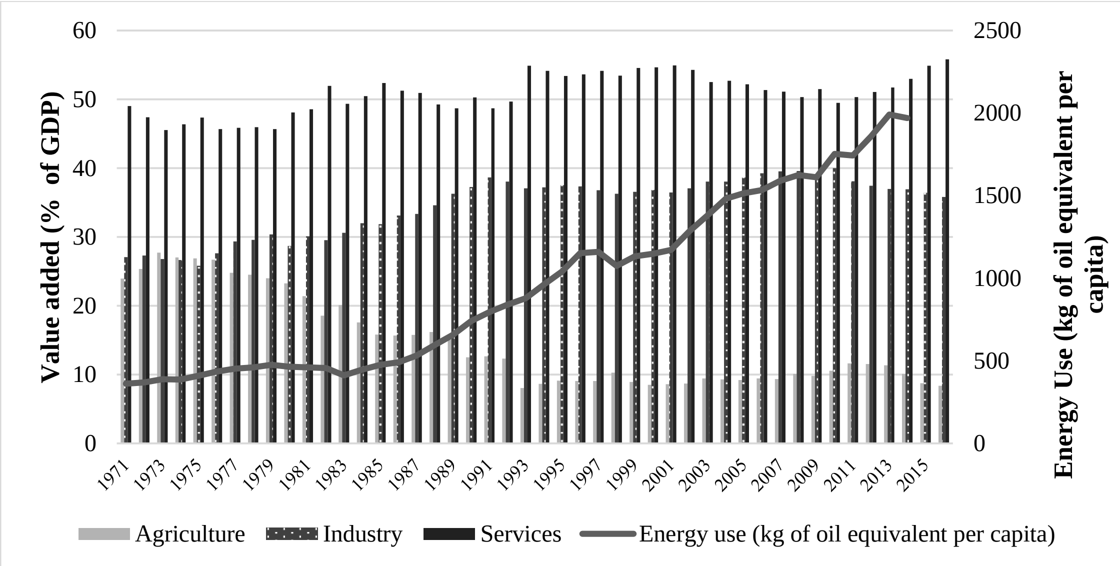

Figure 4.3: Thai Economy and Energy Use

Source: World Bank (2017)

World Bank (2019) defined gross domestic product as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. The expansion of goods and services in a nation can lead to higher consumption, increase in labour demand and high income of labour. This consequently implies an increase in GDP which is referred to as economic growth. Therefore, GDP is often used to measure the expansion in a nation's economy or economic growth. This study will use GDP per capita as a proxy of economic growth following Kahsai et al. (2012), Zhang and Xu (2012), Chang (2015), Destek (2015), and Menegaki and Tugcu (2016).

4.3.2 Energy Use in Thailand

Energy use in Thailand have increased substantially during 1990 to 2014. It rose from 741.28 kg. of oil equivalent per capita in 1990 to 1,969.63 kg. of oil equivalent per capita in 2014 as shown in Figure 4.4. This is in line with the increasing trend of energy intensity[8]. In term of energy intensity level of primary energy, Figure 4.5 shows that in 2014 Thailand's energy intensity was higher than the world average and many developed countries such as Japan, the European Union, OECD countries, United Kingdom and other high income economies. While the energy intensity of most countries on the list is declining, Thailand's energy intensity was increasing, and this may affect the economic competitiveness of Thailand in the future (World Bank, 2017).

Furthermore, Figure 4.4 depicts the inconsistency trend of energy use and GDP growth. That is energy intensity and energy use per capita in Thailand have increased trend during 1990-2014, while GDP growth fluctuated over that period. However, the historical data cannot explain accurate relationship between energy use and economic growth. It is of interest to investigate such relationship in Thailand context by using econometric analysis.

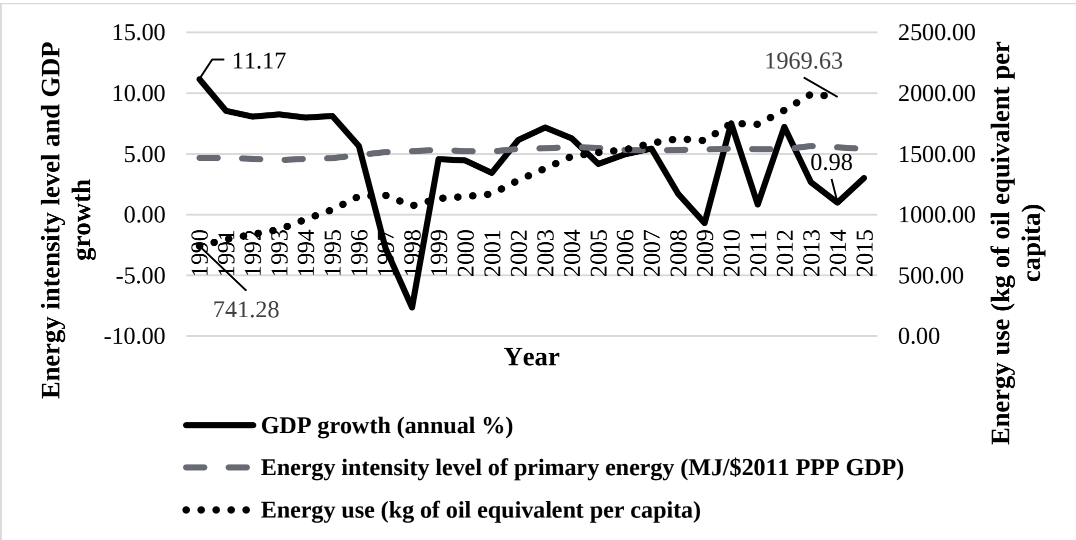

Figure 4.4: The Relationship between Thailand's Energy Intensity, Energy Use and GDP Growth

Source: World Bank (2019)

[8] Energy intensity is the ratio of the amount of energy used to produce one unit of economic output with a lower ratio indicating that less energy is used to produce one unit of output.

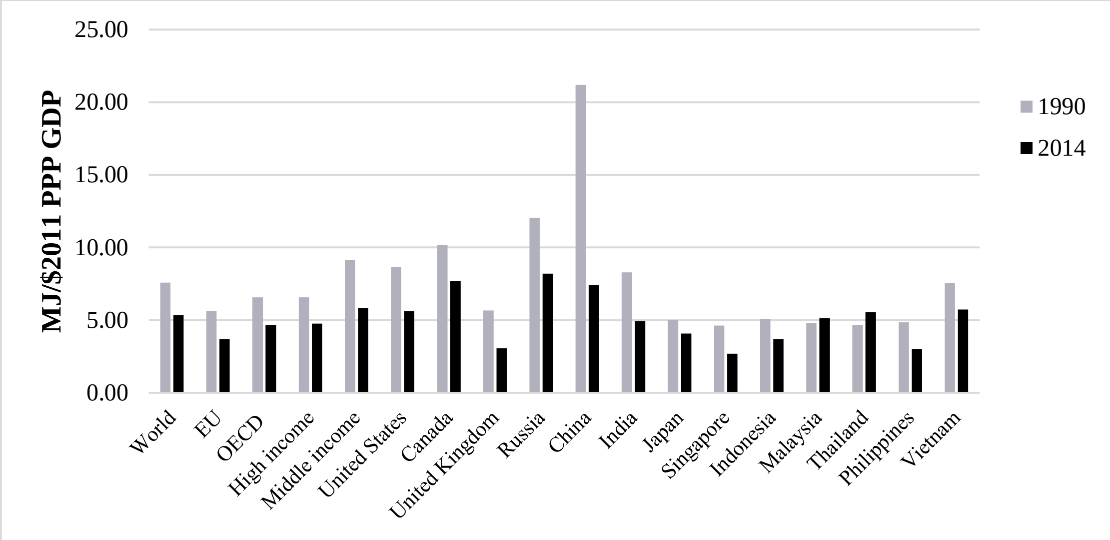

Figure 4.5: Energy Intensity Level of Primary Energy

Source: World Bank (2017)

In this chapter, we will use the overall energy consumption measured by kilogram (kg) of oil equivalent per capita to neutralise this effect following Kyophilavong et al. (2015) and Shahbaz et al. (2017).

4.3.3 Financial Development

The deregulation of Thailand's financial market and capital account liberalisation combined with the recession in European countries and stagflation of the Japanese economy during the 1990s led to enormous amounts of capital inflow from aboard to Thailand. Substantially, they were prime years for domestic investment and the banking sector. During 1990-1996, Thailand's investment rate ranged from 39.94 to 41.73 percent of GDP, which was in the first rank compared to the other countries in the same region, whereas the GDP growth was 8.08 to 8.94 percent (Laplamwanit, 1999). In addition, more than 50 banks and non-bank financial institutions were established. The early 1990s was a golden era for Thailand's banks as the banks could charge up to 4 percentage points more interest than they paid on deposits. As a result, they were ranked among the world's most profitable banks. Figure 4.6 illustrates that in 1997, the financial market in Thailand experienced its peak as domestic credit provided by the financial sector accounted for 178.42 percent of GDP and domestic credit to the private sector accounted for 166.50 percent of GDP. Unfortunately, a large amount of capital had been put into non-productive sectors, mainly real estate, and only small portion of the capital inflow had been distributed into real sectors. As a result, the Thai economy faced a severe credit crunch problem that led to financial crisis in 1997. The GDP growth hit its lowest rate, -7.63 percent, in 1998. As mentioned earlier, this illustrates the crucial role of the banking sector in Thailand's financial transactions, which possibly has a strong relationship with economic growth.

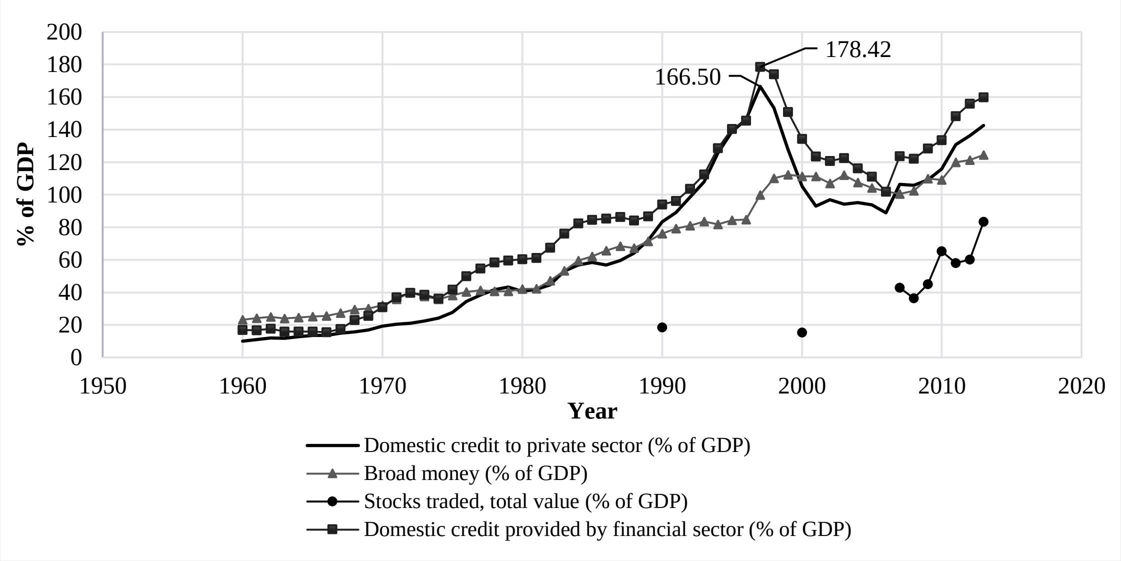

Figure 4.6: Thailand's Financial Development Indicators

Source: World Bank (2017)

There are several indicators of financial depth used in the empirical literature as a proxy for financial development. For instance, the ratio of broad money (M2) to GDP is how the World Bank defines as a standard measure of financial development. Khan and Qayyum (2006) argue that this ratio is more appropriate to measure the extent of monetarisation rather than financial development. Apart from this, the ratio of commercial bank assets divided by commercial bank plus central bank assets, liquid liabilities to GDP, ratio of narrow money to GDP, ratio of quasi money to income, and ratio of currency to M2 have been used as a proxy for financial development in the literature. However, the most widely suggested proxy for financial development in the literature is the financial intermediation ratio, which denotes the credit provided by financial intermediaries to the private sector as a percentage of GDP. Calderon and Liu (2003) state that this financial intermediation ratio is better than other proxies for financial development used in previous studies and more directly linked to investment and growth. Kargbo and Adamu (2009) also believed that the efficiency of resource allocation in the economy can be measured by the ratio of domestic credit to the private sector to GDP because this ratio excludes the public sector and considers the private sector as a more efficient and productive agent in utilising funds in comparison with the public sector. In other words, this measure represents more precisely the role of financial intermediaries in channelling funds to private participants in the market. Hence, this study will employ this proxy for financial development and expect the positive impact of this measure on economic growth as mentioned in Kargbo and Adamu (2009), Al-Malkawi et al. (2012), Chtioui (2012), Ozturk and Acaravci (2013), Destek (2015), and Sehrawat and Giri (2015).

4.3.4 Gross Fixed Capital Formation

The World Bank (2019) defines gross fixed capital formation as a gross domestic fixed investment that includes the value of land improvement, plant, machinery, and equipment purchases, and the construction of roads, railways and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

The annual gross fixed capital formation of Thailand has been varied for the past 50 years. According to Figure 4.7, the annual growth rate of gross fixed capital formation was more than 7 percent from 1961 to 2016 with the highest average growth at 15.15 percent during the boom period in the country from 1987 to 1996. At its peak in 1990, the annual gross fixed capital formation was 29.60 percent, whereas in 1998, gross fixed capital formation hit the lowest growth at -44.03 percent compared to the previous year as a result of the Asian financial crisis. The massive increase of gross fixed capital formation in Thailand at that time was due to the huge amount of investment, particularly from foreign investment. Phongpaichit (1996) reported that the average annual of net foreign direct investment inflow rose from THB 6.6 billion in 1980-1987 to THB 47.1 billion in 1988-1993. Coxhead (1998) indicates that the key drivers of the Thai economy becoming an ideal host for foreign investment in the 1980s were low wages, reductions in trade restrictions, conservative economic management and a stable exchange rate. Hence, during the 1990s Thailand had become the 9th largest exporter of computers and ranked as the 8th in terms of capital inflows among the developing countries, or 22nd in the world (Kunsabfueng, 2001).

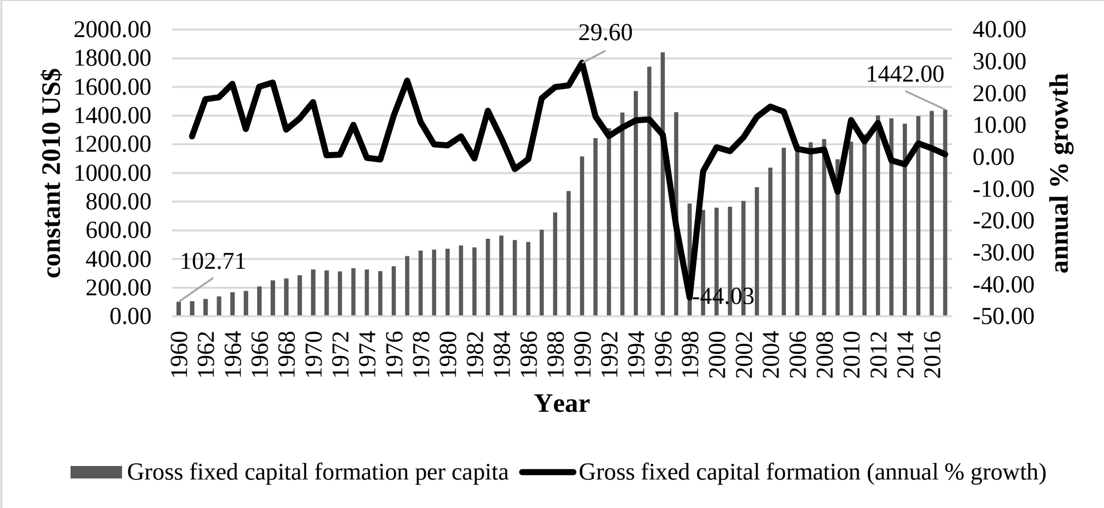

Figure 4.7: Gross Fixed Capital Formation in Thailand

Source: World Bank (2019)

This present study will employ gross fixed capital formation as a proxy for capital input in the production function following Paul and Bhattacharya (2004), Soytas et al. (2007), Alam et al. (2011), Akkemik and Goksal (2012), and Azam et al. (2015). This measure is expected to have a positive impact on economic growth.

4.3.5 Population

The population of Thailand was 69,183,175 as of 13 July 2018, based on the latest United Nations (2018) estimates. Its population is equivalent to 0.91 percent of the total world population and ranks twentieth in the list of countries by population size. During 1960 to 1982, the male population was greater than the female. Since then, the structure of population has changed and the female population is now higher than the male population as shown in Figure 4.8. Thailand's population is expected to reach 69.68 million by 2025 and about half of these people will be living in Bangkok, which is not only the capital but also the most populous city. The population density in Thailand has increased every year and is equal to 133.33 people per square kilometre in 2018, which ranks as the eighty-sixth in the world (IndexMundi, 2018). However, the population growth in Thailand has been as fast as in China, Singapore, Taiwan and South Korea and consistent with the trend of lower population growth in Asia, which started in the early 1970s. That is, Thailand's population in 1970 grew by 2.91 percent, in 1990 the figure was 1.40 percent and in 2017 just 0.25 percent. The reason for the slowing of population growth in Thailand can be explained by a few factors. First, there has been a decline in the birth rates in Thailand over the years, according to the World Bank (2019) which showed that the Thai birth rate dropped from around 42.74 per thousand people in 1961 to 19.22 per thousand people in 1990, then again to 10.33 per thousand people in 2016. This represents one of the most dramatic declines in birth rates in the world. Second, a growing number of people are not getting married or having children as they wish to be more independent. Third, the traditional role of women that ties them to the home has been changed; women study and have jobs. Finally, a smaller family is more compatible with working life and makes it easier to accommodate in complex living conditions.

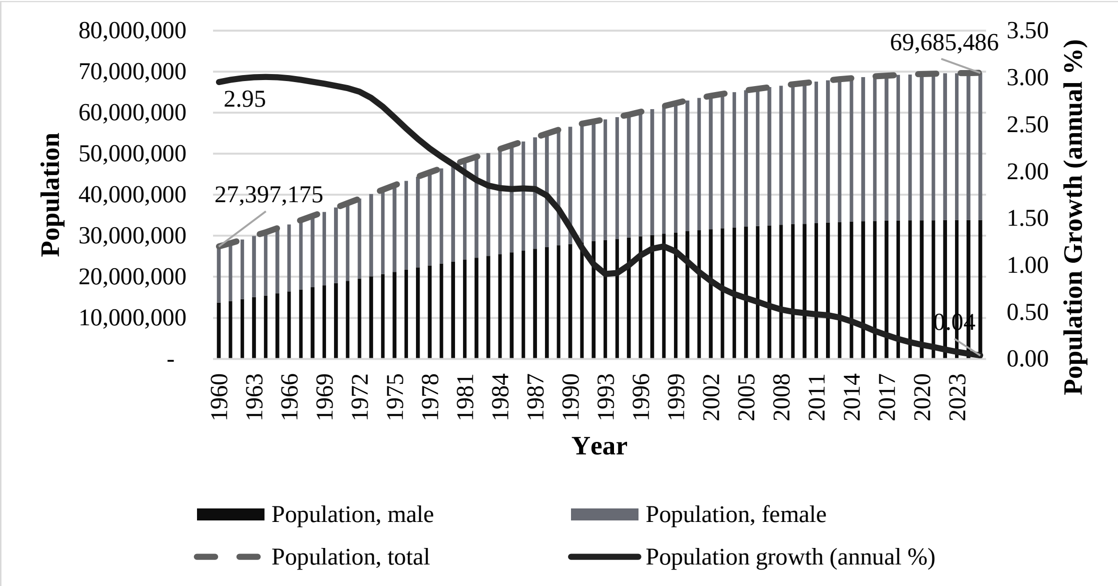

Figure 4.8: Thailand's Population during 1960-2025

Sources: World Bank (2019): data from 1960-2017; and United Nations (2018): data from 2018-2025

There are two arguments about the role of population in the process of economic growth in literature. First, the pessimistic thought, from those called "doomsters", claims that population growth has a negative impact on economic growth. Coale and Hoover (1958) point out that population growth and the subsistence burden hamper capital accumulation in developing countries. This view has been supported empirically by Hasan (2010) and Yao et al. (2013) in case of China. On the other hand, the optimistic thought, from boomsters, describes the positive impact linking population growth and economic expansion (Furuoka, 2018). This study uses population growth as a proxy for labour input following Darrat and Al-Yousif (1999), Liu (2009), Garza-Rodriguez et al. (2016), and Furuoka (2018).

4.3.6 Sources of Data

This study utilises annual data for 1971-2014 taken from the World Development Indicators (World Bank, 2017). This time span is the longest time period for which data on all variables was available. GDP per capita (in constant 2010 US$) is used as a proxy for economic growth. Overall energy consumption, measured by kilogram (kg) of oil equivalent per capita, is used as a proxy for energy consumption. Financial development is measured by domestic credit to the private sector as a share of GDP. These variables have been used in numerous studies, such as Kargbo and Adamu (2009), Azam et al. (2015), Chang (2015), Kumar et al. (2015), Kyophilavong et al. (2015), and Shahbaz et al. (2017). Gross fixed capital formation per capita (in constant 2010 US$) is used as a proxy for capital input in the model[9] following Soytas et al. (2007), Alam et al. (2011), Akkemik and Goksal (2012), and Azam et al. (2015). In addition, population growth as an annual percentage is used as a proxy for labour input in line of Furuoka (2018). All data, except population growth, have been transformed into a natural logarithmic form before investigating cointegration with the ARDL analysis.

4.4 Methodology

There are numerous empirical studies that investigate the long-run relationship of energy consumption and economic growth by employing cointegration techniques. The Engle and Granger method and the Johansen technique are the two widely applied methods to test for cointegration between variables. Asteriou and Hall (2011), and Ang (2010) cited in Samargandi et al. (2014) state that the Engle and Granger method is a single equation approach. If this method applies to the model that has two cointegrated variables under consideration, it can generate conflicting results. For the Johansen technique, it is difficult to interpret each implied economic relationship and to find the most appropriate vector for the subsequent test in a case of more than one cointegrating vector. Moreover, the drawback of both the Engle and Granger method and Johansen technique is these techniques require all the considered variables integrated of order one, $I(1)$. They cannot

[9] Capital stock data are not readily available. However, it is possible to obtain by using the perpetual inventory method (PIM), Sari and Soytas (2007) pointed out that the use of capital stock series estimated with the PIM is problematic since the variance in capital stock computed using this method is correlated with the change in investment. Therefore, we control for investment in fixed capital which may be a reliable proxy for changes in capital stock, assuming a constant depreciation rate (Soytas et al., 2007; Akkemik and Goksal, 2012).

be applied if there are a mix of $I(0)$ and $I(1)$ variables, as described by Samargandi et al. (2014).

This study employs the autoregressive distributed lag (ARDL) bounds testing approach to cointegration introduced by Pesaran and Shin (1999) and later extended by Pesaran et al. (2001) to investigate the existence of a long-run equilibrium relationship among considered variables. The bounds testing approach has several advantages in comparison to other approaches widely used in cointegration analysis. Firstly, Pesaran and Shin (1999) state that the serial correlation and endogeneity problems can be corrected by an ARDL approach with appropriate lags. Secondly, the ARDL technique is flexible and can be applied regardless of whether the variables are $I(0)$ or $I(1)$ but not $I(2)$. Thirdly, the ARDL bounds testing approach is preferable to other methods when the sample size is small. Finally, the ARDL technique generally presents unbiased estimates of the long-run model and valid t-statistics, even when some of the regressors are endogenous (Odhiambo, 2009; Islam et al., 2013). In addition, Samargandi et al. (2014) state that the ARDL technique enables testing simultaneously for the long-run and short-run relationships between the variables in a time series model. Therefore, this empirical study will apply ARDL method to investigate short and long-run relationship among considered variables. Our model adopts from Shahbaz et al. (2013a).

4.4.1 Model Specification

The modelling framework in this empirical study use to examine the relationship between economic growth, energy consumption, financial development, gross fixed capital formation and population growth can be specified as follows;

$$GDP = f(EC, FD, GFCF, Pop) \qquad \text{.....(4.1)}$$

where GDP is gross domestic output; EC is energy use; $GFCF$ is gross fixed capital formation; and Pop is population growth.

The logarithmic linear specification of equation (4.1) is as follows;

$$lnGDP_t = \beta_0 + \beta_1 lnEC_t + \beta_2 lnFD_t + \beta_3 lnGFCF_t + \beta_4 Pop_t + \varepsilon_t \qquad \text{.....(4.2)}$$

where $lnGDP_t$ represents GDP per capita; $lnEC_t$ is energy consumption per capita; $lnFD_t$ is domestic credit to private sector as share of GDP; $lnGFCF_t$ represents gross fixed capital formation per capita; and Pop_t represent population growth. The term ε_t represents a random error term assumed to be normally distributed, and ln denotes that the variables have been transformed to natural logs.

(1) Co-integration with ARDL

To examine long-run relationships among model variables, we apply the ARDL bounds testing approach to cointegration (Pesaran et al., 2001). The bound testing approach allows a cointegrating relationship to be estimated using the ordinary least squares (OLS) technique after the lag order is selected. According to that, this test is easier to apply than other multivariate cointegration methods such as Johansen and Juselius (Sehrawat and Giri, 2015). The ARDL procedure involves the estimation of Equation (4.2) as follows:

$$\Delta lnGDP_t = \alpha_0 + \alpha_1 lnGDP_{t-1} + \alpha_2 lnEC_{t-1} + \alpha_3 lnFD_{t-1} + \alpha_4 lnGFCF_{t-1} + \alpha_5 Pop_{t-1} + \sum_{i=1}^{p-1}\beta_i \Delta lnGDP_{t-i} + \sum_{i=0}^{p-1}\gamma_i \Delta lnEC_{t-i} + \sum_{i=0}^{p-1}\rho_i \Delta lnFD_{t-i} + \sum_{i=0}^{p-1}\sigma_i \Delta lnGFCF_{t-i} + \sum_{i=0}^{p-1}\mu_i \Delta Pop_{t-i} + \varepsilon_t \quad \text{.....(4.3)}$$

where α_0 is a constant parameter; and Δ is the difference operator. The first part of the Equation (4.3) with α_1, α_2, α_3, α_4 and α_5 refer to the long-run elasticity coefficients and the second part with the β, γ, ρ, σ, and μ refer to the short-run share coefficients. Jalil and Feridun (2011) suggest that the optimal lag length for each variable can be selected from the ARDL estimated $(p+1)^k$ number of regressions, where p represents the maximum number of lags and k is the number of variables in the equation. The decision to select the ARDL model is based on either the Akaike Information Criteria (AIC) or the Schwartz-Bayesian Criteria (SBC). The AIC is known for selecting the maximum relevant lag length, whereas the SBC is known for selecting the smallest possible lag length. In this current study, the optimal lag structure for the regression is selected by the Akaike Information Criterion (AIC). In order to test for cointegration, we compare the computed F-statistic with the critical bounds. The null hypothesis of no long-run relationship between the variables in Equation (4.3) is $H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ against the alternative hypothesis of cointegration $H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$.

(2) ARDL Bounds Test Procedure

After specifying the ARDL model, then we estimate Equation (4.3) by OLS method in order to test for the existence of the long-run relationship among variables. Pesaran et al. (2001) proposed using the standard joint significance F-test on the lagged levels of variables to test the presence of a long-run relationship. Two asymptotic critical bounds are used to test for cointegration when the independent variables are $I(d)$. The lower bound is applied if the regressors are $I(0)$, and the upper bound is used for $I(1)$. If the F-statistic is below the lower critical bound, the null hypothesis of no cointegration cannot be rejected. If the F-statistic exceeds the upper critical bound, variables have a long-run relationship regardless of the order of integration, $I(0)$ or $I(1)$. Nevertheless, if the F-statistic falls between the two bounds, inference is inconclusive demanding revision and re-specification of the model. When the order of integration for all variables is known to be $I(1)$, then the decision is made based on the upper bound. Similarly, if all the series are $I(0)$, then the decision is made based on the lower bound. Once the cointegration is established the conditional ARDL long-run model can be estimated as:

$$\Delta lnGDP_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_1 lnGDP_{t-i} + \sum_{i=0}^{p-1} \alpha_2 lnEC_{t-i} + \sum_{i=0}^{p-1} \alpha_3 lnFD_{t-i} + \sum_{i=0}^{p-1} \alpha_4 lnGFCF_{t-i} + \sum_{i=0}^{p-1} \alpha_5 Pop_{t-i} + \varepsilon_t \quad .....(4.4)$$

A dynamic unrestricted error correction model (UECM) can be derived from the ARDL bounds testing through a simple linear transformation to obtain the short-run dynamic parameters. The advantage of UECM is it integrates the short-run dynamic with the long-run equilibrium without losing any long-run information (Sehrawat and Giri, 2015). Thus, the model can be written as:

$$\Delta lnGDP_t = \delta_0 + \sum_{i=1}^{p-1} \beta_i \Delta lnGDP_{t-i} + \sum_{i=0}^{p-1} \gamma_i \Delta lnEC_{t-i} + \sum_{i=0}^{p-1} \rho_i \Delta lnFD_{t-i} + \sum_{i=0}^{p-1} \sigma_i \Delta lnGFCF_{t-i} + \sum_{i=0}^{p-1} \mu_i \Delta Pop_{t-i} + \theta ECM_{t-1} + \varepsilon_t \quad .....(4.5)$$

where β, γ, ρ, σ, and μ refer to the short-run dynamic coefficients to equilibrium; and ECM_{t-1} is the error correction term in which θ explains the speed of adjustment after the short-run shock back towards the long-run equilibrium.

This chapter also conducted diagnostic and stability tests to ensure the goodness of fit of the model. The diagnostic tests evaluate the serial correlation, functional form, non-normality and heteroscedasticity of the model. In addition, this study applied the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) to test the stability of the model as proposed by Brown et al. (1975).

(3) Toda and Yamamoto Approach to Granger Causality Test

The ARDL cointegration approach indicates the presence or absence of a cointegration relationship between considered variables, though it cannot specify the direction of the causal relationship between them. Hence, the Toda and Yamamoto causality test is applied to evaluate the causal relationship among the variables. The Toda and Yamamoto (1995) procedure has been found to be superior to ordinary Granger causality tests, since it provides a method to test for the existence of non-causality regardless of whether the variables are $I(0), I(1), or\ I(2)$, non-cointegrated or cointegrated of any arbitrary order (Wolde-Rufael, 2010; Farhani et al., 2014; Kumar et al., 2015; Furuoka, 2018). On the other hand, the error correction method cannot be applied for Granger causality test when the series have mixed order of integration and the standard (pair-wise) Granger causality test will require that all variables used are strictly stationary (Kumar et al., 2015).

The Toda and Yamamoto (1995) procedure employed a modified Wald (MWALD) test for restriction on the parameters of the vector autoregression (VAR). This procedure requires augmenting the VAR($k + d_{\max}$) in level. The correct order of the VAR system is augmented by the maximal order of integration of the variables in the model (d_{max}) and the optimal lag length (k). The VAR($k + d_{\max}$) is then estimated with the coefficients of the last lagged d_{max} vector being ignored. The Wald statistic follows chi-square distribution asymptotically with degrees of freedom equal to the number of the excluded lagged variables. This is true irrespective of whether the process is cointegrated or stationary (Ghosh and Kanjilal, 2014). Therefore, the Toda-Yamamoto version of VAR($k + d_{\max}$) in this study can be written as:

$$\begin{aligned} lnGDP_t = \alpha_0 &+ \sum_{i=1}^{k} \alpha_{1i} lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} lnGDP_{t-j} + \sum_{i=1}^{k} \eta_{1i} lnEC_{t-i} + \sum_{j=k+1}^{d_{max}} \eta_{2j} lnEC_{t-j} \\ &+ \sum_{i=1}^{k} \phi_{1i} lnFD_{t-i} + \sum_{j=k+1}^{d_{max}} \phi_{2j} lnFD_{t-j} + \sum_{i=1}^{k} \delta_{1i} lnGFCF_{t-i} \\ &+ \sum_{j=k+1}^{d_{max}} \delta_{2j} lnGFCF_{t-j} + \sum_{i=1}^{k} o_{1i} Pop_{t-i} + \sum_{j=k+1}^{d_{max}} o_{2j} Pop_{t-j} + \lambda_{1t} \end{aligned} \quad (4.6)$$

$$\begin{aligned} lnEC_t = \beta_0 &+ \sum_{i=1}^{k} \beta_{1i} lnEC_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j} lnEC_{t-j} + \sum_{i=1}^{k} \theta_{1i} lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{2j} lnGDP_{t-j} \\ &+ \sum_{i=1}^{k} \vartheta_{1i} lnFD_{t-i} + \sum_{j=k+1}^{d_{max}} \vartheta_{2j} lnFD_{t-j} + \sum_{i=1}^{k} \upsilon_{1i} lnGFCF_{t-i} \\ &+ \sum_{j=k+1}^{d_{max}} \upsilon_{2j} lnGFCF_{t-j} + \sum_{i=1}^{k} \tau_{1i} Pop_{t-i} + \sum_{j=k+1}^{d_{max}} \tau_{2j} Pop_{t-j} + \lambda_{2t} \end{aligned} \quad (4.7)$$

$$lnFD_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} lnFD_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} lnFD_{t-j} + \sum_{i=1}^{k} \varphi_{1i} lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \varphi_{2j} lnGDP_{t-j} + \sum_{i=1}^{k} \mu_{1i} lnEC_{t-i} + \sum_{j=k+1}^{d_{max}} \mu_{2j} lnEC_{t-j} + \sum_{i=1}^{k} \kappa_{1i} lnGFCF_{t-i} + \sum_{j=k+1}^{d_{max}} \kappa_{2j} lnGFCF_{t-j} + \sum_{i=1}^{k} \xi_{1i} Pop_{t-i} + \sum_{j=k+1}^{d_{max}} \xi_{2j} Pop_{t-j} + \lambda_{3t} \quad (4.8)$$

$$lnGFCF_t = \pi_0 + \sum_{i=1}^{k} \pi_{1i} lnGFCF_{t-i} + \sum_{j=k+1}^{d_{max}} \pi_{2j} lnGFCF_{t-j} + \sum_{i=1}^{k} \rho_{1i} lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \rho_{2j} lnGDP_{t-j} + \sum_{i=1}^{k} \omega_{1i} lnEC_{t-i} + \sum_{j=k+1}^{d_{max}} \omega_{2j} lnEC_{t-j} + \sum_{i=1}^{k} \psi_{1i} lnFD_{t-i} + \sum_{j=k+1}^{d_{max}} \psi_{2j} lnFD_{t-j} + \sum_{i=1}^{k} \zeta_{1i} Pop_{t-i} + \sum_{j=k+1}^{d_{max}} \zeta_{2j} Pop_{t-j} + \lambda_{4t} \quad (4.9)$$

$$Pop_t = \sigma_0 + \sum_{i=1}^{k} \sigma_{1i} Pop_{t-i} + \sum_{j=k+1}^{d_{max}} \sigma_{2j} Pop_{t-j} + \sum_{i=1}^{k} \varpi_{1i} lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \varpi_{2j} lnGDP_{t-j} + \sum_{i=1}^{k} \chi_{1i} lnEC_{t-i} + \sum_{j=k+1}^{d_{max}} \chi_{2j} lnEC_{t-j} + \sum_{i=1}^{k} \varsigma_{1i} lnFD_{t-i} + \sum_{j=k+1}^{d_{max}} \varsigma_{2j} lnFD_{t-j} + \sum_{i=1}^{k} \varrho_{1i} lnGFCF_{t-i} + \sum_{j=k+1}^{d_{max}} \varrho_{2j} lnGFCF_{t-j} + \lambda_{5t} \quad (4.10)$$

where the series are defined in (4.6) - (4.10). The null hypothesis of no causality is rejected when the $p-values$ fall within the desired 1-10% of level of significance. From (4.6) we can test the hypothesis that the Granger causality running from $lnEC, lnFD, lnGFCF\ and\ Pop\ to\ lnGDP$, implies $\eta_{1i} \neq 0 \forall i$, $\phi_{1i} \neq 0 \forall i$, $\delta_{1i} \neq 0 \forall i, and\ o_{1i} \neq 0 \forall i$, respectively. Likewise, in (4.7), Granger causality running from $lnGDP, lnFD, lnGFCF\ and\ Pop\ to\ lnEC$, implies $\theta_{1i} \neq 0 \forall i$, $\vartheta_{1i} \neq 0 \forall i, \upsilon_{1i} \neq 0 \forall i, and\ \tau_{1i} \neq 0 \forall i$, respectively. In (4.8) $lnGDP, lnEC, lnGFCF\ and\ Pop$ Granger causes $lnFD$ if $\varphi_{1i} \neq 0 \forall i$, $\mu_{1i} \neq 0 \forall i$, $\kappa_{1i} \neq 0 \forall i, and\ \xi_{1i} \neq 0 \forall i$, respectively. In (4.9) $lnGDP, lnEC, lnFD\ and\ Pop$ Granger causes $lnGFCF$ if $\rho_{1i} \neq 0 \forall i$, $\omega_{1i} \neq 0 \forall i$,

$\psi_{1i} \neq 0\forall i, and \neq \zeta_{1i}0\forall i$, respectively. Finally, in (4.10) $lnGDP, lnEC, lnFD\ and\ lnGFCF$ Granger causes Pop if $\varpi_{1i} \neq 0\forall i,\ \chi_{1i} \neq 0\forall i,\ \varsigma_{1i} \neq 0\forall i, and\ \varrho_{1i} \neq 0\forall i$, respectively.

Given the above equations, the three main public policy of Thailand are: economic growth, energy conservation and financial development, it is of interest to examine the linkage of these variables. The knowledge of the precise relationship among considered variables and their direction is valuable for policymakers for an energy-dependent economy such as Thailand as they have significant policy implications. If the causality runs from economic growth to energy consumption or no causality between these two variables, energy conservation policies can be rational policy for the government to apply without restricting the growth of the economy. On the other hand, the bidirectional causality or unidirectional causality from energy consumption to economic growth implies a shortage of energy will negatively affect income and thereby be harmful on economic growth. It is also important to investigate the relationship between financial development and economic growth because if financial development Granger causes economic growth, any restrictions in domestic credit to private sector may lower potential growth of the economy.

4.5 Empirical Results

4.5.1 Descriptive Statistics

The results of the descriptive statistics and Pair-wise correlation analysis in Table 4.4 show that GDP, energy use, financial development, gross fixed capital formation, and population growth are normally distributed, which is confirmed by Jarque-Bera test statistics. In the correlation matrix, we find that energy consumption, financial development, and gross fixed capital formation are positively correlated with economic growth whilst the population growth is negatively correlated with GDP. Energy consumption has a strong positive correlation between the variables GDP, domestic credit to private sector and gross fixed capital formation, while it has a negative correlation with population growth. It is also noteworthy that the variable population growth has negative correlation with all the considered variables.

Table 4.4: Descriptive Statistics and Correlation Matrix

	LNGDP	LNEC	LNFD	LNGFCF	POP
Mean	7.826405	6.709371	4.285992	6.659196	1.404126
Median	7.998148	6.754577	4.511580	6.680127	1.181839
Maximum	8.628681	7.596711	5.115020	7.518251	2.886010
Minimum	6.853130	5.887709	3.023674	5.748945	0.400861
Std. Dev.	0.572736	0.573444	0.597209	0.536964	0.766627
Skewness	-0.252435	0.027646	-0.634173	-0.254586	0.416547
Kurtosis	1.653251	1.468077	2.310789	1.770760	1.939285
Jarque-Bera	3.792483	4.308051	3.820141	3.245526	3.335133
Probability	0.150132	0.116016	0.148070	0.197353	0.188706
Sum	344.3618	295.2123	188.5837	293.0046	61.78154
Sum Sq. Dev.	14.10512	14.14003	15.33633	12.39821	25.27185
LNGDP	1	0.984191	0.930902	0.903388	-0.988533
LNEC	0.984191	1	0.877370	0.846348	-0.958197
LNFD	0.930902	0.877370	1	0.925547	-0.925518
LNGFCF	0.903388	0.846348	0.925547	1	-0.903844
POP	-0.988533	-0.958197	-0.925518	-0.903844	1

4.5.2 Unit Root Test

Although the ARDL cointegration approach does not require a pre-test for unit roots, testing might be suggested for unit roots regardless of the presence of integrated stochastic trend of $I(2)$. Therefore, all variables in this model were tested for stationarity prior to estimating cointegration via Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. We test the presence of unit root including intercept, and trend and intercept. In general, the ADF and PP tests with intercept and intercept plus trend deterministic specification indicate that all variables are non-stationary at levels, but stationary at first differences. For KPSS test, for all variables, we cannot reject the null hypothesis of stationary at the 10 percent level of significance with both intercept and intercept plus trend deterministic specification at first difference levels. Therefore, we can conclude that all our series are integrated of order one, or $I(1)$ as shown in Table 4.5.

Table 4.5: Stationary Test

Variable	Include in test equation	ADF		PP		KPSS	
		Level	1st difference	Level	1st difference	Level	1st difference
LnGDP	Intercept	-1.4589	-3.8716***	-1.1669	-3.8716***	0.8278	0.1731*
	Trend and intercept	-1.6291	-4.0377**	-1.2866	-4.0772**	0.1545***	0.0726*
LnEC	Intercept	0.0023	-4.8756***	-0.1409	-4.9790***	0.8255	0.0977*
	Trend and intercept	-1.9123	-4.7980***	-2.0060	-4.9080***	0.0934*	0.0917*

Table 4.5: Stationary Test, Continued

Variable	Include in test equation	ADF		PP		KPSS	
		Level	1st difference	Level	1st difference	Level	1st difference
LnFD	Intercept	-2.1230	-3.4894**	-1.9324	-3.4927**	0.7241***	0.2389*
	Trend and intercept	-2.2107	-3.6847**	-1.6287	-3.7001**	0.1758***	0.0711*
LnGFCF	Intercept	-1.9138	-3.7630***	-1.4670	-3.6667***	0.6558***	0.0968*
	Trend and intercept	-2.5273	-3.7742**	-1.8149	-3.5965**	0.1341**	0.0572*
Pop	Intercept	-4.1090***	-2.1127	-1.6664	-2.6570*	0.8190	0.1765*
	Trend and intercept	-0.7461	-6.9757***	-1.8827	-2.8252	0.1734***	0.0334*

Note: 1. ADF, PP and KPSS refer to Augmented Dickey-Fuller test, the Phillips-Perron test and Kwiatkowski-Phillips-Schmidt-Shin test, respectively.

2. The ADF and PP critical values are based on Mackinnon (1996) and KPSS are based on Kwiatkowski et al. (1992).

3. The optimal lag based on the Schwarz Information Criteria (SIC) for ADF. For PP and KPSS, Barlett Kernel is used as the spectral estimation method. The band width is selected automatically using the Newey-West method in Eviews 11.

4. The null hypothesis for ADF and PP tests is that a series has a unit root (non-stationary) and for KPSS, the series is stationary.

5. ***, ** and * indicate the significance at 1%, 5% and 10% levels, respectively.

4.5.3 ARDL Cointegration Test

It is important to select an appropriate lag length before estimate Equation (4.3) by OLS method to test for the existence of the long-run relationship among variables as suggested by Sehrawat et al. (2015) that the ARDL F-statistic is quite sensitive to the selection of lag order because the appropriate lag order can avoid the serial correlation and over parameterisation problems of the error terms. Therefore, the lag length selection has carried out by estimating the unrestricted VAR. The maximum lag-length selected for the ARDL estimation for long-run association and short-run dynamics is 3 ($k = 3$), which is supported by the majority of the lag selection criteria (LR, FPE, AIC, HQ) as presented in Table 4.6.

Table 4.6: Lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	78.37583	NA	1.92e-08	-3.579309	-3.370336	-3.503212
1	363.6501	487.0536	5.94e-14	-16.27561	-15.02178	-15.81904
2	439.8904	111.5712	5.16e-15	-18.77514	-16.47645*	-17.93809
3	**481.7565**	**51.05616***	**2.64e-15***	**-19.59788***	**-16.25432**	**-18.38034***

Notes: 1. LR: sequential modified LR test statistic, FPE: final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, and HQ: Hannan-Quinn information criterion.

2. *indicates lag order selected by the criterion

Then the model was estimated with a maximum of three lags of both the dependent variables and the regressor followed the Akaike Information Criterion (AIC) method. Out of the 2,500 models evaluated, the procedure has selected an ARDL (1, 1, 0, 1, 2) model. This means the dependent variable has a single lag, a single lag of lnEC, a zero lag of lnFD, one lags of lnGFCF, and two lags of Pop.

Table 4.7: Results of ARDL Cointegration Test

Estimated models	**AIC Optimal lag length**	**F-statistics**	**Result**
$F_{GDG}(lnGDP_t/lnEC_t,\ lnFD_t, lnGFCF_t, Pop_t)$	1,1,0,1,2	13.02019***	Cointegration
Critical Value Bounds			
	Lower bounds I(0)	Upper bounds I(1)	
N=40			
10%	2.427	3.395	
5%	2.893	4.000	
1%	3.967	5.455	
N=45			
10%	2.402	3.345	
5%	2.850	3.905	
1%	3.892	5.173	

Note: 1. ***, ** and * indicate the significance at 1%, 5% and 10%, respectively.

2.Critical values for lower bound and upper bound are from Narayan (2005) case II: restricted intercept and no trend.

3. $N = 42$.

The result of the ARDL cointegration test in Table 4.7 shows clearly that the long-run association exists between the variables when economic growth is used as the dependent variable. The $F - statistics$ (13.02019) is significant at 1% level for the sample size of 40 and 45. It is worth noting that we use these critical bounds from Narayan (2005) rather than Pesaran et al. (2001) to make reliable inference on cointegration of our model because these bounds statistics are applicable for sample size between 30 and 80 with the intervals of 5, while the critical bounds statistics from Pesaran et al. (2001) are appropriate with the sample size of more than 80. Sample size in this study is 42.

4.5.4 The Short- and Long-Run Analysis

After establishing cointegration, we evaluate the long-run and short-run impact on economic growth from energy consumption, financial development, gross fixed capital formation and population growth by using Equation (4.4) and (4.5). The empirical results reported in Table 4.8 show that in the short-run, the impact of energy consumption on economic growth is positive and significant at a 5 percent level of significance. Other things remaining constant, the coefficient of energy consumption reveals 0.11 percent of economic growth increases due to 1 percent rises in energy consumption. This finding is consistent with the literatures. Kyophilavong et al. (2015) conclude that energy consumption has a positive relation to economic growth in the case of Thailand in the short-run. Fang and Chang (2016) also report that energy consumption boosts economic growth in a sample of 16 countries including Thailand. The impact of gross fixed capital formation has significant positive impact on economic growth at a 5 percent level of significance. A 1 percent increase in capital boosts economic growth by 0.03 percent. This finding is consistent with Shahbaz et al. (2013a), who indicate that capital use enhances economic growth in China. In addition, the finding shows the negative impact of population growth and economic growth at a 1 percent level of significance. A 1 percent increase in population growth leads to a 0.15 percent decrease in economic growth. This may seem counterintuitive, but it is in line with Yao et al. (2013), who state that population size has negatively direct effect on economic development. Greater population size leads to increases in consumption, decreases in saving, subsequently lower gross domestic product (GDP) per capita. Interestingly, the finding marks that financial development has a positive but insignificant impact on economic growth, indicating that the Thai economy might not benefited from financial development in the short-run. This result differs from Samargandi et al. (2014) and Magazzino (2018), who find a negative but insignificant short-run impact of financial development on economic growth in Saudi Arabia and Italy, respectively.

The negative and statistically significant effect of ECM_{t-1} justify the established long-run relationship between the series. The finding in Table 4.8 reports that the coefficient of ECM_{t-1} is -0.3495 and statistically significant at 1 percent level. This confirms our established long-run relationship among the variables of the model. The coefficient of error term denotes the speed of adjustment from the short-run towards long-run equilibrium path. Therefore, this implies that any deviation from the long-run relations disappears as the economy converges to the long-run equilibrium by 34.95 percent each year.

The long-run analyses are presented in Panel B of Table 4.8, which shows a similar relationship between dependent and independent variables but greater impact in comparison to the short-run effect. Energy consumption has a positive significant impact on economic growth at a 1 percent level of significance. A 1 percent increase in energy use stimulates economic growth by 0.31 percent. This means that an increasing in energy use from production and consumption of private and public sectors lead to investment and the growth of economy. Moreover, it implies that energy demand plays a relevant role to enhance economic growth in Thailand. The positive and significant effect of energy use is consistent with Shahbaz et al. (2013a) for China experience, Kyophilavong et al. (2015) for Thailand experience, and Fang and Chang (2016) for 16 countries in Asia Pacific region. Remarkably, financial development has a positive but insignificant impact on economic growth, indicating that the Thai economy might not benefited from financial development. This finding may be attributed to the fact that during the period under analysis, the financial sector was still limited and inaccessible, which it would be capable to promoting economic growth. In addition, the inefficient allocation of resources by bank coupled with the absence of favourable investment environment due to politic instability and Asian financial crisis may slow the overall economic growth in Thailand. This result is in line with Sehrawat and Giri (2015), who use the ratio of the sum of credit to the private sector and market capitalization to GDP and the ratio of market capitalization to GDP as proxies of financial development to analyse the impact of financial development on economic growth in India. Their results reveal a positive but insignificant long-run impact of financial development on economic growth. However, our finding differs from Majid (2007), who finds a positive and significant impact of financial development on economic growth in Thailand at a 10 percent level of significance. His result implies the success of Thai authority in controlled price stability and financial sector in speeding up the economic growth of the country in the aftermath of the 1997 financial crisis. The plausible reason of this contrast finding might due to the fact that we have included other variables such as energy consumption and labour as well as the difference of time span.

This explains clearly that the difference of dataset can lead to different result. In addition, Samargandi et al. (2014) find a negative but insignificant impact of financial development on economic growth in Saudi Arabia.

Table 4.8: Short- and Long-Run Analysis

Dependent variable = $LnGDP$			
Panel A: Short-run results[10]			
Variable	Coefficient	t-statistic	Prob. value
$Constant$	1.9793***	3.3196	0.0023
$\Delta LnEC$	0.1079**	2.5124	0.0172
$\Delta LnFD$	0.0152	1.0427	0.3049
$\Delta LnGFCF$	0.0299**	2.1845	0.0364
ΔPop	-0.1493***	-3.1557	0.0035
ECM_{t-1}	-0.3495***	-9.5041	0.0000
Panel B: Long-run results[11]			
Variable	Coefficient	t-statistic	Prob. value
$Constant$	5.6627***	13.3602	0.0000
$LnEC$	0.3086***	6.8180	0.0000
$LnFD$	0.0434	1.0841	0.2864
$LnGFCF$	0.0856**	2.5254	0.0167
Pop	-0.4270***	-10.0374	0.0000
Panel C: Diagnostic tests			
Test	F-statistic	Prob. value	
$\text{Jarque} - \text{Bera}$	2.3171	0.3139	
x^2 $Serial$	1.3508	0.2773	
x^2 $Arch$	1.3417	0.2766	
x^2 $Ramsey$	0.6334	0.4322	

Note: 1. ***,** and * indicate the significance at 1%, 5% and 10% levels, respectively.

2. The normality test is based on a test of Jarque-Bera of residual. The serial correlation is tested by the Breusch-Godfrey Serial Correlation LM test (the null is no serial correlation). The heteroscedasticity is tested by the ARCH test (the null is no heteroscedasticity). The Ramsey RESET test is used to specify the functional form of the model (the null is no specification errors).

Gross fixed capital formation has a positive significant impact on economic growth at 5 percent level of significance. A 1 percent increase in gross fixed capital formation induces

[10] The results of short-run computed from Equation (4.5).

[11] The results of long-run computed from Equation (4.4).

economic growth by 0.09 percent. Gross fixed capital formation enhances domestic production through investment activities and boost economic growth. This empirical evidence supports the findings by Kargbo and Adamu (2009) for Sierra Leone, Shahbaz et al. (2013a) for China, and Fang and Chang (2016) for 16 countries in Asia Pacific region. On the other hand, population growth has a negative significant impact on economic growth at a 1 percent level of significance. A 1 percent increase in population growth lowers economic growth by 0.43 percent. This happens due to the change in resource allocation of population, more population lead to increase in consumption, lower savings, finally, lessen the GDP. This finding is in line with the findings by Furuoka (2018), who concludes a negative long-run relationship between population and economic growth in China. Similar results are also found from earlier empirical studies by Hasan (2010), and Yao et al. (2013). Overall, the aforementioned results indicate that energy consumption, gross fixed capital formation as well as population growth are the important determinants for the quantity of economic growth in Thailand.

The results of diagnostic tests in Panel C of Table 4.8 show that the model passes all diagnostic tests. This means the error term is normally distributed, free of serial correlation and no problem of autoregressive conditional heteroscedasticity. In addition, the Ramsey reset test indicates that functional form for the short-run model is well constructed.

Furthermore, this study conducts the cumulative sum (CUSUM)[12] and the cumulative sum of square (CUSUMsq) tests on the recursive residuals for the chosen ARDL model. Figures 4.9 and 4.10 show that the plots of CUSUM and CUSUMsq lie inside the critical bands at the 5 percent level of significance. These confirm the stability of the parameters.

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[12] Brown et al. (1975) stated that the formula of CUSUM test is $W_t = \sum_{r=k+1}^{t} \frac{w_r}{s}$, and the CUSUMsq is $S_t = (\sum_{r=k+1}^{t} w_r^2)/(\sum_{r=k+1}^{T} w_r^2)$.

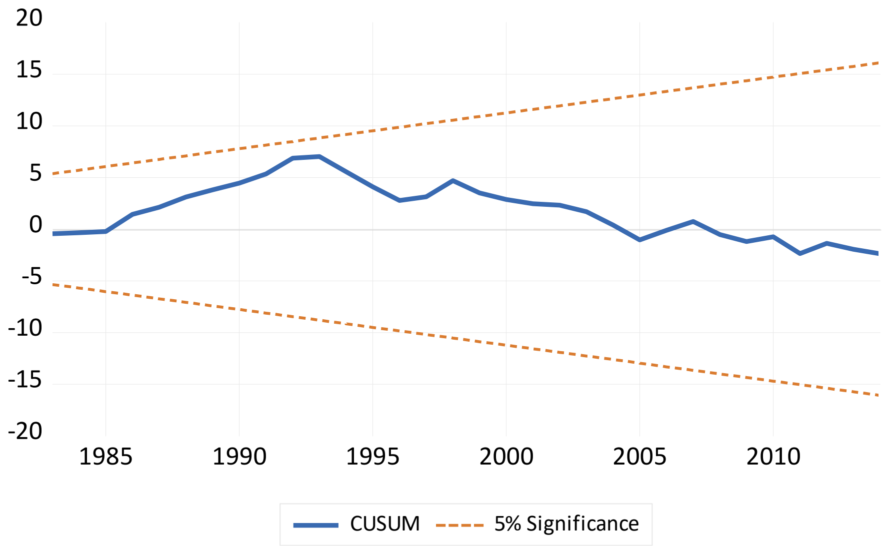

Figure 4.9: Plot of Cumulative Sum of Recursive Residuals

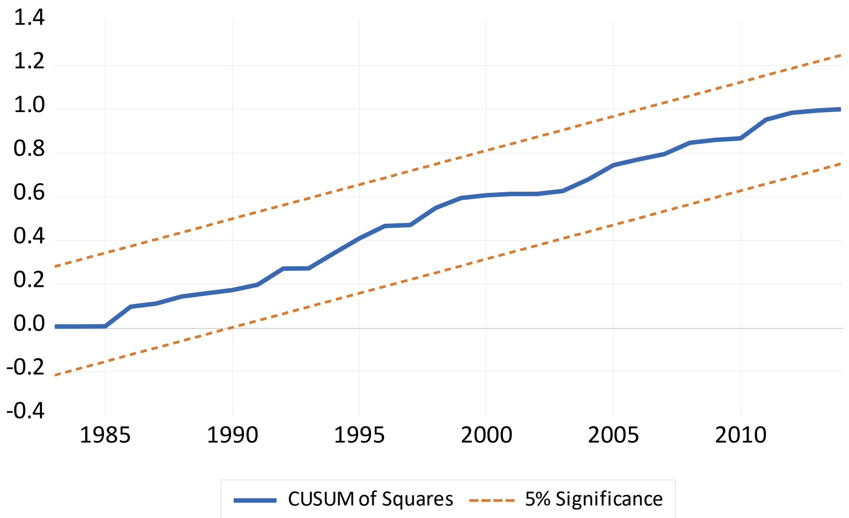

Figure 4.10: Plot of Cumulative Sum of Squares of Recursive Residuals

4.5.5 The Toda-Yamamoto Granger Causality Test

From the unit root results in Table 4.5, we note that the maximum order of integration is 1 ($d_{max} = 1$), and the optimal lag length (k) chosen is 3 (Table 4.6). Therefore, the maximum lags (l) that can be used to carry out the non-causality tests is 3 ($l = d_{max} + k \leq 3$) as stated by Toda and Yamamoto (1995) that the test (MWALD) statistic is valid as long as the order of integration of the process does not exceed the true lag length of the model.

The results of the Toda-Yamamoto version of the Granger causality tests in Table 4.9 indicate that the null hypothesis of non-causality from gross fixed capital formation

($lnGFCF$) and population growth (Pop) to economic growth ($lnGDP$) is rejected at 10% level of significance. These findings show a unidirectional causality running from gross fixed capital formation to economic growth ($\mathcal{X}^2 = 7.5362$), and population growth to economic growth ($\mathcal{X}^2 = 6.6013$). The finding of unidirectional causality running from fixed capital formation to economic growth implies that economic growth is affected by fixed capital formation. This means any policy related to gross fixed capital formation may has impact on economic growth. Gross fixed capital formation enhances domestic production through investment activities and boost economic growth. This finding is consistent with Wolde-Rufael (2010) for India, Farhani et al. (2014) for Tunisia and Furuoka (2016) for China and Japan. The unidirectional causality running from population growth to economic growth implies that any policy related to population growth will has impact on economic growth. Population growth can be either promote or supress economic growth through their resource allocation as consumers and producers in economy. This finding is consistent with Darrat and Al-Yousif (1999), who report that economic growth is caused by population growth in Thailand. However, it differs from Furuoka (2018), who employs Toda-Yamamoto causality test and finds bidirectional causality between population and economic growth in China.

Table 4.9: The Granger Causality Test Results based on Toda-Yamamoto Procedure

Excluded variable	**Dependent variable**					**Causality inference**
	$lnGDP$	$lnEC$	$lnFD$	$lnGFCF$	Pop	
$lnGDP$	-	36.8381*** (0.0000)	3.4945 (0.3215)	5.3955 (0.1450)	0.8066 (0.8479)	$lnGDP \rightarrow lnEC$
$lnEC$	1.2428 (0.7428)	-	0.0638 (0.9958)	1.0674 (0.7849)	2.8212 (0.4200)	
$lnFD$	0.8060 (0.8480)	1.4054 (0.7043)	-	0.5882 (0.8991)	0.7113 (0.8705)	
$lnGFCF$	7.5362* (0.0566)	18.3219*** (0.0004)	4.5792 (0.2053)	-	2.6802 (0.4436)	$lnGFCF \rightarrow lnGDP$ $lnGFCF \rightarrow lnEC$
Pop	6.6013* (0.0858)	31.8359*** (0.0000)	1.3442 (0.7187)	7.2875* (0.0633)	-	$Pop \rightarrow lnGDP$ $Pop \rightarrow lnEC$ $Pop \rightarrow lnGFCF$

Note: 1. Figures in the parentheses (·) denote the $p-values$ and reported underneath the corresponding $MWALD-statistics$ ($\mathcal{X}^2$).

2. Significance within 1-10% level indicates presence of causality.

3. ***, ** and * indicate the significance at 1%, 5% and 10% levels, respectively.

4. df =3.

5. $\rightarrow$ denotes a unidirectional causality.

In addition, the null hypothesis of non-causality from economic growth ($lnGDP$), gross fixed capital formation ($lnGFCF$) and population growth (Pop) to energy consumption ($lnEC$) is rejected at 1% level of significance. The unidirectional causality running from GDP to energy consumption supports the conservation hypothesis, which implies that increasing consumption of energy is a consequence of economic growth but the growth itself is not constrained by the level of energy consumption. This means energy consumption is fundamentally driven by economic growth, and the policy of conserving energy consumption may be implemented with little or no adverse effect on economic growth. This finding may be attributed to the fact that the economic growth in Thailand is largely supported by economic growth of services and industry manufacturing sectors which rely on energy sources. The more production of goods for domestic consumption and exports, the more energy use requires. This result is consistent with the results from Lise and Van Montfort (2007) for Turkey, Ang (2008) for Malaysia, Zhang and Cheng (2009) for China, Chang (2010) for China, Bartleet and Gounder (2010) for New Zealand, Boutabba (2014) for India, Yildirim et al. (2014) for Thailand, Malaysia, Indonesia and Philippines, and Magazzino (2018) for Italy. However, this result contradicts the findings of Kyophilavong et al. (2015), who reveal bidirectional causality between energy consumption and economic growth in Thailand. The difference of this result might be due to the difference of additional variable, as Kyophilavong et al. (2015) incorporate trade openness in the model but this present study did not focus on trade openness. The finding of this study also differs from empirical studies by Chiou-Wei et al. (2008) and Azam et al. (2015), which supported the neutrality hypothesis in Thailand. On the other hand, Asafu-Adjaye (2000), and Akkamik and Goksal (2012) find feedback relationship between energy consumption and economic growth in Thailand.

In addition, we detect the causality relationship running from gross fixed capital formation to energy consumption. This can be explained that the investment in fixed capital lead to the use of energy. For instance, the construction of roads, railways, offices, private residential dwellings, and commercial and industrial buildings require energy to run the constructions in every process. This finding is in line with Azam et al. (2015), who find unidirectional causality running from gross fixed capital formation to energy consumption in Thailand. The unidirectional causality running from population growth to energy consumption implies that higher population growth leads to higher energy consumption. This is consistent with Islam et al. (2013), who report energy consumption is influenced by population in Malaysia.

Furthermore, the finding reveals unidirectional causality running from population growth to gross fixed capital formation ($\mathcal{X}^2 = 7.2875$). This implies that an increase in population growth affects gross fixed capital formation through investment in private residential dwellings. This is in line with Noor and Siddiqi (2010), who employ panel Granger causality approach and detect unidirectional causality running from labour to capital in Bangladesh, India, Nepal, Pakistan and Sri Lanka.

Interestingly, we do not find any causality between financial development ($lnFD$) and economic growth ($lnGDP$), and between financial development ($lnFD$) and energy consumption ($lnEC$). Our absence of causality between financial development and economic growth corroborates the findings of ARDL approach which report no short-run and long-run impact from financial development to economic growth. This finding indicates that these two variables evolve independent of each other, which is supported by the neutrality hypothesis proposed by Lucas (1988). This result is in line with Chtioui (2012) for Tunisia, Boutabba (2014) for India, Kumar et al. (2015) for South Africa, Faisal et al. (2016) for China, and Duarte et al. (2017) for Cabo Verde. However, this result differs in regard to a bidirectional causality detected by Majid (2007) in Thailand. The inconsistencies in the findings could be due to differences of the study period as well as the methodology and variables used. Majid (2007) uses dataset only after 1997 financial crisis and applies the vector error correlation model (VECM), whereas this present study employs the most up-to-date data covering the period of 1971 to 2014 and utilises the Toda-Yamamoto approach for causality test. In addition, this study also includes other variables to minimise omitted variable biasness.

On the other hand, our results of no causal relationship between financial development and energy consumption is consistent with Shahbaz et al. (2013b) for Indonesia, Kumar et al. (2015) for South Africa and Sehrawat et al. (2015) for India.

4.6 Conclusion and Policy Implications

This chapter has examined the relationship between financial development, energy consumption and economic growth in Thailand over the period 1971-2014. Unlike the existing and growing literature on the energy-growth nexus, this study contributes to the literature in this topic by incorporating financial development in the model and focuses only on the Thai context. The bounds testing approach to cointegration was applied to estimate the long-run relationship and short-run dynamic parameters of the model. The test indicates cointegrating relationships among economic growth, energy consumption, financial development, gross fixed capital formation and population. The ARDL and Toda-Yamamoto tests reveal two main findings as follows.

First, the ARDL results indicate that in both the short-run and long-run, energy consumption, and gross fixed capital formation exerted positive effects on economic growth, while the population growth has negative impact on economic growth. This means energy consumption and gross fixed capital formation are considered as indispensable ingredient for economic growth, whereas the population growth is detrimental to economic growth in Thailand. Interestingly, the empirical finding of this study shows that financial development has no impact on economic growth.

Second, the Toda-Yamamoto Granger causality results reveal a unidirectional causality running from gross fixed capital formation and population growth to GDP, a unidirectional causality running from GDP, gross fixed capital formation and population growth to energy consumption, and a unidirectional causality running from population growth to gross fixed capital formation. In addition, the findings indicate the absence of causal relationship between financial development and energy consumption, and between financial development and economic growth.

Two important policy implications can be draw from the findings presented in this study. First of all, the unidirectional causality running from GDP to energy consumption, which is consistent with conservation hypothesis, suggests that the policy of conserving energy consumption may be implemented with little or no adverse effect on economic growth. This means strategic approaches for sustainable development with an environmental protection through green growth engine in the Thailand 4.0 economic model and the Thailand 20-year energy efficiency development plan may be appropriate to implement as planned. For instance, the government should provide financial support for campaign expenditure and/or funding for energy-saving activities, encourage the purchase of high energy efficiency equipment/ appliances by using financial and tax measures as well as persuade large business operators to invest in energy conservation activities and organize training courses for experts in the field of energy efficiency. These measurements will enhance domestic production and consumption through investment activities in fixed capital and human resource, consequently boost economic growth with more efficient use of energy. Moreover, the government may reduce subsidies on energy prices and adjust the prices of all energy types to reflect the actual costs of energy. This scheme not only recognise the importance of energy conservation and efficient use of energy to all social members, but also benefits fiscal budget. Apart from that, Thailand can also meet the agreed target of energy conservation promotion which was ratified by government leaders at the Asia-Pacific Economic Cooperation (APEC) Summit in 2007 without a reduction in consumption, production, investment or deterioration in the growth of the economy. Secondly, the absence of causality between financial development and economic growth is consistent with the neutrality hypothesis proposed by Lucas (1988). This implies that financial development and economic growth are independent and not causally related. This is plausible in Thailand because many people have limited access to formal financial services, particularly micro and small businesses. Although the fact that the ratio of domestic credit to the private sector to GDP is high, the credit might be funded into non-income generating and consumption activities rather than investment. This reflects the inefficiency of fund allocation of financial sector. Therefore, the financial sector may increase their efficiency by strictly review and promote sound financial policies that support funding to the productive sectors which can generate income and investment rather than offer credit for consumption activities. Additionally, financial sector may extend their services to various group of citizens covering small and medium enterprises and more accessible in both rural and urban areas.

The findings in this chapter contributes to the empirical literature in the relationship between energy consumption, financial development and economic growth, especially on the Thai context, despite the relationship on this topic merits further and deeper investigation. Future studies may extend this study by using gross regional product (GRP) or gross provincial product (GPP) instead of gross domestic product (GDP). This study considers only total energy consumption, future researches would employ different types of energy such as electricity or renewable energy. Another possibility for further research is to use other proxies for financial development including indices of stock prices or volume of the stocks traded of their share to GDP, broad money, real domestic credit to private sector per capita, using interaction terms for financial development and investment in the various sectors of the Thai economy.

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Chapter 5 : Conclusion

Chapter 1 provides an introduction to a significant problem that inspired this thesis and summarises the major stylised facts of Thai economy since the boom period of 1980 until 2018. Particularly in the 1980s, Thailand was one of the most widely cited development success stories, with sustained strong growth and impressive poverty reduction. The country has transformed its industrial base from agriculture to export-oriented manufacturing. Although Thailand had faced many unexpected shocks during that transformation period, including the 1997-1998 Asian financial crisis, the 2008 global financial crisis, the 2011 floods and the coups in 2006 and 2014, a good track record of sound economic policies, high saving and investment, and low inflation has shifted country from being a lower-middle income country to an upper-middle income country since the early 2010s. In addition, this chapter addressed the aims of the *Thailand 4.0* policy to attain developed country status by 2036 and to unlock the country from middle-income trap, inequality trap and imbalanced trap. The reforms focus on economic stability, human resource development, competitiveness enhancement, social equality, green growth and rebalancing and public management. This plan includes investment in many projects from the public sector and through the *Pracharath* or Public-Private-People Partnership (PPPP). Therefore, government revenue which mainly comes from tax collection will be a key determinant for public investment. Any change in tax revenue may have direct effect on public spending, growth and social equality. Apart from government revenue, the production inputs, particularly in energy and financial development, are widely accepted as the main source of the country's economic growth. However, the impact of tax policy, energy consumption and financial development on growth have rarely been studied directly. There is no previous research using the partial and general equilibrium approach to investigate these effects in the Thai context. Therefore, the primary focus of this thesis is to investigate the impacts of tax reform, energy consumption and financial development on the growth and efficiency of the Thai economy. The main contribution of this thesis is to measure the impacts of taxes on economic growth and to assess the cause effect relations between growth, energy consumption and financial development.

Chapter 2 aimed to analyse the impacts of tax reform, mainly the reform of value added tax (VAT) and corporate income tax (CIT), on growth as well as welfare and reallocation of resources across production sectors. Before applying the static CGE, this chapter presents the overview of taxation in Thailand, followed by the review of existing literature and highlight some interesting findings from the previously conducted studies that applied the CGE modelling approach: a static CGE model in this study was based on Bhattarai (2008a) with some modifications to capture the characteristics of the Thai economy. This model begins with restructuring the 180 sectors input-output table for 2010 obtained from the Office of the National Economics and Social Development Board (2016) into 18 production sectors. Then, we develop an appropriate model structure which includes a representative household, a government sector and the rest of the world. Next step, we employ the values of the elasticity based on values widely accepted in the previous studies. Finally, the model was calibrated and simulated to examine the economy-wide impacts of changes in VAT and CIT rates on allocation of labour and capital inputs, on output and supply as well as on prices and rental rates across sectors and on the levels of household's utility and public welfare in Thailand. There are six scenarios in this model which include three scenarios in a VAT case and another three scenarios in a CIT case. The findings indicate that increasing the VAT rate from 7 to 10 percent becomes a more desirable policy action than eliminating VAT on the basis of economy-wide welfare analysis because utility from the public services for households more than compensates for the loss of utility due to higher tax rates. For CIT, decreasing CIT rate from 30 to 20 percent is a preferable policy as the overall net changes in welfare with the 20 percent CIT rate are better than those of 23 percent CIT rate, by comparison. Finally, we use the sensitivity analysis to checks the robustness of the model results. Robustness of results was confirmed with all other computations.

The aim of Chapter 3 is to evaluate the effect of a reduction in PIT rate on redistribution and growth in Thailand. Although Thailand has successfully reduced poverty, society inequality remains a crucial problem, especially as the disposable household income showed uneven distribution more than other neighbouring countries such as Indonesia, India and Vietnam. Therefore, the policymakers try to diminish this inequality by making reforms in PIT. The latest reform applied to the tax year 2017, which the key reform concerning increasing the minimum income threshold and reducing the tax rates in some income bracket by comparison to before tax year 2014. This reform would definitely affects the government revenue and the redistribution. Therefore, this study develops the dynamic CGE model to assess the impacts of that policy. The advantage of the dynamic CGE model is that it offers deep analysis on the intertemporal behaviour of households and firms and of their economic activities including consumption, investment, exports and imports. In addition, the dynamic CGE explains the path of change in the short-run and long-run of the proposed policy. The model in this study was built from the 2011 Input-Output Table collected from OECD and household data from National Statistical Office of Thailand. The model included 5 households, 33 production sectors, a government sector and the rest of the world. The findings disclose that the reduction in PIT rate is helpful in improving the equality in the distribution of income and consumption in both the short-term and long-term. Specifically, the households in the first, second and third quintiles are better off from the reformed policy. Additionally, this reform increases private consumption, investment, employment, capital stock, export, import and GDP regarding the increase in disposable household income. For tax revenue, the total revenue remains at the same level, despite the revenue from PIT collection decreasing because of an increase in other tax revenues can compensate for the drop in PIT revenue.

Chapter 4 investigates the association between economic growth and the determinants of growth following the neo-classical theory which states that labour, capital and technology are three crucial factors for economic growth. This chapter incorporates the energy consumption and financial development into the neo-classical model because it is widely accepted that these two factors recently have impacted on growth as with labour and capital. However, the empirical results on this topic have been varied and sometimes revealed to be conflicting according to the different time periods, proxy of variables, econometrics methodologies and country characteristics. Most of the previous literatures investigate these relationships by applying a multi-country study rather than focusing on a single-country and emphasising in advanced and emerging economies. None of the existing studies explore this topic in Thailand as a single-country study. This chapter uses annual data for the period of 1971 to 2014 taken from the World Development Indicators. It employs the ARDL and Toda-Yamamoto tests to examine the long-run relationship and the direction of causality between energy consumption, financial development and economic growth. The findings of the ARDL test show that energy consumption and gross fixed capital formation fuel economic growth in both the short-run and long-run, whereas the population growth is detrimental to economic growth in Thailand. Meanwhile, the results of the Toda-Yamamoto Granger causality test identify a unidirectional causality running from economic growth to energy consumption, which is consistent with conservation hypothesis. This means the Thai government can implement a stronger energy conservation policy without compromising economic growth in the long-run. In addition, the test reveals a unidirectional causality running from gross fixed capital formation and population growth to energy consumption; a unidirectional causality running from gross fixed capital formation and population growth to economic growth. On the other hand, there is absence (neutrality) of any causality between financial development and energy consumption as well as between financial development and economic growth. This implies that financial policy has little or no impacts on energy consumption and economic growth in Thailand.

Finally, three research directions deserve further investigation, outside the scope of this thesis. Firstly, the simple static CGE in this thesis started with a single representation household and stressed on the impact of changes in VAT and CIT rates. Further scope remains for full impact analysis of comprehensive reforms such as the goods and services tax (GST) with dynamic models and many households.

Secondly, the dynamic CGE model investigated only the impact of PIT change on the economy. This would therefore apply for other tax policies or even other fiscal or financial policies such as a pension or health care policy, with some modifications to suit that scopes. In addition, future study can extend this model to be more realistic by applying different types of labour.

Thirdly, the energy-finance-growth nexus such as in this thesis is well suited for the analysis at country level because each country has specific characteristics and the precise knowledge of this relationship can guide the policymakers to implement appropriate policies that will not deteriorate economic growth. However, this model can be applied to the regional or provincial level which might lead to different policy implications in different regions or provinces. Future researches would employ different types of energy such as electricity or renewable energy. Another possibility for further research is to use other proxies for financial development including indices of stock prices or volume of the stocks traded of their share to GDP, broad money, real domestic credit to private sector per capita.