Faculty of Economics, Thammasat University

TRESP

THAMMASAT REVIEW OF ECONOMIC AND SOCIAL POLICY

Volume 6, Number 2, July - December 2020
ISSN 2465-390X (Print)
ISSN 2465-4167 (Online)

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Thammasat Review of Economic and Social Policy

Thammasat Review of Economic and Social Policy (TRESP) is a double-blind peer reviewed biannual international journal published in June and December. The journal is managed by the Research Committee under the supervision of the Academic Affairs Division of the Faculty of Economics, Thammasat University. Our editorial board and review panel comprise of academicians and practitioners across various areas of economic and social policies. The goal of the journal is to provide up-to-date practical and policy-oriented analysis and assessment of economic and social issues, with particular focus on Asia and the Pacific region. However, research findings from other parts of the world that are relevant to the theme of the journal may be considered.

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Our journal is dedicated to serve as a platform for debate and critical discussion pertaining to the current issues of public policy. The outcome of such research is expected to yield concrete policy implications. Some of the targeted issues include urban and regional socio-economic disparities, ageing society, healthcare, education and welfare policies, environmental and natural resources, local communities, labor migration, productivity, economic and political integration, political economy, macroeconomic instability, trade and investment, fiscal imbalances, decentralization, gender issues, behavioral economics and regulations; and law and economics. The journal makes its best effort to cater a wide range of audience, including policymakers, practitioners in the public and business sectors, researchers as well as graduate students.

Articles should identify any particular issue concisely, address the problems of the research explicitly and supply sufficient empirical data or strong evidence and substantial argument to support the discussion of policy initiatives asserted by the author(s). Theoretical and applied papers are equally welcome provided their contributions are policy-relevant.

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Research Articles

Editorial Introduction

Since the beginning of 2020, the advent of Covid-19 has impacted industries and workers worldwide with varying magnitude and dimension. For Thailand, as an emerging country, its economy is highly dependent on exports which accounts for more than two-third of its GDP. Industries being seriously affected are particularly those relying on foreign demands, namely automobile, computer, chemical products, air conditioners, machinery, oil, plastic and rubber products. Contemporaneously, domestic demands are constrained, especially in the sectors of tourism, retail sales, automobile and real estate. In this difficult time, we are grateful to all our contributors, the boards, the reviewers, the authors and the readers.

This issue contains a well-diversified combination of quality research findings that have important policy implications, particularly for developing and emerging countries. The first article of this issue, "Performance of Foreign Investment Enterprises in Developing Economies: the Case of Vietnam Redux" by Tran Van Hoa is an empirical investigation into the growth and performance of Foreign Investment Enterprises (FIEs) in Vietnam. The author makes use of Vietnam's business survey data to explore how domestic factors, such as capital, labour, government policy, and legal reforms, have impacted the growth and performance of FIEs. The paper also looks at how FIEs have responded to various regional and international crises over the past decades.

Vietnam is a fast growing economy which has gone through many major changes over the past decades. The author highlights some of these changes, noting in particular the effects of the Doi Moi reforms in 1986, and Vietnam's increasing openness and economic integration into the global

economy in the years leading up to and after Vietnam's accession to the World Trade Organization in 2007.

The article separates FIEs into two broad groups, 100%-owned FIEs and joint-venture FIEs. The author notes that foreign investment in Vietnam is generally concentrated in four sectors: mining, manufacturing, electricity, and water. A seemingly unrelated regressions (SUR) model is constructed to identify the factors which impact the performance of these two types of FIEs.

The paper finds that joint-venture FIEs have outperformed 100%-owned FIEs over the period studied, and that the results would seem to indicate that the two types of FIEs have different production technologies, and respond differently to domestic reforms. The author concludes by highlighting that the biggest contributors to the success of FIEs are economic liberalization and legal reforms, and suggests a way forward for continued growth being the improvement of management methods and human resources training to boost entrepreneurship and labour productivity. The author, however, points out that it is important to be aware of the potential negative effects of the contagion that arise upon increased economic integration.

The second article, "Carbon Pricing and International Competitiveness for Thailand and ASEAN" by Chayun Tantivasadakarn is a timely investigation into the ways in which Thailand may meet its carbon emission reduction commitments in line with the Paris Agreement. Climate change is a pressing issue which all countries have agreed must be tackled, and this article helps us to understand how policies to reduce carbon emissions will impact specific sectors within Thailand.

The author investigates potential pathways for Thailand to implement carbon pricing measures, namely the implementation of an Emissions Trading System (also known

as cap and trade), or the imposition of a carbon tax. A version of the Global Trade Analysis Project (GTAP) model is used to simulate the impacts of Thailand unilaterally imposing carbon pricing measures, as well as a scenario where five ASEAN countries (Indonesia, Malaysia, Singapore, the Philippines, and Thailand) jointly implement carbon pricing measures.

The author finds that, while both methods of carbon pricing in both scenarios may lead to slight decreases in welfare and international competitiveness, for Thailand the scenario which causes the least negative impacts was a joint implementation by the ASEAN countries of a carbon tax. The implications for Thailand from the research are clear: Thailand needs to work with its neighbours in order to achieve its emissions reduction commitments in the least damaging way.

The third article, "Demographic Change and Fiscal Sustainability of Old Age Allowance Policy" by Teerapong Wijaranavarn, employs a scenario analysis of the challenges of an ageing population which Thailand, like many other developed and developing countries, will soon need to address. Though the changes brought about by an ageing society will impact every sector of the economy, this research paper focuses on Thailand's old age allowance policy which provides support for individuals over the age of 60. Given the demographic trend in Thailand, the number of individuals qualifying for such support will increase. At the same time, government revenue is declining as the working population decreases due to a declining national birth rate.

The author makes use of an Overlapping Generations Model in a general equilibrium setting to present policy options for simultaneously providing support for aged individuals, financing increased expenditures, and taking government debt into account.

The model compares the effects of increasing personal income taxes or increasing value-added taxes to raise

government revenue. The author finds increasing value-added taxes to be a more preferred policy option for the government. The research also indicates that increasing the old age allowance will have a positive impact on the economy by acting as a fiscal stimulus, while also raising the welfare of the elderly. However, the author notes that care must be taken not to increase government debt to the unsustainable amounts.

Thammasat Review of Economic and Social Policy (TRESP) is a young biannual double-blind peer reviewed international journal published in June and December. Its first publication was in December 2015. Upon celebrating its third year of publication in 2019, Thammasat Review of Economic and Social Policy (TRESP) has successfully applied for inclusion in Thailand Citation Index (TCI) database, Tier 2. In the evaluation, 65 out of 114 applied journals passed the comprehensive criteria. The Faculty of Economics, Thammasat University and the Editorial Team of TRESP seek to provide an effective platform for reflecting practical and policy-oriented perspectives that links the academic and policymaking community. Having devoted to our 'knowledge-for-all' philosophy so as to drive our society forward, the Faculty decided that TRESP published in an open access model. There are no submission and publication fees. However, the submitted manuscripts must be policy relevant and comply with the scope and requirements of the journal. Authors are responsible for the published articles. The views and opinions expressed in the articles do not necessarily reflect those of the Editors and the Editorial Board. For further information and updates on this journal, or to submit an article, please visit our website at www.tresp.econ.tu.ac.th.

Euamporn Phijaisanit
Editor-in-Chief

Thammasat Review of Economic and Social Policy
Volume 6, Number 2, July – December 2020

Research Article
Received: 5 April 2020
Revised: 20 June 2020
Accepted: 23 June 2020

Performance of Foreign Investment Enterprises in developing economies: the case of Vietnam Redux[1]

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[1] An early version of the paper was presented at the Econometric Research in Finance conference on 14 September 2018, organised by the Warsaw School of Economics, in Warsaw, Poland.

ABSTRACT

The paper studies the growth and performance of foreign investment enterprises in developing countries in the context of global economic integration, financial crises and domestic reform with a focus as a case study on Vietnam with its official updated business survey data. A SUR mixed micro and macro model of enterprise performance is constructed to provide empirical findings and evidence-based policy implications on the role of capital, labour, investment, monetary and development policy, entrepreneurship, and legal reform in this important private sector's performance. The findings show the importance of employment, global crises, entrepreneurship and especially beneficial legal reform in assisting these enterprises' performance as measured by high profitability per capital invested and per enterprise turnover. Openness in particular helps the dominantly high performance of joint ventures.

Keywords: Foreign investment enterprises, capital and investment, entrepreneurship, domestic reform and economic integration, business and trade policy.

JEL Classification: C51, C53, F14, F17, F31

1. Introduction

Vietnam, a major transition economy in South East Asia and an important member of the Comprehensive and Progressive Trans-Pacific Partnership, has achieved remarkable economic growth and development since the introduction of its economic reform (Doi Moi) beginning in 1986 (Harvie and Tran, 1997; Phan et al., 2006; Tran, 2012). In particular, Vietnam's opening-up policy (the so-called free-market-with-a-socialist orientation reform), new laws on the enterprises in 2001, 2006 and 2014, and high economic growth have had a deep beneficial impact on the development, transformation, dynamic structure, entrepreneurship and performance of its industrial sector (Ronnas and Ramamurpthy, 2001; GSO, 2018). In recent years however, the country has faced serious problems. These include high inflation in 2007-08 immediately after its 2007 World Trade Organization (WTO) accession and also in 2012, the rise of China's growth, exports and regional economic power, the impact of the global financial crisis (GFC) that started late in 2008 and was still lingering in 2010s, the 2011-2012 Euro sovereign debt crisis and its global contagion, and the slow-down of regional economies in the mid-2010s. All these developments have adversely affected Vietnam's growth, industrial development, enterprise performance, living standards, and legal and institutional infrastructure.

The paper is a rigorous econometric study on the performance of one of Vietnam's important high-growth and high-profit industrial private sectors, namely the foreign investment enterprises (GSO, 2018), during the past 20 years or so, and the role of capital, labour, investment, development policy, entrepreneurship, legal reform, crises and economic integration on this performance. Its main focus is on

constructing a multi-equation model of enterprise performance (measured in terms of the sector's profit rates) to provide empirical findings to confirm or reject the relevance of this causal role. Policy implications from the findings for corporate and government decision-makers are then briefly discussed.

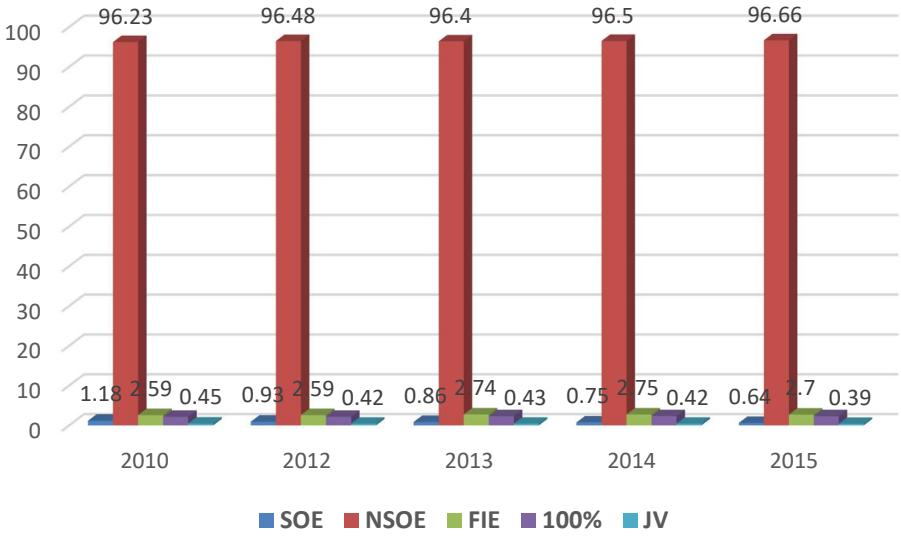
The plan of the paper is as follows: in Section 2, historical and survey statistical data are used to describe the main structural and performance characteristics of the foreign investment enterprises in Vietnam and in relation to the features of the other two major sectors, namely, state-owned and non-state-owned enterprises. A seemingly unrelated regression (SUR) model of enterprise performance incorporating both industrial production process and economic integration developments is constructed in Section 3 to explore and confirm the causal relationships between the sector's performance and its testable postulated contributing microeconomic, macroeconomic, entrepreneurial, crisis and legal reform drivers. Section 4 reports the empirical findings based on available enterprise data for 2000-2014 published by Vietnam's General Statistical Office. Section 5 provides an analysis of the findings and their policy implications. Conclusions are given in Section 6.

2. Vietnam's Foreign Investment Enterprises and their performance

After many decades of devastating colonial and independence wars and their aftermaths, Vietnam has achieved much in recent years with its 1986 renovation reform (Harvie and Tran, 1997) and earned increasing international acclaim (World Bank, 2018). An important result of this achievement is the transformation and dynamics of the economy as observed, during the period 2010-2015, through the structural enterprise movements (Figure 1), enterprise

output shares (Figure 2) and enterprise profit rate (Figure 3) of its three principal sectors by ownership. These are the state-owned (SOE), non-state-owned (NSOE), and foreign investment enterprises (FIE) (and its two subsectors, 100% and joint-venture (JV)). Reasons for foreign ownership and mode of entry choice were explored by Tsang (2005). In Figure 1, we note that while the proportion of NSOEs in Vietnam had posted a small rise from 96.23% to 96.66% during the period, the relative number of SOEs had had a marked decline, due to, to a large extent, the government industry reforms, from 1.18% in 2010 to 0.64% in 2015. The FIE sector share on the other hand showed a rise from 2.59% in 2010, to 2.75% in 2014 and a dip to 2.70% in 2015. In 2015, the total number of enterprises in Vietnam was 442,485.

Figure 1. Enterprise Shares (%) by Ownership, 2010-2015



Note: Data in Figures 1-5 from GSO (2018) and own calculations.

Figure 2 shows the trend in real gross domestic product (GDP) at 2010 prices of three sectors (SOE, NSOE and FIE) and three of NSOE subsectors (private, collective, and household) during 2005 to 2016. The figure indicates a rising trend of all sectors and subsectors and especially a faster trend for the NSOE and FIE sectors since 2010 (the post-global-financial crisis), and that the household subsector GDP had exceeded the SOE GDP also since 2010. The NSOE GDP, as a result of its largest enterprise share (Figure 1), is the largest at VND1,138,877 billion in 2016, followed by the SOE GDP at VND848,292 billion and by the FIE GDP at VND489,817 billion. Some interesting features of the sectoral GDP trend can be seen better in Figure 3 where the GDP shares by ownership are given for 2005 and 2016.

Figure 2. Real GDP (VND billion) by Ownership, 2005-2016

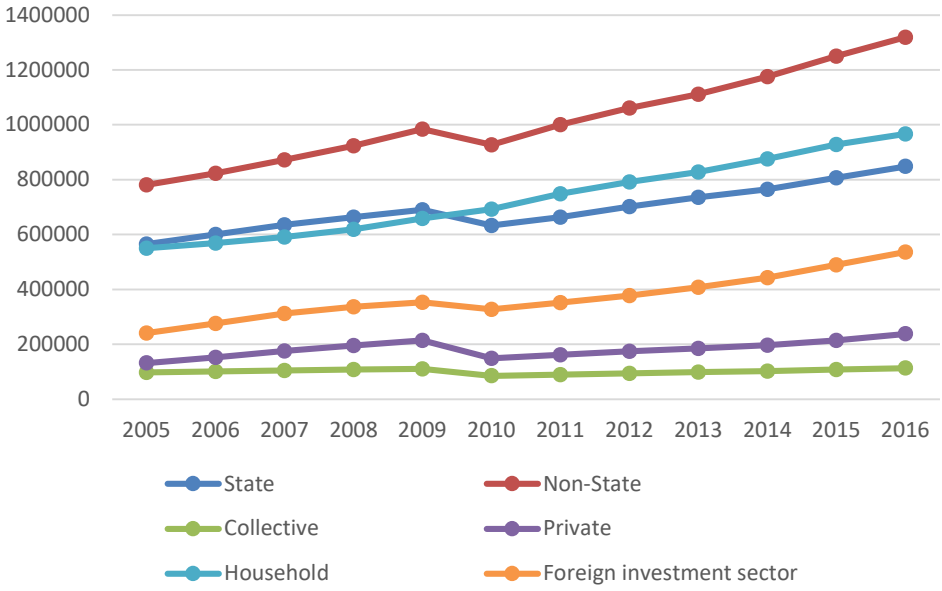
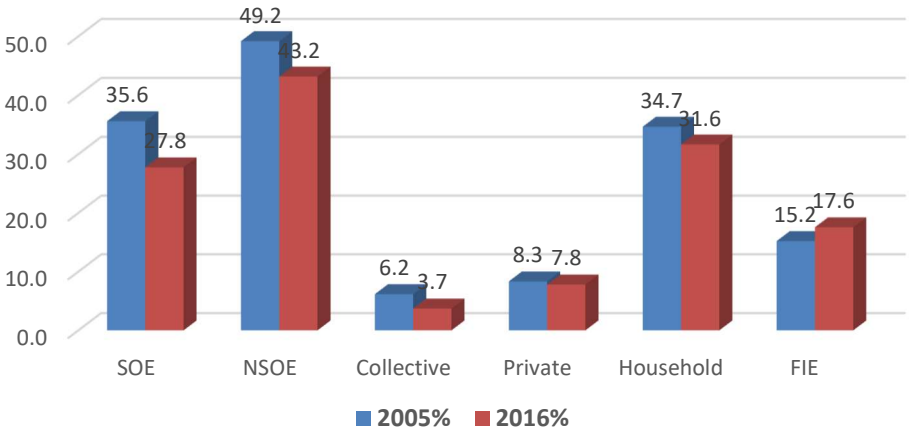


Figure 3 shows that while the NSOE sector has the largest enterprise share at over 96% on average during 2010-2015 (Figure 1), its proportion in terms of national real GDP came only at 49.2% in 2005 and 43.2% in 2016. In comparison, the SOE sector's real GDP share was, because of its size per enterprise, at 35.6% in 2005 and 27.8% in 2016. Both the SOE and NSOE sectors show a substantial declining share of real GDP during the period. In particular, all three subsectors of the NSOE, namely, the collective, private and household, uniformly show a decline in real GDP share between 2005 and 2016. The importance of the FIE sector in Vietnam's economy can be seen from this figure where, in spite of its relative small enterprise share of over 2.6% on average (see Figure 1), its real GDP share was however at 15.2% in 2005 and 17.6% in 2016. In fact, the FIE sector is the only sector in the country that shows an increase in real GDP share during the period.

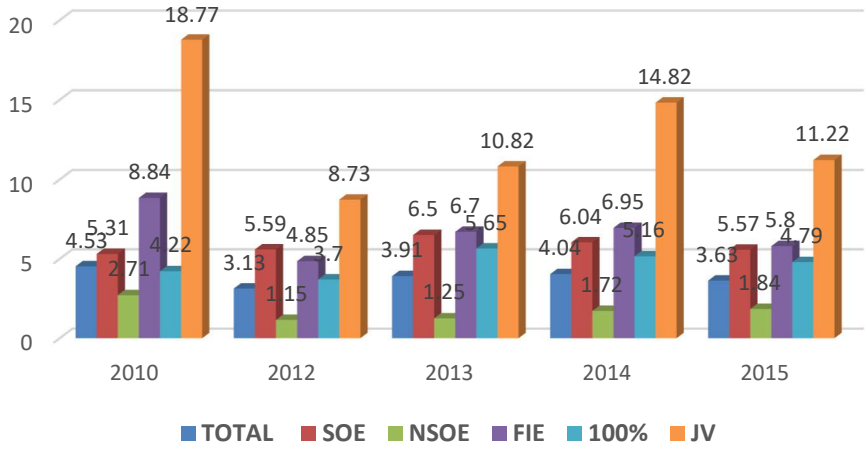
Figure 3. Output Shares (%) by Ownership, 2005 & 2016



Note: 2005% and 2016% denote the output shares by ownership in 2005 and 2016 respectively.

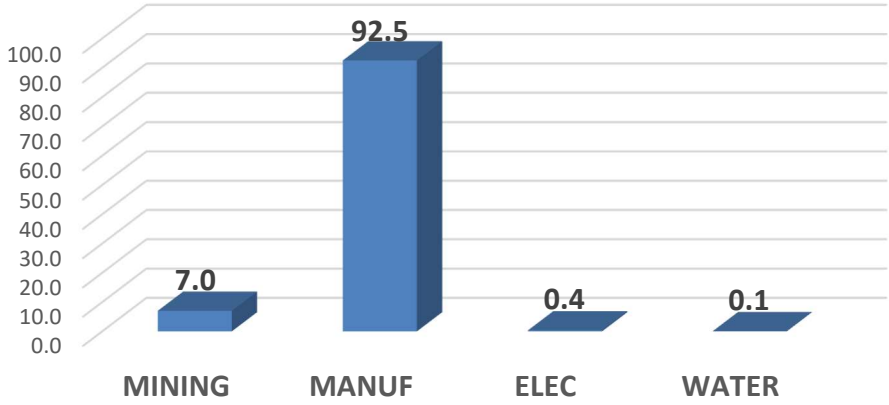
What has contributed to the remarkable growth and economic performance of Vietnam's FIE sector during the period under study? Some data to support this potential contribution are given in Figure 4 where the profit rates of the various sectors/subsectors of Vietnam's enterprises between 2010 and 2015 are given. From this figure, we note the dismal lowest rate of the NSOE sector, compared even to the SOE sector that has been universally domestically and externally criticised for its supposedly inefficient government-subsidised management and operation. Most significant observations from the figure are that except in 2012, the FIE sector as a whole outperforms all other sectors. More specifically, the FIE subsector, namely joint-venture, uniformly outperforms all other sectors and subsectors (e.g., 100% owned) by a large margin for the whole period. For example, in 2015, the profit rate was 3.63% for the whole country, 4.47% for SOE, 1.84% for NSOE, 4.79% for 100%-owned, and 11.22% for joint-venture.

Figure 4. Profit Rates (%) by Ownership, 2010-2015



It should be noted that the FIE in Vietnam is involved almost wholly in four subsectors where foreign capital and expertise are generally required: mining, manufacturing, electricity and water. The largest proportion (92.5%) of the FIE GDP sector is in manufacturing (Figure 5).

Figure 5. Real GDP Shares (%) of Major FIE Sectors, 2010



It is well-known that the performance of enterprises can be measured conventionally by output (real GDP) growth or productivity (output per employee) using the production function or alternative growth theory approaches (McMahon et al., 2009), sales (Thang and Trung, 2011) or even export growth (Pham, 2001). In terms of the theory of international business (Cavusgil et al., 2012), it can also be measured justifiably in terms of the survival rate of enterprises, the growth of enterprise output shares, employment in the firms, capital invested and fixed assets, wage rates paid, and even the financial contribution of enterprise activities to national revenue (GSO, 2018).

In this paper, we will focus on the performance of enterprises, especially foreign investment enterprises in Vietnam, as measured by two important criteria: profit rate per capital and profit rate per enterprise turnover. A justification is that the profit rate attained is a good indicator of an enterprise's success and *a fortiori* survival rate and potentially domestic and external expansion. The historical performance of the SOE, NSOE and FIE sectors and the two FIE sub-sectors of 100% owned and joint-venture enterprises in Vietnam during 2010-2016 in this context is given in Figures 1-4. In these figures, we note the prominent sustained dominance of the FIE sector's high profit rate performance over the SOE and NSOE sectors. A study on the causes or drivers of this performance for 100%-owned and especially joint-venture FIEs is particularly interesting and important for foreign business operation and planning strategy especially in developing and open economies such as Vietnam.

The literature on the relationship between enterprise performance, defined variously as growth, survival, exports and sales, and its potential determinants has been limited. Previous studies by McKinnon (2003), Hansen and Tarp (2004), Rauch and Watson (2004), Baumol (2007), and Vinig and Kluijver (2007) have focused chiefly on this relationship by descriptive analysis of time-series and survey data. As correlational or associative analysis, these studies lack causality content. Related studies of enterprise performance causality from a conventional production function framework have been reported by Pham (2001) and Thang and Trung (2011). A previous macroeconomic study on the firm performance in terms of the growth of enterprise output shares in Vietnam has also been reported (Tran, 2011 and 2012). Vu and Nguyen (2013) investigated by panel regression the effects of banking relationships on firms' returns on assets and equities in Vietnam. However, a rigorous multi-sectoral

modelling study of causality of the enterprise performance in terms of profit rates in an open developing economy with economic integration commitments and with existing production technology in general and in Vietnam in particular is conceptually and empirically desirable for foreign enterprise development policy analysis. But this kind of study is currently lacking. The study is also relevant to a better understanding of the success, survival and expansion of FIEs in developing economies from an international business strategic development perspective (Cavusgil et al., 2012).

In this context, the paper will focus on an econometric modelling study of the causality of the FIE sector's high performance, expressed as profit rates, in a major transition developing open economy, namely Vietnam, for corporate and government policy analysis. It will address the following specific research questions:

(i) What fundamentally contributes to the high performance of the 100%-owned and especially joint-venture foreign investment enterprises in Vietnam in recent years?

(ii) Are these contributors different for these two sub-sectors and why?

(iii) Did the 2006 and 2014 legal reforms assist in this performance?

(iv) What are the effects of economic integration and financial crises on the FIE performance in Vietnam?, and

(v) What are best practice strategies for FIE development and survival in Vietnam.

3. A mixed micro-macro model of enterprise performance in the context of production technology, domestic reform & economic integration

Theoretical Framework – An early detailed study based on a descriptive analysis of the data from two large 1991 and 1997 surveys of Vietnam's enterprises was carried out by the World Bank and reported by Ronnas and Ramamurpthy (2001). A number of quantitative studies especially on the impact of human resource management and training on Vietnam's enterprise performance in terms of output and organisation in a production function framework has also been undertaken (e.g., Thang and Trung, 2011). A previous quantitative study on the foreign investment enterprise performance in terms of exports and sales using a non-production function framework has also been carried out by Pham (2001). A more recent comprehensive official data report on the three principal sectors' activities, output, industrial structure and dynamic transformation based on the nine annual surveys of Vietnam's enterprises between 2000 and 2008 is given by Vietnam's General Statistical Office (GSO, 2020). A macroeconomic multi-structural equation model of output growth share performance for Vietnam's enterprises classified by ownership (i.e., SOEs, NSOEs and FIEs) in the context of economic integration has been constructed and reported (Tran, 2012). Econometric modelling study of the causality of the performance in terms of profit rates of the FIE sector in Vietnam, while crucial for strategic business development, has not been carried out and reported with data updated to 2014.

In the present paper, a number of theoretical and methodological innovations in modelling enterprise performance will be introduced. First, we assume conceptually that the enterprises and their performance in an open economy, developed and developing, with economic integration

(globalisation) commitments are constrained by two sets of complementary factors: domestic and international. Second, domestically, the enterprises operate in a generalised meta-production framework where capital, labour, entrepreneurship, and legal enterprise reform are assumed to play an important part in determining their performance. Third, internationally, as the country has economic integration commitments and benefits in the form of liberalised trade in goods (exports and imports), investment (portfolio and foreign direct investment) and financial services as sanctioned by the WTO (WTO, 2018), the enterprises and their performance are assumed to be concurrently affected by these factors. This is a modelling specification feature distinct from conventional stochastic frontier analysis. As has been mentioned earlier, enterprise performance in our study is defined as profits per capital invested and profits per enterprise turnover. For pragmatic functional specification reasons, only the linear model is specified for the study (see Tran, 2012, for other functional forms that can be adopted). Finally, as the FIE sector in Vietnam consists of two subsectors, namely 100%-owned FIEs and joint-ventured FIEs, the two subsectors are related functionally by virtue of the adding-up property (i.e., FIE = 100%-owned FIE + joint-ventured FIE), As a result, ordinary least-squares estimation in this case is inefficient, and a multi-equation model of 100%-owned and joint-ventured FIE equations without endogeneity should be efficiently estimated by an appropriate generalised least-squares method such as Zellner's SUR (seemingly unrelated regression).

The Model - A simple mixed micro macro model of the enterprise profit determination within the conceptual framework of meta production function technology, Johansen (1982) add- and sub-factors, and regional and global economic

integration theory (WTO, 2018) and its key testable causal determinants can then be written generally in implicit form as

$$P = P(L, K, I, W, TO, T, FDI, D, C, C06, C14) \qquad (1)$$

where P=PK, profit per capital or P=PT, profit per enterprise turnover, L=average employees per enterprise, K=average capital per enterprise (VND billion), I=average fixed assets and long-term investment per employee, W=average monthly labour wages per employee, TO=average business turnover per employee, T=trade openness [(exports+imports)/GDP], FDI=foreign direct investment/GDP, D=entrepreneurship or its proxy, C=global financial crisis, C06=2006 legal reform, and C14=2014 legal reform.

The model's theoretical foundation can be briefly described as follows. In (1), enterprise performance or profit is assumed for testing purposes to be determined by the conventional domestic production factors of labour (L) and capital (K), augmented by fixed assets and long term investment (I), labour wage costs (W), business turnover (TO), management skills or entrepreneurship or its proxy indicator (D), global financial crisis (C), and the legal reforms in the form of Vietnam's 2006 and 2014 Laws of Enterprises. Importantly, this performance is also assumed to be determined by the international factors such as trade liberalisation or openness (T) and foreign direct investment (FDI) in the context of economic integration theory for open economies with free trade agreement commitments.

The model (1) implies an implicit flexible functional relationship among its determinants that can be highly nonlinear and that, as it stands, cannot be statistically estimated. A derived model from (1) based on its planar approximations can be obtained for empirical implementation (see Tran, 1992, 2012). Due to data limitations however, this

general approach is not taken here. As a simple specification for illustration purposes, the model (1) can be written explicitly for empirical implementation in its linear form as (a log form is not appropriate as some data on profits in the early 2000s were negative).

$$P = \alpha_1 + \alpha_2 L + \alpha_3 K + \alpha_4 I + \alpha_5 W + \alpha_6 TO + \alpha_7 T + \alpha_8 FDI + \alpha_9 D + \alpha_{10} C + \alpha_{11} C06 + \alpha_{12} C14 + \mu \quad (2)$$

where the α's are regression parameters and μ is the disturbance with regular statistical properties representing other potential determinants omitted from the model.

The Data – The enterprise production and performance data for the model were obtained from the national surveys of Vietnam's General Statistical Office (2018), and trade and FDI data from the Asian Development Bank (2018). While the ABD macro data are available from 1990 to 2016, the GSO survey data are available only from 2000 to 2014, the sampling period adopted was from 2000 to 2014. Three qualitative variables were used for the GFC and the introduction of the Law of Enterprises in 2006 and 2014. The trend of the two profit rates (i.e., per capital invested and per enterprise turnover) over the sample period can also be attributed to enhanced entrepreneurship and improved business management skills over time or a deterioration of them which can also be equated partially to development progress of the country. This was proxied for simplicity by a trend variable.

4. Substantive findings

The empirical findings by the SUR estimation method for the model of enterprise performance (2) applied to two types of profit rates (per capital – PK - and per enterprise turnover -

PT) and simultaneously to both 100%-owned (100) and joint venture (JV) FIEs (that is, PK100, PKJV, PT100 and PTJV) in Vietnam for official 2000-2014 survey data are given in Table 1.

Table 1. Vietnam's Foreign Investment Enterprise Performance – SUR Estimation

Variable	Profit Rate per Capital		Profit Rate per Turnover	
	100%-owned	Joint Venture	100%-owned	Joint Venture
Constant	-0.922	-24.044	-0.286	-15.143
Employment	0.013*	0.235**	0.019**	0.159**
Capital	0.005	-0.009	0.001	0.017**
Fixed Assets	-0.007	0.013	-0.011	0.024**
Wages	0.045**	-0.060	0.061**	-0.076*
Turnover	-0.041**	0.003	-0.056**	-0.015**
Openness	0.009	-0.566**	0.007	-0.509**
FDI/GDP	0.024**	-0.013	0.037**	0.016
Entrepreneurship	0.263**	3.325**	0.352**	3.888**
Law 2006	0.178	5.918**	0.018	5.002**
Law 2014	-2.511**	7.324**	-3.391**	9.403**
GFC 2009	2.378**	-20.063**	3.496**	-18.820**
RSQ	0.972	0.966	0.965	0.960
DW	3.178	2.660	3.357	2.721
ADF-p	0.195	0.118	0.702	0.040

Notes. **=Significant at 5%, *=Significant at 10%, RSQ=R-squared, DW=Durbin-Watson statistic. ADF-p=Augmented Dickey-Fuller p-value for the equation residuals.

As described above, all variables represent the key conventional production technology process (labour, capital, wages and fixed assets/investment), legal reforms, Johansen add- and sub-factors, and the major economic integration activities (trade and FDI – a financial variable was not

introduced and tested due to unavailable data). While the degrees of freedom are moderate the serious econometric problem of high goodness-of-fit (RSQ) and low Durbin-Watson values in the estimated models was not present. Also as described above, the SUR instead of the ordinary least squares is used on the ground that within the FIE sector, there is likely some correlation between the activities of the 100%-owned and joint venture FIE sub-sectors. In addition, the panel regression estimation method was not employed due to the fact that the performance of the two sub-sectors is likely to be structurally characterised by their own determinant factors, and this likely structural or behavioural discrepancy is the model's objective or focus for testing purposes. As is well-known, the SUR estimates are statistically consistent and efficient in the class of generalised least squares estimators.

Judged from the results reported in the table, the standard statistical performance of the estimated models of enterprise performance in terms of profit rates for Vietnam's 100%-owned and joint venture FIEs appears good in terms of the conventional R^2 and a lack of first-order serial correlation. It is also econometrically consistent and efficient. The augmented Dickey-Fuller tests also indicate their residuals are statistically stationary at the 1% significance level. Policy implications are derived from these empirical findings.

In addition and more importantly, the modelling performance of Vietnam's 100%-owned and joint venture FIE profit rates per capital (PK100, and PKJV) and per turnover (PT100 and PTJV) and their 3SLS estimates PK1003, PKJV3, PT1003 and PTJV3 respectively is given graphically in Figures 6 and 7. These figures reflect the Friedman (1953)-Kydland (2006) criterion of data-model close representation or simply empirical fit.

Figure 6. Modelling Performance of FIE Profit/Capital %

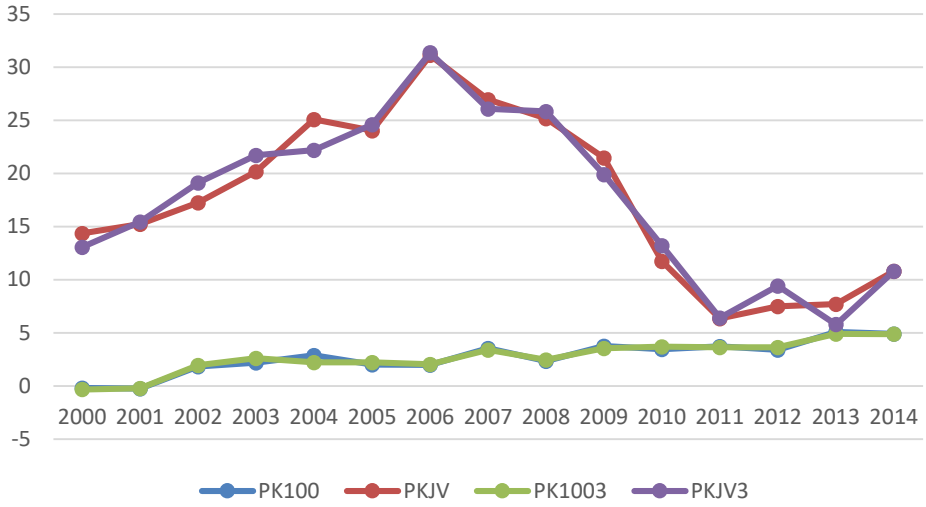
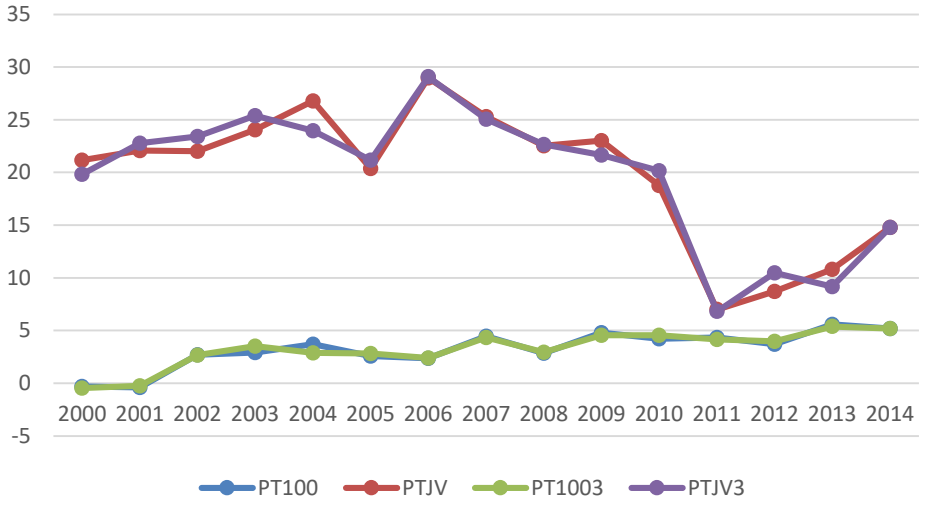


Figure 7. Modelling Performance of FIE Profit/Turnover %



From these figures, the model emulates very well the trend, the troughs, the peaks and especially the turning points of Vietnam's FIE profits during the volatile period in the country where the global financial crisis of 2008 took place, its WTO membership in 2007 was approved, and various national economic and enterprise reforms were adopted. Policy implications of our findings and their credibility are based on these characteristics and briefly described in the section below.

5. Policy implications for Foreign Investment Enterprises

The performance of FIEs in the 100%-Owned and Joint Venture Sub-sectors

It is interesting that the findings do not support the assumption of identical causal effects on the performance for both 100%-owned and joint venture FIEs in Vietnam. This outcome is expected as the observed performance (survey data by GSO, 2018) shows that the joint venture FIEs completely dominate the 100%-owned FIEs (see Figure 4) due probably to different contributors. One important modelling implication of this is that a combined study of these two sub-sectors would be inappropriate conceptually and methodologically and in policy analysis and practical implementation. Another implication for serious research in this field is that the use of panel data regression with constant effects from all determinants over all sub-sectors for example for this kind of study would also be inappropriate. A third implication is that while the 100%-owned and joint venture FIEs are two separate legal entities, our findings show that they also have apparently operated under two different production technologies and responded differently to the impact of legal reforms and

economic integration. These enterprises require therefore separate study, analysis and strategic policy.

What Are Fundamental Production and Integration Drivers of FIE Performance?

For 100%-owned FIEs – The sub-sector is characterised by relatively weak performance or low profit rates. The findings indicate that employment, wages and turnover are significant factors to FIE performance in terms of both profits per capital and per turnover. While openness does not appear to have a significant positive impact on the FIE profit rates, the importance of economic integration via FDI in-flows here cannot be underestimated for the survival and expansion of this FIE sub-sector. The 2006 legal reform with its limitations appears to have a positive but only statistically weak effects on this sub-sector's performance indicators. In contrast, the legal reform of 2014 creates only strong uncertainty in operation and profit outcomes in its introduction and this is reflected in its negative impression impact. Fixed assets and long-term investment surprisingly seem to have dampening effects. These reflect apparently the low quality or inappropriate business strategies for these FIEs. Both profit equations have a very high empirical fit. Entrepreneurship as a separate and important factor of achieving high profits for this sub-sector is strongly and statistically validated.

For joint-venture FIEs – Joint-venture FIEs have a much higher success (profit) rate than 100%-owned FIEs and the causality of this superior performance seems to be more complex. For this sub-sector of FIEs, the profit rates are strongly and dominantly supported by factors such as labour, fixed assets and long term investment, and especially the 2006 and 2014 legal reforms. These validate the important contributing role of labour and investment strategies in the

sub-sector and the view that a favourable business environment is crucial to a private sector, namely the FIEs, in Vietnam. In fact, the largest contributors to the performance of these FIEs as measured by the size of the impact parameters in the estimated model are the 2006 and 2014 legal reforms. Again, as in the case of 100%-owned FIEs, entrepreneurship as a separate and important factor of profit performance is also statistically supported in the joint venture sub-sector.

Is FIE Performance Affected by Economic Integration and Crises?

Economic integration has played a crucial part in Vietnam's economic "miracles" and put the country in the group of high growth economies in the world, and contributed to the establishment of FIEs and their high profit achievement especially in the recent years. In addition, the country's 1987 Doi Moi openness policy has also led to its industry, investment, structural and especially legal reforms (Hansen and Tarp, 2004). The results of this integration and reforms have however mixed benefits on the FIE performance by both profit per capital and profit per enterprise turnover measures in our study. A possible reason for this is that these enterprises, due to their independent or collaborative nature, are likely to use different levels of local knowledge and resources and network in addition to their overseas expertise and investment to manage more successfully their businesses. Strategically for business planning, joint-venture FIEs appear thus the best form, in terms of profits, of business development and operation in the case of Vietnam. The causes of high profits appear however more complex empirically. The large and different impacts of Vietnam's 2006 and 2014 legal reforms on the 100%-owned and especially joint-venture FIEs has been noted in Table 1 above.

Finally, while the usual expectation is that Vietnam's FIEs should be affected by the contagious GFC, our findings indicate that the situation is again more complex, perhaps due to the country's status as a transition economy with a strong state-control management and different corporate ownership structure and operation. The profit rates of the 100%-owned and joint venture FIE sub-sectors appear to have reacted differently to the contagion of the crisis in our study.

Entrepreneurship in Vietnam's FIEs

If the thesis that innovation and entrepreneurship are the key elements for enterprise success domestically (via increased productivity and efficiency) (see Nguyen et al., 2009; EC, 2012) and in international trade (via expanded exports) (see Pham, 2001; Nguyen et al., 2007) through enhanced competitiveness and comparative advantages is correct, then our model's findings with proxy measurement and with Vietnam's enterprise data can provide some statistical support for this thesis. There are a number of reasons for this. First, as our measurement reflects the accumulated knowledge or the dynamics and transformations of the economy in general and the FIE sub-sectors in particular over time, it captures the essence of innovation and entrepreneurship. Second, while entrepreneurship can produce high productivity and subsequently, as postulated and empirically validated, high profit, it can represent other contributors to profitability that conventional production technology, legal reforms and say Vietnam's trade liberalisation obligations and their effective implementation under its various regional and global trade agreements cannot capture. Our findings appear to support this hypothesis. An important policy implication is that, to improve labour and capital productivity in Vietnam's FIEs in the context of the

country's early development stages, capital and human resource management training for managers and directors for enterprises in general and for FIEs in particular in Vietnam would be a high priority. This implication is also compatible with the strong focus for funding support to Vietnam's enterprises in general and FIE sub-sectors in particular by national and international donors and policy-makers (IFC, 2009).

6. Conclusion

In the preceding sections, we have discussed the role of FIEs and their transformations, dynamics and performance in the Vietnamese economy in recent years. We then constructed a simple model of enterprise performance with micro, macro-economic and international trade foundations to explore and identify the fundamental factors for these FIEs' success, survival and possible expansion domestically and internationally in the two FIE sub-sectors in focus, namely 100%-owned and joint-venture FIEs. We have found mixed results for the conventional production factors of labour and capital, but strong support for the effects of economic integration, legal reforms and entrepreneurship on these enterprises' performance as measured by the profit rates. We speculate that, due to the development stage of the country, the enterprise performance has benefited from its trade and FDI liberalisation and co-operation with its trading partners (Tran, 2012) as has also increasing entrepreneurship capacity as a result of this engagement with the regional and global economies. We also caution about the risks of possible damaging contagion of the regional and global financial crises on this performance and call for appropriate policy to avoid them or to mitigate, to some extent, their adverse effects for national, regional and global benefits.

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Thammasat Review of Economic and Social Policy
Volume 6, Number 2, July – December 2020

Research Article
Received: 28 April 2020
Revised: 2 August 2020
Accepted: 4 August 2020

Carbon Pricing and International Competitiveness for Thailand and ASEAN*

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* This article is based on a Thai-language research funded by the Thailand Research Fund. This version of the article has been abridged and amended based on peer-reviewed feedback.

ABSTRACT

The main purpose of this paper is to provide an economic analysis such that policy makers may decide which carbon pricing measures, between carbon markets or Emission Trading System (ETS) and carbon taxes, would be more appropriate for Thailand based on their impacts on production, consumption, exports, imports, social welfare and international competitiveness. We find that a carbon tax measure that is jointly implemented by five ASEAN countries would be the most suitable for Thailand. This is because it can mitigate carbon dioxide emission to the target level while generating fewer negative impacts on production, consumption, exports, imports, social welfare for Thailand. It also causes less unfavorable economic effects as compared to the case of Thailand's unilateral carbon tax implementation or the case of carbon market, either unilaterally or jointly. Both carbon taxes and ETS, for the same mitigation target, does not significantly affect Thailand's international competitiveness. However, a joint carbon tax measure has fewer negative impacts on competitiveness as compared to unilateral implementation and even improves Thailand competitiveness in some sectors.

Keywords: Carbon market, emission trading system, carbon tax, carbon pricing, international competitiveness, NRCA, economic impacts, Thailand, ASEAN.

JEL Classification: Q540, F180

1. Introduction

Carbon pricing mechanisms, consisting of carbon taxes and carbon Emission Trading Systems (ETS), are carbon emission mitigation measures considered to be very effective, as they are designed to correct for market failure due to negative externality effects of carbon emission.

As of 2020, there have been 61 initiatives either to implement or to schedule carbon pricing for implementation (World Bank, 2020). This consists of 31 emission trading systems in regional, national and subnational jurisdictions, and 30 carbon taxes, primarily applied on a national level. In total, these carbon pricing initiatives cover 12 gigatons of carbon dioxide equivalent ($GtCO_2e$), or about 22 percent of global GHG emissions. Carbon taxes are used worldwide and mostly implemented in Scandinavian countries, some provinces of Canada and the United States of America. Scandinavian countries have applied carbon taxes since the 90s. On the other hand, Australia has applied a carbon tax since 2012 and has experienced huge political resistance as it has significantly impacted production costs and competitiveness. The Australian government has finally replaced the carbon tax with an ETS. These incidents suggest that appropriate carbon pricing may not be the same for each country and warrants further investigation.

Carbon pricing has been the main instrument that the Annex I countries of the Kyoto Protocol have used to fulfill their obligations. However, as the non-Annex I countries are not required to mitigate, the total emission from the latter group has been increasing drastically. The global concentration of carbon dioxide has exceeded 400 ppm since May 2013 and is still rising (Scripps Institution of Oceanography, 2013). This carbon dioxide concentration statistic is a warning signal that the average global temperature

will rise closer to the threshold level of 2°C above pre-industrial levels, a threshold level which climate scientists have predicted will cause serious climate disasters.

As a consequence, negotiators from developed countries have been pressing the non-Annex I countries, especially the so-called BASIC Group [1], to start sharing the mitigation responsibility since the 15th Conference of the Parties or COP 15 of UNFCCC at Copenhagen in 2009. In 2015, at the COP 21 in Paris countries adopted the Paris Agreement. The new agreement aims at strengthening the global response to the threat of climate change by keeping the global temperature rise to be below 2°C by the end of this century, and if possible, to pursue efforts to limit the temperature increase even further to 1.5°C.

However, the Climate Action Tracker has estimated that the Intended Nationally Determined Contributions (INDCs) proposed by all parties before the conference in Paris can only limit the increase of temperature to 2.7°C and there is still a significant emissions gap that need global cooperation to maintain the 2°C limit by the year 2025. The emission gap is estimated to be around 11–13 $GtCO_2e$ and is about 14–16 $GtCO_2e$ for 1.5°C (Climate Action Tracker, 2015). Even worse, the latest update released at COP 25 in Madrid on December 10th 2019 indicated that most governments seem determined to continue embracing fossil fuels, and even if they met their Paris Agreement pledges, we would see a warming of 2.8°C by the end of this century (Climate Action Tracker, 2019).

The above emission gap suggests that all countries must increase their efforts in order to reach the common target. According to the Paris Agreement, each member is required to contribute to the common goal by submitting the Nationally

[1] The group consists of Brazil, South Africa, India, and China.

Determined Contributions (NDCs). Although the NDC is not a legally binding emission target, all members must report their progress toward their NDCs and revise them regularly. Developing countries, including Thailand, will therefore be pressured to put additional mitigation measures to reach higher and higher contribution targets.

According to the country's 2005 National Communication, Thailand emitted 351.3 $MtCO_2e$ and was ranked 24th globally. Emissions was amount to 5.6 tCO_2e per capita which was 71st in global rankings, rising continuously from 107th in 2000. These statistics clearly show that Thailand will be forced by international peers to submit more ambitious contributions. As a result, the country will need much stronger measures than just energy efficiency and renewable energy measures. Hence, it is inevitable that carbon pricing measures such as a carbon tax or ETS will be in the policy menu in the near future.

In order to justify whether carbon pricing should be used or not, policy makers must have sufficient information about the economic impacts of such measures. Carbon pricing internalizes the externality effects of the carbon dioxide emission back to the polluter. This in turn raises the cost of production and market price, which can cause several impacts on production, exports, imports, GDP, and the national social welfare. The additional costs can also reduce the international competitiveness of the goods being produced. As Thailand's degree of openness[2] has always been well above 100%, applying a carbon pricing policy that might affect its international competitiveness is definitely a serious economic and political issue. The main objective of this paper is, therefore, to provide the impact assessment of carbon pricing measures on important economic activities, national welfare,

[2] For instance, the degree of openness for Thailand in 2016 was 123%. See https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS

and the international competitiveness of Thailand and ASEAN.

This paper is organized as follows: section 2 provides a literature review on the impacts of carbon pricing, while section 3 describes the methodology used in this paper. Section 4 provides the results and discussion. Lastly, Section 5 concludes and summarizes the findings and policy implications.

2. Literature review

The heterogeneity of energy generation as well as the sources of CO_2 implies that conventional technology and performance standards would be infeasible, if not, excessively costly (Newell and Stavins, 2003). Therefore, it is generally agreed among economists that carbon pricing is one of the most effective instruments for CO_2 mitigation (Metcalf, 2009; Kaplow, 2010; Bowen, 2011; Baranzini et al., 2017; Borenstein et al., 2018). The efficiency of carbon pricing emerges from the incentive to abate emissions up to the marginal abatement cost. At the same time, it also induces users to seek substitutes for carbon-intensive fuels which reduce abatement costs even further by inducing carbon-friendly technological change (Newell, Jaffe, and Stavins 1999).

Although the cost effectiveness of carbon pricing is widely acknowledged among economists, there is less agreement regarding the choice of specific carbon-pricing policy measures. Some support carbon taxes (Mankiw, 2006; Nordhaus, 2007), while others prefer cap-and-trade mechanisms (Ellerman, Joskow, and Harrison 2003; Keohane, 2009). This leads to the question: how do the two major instruments to carbon pricing compare on relevant dimensions, such as the impacts on various economic aspects?

The survey done by Stavins (2019) shed light on the above question. In summary, carbon tax and ETS systems share some similar characteristics and outcomes, and in many cases are fully equivalent when they are designed in ways that make them truly comparable. A carbon tax and an ETS with auctioned permits are fully equivalent for incentives for emission reductions under no uncertainty[3]. They are very similar in terms of inducing carbon-saving innovations (Milliman and Prince 1989; Jung, Krutilla, and Boyd, 1996; Fischer, Parry, and Pizer 2003)[4], possibilities for raising revenue when ETS is implemented with auctioned permits (Goulder and Schein 2013), costs to regulated firms when revenue-raising instruments are employed (Goulder and Hafstead 2018)[5], and distributional impacts (Goulder and

[3] Both instruments provide equivalent incentives for firms to carry out abatement until the marginal abatement costs are equal to either the carbon tax rate or the market-determined carbon price. Thus, all firms operate at the same marginal cost. In effect, both systems can achieve the same emission target at the same minimized compliant costs, summation of aggregate abatement costs, and marginal external costs.

[4] Carbon pricing can induce innovation through two channels: the abatement cost effect and the emission payment effect. For the first effect, innovation reduces the marginal abatement cost, which encourages more emission abatement under a carbon tax, while under the ETS system total emissions by definition remains constant. As a result, firms under a carbon tax system invest more for cleaner innovations. For the emission payment effect, firms under the ETS with auctioned permits can gain from the fall in permit price resulting from carbon-saving innovations. This second effect is not present under a fixed carbon tax or an ETS with free permits. The model and numerical simulation by Fischer et al.(2003) show that the overall effects of neither system dominates.

[5] The cost of a carbon tax or ETS system with auctioned permits depends on the method of revenue recycling. According to Goulder and Hafstead 2018 the net costs range from 15% with a lump-sum redistribution of revenue (rebates), 26% with recycling through rate cuts in payroll taxes, individual income taxes, or 67% with corporate income taxes.

Schein 2013)[6]. For transaction costs aspects that affect the compliance costs, the average transaction cost of the ETS system varies negatively with the initial permits, which make it distinctively different from that of the carbon tax system (Stavins, 1995). Furthermore, there can be real differences between these two approaches on the dimensions of efficiency in the presence of uncertainty (Weitzman, 1974)[7], and the different impacts of balanced technological change on carbon prices and emissions[8]. Lastly, they are significantly different for price volatility since the carbon tax fixes the price and letting the emission to vary, while the ETS system fixes the emission, thus, leaving the price volatile[9].

[6] A cap-and-trade system with auctioned permits is similar to a carbon tax from the perspective of regulated firms. Similarly, a carbon tax system with tradable tax exemptions for a specified quantity of emissions (the tax is levied only on emissions above a threshold), can mimic a cap-and-trade system with freely allocated permits.

[7] When the slope of the marginal abatement cost function exceeds that of the marginal benefit function, a carbon tax, is likely to be more efficient (smaller social losses due to resource misallocation arising from mistaken predictions of future costs) than an ETS system. However, when the opposite is true – that is, the slope of the marginal benefit function exceeds the slope of the marginal abatement cost function – then an ETS system would be more efficient.

[8] Under ETS system, reduction of marginal abatement costs due to balanced technological change decreases carbon prices, leaving aggregate emissions unchanged. In contrast, such technological change, under carbon tax system results in an increase in carbon prices, but a decrease in aggregate emissions.

[9] In the presence of economic growth which generate higher emissions, a fixed supply of permits under a ETS system (as a quantity instrument) implies that permit demand will increase and likewise the carbon price, leaving the emission fixed. The opposite is true during a recession. On the other hand, under the carbon tax system, an economic growth/recession will not change the carbon price (since the rate is fixed), but will lead to more/less emissions, respectively.

Early theoretical studies hypothesize that ambitious environmental regulation can impose significant costs, slow productivity growth, and eventually erode the international competitiveness for that country (Pethig, 1975; Siebert, 1977; Yohe, 1979; McGuire, 1982). However, the study by Jaffe et al. (1995) shows that there is relatively little evidence supporting such hypothesis. This latter study categorizes "competitiveness" into broad categories: 1) the change in net exports of certain goods, 2) the degree of relocation of production of pollution-intensive goods from countries with stringent environmental regulations toward those with less, and 3) the degree of offshore investment by countries with carbon pricing towards those with less or no carbon pricing.

The empirical result regarding the change in net exports is not conclusive: some find negatively correlated relationships between net exports and environmental compliance costs (Kalt, 1988), some discover that they are insignificantly correlated (Tobey, 1990; Grossman & Krueger, 1993). For the second indicator of competitiveness, several studies indicate that pollution-intensive industries have shifted away from developed countries toward developing countries, although the observed magnitude of changes are small (Low & Yeats, 1992; Robinson, 1988). Lastly, for the shift in foreign investment indicator, the evidence indicates that investment migration to less stringent environment regulation in developing countries is weak (Leonard, 1988; Bartik, 1989; Friedman et al., 1992).

More recent direct studies on carbon pricing such as Siegmeier, Mattauch and Edenhofer (2018) have found evidence which opposes the conventional belief that strict environmental measures inevitably lead to deindustrialization. The conclusion aligns with the work by Linus Mattauch which explains that even though carbon pricing may reduce the economic rents of fossil fuel, it induces the transfer of capital

to other more productive industries. Moore, Großkurth, and Themann (2018) studied the impacts of the EU ETS and found that carbon pricing did not devalue the asset bases of the multinational enterprises in the EU, but actually increased their average value by 12.1%. In addition, Calel and Dechezleprêtre (2016) have found that companies that were regulated by the EU ETS have increased their low carbon innovation (measured by the number of patents) by 10% without reducing other innovation levels. The Executive Briefing of Carbon Pricing Leadership Coalition (June 2016) also concluded that carbon pricing measures do not affect competitiveness. The evidence is clear, since Norway, Sweden, Switzerland, France, and British Columbia (a province of Canada) have all been using carbon pricing without negative effects to either their industries or economic growth. On the contrary, British Columbia has been using carbon tax since 2008 together with tax revenue rebate to mitigate the burdens of personal income and corporate income taxes. This particular measure successfully reduced emission by 15% from "business as usual" (BAU). British Columbia still grew at 12.4% during 2007–2014, higher than the average Canadian growth rate. It even created 68,165 new clean jobs during 2010–2014, and increased 200 new clean technology firms and generated 1.7 billion Canadian dollars per annum (UNFCCC, 2019).

Impact studies for ASEAN countries are also available. For the individual ASEAN country case, for example, Tantivasadakarn et. al. (2008), Wattanakuljarus and Wongsa (2011), Kumsup et. al. (2014), Sutummakid et. al. (2015), and Puttanapong et. al. (2014) studied Thailand. For other ASEAN country case, there is Corong (2008) on the Philippines, Coxhead, Wattanakuljarus and Chan (2013) on Vietnam, and Yusuf and Resosudarmo (2015) on Indonesia. At the multi-country level case, work was done by Nurdianto and

Resosudarmo (2016). The result from these works consistently show that carbon pricing is an effective instrument for carbon mitigation and there are slight consequential costs on economic variables and social welfare. However, none of these papers have addressed the issue of international competitiveness which is the knowledge gap that this paper aims to bridge.

3. Methodology and the model

3.1 The model

In order to evaluate the impact of a carbon tax on several macroeconomic variables, especially international competitiveness, this paper uses a general equilibrium model called GTAP-E version 9 which is an extension of the GTAP model, the Global Trade Analysis Project (Hertel, 1997), by Burniaux and Truong (2002) and revised by McDougall and Golub (2007). It is a computable general equilibrium model, based on an economic database of 140 countries, which each has 57 production sectors, equipped with the capability to calculate the impact of carbon pricing measures on production, consumption, exports, imports, GDP, and welfare. More importantly, since it was originally designed as a trade analysis model, we can use the impacts on trade flows to further calculate the changes in international competitiveness. The model assumes each country or group of countries has a representative household that maximizes an aggregate utility function. The household receives income from selling factors of production (unskilled labor, skilled labor, capital, land, and natural resources) to the firms. The household's net income after taxes is divided into three parts: consumption, buying government provided goods, services, and savings. Demand from the government sector is governed by the Cobb-Douglas

function while the household demand takes the form of constant difference of elasticity functions. On the production side, the model assumes a perfectly competitive market structure for every sector. Each firm maximizes profit and receives normal profit in the long run. Technology is assumed to behave according to nested Leontief and constant elasticity of substitution (CES) production functions. There are two global service sectors. The first is the international transport sector, which provides international transportation and links the FOB and CIF values[10]. The second are global financial services that link world savings and investment.

The GTAP-E model extends the standard GTAP model that incorporates a more detailed specification of the energy sectors and related carbon emission. Goods and services are produced via nested-CES functions by combining value-added-energy with other intermediate inputs which consist of both domestic and foreign sources. Value-added-energy is the combination of natural resources, land, skilled labor, unskilled labor, and capital-energy composite, where energy types are substitutable according to the elasticity of substitution of energy. Non-electricity energy consists of coal and non-coal (gas, oil, petroleum products).

Government expenditure in GTAP-E model is governed by nested-CES functions that combines energy composites and non-energy composites. Household expenditure also consists of energy composites and non-energy composites, but its behavior is given by the constant-difference of elasticities (CDE) function.

This paper classifies countries into 17 countries or regions: The United States (USA), European Union 27 (EU27), Eastern Europe and former Soviet Union (EEFSU), Japan (JPN), Other Annex 1 countries (RoA1), Net energy

[10] FOB stands for Free on Board and CIF stands for Cost, Insurance and Freight.

exporting countries (EEx), China (CHN), India (IND), Thailand (THA), Indonesia (IDN), Malaysia (MYS), the Philippines (PHL), Singapore (SGP), Vietnam (VNM), Cambodia and Laos (Khm_Lao), the rest of ASEAN (Oth_ASEAN), and the rest of the world (ROW). For the product classification, we group goods and services into 18 groups: Rice paddies and processed rice (Rice), oil seeds (OilSeed), sugar cane and sugar (Sugar), non-rice primary agriculture, forestry, and fishery (Oth_agr), coal mining (Coal), crude oil (Oil), natural gas extraction, gas manufacture and distribution (Gas), petroleum products (Oil_pcts), electricity, food industries besides rice (Food_ind), chemical, rubber, and plastic products (CRP), energy-intensive industries beside CRP (En_Int_ind), automobile and parts (Auto_ind), electronic equipments (Electronic_ind), machinery and equipment (Machinery_ind), other industries (Oth_ind), transport services (Transport), and other services (Oth_ser).

3.2 Scenarios

To analyze the impacts of the carbon pricing measure, this paper assesses the impact in four scenarios: 1) unilateral ETS by Thailand (UETS), 2) unilateral carbon tax by Thailand (UCTax), 3) Joint ETS by ASEAN5 (JETS), and 4) Joint carbon tax by ASEAN5 (JCTax). The term "unilateral" used here means Thailand is the only country that uses the carbon pricing measure, either the ETS or the carbon tax to meet the emission reduction by 20% from her BAU emission[11]. The

[11] According to Thailand's Nationally Determined Contribution (NDC), Thailand intends to reduce her greenhouse gas emissions by 20 percent from the projected BAU level by 2030. The same 20% emission reduction target is, therefore, chosen here in this study to mimic the submitted target

term "joint" on the other hand means five ASEAN countries: Indonesia, Malaysia, Singapore, the Philippines, and Thailand, jointly use the carbon pricing measure to meet the 20% reduction from the BAU emission level of each country. The same target for all ASEAN members is chosen here for consistency and comparison purpose to the unilateral case.

The implementation of the ETS in the GTAP-E model is achieved by setting a 20% cap on CO_2 from BAU in three sectors, namely electricity, energy intensive industries, and other industries. In order to make the impact assessment comparable for carbon tax scenarios, the tax is charged on all energy sectors: i.e., Coal, Oil, Gas, Oil_pcts, and Electricity, such that the CO_2 emission is reduced by 20%.

The shock to the GTAP-E model in each scenario will generate new general equilibrium endogenous values. Then, the percentage changes of production, exports, imports, GDP, and welfare of each scenario compared with the based case are presented and analyzed. In addition, the exports value of each product or service for the BAU and each scenario are used to calculate the international competitiveness. The index used in this paper is described in section 3.3. Both overall economic and competitiveness results are presented in Section 4.

3.3 Indexes for international competitiveness

Conventionally, international trade economists often employ Balassa's Revealed Comparative Advantage Index (RCA) as a tool to calculate the degree of competitiveness and the index can be calculated from the following formula (see Balassa, 1965)[12]. Although the RCA index is relatively simple

although the mitigation tools proposed in the NDC are mainly energy efficiency improvement and renewable energy.

[12] The Balassa index is given by $RCA_{ij} = (X_{ij} / X_i) / (X_{wj} / X_w)$ where the variables in the formula are defined the same way as those given in

to be calculated and interpreted, it is not appropriate to be used for cross-country comparison[13]. Therefore, in this study, we use the Normalized Revealed Comparative Advantage (NRCA)[14] which can be calculated by[15]

$$NRCA_{ij} = \left(X_{ij}/X_w - X_{wj}X_i/X_wX_w\right) \quad (1)$$

Where X is the export value of goods, i stands for the country index, j is the goods index, and w represents the export value at the world level. Hence, X_{ij} is the export value of goods j from country i, while X_{wj} is the total world export value of goods j, and X_w is the total world export value of all goods.

It is possible to prove that the $NRCA_{ij}$ has a range of values between -2.5 and 2.5 with a zero midpoint value, which means that country i neither has comparative advantage nor disadvantage in goods i. A positive or negative value means country i has a comparative advantage or disadvantage in that goods, respectively. (Yu et al., 2009). This index is adopted here instead because when the value of NRCA for a product increases or its comparative advantage rises, the remaining

equation (1). The RCA index is very easy to be interpret; i.e., if $RCA_{ij} > 1$, it means country i has a comparative advantage[12] in product j and if $RCA_{ij} < 1$ it means country i has a comparative disadvantage in product j.

[13] The maximum value of RCA_{ij} depends on the value of $X_w/X_{wj,}$ which vary across products and time. This dependence on size variability creates inconsistent interpretations for cross country comparison. See details in Benedictis & Tamberi, 2002.

[14] Yu, Cai & Leung (2009) "The normalized revealed comparative advantage index," *Annals of Regional Science*, Vol. 43, 267-282.

[15] For actual applications, Yu et al. (2009) advises to multiply the formula by 10,000. This is because the formulae normalize the Balassa's RCA index by dividing it with world total export value, which is generally very large with respect to each product value of each country. Without the multiplication of 10,000, the calculated index will be very small.

products' comparative advantages will always fall. This is due to the fact that the summation of all products' NRCAs always equal to zero. As a result, the index is appropriate for international competitiveness comparison. Moreover, the index is not dependent on the level of classification details or the selection of countries used for comparison[16].

4. Impact assessment of carbon pricing

The results in this section consists of five parts. The impact on changes in production will be presented in section 4.1, followed by the impact on exports and imports in section 4.2, GDP in section 4.3, welfare in section 4.4, and competitiveness in section 4.5. Note that due to the multi-dimension nature of the results involving four scenarios, 18 sectors, and 17 countries or regions, it will take too much space to present all permutation of cases. Hence, for the sake of brevity, results related to production (4.1), imports and exports (4.2), welfare (4.4), and the impact on competitiveness pattern will be presented only for Thailand. However, for the impacts on GDPs and the initial competitiveness patterns in ASEAN, the result for all ASEAN members will be presented.

From the database of GTAP-E, in 2011, Thailand emitted 242.197 $MtCO_2$, which were mainly from the petroleum products (103.233 $MtCO_2$), followed by coal (71.303 $MtCO_2$) and natural gas (67.584 $MtCO_2$). These emission levels will be treated as the emission under the BAU. As mentioned earlier, we simulated four scenarios of carbon pricing measures 1) Unilateral ETS by Thailand (UETS), 2) Unilateral carbon tax by Thailand (UCTax), 3) Joint ETS by ASEAN5 (JETS), and 4) Joint carbon tax by ASEAN5 (JCTax). In the following,

[16] See details in Sanidas & Shin (2010).

Table 1 to Table 5 summarizes the assessment impacts on production, imports, exports, GDPs, and welfare, respectively.

4.1 Production

It is clear from Table 1 that the production of the energy sectors and the carbon-intensive sectors are affected the most by carbon pricing measures. Regardless of which scenario of carbon pricing, Coal, Gas, Electricity, Oil_pcts, Transport, En_Int_ind are among the sectors the has the highest negative percentage changes. Note that carbon pricing does not always negatively affect all sectors. In fact, production of many sectors, such as Electronic_ind, Machinery_ind, Food_ind, Sugar, have been increased for all scenarios. The increase comes from the general equilibrium adjustment of the economy. As some industries are shrunk by the relatively higher costs, the resources released by these industries flows to other remaining industries that have higher profits, causing them to expand until every industry has normal profits in the long run again. However, the overall production level for all sectors are declined for all scenarios ranging from -0.01% to -2.52%. Notice also that the carbon taxes, both UCTax and JCTax, generate less negative impacts on production than the ETSs.

Table 1. Comparing the impact of ETS and Carbon Tax on Production by sectors for 20% CO_2 emission reduction

Sectors	(1) UETS (%)	(2) JETS (%)	(2)–(1) (%)	Sectors	(3) UCTax (%)	(4) JCTax (%)	(4)–(3) (%)
Coal	-28.79	-22.22	6.57	Coal	-82.84	-84.22	-1.38
Gas	-21.91	-23.26	-1.35	Electricity	-14.44	-14.30	0.14

Sectors	(1) UETS (%)	(2) JETS (%)	(2)–(1) (%)	Sectors	(3) UCTax (%)	(4) JCTax (%)	(4)–(3) (%)
Electricity	-16.55	-16.3	0.25	Gas	-13.66	-13.84	-0.18
Transport	-16.09	-15.54	0.55	En_Int_ind	-13.06	-12.61	0.45
Oil_pcts	-8.76	-15.45	-6.69	Transport	-6.25	-6.08	0.17
En_Int_ind	-8.17	-5.8	2.37	Oil_pcts	-2.62	-2.78	0.07
Oil	-4.12	-5.4	-1.28	Auto_ind	-0.53	-0.71	-0.16
Auto_ind	-1.07	-1.04	0.03	Oth_ser	-0.47	-0.46	-0.18
OilSeed	-1.02	0.08	1.10	Rice	-0.26	-0.32	0.01
Rice	-0.76	-0.27	0.49	OilSeed	0.13	0.15	-0.06
Oth_ser	-0.71	-0.65	0.06	Oth_agr	0.24	0.24	0.02
Oth_agr	-0.28	0.2	0.48	Food_ind	0.76	0.73	0.00
Sugar	0.15	1.76	1.61	Sugar	0.76	0.73	-0.03
Food_ind	0.16	1.77	1.62	Oth_ind	1.34	1.33	-0.03
Oth_ind	1.74	4.02	2.28	Machinery_in	1.64	1.39	-0.01
Machinery_in	2.65	5.97	3.32	Oil	1.71	1.46	-0.25
CRP	3.27	-11.65	-14.92	CRP	3.10	3.28	-0.25
Electronic_i	5.37	10.24	4.87	Electronic_i	3.56	3.57	0.18
All sectors	-1.78	-2.52	-0.74	All sectors	-0.01	-0.01	0.01

4.2 Exports and Imports

For exports, Table 2 shows that the impact of carbon pricing on exports is similar to the case of production. Energy sectors and energy intensive sectors; i.e. Gas, Electricity, Transport, are most negatively affected as their production costs increase relatively faster than those less energy intensive sectors. However, exports of Coal and Oil increase since the carbon pricing dampens the local demand and causes higher net returns for exports. Exports of sectors that are labor intensive; e.g., Electronic_ind and Auto_ind, increase since by the reallocation of resource as mentioned in the production case.

The patterns are quite similar for all scenarios, however, in most cases the unilateral measures, both ETSs and carbon taxes, have more negative impacts on exports than the joint measures as shown by the changes of exports for all sectors; e.g., -8.77% for UETS and 0.25% for JETS. Notice also that for most sectors that exports decreased, the carbon taxes generally have less negative impacts than those of the ETSs.

Table 2. Comparing the impact of ETS and Carbon Tax on Exports by sectors for 20% CO_2 emission reduction

Sectors	(1) UETS (%)	(2) JETS (%)	(2)–(1) (%)	Sectors	(3) UCTax (%)	(4) JCTax (%)	(4)–(3) (%)
Gas	-167.30	-122.51	44.79	Electricity	-100.38	-97.47	2.91
Electricity	-87.64	-125.23	-37.59	Gas	-19.49	-22.46	-2.97
Transport	-28.15	-32.69	-4.54	En_Int_ind	-19.08	-18.44	0.64
Oil_pcts	-13.25	-4.09	9.16	Transport	-12.45	-12.06	0.39
En_Int_ind	-11.77	-9.05	2.72	Sugar	-5.26	0.00	5.26
Sugar	-8.69	0.00	8.69	OilSeed	-1.74	-1.74	0.00
OilSeed	-3.29	-5.16	-1.88	Rice	-0.42	-0.53	-0.11
Rice	-0.93	-0.48	0.45	Oth_agr	0.20	0.20	0.00
Oth_agr	-0.47	-0.77	-0.30	Oil_pcts	1.22	-0.37	-1.59
Machinery_in	-0.07	7.81	7.88	Food_ind	1.26	1.20	-0.06
Food_ind	0.42	3.14	2.72	Machinery_in	2.42	2.09	-0.33
Oil	0.60	22.91	22.31	Auto_ind	3.00	2.55	-0.45
Oth_ind	2.56	10.22	7.66	CRP	3.58	3.75	0.17
Auto_ind	2.79	6.16	3.37	Oth_ind	3.70	3.64	-0.06
Oth_ser	3.81	12.45	8.64	Electronic_i	3.82	3.84	0.02
CRP	4.78	-13.70	-18.48	Oth_ser	4.61	4.67	0.06
Electronic_i	7.29	10.88	3.59	Oil	9.72	10.03	0.31
Coal	8.04	26.65	18.61	Coal	47.28	38.69	-8.59
All sectors	-8.77	0.25	9.02	All sectors	0.91	0.85	-0.06

Table 3 presents the impact of carbon pricing on imports, which shows somewhat opposite patterns as the export side. For example, Coal and Oil imports decrease while Electricity and Transport increase. The impact on country level imports for all scenarios are negative. The carbon taxes generally also

have fewer negative impacts on imports than those of the ETSs.

Table 3. Comparing the impact of ETS and Carbon Tax on Imports by sectors for 20% CO_2 emission reduction

Sectors	(1) UETS (%)	(2) JETS (%)	(2)–(1) (%)	Sectors	(3) UCTax (%)	(4) JCTax (%)	(4)–(3) (%)
Coal	-19.89	-19.88	0.01	Coal	-28.54	-0.36	28.18
Oil_pcts	-14.44	-20.81	-6.37	Oil_pcts	-5.55	-0.29	5.26
Oil	-9.76	-17.55	-7.79	Oil	-3.56	-0.06	3.50
Gas	-9.08	-13.8	-4.72	Gas	-3.54	0.24	3.78
Machinery_in	-4.16	-5.34	-1.18	Machinery_in	-2.78	-0.08	2.70
Oth_ser	-2.97	-5.41	-2.44	Oth_ser	-2.16	-0.01	2.15
Oth_ind	-2.88	-4.55	-1.67	Oth_ind	-1.91	-0.02	1.89
Auto_ind	-2.42	-3.07	-0.65	Auto_ind	-1.44	-0.01	1.43
Food_ind	-0.08	-0.17	-0.09	Food_ind	0.02	0.06	0.04
CRP	0.45	-1.98	-2.43	Rice	0.15	-0.21	-0.36
OilSeed	0.57	1.89	1.32	CRP	0.29	-0.01	-0.30
Rice	0.67	-0.36	-1.03	Oth_agr	0.52	-0.02	-0.54
Oth_agr	0.91	0.89	-0.02	OilSeed	0.76	-0.01	-0.77
Electronic_i	1.30	3.57	2.27	Electronic_i	0.86	0.11	-0.75
En_Int_ind	1.43	3.04	1.62	En_Int_ind	1.23	-0.03	-1.26
Sugar	2.19	3.69	1.5	Sugar	1.35	-0.02	-1.37
Transport	6.66	5.8	-0.87	Transport	2.12	-0.13	-2.25
Electricity	40.94	40.85	-0.09	Electricity	29.22	0.41	-28.81
All sectors	-2.34	-3.93	-1.59	All sectors	-1.23	-0.03	-0.03

4.3 Gross Domestic Products

Table 4. Comparing the impact of ETS and Carbon Tax on GDPs by countries for 20% CO_2 emission reduction

Countries	(1) UETS (%)	(2) JETS (%)	(2)–(1) (%)	(3) UCTax (%)	(4) JCTax (%)	(4)–(3) (%)
USA	0.001	0.004	0.003	0.0003	0.001	0.001
EU27	0.002	0.017	0.015	0.0012	0.006	0.005
EEFSU	-0.005	-0.024	-0.019	-0.0024	-0.023	-0.021
JPN	0.001	0.012	0.011	0.0004	0.005	0.005
RoA1	0.001	0.003	0.002	0.0003	0.002	0.001
EEx	-0.001	-0.008	-0.007	0.0000	-0.002	-0.002
CHN	0.001	0.004	0.003	0.0005	0.002	0.002
IND	0.002	0.026	0.024	0.0013	0.011	0.009
THA	-0.306	-0.447	-0.141	-0.1627	-0.165	-0.003
IDN	-0.002	-0.099	-0.097	-0.0018	-0.02	-0.019
MYS	-0.007	0.43	0.437	-0.0032	0.186	0.189
PHL	-0.002	-0.106	-0.104	-0.0012	-0.041	-0.04
SGP	0.001	-0.064	-0.065	0.0001	-0.019	-0.019
VNM	-0.007	-0.067	-0.06	-0.0038	-0.02	-0.016
Khm_Lao	0.004	0.029	0.025	0.0154	0.022	0.006
Oth_ASEAN	-0.024	-0.041	-0.017	-0.009	-0.011	-0.002
ROW	0.002	0.008	0.006	0.001	0.003	0.002
World	-0.001	0.004	0.005	-0.0003	0.002	0.002

4.4 Welfare

Table 5 summarizes the impact of carbon pricing on welfare. The welfare change for Thailand in all scenarios is negative, ranging from -US$467.18 million to -US$745.79

million. According to GTAP-E, it is possible to disaggregate the welfare change in to three effects: i.e., Allocative efficiency effect, Term of trade effect, and Investment-saving effect. As shown in the table, the main reason for net welfare losses comes from the large negative impact of the allocative efficiency effect, ranging from -US$1,058.91 million under the UETS and -US$1,545.44 million under the JETS. This effect is generated by the reallocation of resources away from the BAU market equilibrium. This effect under the JETS scenario has the highest negative value. Both ETS scenarios generate positive impacts on welfare via the term of trade effect and the investment-saving effects. However, they are not sufficient to compensate and bring the total welfare to be positive.

Note that under perfect competition and no externality problems, the initial BAU market equilibrium is supposed to allocate resources in the most efficient way. When we impose ETS or carbon taxes to shock the market, there will be losses in efficiency, which is captured by the negative value of the allocative efficiency effect. However, when the externalities from CO_2 emission are present, the allocative efficiency should be canceled by the reduction of the external cost, which can bring the net effect to positive provided that the savings from external costs are sufficiently large.

Both carbon tax scenarios have less negative allocative efficiency, -US$562.54 Million under the UCTax and -US$571.47 million under the JCTax. Their corresponding terms of trade effects are both negative; the investment-saving effects are positive, but quite smaller. Hence, the total welfare changes are also negative: -US$564.71 million, -US$590.57 million, respectively.

Table 5. Comparing the impact of ETS and Carbon Tax on Thailand Welfare for 20% CO_2 emission reduction

Unit: US million

Countries	(1) UETS	(2) JETS	(2)-(1)	(3) UCTax	(4) JCTax	(4)-(3)
Allocative Efficiency	-1,058.91	-1,545.44	-486.53	-562.54	-571.47	-8.93
Term of Trade	537.32	708.05	170.73	-41.29	-54.95	-13.66
Investment-Savings	54.4	91.6	37.20	39.12	35.85	-3.27
Total welfare changes	-467.18	-745.79	-278.61	-564.71	-590.57	-25.86

4.5 International competitiveness

Table 6. The Normalized Revealed Comparative Advantage Indexes (NRCA) of ASEAN countries by sectors in 2011 for the BAU case

Sectors	Thailand (THA)	Indonesia (IDN)	Malaysia (MYS)	The Philippines (PHL)	Singapore (SGP)	Vietnam (VNM)	Cambodia &Laos (Khm_Lao)	Other ASEANs
Electronic_i	9.35	-3.79	27.25	9.95	25.22	1.39	-0.48	-0.68
CRP	8.28	2.13	1.13	-2.66	3.41	-2.99	-0.51	-0.86
Food_ind	6.59	9.05	9.09	0.50	-4.55	1.88	-0.21	-0.22
Rice	3.27	-0.11	-0.14	-0.03	-0.18	1.55	0.07	0.09
Transport	2.08	-2.24	-0.23	0.61	1.35	-1.47	0.19	-0.17
Auto_ind	1.59	-5.53	-6.87	-1.77	-9.20	-3.03	-0.43	-0.62
Sugar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	-0.32	-0.31	-0.36	-0.10	-0.43	-0.09	0.00	-0.02
OilSeed	-0.46	-0.37	-0.39	-0.13	-0.54	-0.18	-0.02	-0.01
Oil_pcts	-0.50	-3.70	-2.55	-1.12	15.35	-1.86	-0.24	-0.35
Oth_agr	-0.87	0.04	-1.71	0.67	-3.21	2.09	0.22	0.91
Coal	-0.87	14.99	-0.84	-0.19	-1.00	0.37	-0.04	-0.06
Machinery_in	-1.45	-8.92	-3.53	0.02	2.48	-2.58	-0.88	-1.22
Gas	-1.59	5.25	2.99	-0.44	-1.85	-0.62	0.00	2.95
Oth_ind	-1.94	5.08	-7.07	-1.75	-15.56	12.48	3.05	-0.28

Sectors	Thailand (THA)	Indonesia (IDN)	Malaysia (MYS)	The Philippines (PHL)	Singapore (SGP)	Vietnam (VNM)	Cambodia &Laos (Khm_Lao)	Other ASEANs
En_Int_ind	-4.76	2.02	-4.63	0.23	-10.52	-2.31	0.11	-0.62
Oth_ser	-8.77	-10.72	-6.68	-1.16	10.44	-4.13	-0.36	-0.84
Oil	-9.64	-2.88	-5.46	-2.63	-11.22	-0.48	-0.48	2.00

Source: Calculated from GTAP-E Version 9 by NRAC formula in equation (2)

The analysis in this part is based the calculation of the NRCA index given in equation (2) (see section 3.3) using the value of exports in year 2011 provided in GTAP-E. Note that a positive $NRCA_{ij}$ value implies that country i has a comparative advantage in goods j and the negative value implies that it has a comparative disadvantage in that goods. The calculated result is provided in Table 6.

Competitiveness Patterns in ASEAN

The sectors of the NRCA index in the Table 6 is sorted by Thailand's competitiveness from the highest to the lowest value. As expected from the Heckscher-Olin Theorem, the sectors that Thailand has comparative advantages are the ones that are labor intensive or natural-resource intensive since Thailand is considered a labor and natural-resource abundant country. The sectors that are ranked highest are, for instance Electronic_ind (9.35), CRP (8.28), Food_ind (6.59), Rice (3.27), Transport [17] (2.08) and Auto_ind (1.59). On the opposite end, the sectors that Thailand has the most comparative disadvantages are Oil (-9.64), Oth_ser (-8.77),

[17] The main sub sector that has the comparative advantage is air transport, which is used most by the tourism industry. However, GTAP-E does not classify tourism as a separate sector.

En_Int_ind [18] (-4.76), Oth_ind (-1.94), Gas (-1.59), and Machinery_ind (-1.45). Notice that these products intensively use Thailand relatively scarce resources, namely capital and fossil fuel.

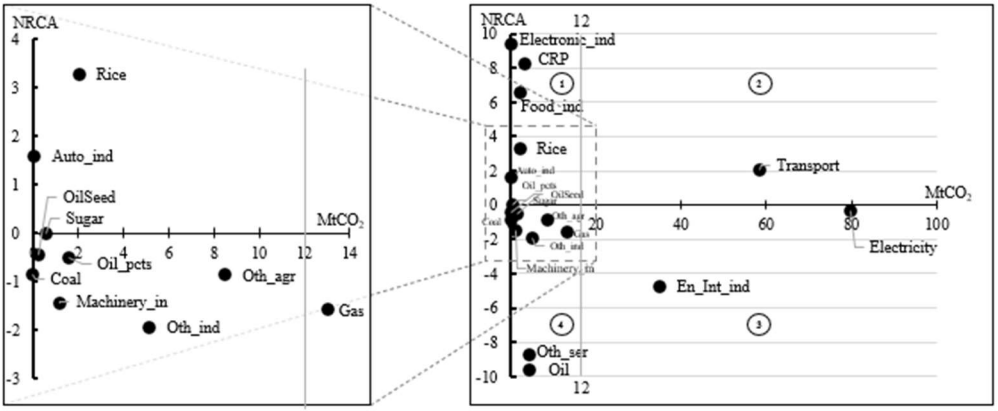
Table 6 also shows other ASEAN countries pattern of competitiveness. For instance, Indonesia has the highest NRCA in Coal (14.99) which is also the highest in ASEAN followed by Food_ind (9.05) and Gas (5.25). Malaysia has the highest NRCA in Electronics (27.25), which is also the highest value in the table. It is followed by Food industry (9.09) and Gas (2.99). For Singapore, it has many competitive sectors, such as Electronic_ind (25.22), Oil_pcts (15.35), Oth_ser (10.44), and CRP (3.41). The Philippines has relatively only one competitive sector which is Electronic_ind (9.95). The sectors that Vietnam has comparative advantages are Rice (1.55), and Electronic_ind (1.39) For Cambodia and Laos, their competitiveness lie in Oth_ind (3.05). Finally, the rest of ASEAN, Myanmar and Brunei are competitive in Gas (2.95) and Oil (2.0). Note that the comparative advantage patterns of ASEAN countries also conform with the prediction of the Heckscher-Olin Theorem, which stipulates that a country will have a comparative advantage in a product that intensively uses its abundant factor.

Competitiveness Patterns in Thailand

Figure 1 provides a snapshot, in 2011, of each sector's relative positions of NRCAs and CO_2 emission. For example the Transport sector's coordinate is plotted on the right panel at 58.29 $MtCO_2$ and 2.08. The left panel enlarge the dense cluster near the origin to show the details.

[18] They include cement, iron and steel, and other metals.

Figure 1. Thailand's competitiveness and CO_2 emission by sectors



Sources: NRCAs from Table 6; CO_2 emission from GTAP-E Version 9.

To better understand Thailand's competitiveness pattern in relation to the level of carbon emission, we chose the average emission of about 12 $MtCO_2$ as a border line between low carbon-intensive and high carbon-intensive sectors, then combine this with the zero value of NRCA to divide Figure 1 into 4 quadrants, with four combinations of characteristics. The 1st quadrant contains sectors that Thailand initially has comparative advantage and emits relatively low carbon emissions i.e., low carbon-intensive. The sectors in this group are Electronic_ind, CRP, Food_ind, Rice, and Auto_ind. Due to their low carbon emissions, we should expect these sectors to remain competitive after Thailand imposes carbon pricing measures, especially the first three sectors with high NRCAs. The 2nd quadrant represents the sector that is also initially competitive, but are relatively carbon intensive. Transport is the only one sector in this group. Carbon pricing measures should decrease its competitiveness drastically, but it may still remain competitive. The 3rd quadrant contains sectors that are neither initially competitive nor relatively low carbon-intensive; hence their comparative disadvantage positions

should be severely worsened by the carbon pricing measures. Sectors in this group are Electricity, En_Int_ind, and Gas. Finally, the sectors in the 4th quadrant are those that are not initially competitive but have low carbon emissions. Carbon pricing measures should mildly worsen this group's comparative disadvantage positions. Sectors in this last group are Sugar, OilSeed, Oil_pcts, Coal, Machinery_in, and Oth_ind. With these four group classifications, we will present an example of the impact of unilateral ETS under UETS scenario on both NRCAs and CO_2 emission in the next subsection.

Impacts of Carbon Pricing on Thailand's Competitiveness: an example

Recalling that all sectors in the 1st quadrant of Figure 2 have comparative advantages and are low carbon-intensive, it is clear that after Thailand imposes unilateral ETS, all sectors in this group are induced to emit less CO_2 as indicated by the respective arrows pointing leftward. Note that longer arrows denote higher CO_2 mitigation. Since both CRP (chemical, rubber, and plastic products) and Food_ind are more carbon-intensive than others, their arrows are relatively longer. The arrows of CRP and Auto_ind also point upward which means their competitiveness actually improved. Arrows of the remaining sectors in the group, on the other hand, slightly point downward, but all the arrow tips are still positive, implying that these sectors can maintain their comparative advantage, as expected, after the ETS is used.

The arrow for Transport sector in the 2nd quadrant is also relatively long (since CO_2 is decreased by 14.82 $MtCO_2$ or 25.4% from its BAU) and also points downward, yet remains slightly positive. This indicates that a 20% CO_2 reduction by

the ETS erodes almost all the competitiveness of this highly carbon-intensive service.

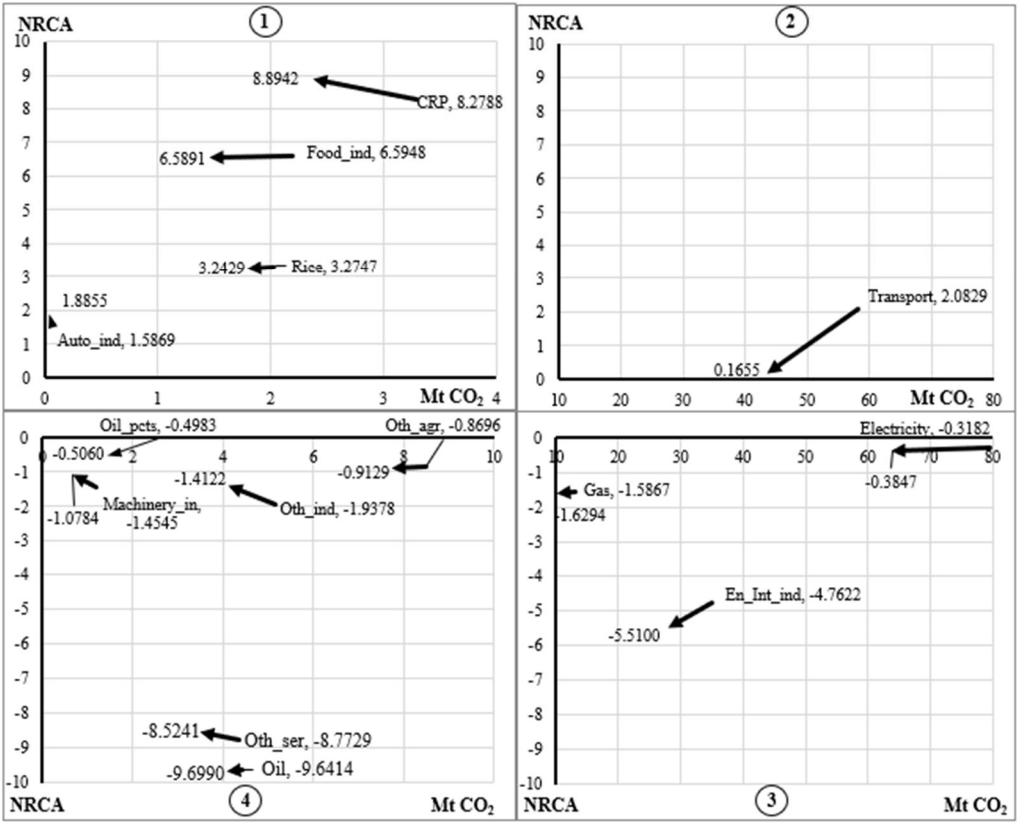
The 3rd quadrant of Figure 2 depicts the impact of the ETS for sectors that are highly carbon-intensive and have no comparative advantages. As expected, all arrows point downwards, indicating that their comparative disadvantages are worsening. For instance, Electricity is forced to mitigate 15.93 $MtCO_2$ or 20% from its BAU, the most amount among all sectors.

As mention earlier, sectors in the 4th quadrant are low carbon-intensive but have no comparative advantages. Hence, they are expected to perform worse under the pressure of carbon pricing. Three sectors, Other_agr, Oil, and Oil_pcts, have lower NRCAs as expected. However, NRCAs of these three sectors, namely Oth_ind, Oth_ser, and Machiner_in, are all improved as indicated by the upward trend of their arrows. The results of the improvement in competitiveness of some sectors in the first group and these surprising results of this last group come from the changes in relative prices in the general equilibrium setting, which can be explain as follows.

Carbon pricing changes the relative prices of goods and services in the world economy, increasing the relative prices of high carbon-intensive sectors and decreasing the relative prices of less carbon intensive sectors. Since comparative advantages are determined by the international relative prices, not the absolute prices, some goods, which are initially cheaper, end up being relatively cheaper than before. They will gain even more comparative advantages, as it is the case for CRP and Auto_ind sectors in the 1st group. Some goods that are initially slightly expensive, and so they initially have no comparative advantages, now become relatively less expensive because they do not impose as much the carbon price as those high carbon-intensive sectors. Thus, the

comparative disadvantages decreases, as happened in the case of Oth_ind, Oth_ser, and Machiner_in sectors in the 4th group.

Figure 2. Impact of unilateral ETS on Thailand's competitiveness and CO_2 emission by sectors



Sources: Same as Figure 1 and from the simulation under TETS.

Comparing the impact of ETSs and Carbon Taxes on Thailand's Competitiveness

The general conclusion from Figure 2 is that Thailand unilateral ETS causes all sectors to emit less CO_2 at the rate

that is positively correlated to their carbon intensity. The unilateral ETS impacts on their competitiveness, however, can be either decrease or increase. An interesting question is which measure among our four scenarios is the most conducive to Thailand's competitiveness?

Table 7 summarizes and compares the percentage changes of Thailand's NRCAs by sectors for all four scenarios. Note that the direction of changes for each sector are consistently the same for all scenarios, although the magnitudes are slightly different. Therefore, Figure 2 should roughly depict the direction and magnitude of carbon pricing impacts on the competitiveness of each sector for all four scenarios. Notice also that there are 12 sectors out of 18 sectors in the table in which the joint carbon pricing measures generate higher NRCAs than their unilateral counterparts (shown by positive signs in the 4th and the last columns of Table 7).

We select one representative sector from each of the four groups in Figure 2 to further compare the impact among these four scenarios. The 1st quadrant of Figure 3 depicts the case of chemical, rubber, and plastic products (CRP), which represents the sector that is low carbon-intensive and competitive, with a positive NRCA index. For this sector, JCTax induces the best outcome for CRP since the joint carbon tax scheme improves the NRCA index the most to 8.90 with the least CO_2 mitigation impact. Both UCTax and UETS generate roughly the same NRCA improvement, but UETS requires more CO_2 mitigation. JETS impacts worst since it is the only one that decreases the NRCA for this sector.

The 2nd quadrant of Figure 3 depicts the case of Transport sector, which represents the high carbon intensive and competitive sector. All carbon measures decrease the competitiveness, but both carbon tax measures cause less burden on both CO_2 mitigation and competitiveness.

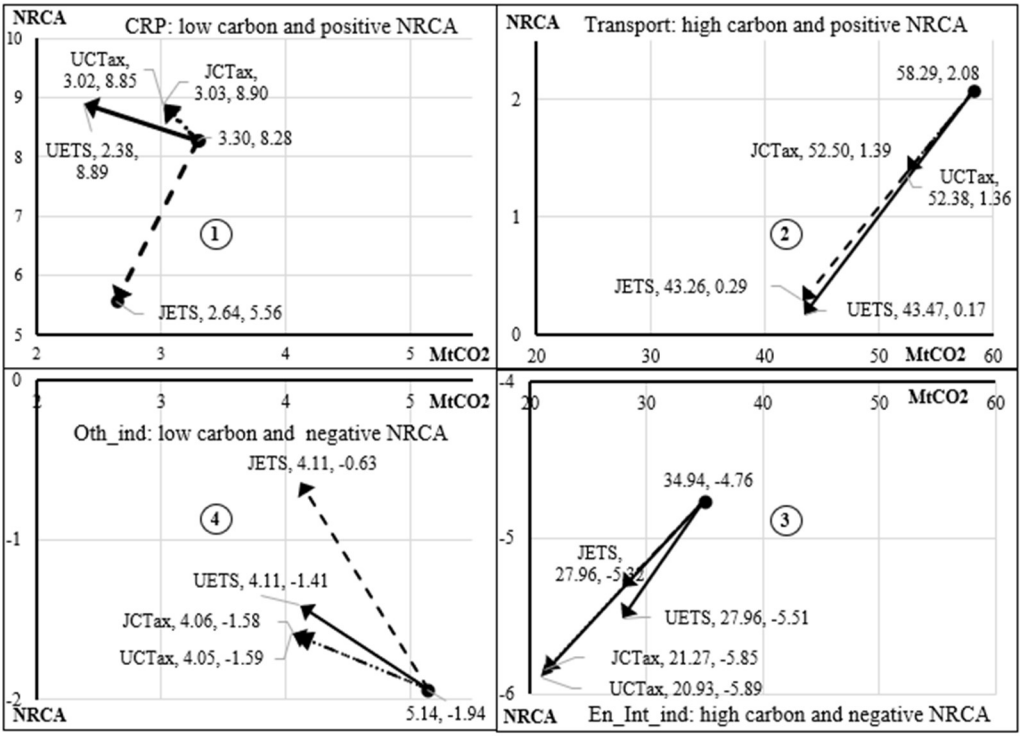
Table 7. Impact of ETSs and Carbon Taxes on Thailand's Competitiveness

Unit: % change from BAU*

Sectors	UETS	JETS	JEST-UEST	UCTax	JCTax	JCTax-UCTax
Electronic_i	5.86%	6.00%	0.14%	5.86%	5.90%	0.04%
CRP	6.91%	7.79%	0.88%	6.89%	7.47%	0.58%
Food_ind	1.11%	1.02%	-0.09%	1.11%	1.02%	-0.09%
Rice	-0.37%	-0.54%	-0.17%	-0.37%	-0.49%	-0.12%
Transport	-34.63%	-33.30%	1.33%	-34.68%	-33.33%	1.35%
Auto_ind	10.71%	8.22%	-2.49%	10.73%	8.12%	-2.61%
Sugar	-0.87%	-0.84%	0.03%	-1.06%	-0.84%	0.22%
Electricity	-16.63%	-16.32%	0.31%	-16.66%	-16.16%	0.50%
OilSeed	-0.93%	-0.90%	0.03%	-0.93%	-0.88%	0.05%
Oil_pcts	-0.84%	-20.25%	-19.41%	-0.35%	-13.83%	-13.48%
Oth_agr	-2.54%	-2.43%	0.11%	-2.55%	-2.37%	0.18%
Coal	-0.41%	0.10%	0.51%	-0.42%	0.09%	0.51%
Machinery_in	12.92%	10.11%	-2.81%	12.98%	10.61%	-2.37%
Gas	-1.11%	-1.23%	-0.12%	-1.10%	-1.47%	-0.37%
Oth_ind	18.12%	18.30%	0.18%	18.12%	18.24%	0.12%
En_Int_ind	-23.63%	-22.91%	0.72%	-23.64%	-22.77%	0.87%
Oth_ser	1.45%	1.57%	0.12%	1.45%	1.57%	0.12%
Oil	-0.69%	-0.46%	0.23%	-0.69%	-0.51%	0.18%

Sources: Calculated from NRAC index given in equation (2) from GTAP-E simulation results.
Note: *To ensure correct signs for the initial negative values, the percentage changes are calculated by (V'- V)/ABS(V), where V = initial value, V' = new value, and ABS() is the absolute value.

Figure 3. Impact of ETSs and Carbon Taxes on Thailand's Competitiveness in selected sectors



We choose energy intensive industries (En_Int_ind) as a representative of the high carbon intensive and not competitive sector. The impacts are shown in quadrant 3 of Figure 3. The impact patterns are similar to those in the 2nd quadrant, except that this time, the ETS measures cause less impacts on the competitiveness.

Finally in the 4th quadrant, other industries sector (Oth_ind) is used as a representative of the low carbon-intensive and not competitive sector. In this example JETS measure helps improve this sector's competitiveness the most. UETS measure is ranked the second while the remaining

carbon tax measures perform about the same. Especially those sectors that are highly carbon intensive. Carbon pricing also can, on the other hand, enhance sectors that are not carbon intensive. The second important point is the joint carbon pricing implementation by ASEAN members on average help to alleviate the negative impacts on competitiveness as compared to the unilateral carbon pricing implementation.

5. Concluding remarks and policy implications

The main purpose of this paper is to provide an economic analysis such that policy makers may decide which carbon pricing measures, between carbon market or Emission Trading System (ETS) or carbon taxes, should be more appropriate for Thailand based on their impacts on production, consumption, exports, imports, social welfare and international competitiveness. Using GTAP-E version 9 to simulate the implementation, we were able to obtain and compare important economic variables between different measures. Furthermore, the degree of international competitiveness by sectors, measured by the NRCA index, was analyzed and compared.

Among the four implementations considered, our conclusion is that the carbon tax measure that is jointly implemented by 5 ASEAN countries is the most suitable for Thailand. This is because it can mitigate carbon dioxide emission to the target level while generating less negative impacts on production, consumption, exports, imports, social welfare. It also causes less unfavorable economic effects as compared to the case of Thailand's unilateral carbon tax implementation or the case of carbon market, either unilaterally or jointly. Both carbon taxes and ETS, for the same mitigation target, does not significantly affect Thailand's international competitiveness. However, joint carbon tax

measure has fewer negative impacts on competitiveness as compared to the unilateral implementation and yet also improves Thailand competitiveness in some sectors.

The above result implies that if, in the future, Thailand has to decide to use a carbon pricing measure to cope with higher mitigation pressure from the UNFCCC, a joint carbon tax among ASEAN countries should be Thailand's first choice. A joint ETS among ASEAN can also be the alternative measure on the negotiation table since this paper has found that the joint carbon pricing are generally more suitable than a unilateral one by an individual country. This unity of ASEAN policy on climate change will also strengthen the spirit of ASEAN community and the negotiation power of the group.

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Thammasat Review of Economic and Social Policy
Volume 6, Number 2, July – December 2020

Research Article
Received: 20 May 2020
Revised: 10 October 2020
Accepted: 12 October 2020

Demographic Change and Fiscal Sustainability of Old Age Allowance Policy in Thailand

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ABSTRACT

Thailand must face the challenges of an ageing society. The government should manage their expenditure and revenue collection in accordance with an increase in the number of elders in the society on account of old age allowance expenditures. Old age allowance aims to cover all elders except those in the pension system. This paper examines the impact of demographic change on fiscal sustainability of old age allowance policy, particularly by setting model, where a computational overlapping generations model is employed under a general equilibrium context. The simulation is divided into 3 parts: the first part is the impact of demographic change on the economy, the second part is the introduction of old age allowance and its impact on fiscal burden, and the third part is the fiscal impact of an increase in government expenditure. The study found that government expenditure will increase as there will be an increasing proportion of aged individuals. The increase in government expenditure causes an increase in public debt, which eventually causes the delay of repayment of public debt and a shift to the next generation. The increase of value-added tax rate generates more revenue collection for the government when compared to increasing personal income tax rate. The value-added tax has more distortionary effect on the economy than an increased personal income tax.

Keyword: Aging society, Old age allowance policy, Fiscal sustainability, Demographic change, Fiscal policy

JEL Classification: E62, H30, H300

1. Introduction

The population structure of Thailand is changing. In the past, people used to have many children due to a lack of family planning. More children meant increased expenditure for the family. Recently however families have started to have fewer children, or no children at all, because of the increased cost of living and higher expenditure. Fewer children decreases Thailand's population growth. Thus, one of the causes of demographic change in Thailand is the decrease birth rate.

Table 1.The prospects of population growth in Thailand

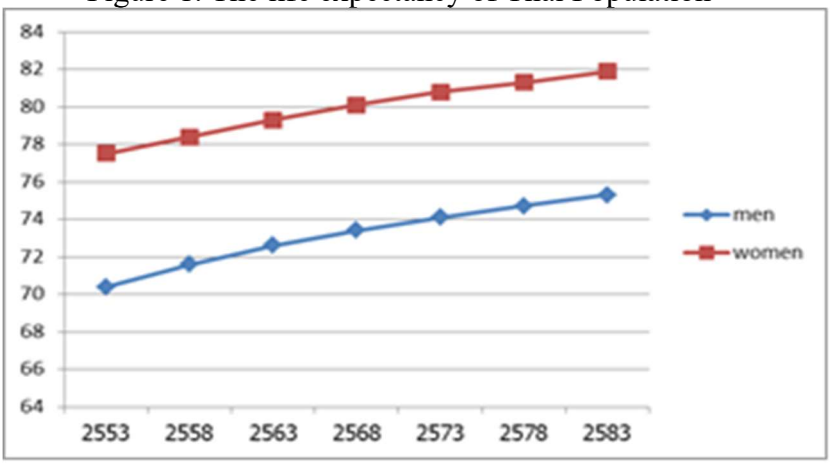
B.E.	Population Growth	Crude Birth rate (per 1,000 people)	Crude Death rate (per 1,000 people)
2558 - 2562	0.18	9.9	8.4
2562 - 2567	0.02	9	9.1
2567 - 2572	-0.11	8.6	10
2572 - 2577	-0.24	8.3	11
2577 - 2582	-0.38	8.1	12.1
2582 - 2587	-0.52	7.9	13.3
2587 - 2592	-0.65	7.7	14.5
2592 - 2597	-0.76	7.6	15.5
2597 - 2602	-0.83	7.6	16.1
2602 - 2607	-0.86	7.7	16.5
2607 - 2612	-0.86	7.8	16.7
2612 - 2617	-0.85	7.9	16.7
2617 - 2622	-0.84	8	16.6
2622 - 2627	-0.82	8	16.5
2627 - 2632	-0.8	8.1	16.4
2632 - 2637	-0.78	8.2	16.2
2637 - 2643	-0.74	8.3	15.9

Source: World Population Prospects, the 2015 Revision

The decreasing birth rate in Thailand shows that there will be less potential labor in the next generation. These workers are burdened with extra costs to look after the elderly because the government collects personal income tax to support the social benefit of the elderly. Table 1 shows that population growth in Thailand is on a negative trend, implying that total population will decrease.

When the government announced a social benefit policy for the elderly, life expectancy is a crucial factor. With an ageing population, the government will incur more expenditure.

Figure 1. The life expectancy of Thai Population



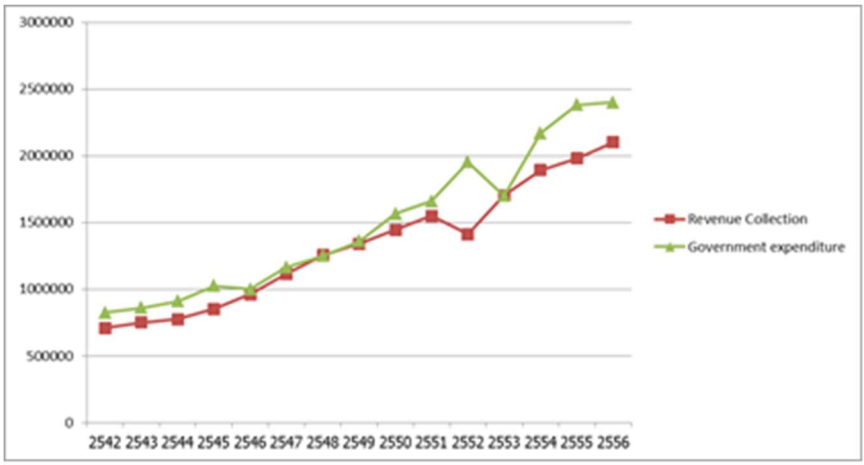
Source: Office of the National Economic and Social Development Board

Figure 1 shows that life expectancy of Thai people is increasing so there will be more old people in the future.

This demographic change affects the allocation of fiscal policy especially government expenditure. It is known that demographic change in Thailand is bound to happen. The government must invest in various areas to support this impact such as in education, public health, and social welfare. These

investments also have an important effect on Thai economy. The private sector must adapt to keep pace with change. When government expenditure increases, the government must collect more revenue to balance revenue collection and government expenditure. If government expenditure exceeds revenue collection over a long time, government will increase public debt.

Figure 2. Revenue collection and the expenditure of the Thai government



Source: Bureau of the Budget

Revenue collection and government expenditure have an important effect on fiscal sustainability. The increase in public debt incurs an interest expense. If public debt is high, then the interest expense will soar and revenue collection may not be sufficient to pay for government expenditure.

The economic activities of the government sometimes show that there are some problems with expenditure which exceeds revenue collection, causing public debt. The

framework for fiscal sustainability suggests a ratio of public debt to GDP below 60 percent in the long run.

Old age allowance and the problem of fiscal policy in the long run

Old age allowance is a guarantee that the government gives to their people when individuals are old. Currently in Thailand, citizens who are 60-69 years old receive 600 Baht per month. For every 10-year increment in age, they receive an additional 100 Baht (up to 1000 Baht for those over 90 years).

Old age allowance is an expenditure of the government which is hard to cancel. In 2558 B.E., the Thai government incurred approximately 61,000 million Baht per year or 0.06 percent of GDP on old age allowance expense. If Thailand transitions into an old age society, there will be more expenditure on old age allowance. It is an important point, because the government must reconsider a budget allocation which supports the demographic change. Importantly increasing old age allowance expenditure needs to consider the dimension of public debt too. If the government cannot collect sufficient revenue, then public debt will increase in the long run and will happen time and again.

This paper aims to examine the impacts of adjusting for an increased old age allowance expenditure to alleviate fiscal burden and to study fiscal policy options of the government in responding to higher expenditure. This paper considers the case of a closed economy where there is no international trade, investment or immigration between countries. Life cycle for each person is assumed to last for two periods- workforce age and old age. After that they die and leave the economy.

The paper sets the initial value for simulation by determining the growth of GDP at period t (B.E. 2558). The

measures of fiscal sustainability of Thailand are as follows: (i) the ratio of public debt to GDP is not over 60 percent, (ii) the burden of the public debt to government expenditure is not over 15 percent, (iii) a balanced budget, and (iv) the proportion of investment budget per government expenditure is not below 25 percent.

2. Literature Review

Demographic change in Thailand

The transition to an ageing society is happening faster than expected. The data of the office of the National Economic and Social Development Board shows that the number of people aged over 60 years is on an increasing trend. Considering the ratio of elders per total population, in 2553 B.E. the ratio of elders per total population was 11.9 percent and it will be approximately 25.12 percent in 2573 B.E. (Suwanrada and Chandoevwit, 2010). This information is in line with the data from the United Nations Population Fund (UNFPA). The data of UNFPA says that population growth in Thailand is slowing down and the population is decreasing. The downward trend in birth rate also shows in hospitals decreased midwifes. The decrease of workforce is a pressing need for the country to enhance labor efficiency.

Suwankesorn (2013) shows that labor supply differs from other types of production factors because it serves the role of production factor and consumer at the same time. If the country can effectively manage the labor supply, it will build the growth of the economy. His result shows that the growth of population is an important factor in the growth of the economy in the ASEAN countries. (Suwankesorn, 2013)

Demographic change and the economy

Among all economic activities in each country, markets are the most important part of the economy: for example the labor market, capital market and goods market. The members in each market consist of households, private sector and government. These three parts are directly connected to the economy. When there are changes in some parts, other parts will be affected too. Demographic change affects all types of markets. It also has an effect on the labor supply of the economy. The decrease in workforce compels the private sector to increase more capital. Meanwhile households must adapt their consumption and leisure in response to the increase in the number of elderlies in each family. The government must adapt the management of expenditure to deal with an ageing society. All these changes show how demographic change impacts the economy.

Demographic change and consumption

Demographic change can affect economic growth because if there are a lot of people in the country, there will be a lot of economic activities. Demographic change impact the household sector. Manprasert (2010) studied the impact of demographic change on the patterns of consumption of Thai households. The results show that if the growth of the elderly's income in the first phase is high, there will be an increment on consumption of some goods such as furniture, vehicles, etc.

Demographic change and private sector

The downward trend in the fertility rate will lead to a decrease in the workforce in the future. Potipiti and Kulkolkarn (2010) studied the impact of demographic change

on production. The result shows that a decreasing workforce within an ageing society will lead to a decrease in the total production and production per capita within next 40 years. Therefore in order to solve this problem, the country should import workforce from other countries.

Demographic change and economic growth

Besides its impact on households, the private sector, and the government, demographic change also impacts economic growth because the three sectors are the main economic activities. Pitsayabut and Punpiamrat (2013) studied old age societies and the economic growth of Thailand. They showed that in the time of transition to an old age society, the aggregate labor supply and aggregate capital cause an increase in total output. The development of technological progress will affect the efficiency of labor supply which can compensate a lack of labor in the workforce age. If there are no developed technologies, the aggregate labor supply and total capital will decrease in the transition to an old age society. Furthermore, the development of technology can relieve the negative economic impact caused by the transition to an old age society.

Demographic change and Fiscal sustainability

One important point is the management of public debt. There should be a balance between revenue collection and government expenditure. Davis and Fabling (2002) studied the efficiency of public policy on demographic change in New Zealand. They found that smoothing taxes is more important to policy efficiency than balancing budget. Asset tax smoothing can yield the average return more than government borrowing.

When the demographic change occurs, the number of the elderly will increase which eventually causes a burden in terms of welfare. Ihori et al (2007) studied the impact of demographic change and public debt in Japan. They found that an old age society leads to an increase in expenditure in the form of public pension, including public health insurance.

The government budget, which is allocated for paying old age allowances, may increase the fiscal sustainability problem. The old age allowance expenditure is a long-term expenditure. To determine the old age allowance, the government must consider the cost of living and the fiscal burden in the long-term. Suwanrada (2014) studied the public reform pension. The paper points out that excessive allocation of old age allowance causes a fiscal problem in the long run. If Thailand's economic growth slows down, old age allowance expenditure will increase steadily and will be much higher than revenue collection of many ministries.

3. Model

This paper employs the Overlapping Generation model for the analysis. This model has the dimension of the difference in the behavior and productivity of the population in each age, which shows the transition from a young society to the old age society. This model is developed from the model in the research of Pisayabut and Punpiamrat (2013). It is assumed that agents live for a finite time and the length of time overlaps at least one period with other agents. This model consists of 3 sectors: household sector, private sector and government sector. These 3 sectors live together in a closed economy. Thus, there is no international trade, international investment, or international immigration.

3.1 Households

People start at 20 years old. They make decisions between consumption and leisure throughout their lifetime. It is assumed that each decision yields maximum utility subject to budget constraint. However, there is uncertainty of death along their lifetime. It is assumed that everyone retires at the age of 60 years old and die at the age of 80 years old. Therefore, people have the time for work between 20-60 years old.

The survival equation is

$$Q_{i,s} = \prod_{j=0}^{s} q_{i,j+1,j} \quad \ldots\ldots\ldots (1)$$

$Q_{i,s}$ = the amount of people that survive since age i to s
j = age of people start at 0 years
s = the last of age of people
q = the amount of people in each age

Each person is assumed to maximize his expected lifetime utility with respect to his own consumption. The household's expected lifetime utility of generation i is given by

$$u_i = \sum_{s=0}^{s-20} \prod_{j=0}^{s} q_{i,j+1,j} \frac{\{u[c_{it}, 1-l_{it}]\}^{(1-1/\gamma)}}{(1-1/\gamma)(1+\rho)^{t-i}} \quad \ldots\ldots\ldots\ldots (2)$$

u_i = the utility throughout a person's life
u [c_{it} , l-l_{it}] = the utility obtained from consumption and relaxation
c_{it} = consumption
l_{it} = the proportion of working
1-l_{it} = the proportion of relaxation
γ = the elasticity of substitution during the periods
ρ= the discount rate of complacency

Determining the utility equation at time t has constant elasticity of substitution (consumption and leisure) that

$$U[c_{it}, 1 - l_{it}] = [c_{it}^{\frac{\varepsilon-1}{\varepsilon}} + \delta(1 - l_{it})^{\frac{\varepsilon-1}{\varepsilon}}]^{\frac{\varepsilon}{\varepsilon-1}} \ldots\ldots\ldots\ldots (3)$$

ε is the elasticity of substitution between consumption and leisure, and δ is parameter that reflects the intensity of satisfaction with the rest compared with consumption.

People in each generation make decisions by maximizing utility subject to the budget constraint. The budget constraint of generation i at time t is

$$A_{it} = \left(1 + \left(\frac{r}{p}\right)_t\right) A_{it-1} + y_{it} - c_{it}(1 - T_c) + \overline{P}_{it} \ldots.(4)$$

A_{it} = the wealth of generation I at time t
y_{it} = the real income after tax
c_{it} = consumption
T_c= value-added tax
$\overline{P}_{it}$= the allowance paid for the elderly at age 60

The condition of paying old age allowance is

$$\overline{P}_{it} \begin{cases} = 0 \,, t = i, i+1, \ldots, i+40 \\ > 0 \,, t = i+41, \ldots \,, i+60 \end{cases}$$

The equation of real income after tax of generation i at time t can be written as

$$y_{it} = \left(\frac{w}{p}\right)_t l_{it} h_{it}(1 - T_w) \ldots\ldots\ldots (5)$$

$(w/p)_t$ = the real wage per effective unit of labor
tax_t = the income tax collected from people aged 20-60
h_{it} = the effective units of labor of generation i

The effective units of labor of generation i is

$$h_{it} = f(age) \times tech_t \text{ …….. (6)}$$

f(age) = age-specific productivity
$tech_t$ = the technology impacts the effective unit of labor

The first order necessary condition yields the Euler Equation

$$C_{it} = q_{i,s+1,s}\{\frac{\left(\frac{r}{p}\right)}{\left(1+\frac{r}{p}\right)(1-T_c)}\left(A_{it-1} + \left(\frac{w}{p}\right)_t l_{it}h_{it}(1-T_w)\right) + \frac{\bar{P}_{it}}{(1-T_c)} - \delta[1-l_{it}]\} \text{ …… (7)}$$

3.2 Private Sector

The firm is assumed to maximize its profit, taking the wage rate and the interest rate as given. The aggregate private production function is assumed to be Cobb-Douglas such that

$$Y_t = aK_t^{\propto}L_t^{1-\propto} \text{ ……. (8)}$$

Y_t = the aggregate output
K_t = the aggregate capital
L_t = the aggregate labor
a = is technology of production of firm

Assuming that in the competitive market the real return of capital and labor is equal to the marginal output of each production factors.
The real return of capital is

$$(r/p)_t = \propto a(\frac{L_t}{K_t})^{1-\propto} \text{ …… (9)}$$

The real return of labor is

$$(\frac{w}{p})_t = (1-\propto)a(\frac{K_t}{L_t})^{\propto} \quad \ldots\ldots\ldots (10)$$

At the equilibrium, the total capital of the economy is equal to total wealth of the economy minus the total public debt in the economy. That is equal to the total wealth of the household plus old age allowance at period t minus the amount of public debt at period t. The relationship of the equation is

$$K_t = A_t - B_t = \sum_{i=t-6}^{t} pop_{it}A_{it} - B_t \ldots\ldots\ldots\ldots (11)$$

$\sum_{i=t-80}^{t} pop_{it}A_{it}$= the total wealth of generation i at period t
A_{it} = the wealth of generation i at period t
Pop_{it} = the ratio of generation i per total population at period t
B_t = the total public debt at period t

At the equilibrium, the total supply labor at period t is

$$L_t = \sum_{i=t-6}^{t} pop_{it}l_{it}h_{it} \ldots\ldots\ldots\ldots (12)$$

$\sum_{i=t-60}^{t} pop_{it}l_{it}h_{it}$= the total supply labor of generation i at period t
Pop_{it} = the ratio of generation i per total population at period t

3.3 Government sector

The government sector is assumed to collect personal income tax and value-added tax from the households in order to pay old age allowance to the elderly. If the revenue is not sufficient for old age allowance, the government will issue bonds and pay interest rate.

The revenue, which is the summation of personal income tax, value-added tax and government bonds, is equal to the government expenditure focused on old age allowance at period t, along with the repayment including interest rate expense. The equation is

$$G_t = \sum_i \overline{P}_{it} + (1 + (r/p)_t)B_{t-1} \text{ …… (13)}$$

$$T_t = B_t + \sum_i (^{w}/_{p})_t \, l_{it} h_{it} T_w + \sum_i C_t(T_c) \text{ …….. (14)}$$

$$G_t = T_t \text{ ……. (15)}$$

$\sum_i \overline{P}_{it}$ = old age allowance expenditure of the government

$(r/p)_t$ = interest rate on public debt at constant price at period t

B_t = public debt at period t

T_t = government revenue at period t

With restrictions, government bonds will not generate crowding-out effects.

3.4 Market Equilibrium

The equilibrium condition in the capital market at period t requires total wealth of the household to be equal to total capital plus public debt

$$A_t = K_t + B_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

The equilibrium condition in the goods market at period t is the aggregate output, which is equal to the sum of household's consumption, private investment and the government expenditure.

$$Y_t = C_t + K_t + G_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (17)$$

3.5 Parameter specifications

1. Elasticity of substitution during the periods = 0.75
2. Discount rate of complacency = 0.015
3. Elasticity of substitution between consumption and leisure = 0.8
4. Intensity of satisfaction with the rest compared with consumption = 0.33
5. Ratio of the return of capital per income of the country = 0.5

4. Results and Simulation Analysis

We estimate the effects of transitioning to an old age society on the economy by simulating the Overlapping Generations model from section 3. For the old age allowance, the payment of old age allowance follows the actual policy in Thailand. The average used in the model is calculated by multiplying the amount with the population. Regarding the length of the simulation, the model is simulated for 87 years because population growth data from World Population Prospects (2015 Revision) shows only 87 years of information.

From the simulation, the results are divided into 3 parts. The first part shows the economic impact from demographic change. The second part shows the relationship between

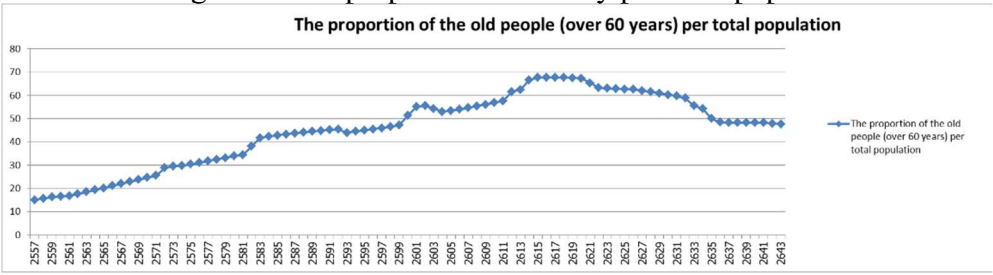
increased old age allowance policy and its fiscal burden. The third part shows the financing options to respond to the increase in government expenditure.

4.1 Economic impact from demographic change

Demographic change affects all economic factors: consumption, GDP, government expenditure, fiscal burden, etc.

In simulating the model, it is assumed that the government collects revenue from personal income tax and valued-added tax. The average of personal income tax rate of Thailand in 2556 B.E. is 9.74 percent, thus the model sets average personal income tax at 10 percent. The value-added tax rate is set at 7 percent for the simulation which corresponds to the actual rate. The government has expenses for the elderly and the repayment of bonds. The old age allowance expenditure is designed to increase step by step: people who are 60-69 years old will receive 600 baht per month, individuals 70-79 years old will receive 700 baht per month, and individuals 80-89 years old will receive 800 baht per month. Individuals over 90 years old will receive 1000 baht per month. In the present, Thailand is an ageing society and will change to an aged society at 2567 B.E., and super-aged society at 2576 B.E.

Figure 3. The proportion of elderly per total population



Source: World Population Prospects, 2015 Revision

Transitioning to an old age society affects factors such as labor supply, consumption, social benefit, fiscal burden, etc. The main reason for this is the increase in the proportion of elderly per total population. In the future, the proportion of the elderly per total population will increase to 67 percent which is termed as a super-aged society.

Table 2. the impact of demographic change on the economy

B.E.	Average proportion of elderly (over 60 years) of total population*	Labor supply	Total consumption	GDP	Government Revenue	Government expenditure	Bond from old age allowance	Fiscal burden	The proportion of bond per person
2558 - 2567	18.365	-1.186	-0.1607	2.539	-0.130	3.887	3.899	1.326	5.146
2568 - 2577	27.801	-1.725	-0.6279	1.586	-0.628	2.533	2.539	0.938	4.339
2578 - 2587	38.574	-1.983	-1.1162	1.005	-1.116	1.777	1.781	0.768	3.840
2588 - 2597	44.839	-2.035	-1.5033	0.634	-1.503	1.287	1.290	0.651	3.394
2598 - 2607	52.472	-1.552	-2.2653	0.416	-2.265	0.903	0.905	0.487	2.496
2608 - 2617	61.955	-1.066	-2.4232	0.301	-2.423	0.621	0.623	0.321	1.706
2618 - 2627	64.389	-0.559	-1.9513	0.244	-1.951	0.456	0.457	0.212	1.021
2628 - 2637	55.744	-0.228	-1.4317	0.221	-1.432	0.359	0.360	0.139	0.589
2638 - 2643	48.083	-0.037	-0.7062	0.197	-0.706	0.293	0.294	0.097	0.330

* average value
Factors not marked by * indicates average percent growth (% growth) that is computed by CAGR.
Source: Author's calculation.

From table 2, the average proportion of elderly of total population is increasing. There will be a lot of elderly in society. On the other hand, labor supply is decreasing, which shows that the transition to an old age society reduces labor supply. The total population is an important factor on consumption. If there are a lot of people in society, there will

be a lot of consumption. Table 2 shows the negative growth trend of consumption, showing a decrease in total consumption.

Decreasing consumption will influence GDP growth, slowing down growth. Table 2 shows the trend of average GDP growth diminishing. This shows the economy in an old age society will slow down. The decrease in economic growth will also affect government revenue collection. Conversely, when the economy grows, the government will collect a lot of revenue in the form of personal income taxes and value added taxes.

Table 2 shows government revenue collection decreasing. Transitioning to an old age society decreases revenue but increases government expenditure, especially old age allowance expenditure. It can also be seen that the increase of old age allowance expenditure is diminishing as it follows the trend of the elderly in the society.

Both the increase in government expenditure and the diminishing GDP growth have an effect on public debt. If the government cannot collect enough revenue, it will issue bonds, affecting public debt through the fiscal burden and the capability of repayment.

Table 2 shows that the growth of the fiscal burden is a diminishing positive trend, following the growth of bonds. Although the fiscal burden of the old age allowance policy is not over 60 percent of GDP, the repayment of public debt must be considered. If the government builds more and more public debt until it cannot repay the public debt, it will shift this duty to the next generation creating inequality between generations. Table 2 shows that the proportion of bond per person is a diminishing growth trend. If the bond per person increases continuously, the next generation will repay more debt.

Simulating longer life expectancy

In the transition to an old age society, the age of the population is an important consideration. The longer the life expectancy of a population, the more government expenditure increases, especially old age allowance expenditure, which is designed to pay continuously until individuals die.

Table 3. Average old age allowance expenditure per year (million Baht)

B.E.	The average of old age allowance expenditure per year (million Baht)						
	Age 80 years (Base case)	Age 81 years	% change	Age 82 years	% change	Age 83 years	% change
	(A)	(B)	((B-A)/A)*100	(C)	((C-B)/B)*100	(D)	((D-C)/C)*100
2558 - 2567	68.585	72.238	5.327	75.839	4.984	79.353	4.635
2568 - 2577	96.293	101.966	5.892	107.668	5.592	113.337	5.266
2578 - 2587	121.509	129.092	6.242	136.820	5.986	144.608	5.692
2588 - 2597	143.533	152.844	6.487	162.406	6.256	172.116	5.979
2598 - 2607	161.786	172.612	6.691	183.812	6.489	195.260	6.229
2608 - 2617	175.802	187.871	6.865	200.431	6.685	213.335	6.438
2618 - 2627	186,450,548.35	199,465,856.40	6.981	213,077,124.50	6.824	227,124,421.43	6.593
2628 - 2637	194,977,706.83	208,733,952.93	7.055	223,161,196.33	6.912	238,089,217.37	6.689
2638 - 2643	200,899,681.95	215,155,430.14	7.096	230,131,420.05	6.961	245,649,999.66	6.743

Source: Author's calculation.

As per table 3, longer life expectancy of a population makes old age allowance expenditure increase at a diminishing

rate. In 2638 – 2643 B.E., if the population lives for 1 year longer, (80-81) , the old age allowance expenditure will increase 7.096 percent. If the population has an increasing longer life expectancy by 1 year; from 81 to 82, then the old age allowance expenditure will increase 6.961 percent. This change shows the old age allowance expenditure increase at a diminishing rate.

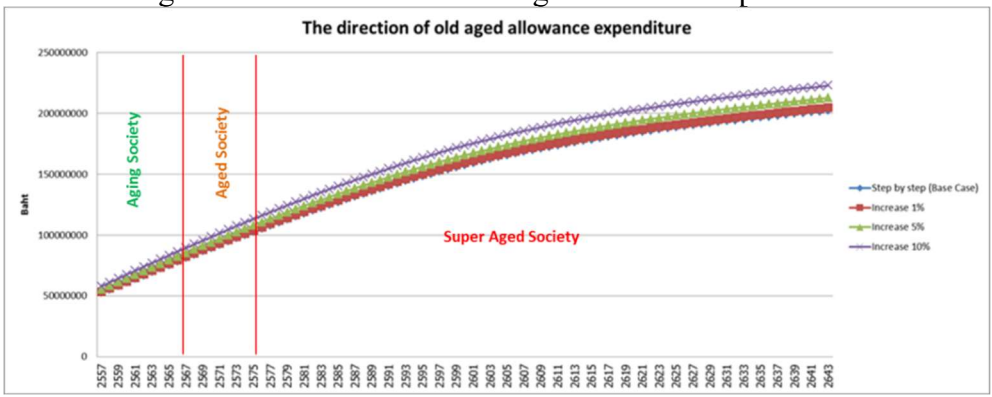
From part 1 we can conclude two points: first is that demographic change in Thailand comes faster than expected. In the simulation, Thailand will change to an aged society at 2567 B.E. There will be some effects on the economy. Economic welfare will be worse. At the level of a super-aged society, GDP will decrease. There will be higher old age allowance expenditures. This will make public debt increase and lead to a fiscal burden. Therefore, it leads to higher avoidance of repayment and shifting burdens to next generations. The second point is that longer life expectancy leads to an increase in government expenditure. Higher government expenditure increases the fiscal burden and more avoidance of repayment and burden shifting to next generations.

4.2 Simulation of increasing old age allowance policy and the impact on fiscal burden

In order to change old age allowance policy, not only must the cost of living of the population be considered, but also the fiscal burden must be considered too. If the government increases old age allowance payments, it may not collect enough revenue which leads to an increase in public debt. The increase in public debt impacts fiscal sustainability. In this situation, it was determined that an increased payment of old age allowance by 1 %, 5% and 10% respectively with the previous assumption. The main expenditure of the government

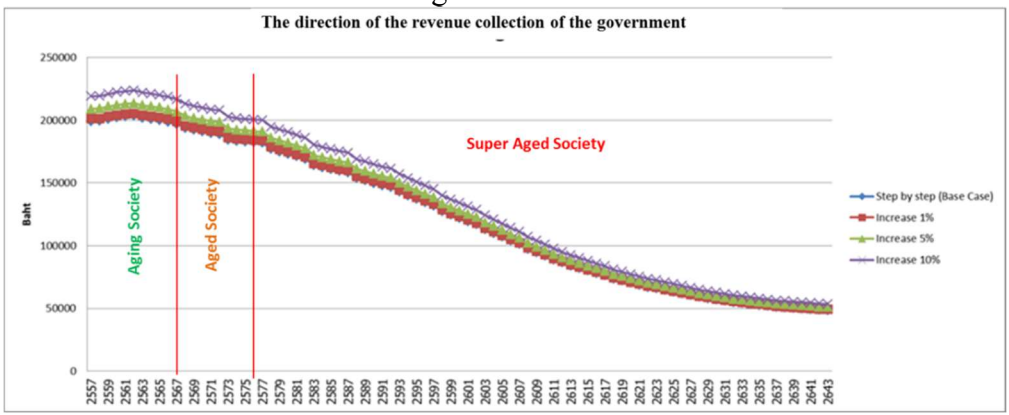
is old age allowance expenditures. The other is the repayment of the debt.

Figure 4. The direction of old age allowance expenditure



Source: Author's calculation

Figure 5. The direction of the revenue collection of the government

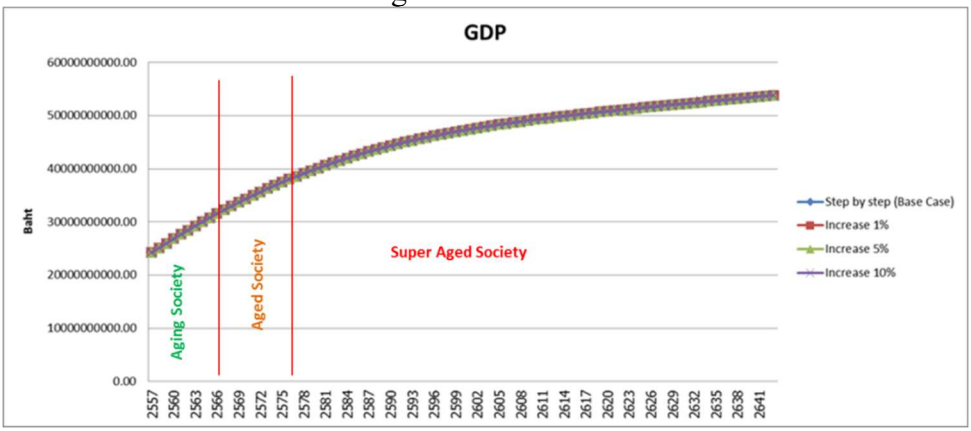


Source: The calculation of researcher

Changing old age allowance costs leads to more government expenditure. Figure 4 shows the increase of old age allowance expenditure, as well as percent change.

Increasing the rate of old age allowance policy makes people have more money to consume, which means the government can collect more value added tax. Figure 5 shows the government's direction of the revenue collection. The more government increases the old age allowance paying rate, the more the revenue increases.

Figure 6. The direction of GDP in the case of changing old age allowance rate

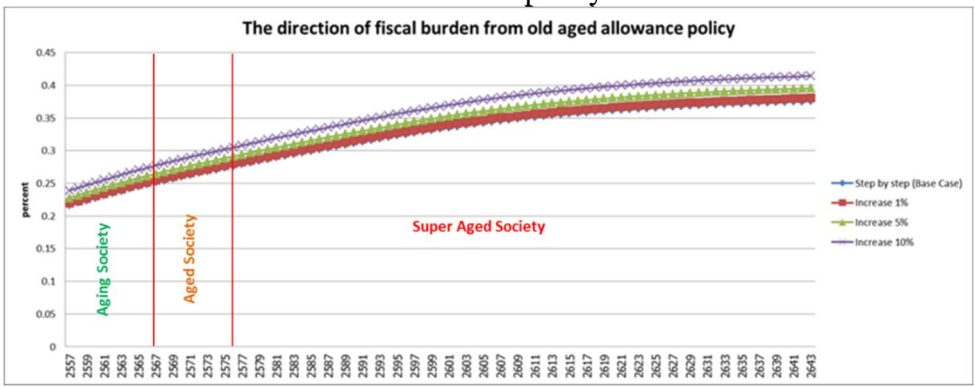


Source: Author's calculation

The changing old age allowance rate also affects the growth of the economy. Figure 6 shows the direction of GDP in the case of increasing old age allowance rate. The increase of old age allowance rate makes people have more money. The more people use money to consume, the more GDP increases.

Increasing the rate of old age allowance increases government expenditure. The transition to an old age society leads to less revenue collection. The increased expenditure and the decreased revenue leads to the government increasing public debt. The increase of public debt brings an increasing fiscal burden.

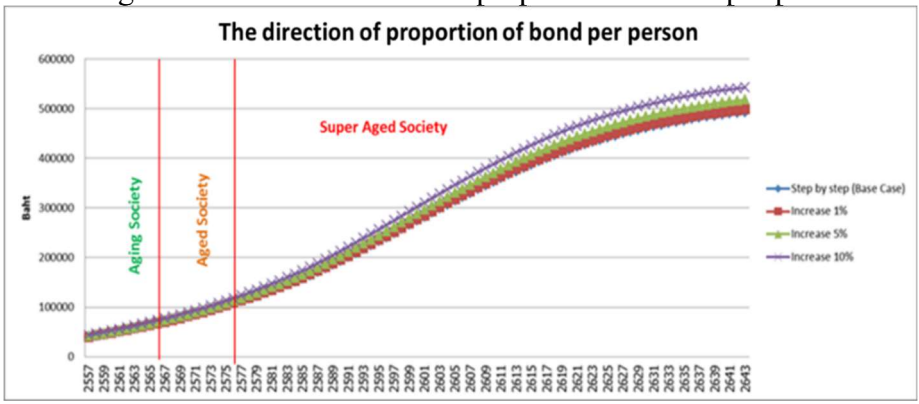
Figure 7. The direction of fiscal burden from old age allowance policy



Source: Author's calculation

Figure 7 shows the direction of fiscal burden from old age allowance policy. The direction increases following the increase of old age allowance expenditure. The higher the percentage, the more fiscal burden increases. Increased fiscal burden brings avoidance of repayment. If the government cannot repay its public debts, it will shift its duty to the next generation.

Figure 8. The direction of the proportion of bond per person



Source: Author's calculation

Figure 8 shows the direction of the proportion of bond per person. The higher the percentage old age allowance policy increases by, the more the proportion of bond per person increases. In 2581 – 2611 B.E., the high positive slope of the bond per person is caused by the high negative slope of revenue collection. In 2613-2643 B.E., the flat positive slope of the bond per person is caused by the flat negative slope of the revenue collection. If the bond per person increases continuously, the next generation will repay more debt. From figure 8, the more the government increases the rate of old age allowance policy, the greater the amount of bonds per person.

Part 2 can be concluded in 3 main points. The first point is that increasing the old age allowance rate leads to higher government expenditure. The second point is that increasing old age allowance rate increases government revenue collection and economic growth. The third point is that lower government revenue and their higher expenditure lead to higher fiscal burden. Fiscal burden which increases will cause the avoidance of repayment and shifting to future generations.

4.3 Government financing in response to increasing expenditure

Government financing is important for fiscal stability, the economic system, the disparity of generations, etc. If the government collects too much tax, social benefit will decrease. If revenue collected from tax is too little, government will build more public debt. The fiscal burden will increase and cause a fiscal problem. People of the next generation must repay more public debt.

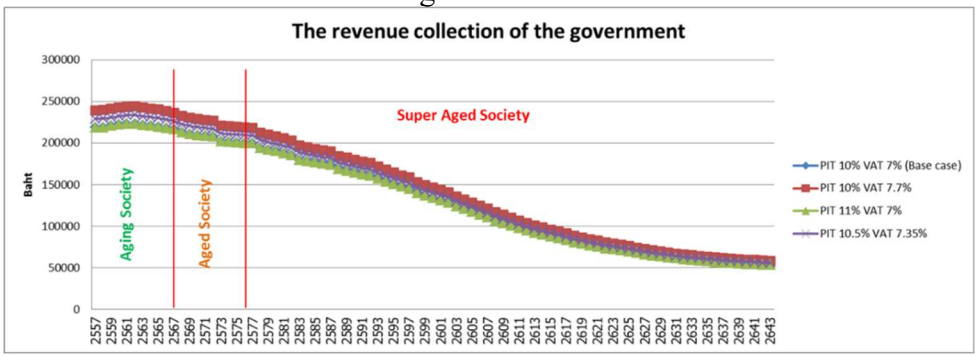
The situation, which is simulated in this part, is an increased old age allowance policy of 10 percent. The change in government expenditure (ΔG) will be constant. The patterns for financing are:

1. Personal income tax rate increases, and value-added tax rate is constant.
2. Personal income tax rate is constant, and value-added tax rate increases.
3. Personal income tax rate increases, and value-added tax rate increases.

Dividing the proportion of revenue collection of the government following the model, the proportion of revenue collection from the value-added tax per total revenue is over 90 percent. Value-added tax is not collected locally but it is collected by the central government.

There are different distortionary effects from both taxes. The increase of personal income tax decreases personal incentive of working because people get less in return. The increase of value-added tax doesn't affect consumption patterns but it affects the value of money for consumption. The result is that the value of total consumption goes down. Therefore, the impact of changing value-added tax rate on the economy is more than the changing personal income tax rate.

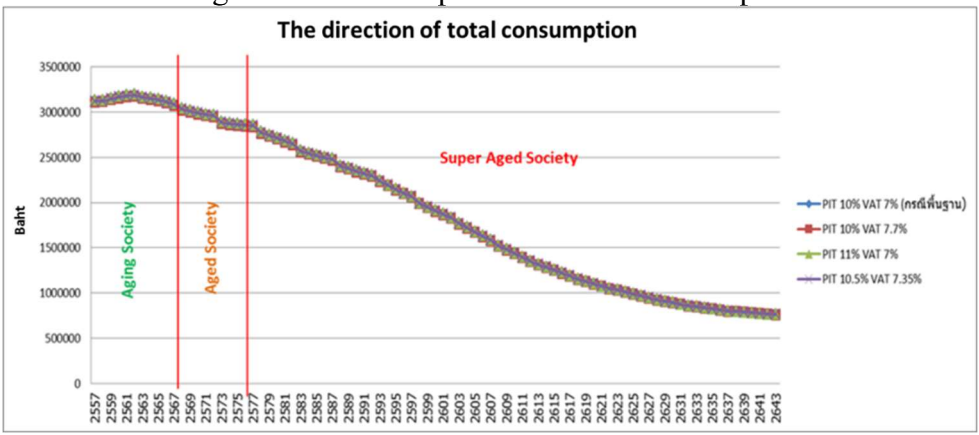
Figure 9. The comparison of revenue collection by the government



Source: Author's calculation.

The financing of government is important. The revenue that is collected is used to pay for social benefits of the elderly. If the government cannot collect enough revenue, it will build public debt. From the simulation, increasing the value added tax rate increases revenue collection more than increasing the personal income tax rate. Increasing personal income tax rate also leads to less income, decreasing consumption and causing revenue collection to decrease. Figure 9 shows the revenue collection of the government. In the case of increasing the value added tax rate by 10 percent, it will increase revenue collection the most.

Figure 10. The comparison of total consumption

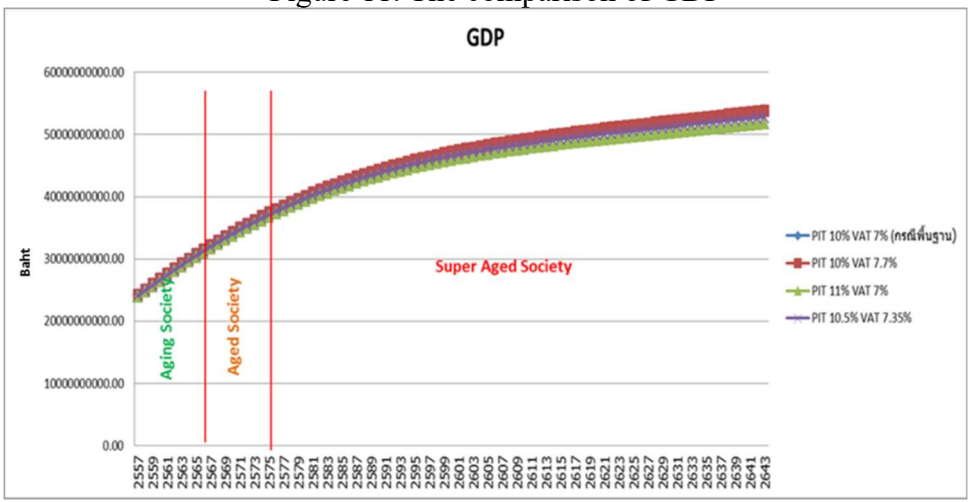


Economic welfare is one of the most significant variables, and it is shown by total consumption. Increasing the value-added tax rate decreases economic welfare. The increase of value added tax rate increases the price of goods. This leads to a fall in total consumption because goods are more expensive. In contrast, increasing personal income taxes affects economic welfare less than value-added tax. Therefore, government financing by increasing value-added tax rate will affect economic welfare more than increasing the personal

income tax rate. Figure 10 shows the comparison of total consumption in the case of changing tax rate.

When the government manages the policy, it must consider the economic growth which affects GDP.

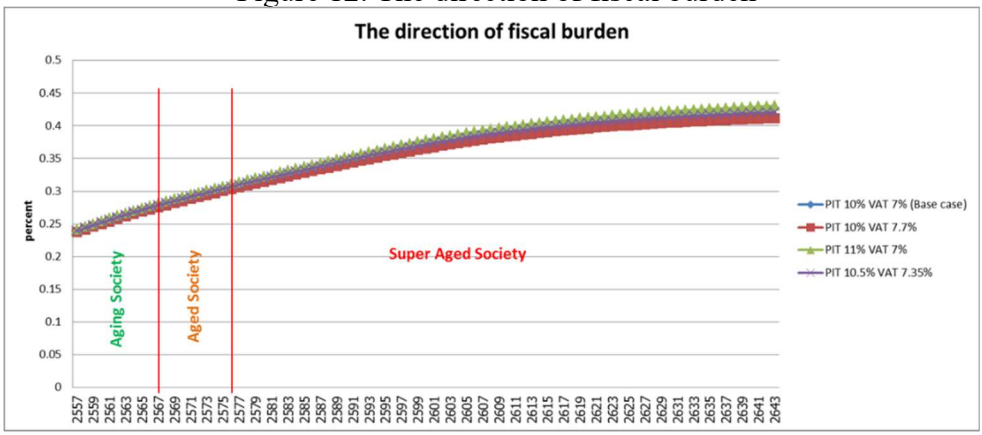
Figure 11. The comparison of GDP



Transitioning to an ageing society affects economic growth. Labor force is important for the economy. Figure 11 shows the direction of GDP. GDP is affected by demographic change. In the case of increasing value-added tax rate by 10 percent, the government will collect more revenue compared to other measures causing higher GDP value.

To reduce the fiscal burden, the government must collect more revenue. Figure 12 shows the direction of fiscal burden. Increasing the value added tax rate can reduce the fiscal burden more than increasing personal income tax rate because of more revenue collection. More revenue collection makes the government build less public debt.

Figure 12. The direction of fiscal burden



Source: Author's calculation

Figure 13. The comparison of the proportion of bond per person

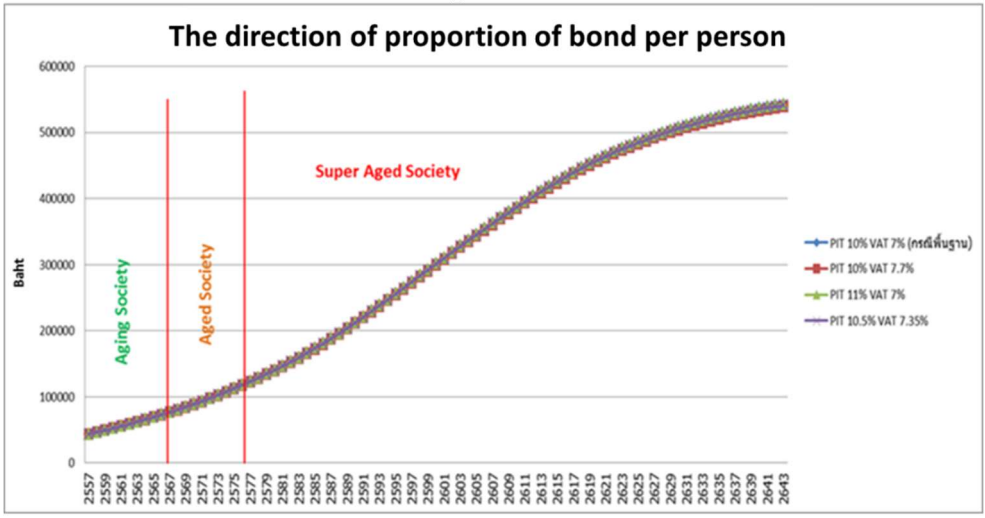


Figure 13 compares the proportion of bonds per person. Whether using any tax patterns to reduce the proportion of bond per person, they cannot reduce and avoid repayment of

public debt and also shift it to next generations. The government should not increase public debt and should reduce the proportion of bond per person.

Part 3 can concluded in 5 main points. The first point is that increasing value-added tax rate increases government revenue collection more than increasing personal income tax. It means that a value-added tax rate increase is more efficient than increasing personal income tax rate because value-added tax is collected from the entire population. Therefore, money value of value-added tax collection is higher than personal income tax collection. The second point is that increasing value-added tax has an effect on population consumption more than increasing personal income tax rates. Increasing value-added taxes increase the price of goods, and leads to a decrease in consumption. The third point is that increasing value-added taxes leads to higher GDP than increasing personal income taxes. The fourth point is that an increased value-added tax decreases the fiscal burden but increasing personal income tax rates cannot reduce the fiscal burden. The fifth point is that if the government still increases public debt every year, financing patterns for decreasing fiscal burden cannot solve the fiscal problem. The avoidance of repayment and a shift to future generations will continue. Not increasing public debt is the best for reducing fiscal burden.

5. Conclusion

The transition of Thailand to an ageing society comes faster than expected. The government should manage expenditure and revenue collection in accordance with the increase of the elderly in society, especially old age allowance expenditure. Old age allowance is paid to all elderly except the people in pension system. The old age allowance expense is

determined according to age. It is paid step by step as per the present policy in Thailand.

This paper examined the impact of demographic change on fiscal sustainability of old age allowance policy by computing an overlapping generations model under a general equilibrium context. This model can show the dimension of transition from the current situation to an old age society. The simulation was divided into 3 parts.

The *first part* is the impact of demographic change on the economy. The study found 2 points. The first point is that demographic change in Thailand comes faster than expected. In the simulation, Thailand will change to an aged society at 2567 B.E. There will be some effects on the economy. Economic welfare will be worse. At the super-aged society stage, GDP will slow down. There will be higher old age allowance expenditures. They make public debt increase and lead to fiscal burden. Therefore, it leads to higher avoidance of repayment and shift to next generations. The second point is that longer life of the population leads to government expenditure increase. Higher government expenditure makes fiscal burden increase and more avoidance of repayment and burden shifting to next generations.

The *second part* is the impact of an increased old age allowance on the fiscal burden. This part presents increasing an old age allowance rate and analyzes impacts on fiscal burden. The study can conclude 3 points. The first point is that increasing the old age allowance rate leads to higher government expenditure. The second point is increasing the old age allowance rate increases government revenue collection and economic growth. The third point is that lower government revenue and higher expenditure leads to a higher fiscal burden. Fiscal burden which increases will cause the avoidance of repayment and shift to next generations.

The *third part* is how to finance the increase of government expenditures. This part presents government financing in response to an increase in old age allowance expenditure, especially to reduce fiscal burden. The study can conclude to 5 points. The first point is that increasing value-added tax rate increases government revenue collection more than increasing personal income taxes. It means a value-added tax rate increase is more efficient than increasing personal income tax rate because value-added tax is collected from the entire population. Therefore, money value of value-added tax collection is higher than personal income tax collection. The second point is that increasing value-added tax rate has an effect on population consumption more than increasing personal income taxes. Increasing value-added tax rate affects the goods price, and leads to a decrease in consumption. The third point is that increasing value-added taxes leads to higher GDP than increasing personal income taxes. The fourth point is that increasing value-added taxes makes fiscal burden decrease but increasing personal income taxes cannot reduce the fiscal burden. The fifth point is that if the government increases public debt every year, changing financing patterns for decreasing fiscal burden cannot solve the fiscal problem. The avoidance of repayment and a shift to next generations will continue. Avoiding increasing public debt is the best for reducing fiscal burden.

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THAMMASAT REVIEW OF
ECONOMIC AND SOCIAL POLICY
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Volume 6, Number 2, July - December 2020

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