POPULATION AGING IN THE OVERLAPPING GENERATIONS MODELS FOR THAILAND

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POPULATION AGING IN THE OVERLAPPING GENERATIONS MODELS FOR THAILAND

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This study develops three stochastic overlapping generations (OLG) models to investigate the effects of mandatory retirement age policy and child allowance policy in an aging economy. From a benchmark model, two features are added respectively in each extended model, namely an exogenous longer retirement age and an endogenous fertility rate, representing the number of children. The calibrated parameters of the Thai economy and population were used, these models provided simulation results to measure the effects of each policy on the macroeconomic variables, including output, capital accumulation, and lifetime consumption, as well as the government transfers and the Pay-as-you-go (PAYG) pension. First, the results showed that a higher mandatory retirement age is always beneficial in the long run for PAYG pension budgets and for government elderly transfers, and thus future generations may enjoy greater consumption than the current ones do. On the contrary, in the long run, such policies can create downsizing effects on capital accumulation and on output. Second, the policy of a higher child allowance is always beneficial in the long run for PAYG pension budgets, the government elderly transfers, and a higher fertility rate with more newborns. The effects on lifetime consumption, capital accumulation and output are similar to previous models, while the net effects remained positive on returns to capital and negative on the wage rate.

Keyword : Overlapping generations model, Aging population, Retirement age, Child allowance

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CHAPTER 1
INTRODUCTION

1.1 Background

In recent years, much attention has been paid to the macroeconomic consequences of population aging across the world. Low fertility rate and high life expectancy are two primary determinants influencing this global trend. These have shifted the age structure toward a greater share of the elderly. In 2017, some ASEAN members, i.e., Singapore, Thailand, and Vietnam are qualified as aged societies. It has been estimated that elderly populations (age 60 or over) is increasing at the rate of 4% per year, and the share oldest cohort (age 80 or over) is increasing at an even faster rate (6% per year) (Thai Gerontology Research and Development Institute, 2018). The rapid change in demographic structure of Thai population poses major challenges to economic development (National Statistical Office, 2016). In general, the rise in the dependency ratio stems from two factors: (1) a decline in the fertility rate and (2) an increase in longevity. The aforementioned factors have highly deteriorated the Thai population aging. By looking at these two factors separately (Table1), the consequences of lower fertility and those of greater longevity brings about important implications for policy makers.

There is a vast literature exploring the link between demographic composition and economic activity. One pioneering work within a general equilibrium framework is Auerbach and Kotlikoff (1987). This paper employed the overlapping generation model (OLG) with the calibrated U.S. data to evaluate the impact of demographic transitions on economic activity. The paper also demonstrates that the OLG model is considered to be the workhorse model for analyzing the economic consequences of demographic transitions and the associated fiscal policy. Miles (1999) also utilizes an OLG model to explore demographic impact, focusing on the U.K. and European countries. In Thailand's population aging has been issues investigated by using the OLG model in two strands of literature. The one strand focuses on the technological progress which helps to improve the aggregate productivity to offset the decline in the number of workers and work hours. The technological progress plays an important role in buffering the negative impact of what would happen (Bisonyabut & Panpiemras, 2012). The other strand, for example, Cheewatrakoolpong and Boonprakaikawe (2010) focuses on the effects of population aging on economic growth with reform pension system.

Table 1 Total fertility rate and elderly survival rates in Thailand

Year	Total fertility rate (per woman)	Survival rate of 60-80 age (percentage)	Life expectancy (years)
1950-1955	6.4	-	52.0
1975-1980	4.0	-	61.4
2000-2005	2.0	36.0	70.8
2025-2030	1.9	49.5	76.8
2045-2050	1.9	56.4	79.1

Source: Population Division, DESA, United Nations (2017)

More recently, the literature has gradually shifted the focus to the issue of the sustainability of social systems, particularly the pay-as-you-go (PAYG) pension system. One possible solution is to change the pension system from unfunded schemes to funded schemes (Jie Zhang & Zhang, 2003). This reform would cause a dramatic effect on individuals during the transition. This study provides a child allowances policy and the postponement of retirement have become popular government policies in recent decades. As the common belief that raising the fertility rate or lengthening of retirement age would lead to a situation where more labour force support fewer elderly, thus reducing the burden placed upon government budgets. Nowadays, the provision of child allowances reduces the cost of raising children, and parents then have incentives to have more children, such as in many developed countries consist of Australia, Japan, and Sweden. This is consistent with a study conducted by van Groezen, Leers, and Meijdam (2003), showing that as three periods overlapping generation model (OLG) with a child allowances on endogenous fertility and pensions sector.

However, the consensus of increasing in the fertility rate leads to a positive impact on pension sector has been questioned by Cigno (2007). Cigno argues that the combined effects of lower births rate, greater longevity and sluggish retirement age is putting public pay-as-you-go pension system. This is consistent with a study conducted by Fanti and Gori (2012) analytically examine the effect of fertility on pensions based on an OLG model with pay-as-you-go pension system and exogenous fertility rate. The study found that pension benefits do not necessarily increase with the fertility rate. Although increasing fertility raises the labour force and generates a positive effect on pension benefits, it also causes a negative effect due to the general equilibrium feedback of the income wage rate.

In this study, the overall impact of population aging on macroeconomic variables will be investigated. This study will provide a clear picture of economic outlooks in aging countries using the dynamic stochastic general equilibrium (DSGE) model with the OLG framework. Parameters of these study are calibrated from the Thai economy. Two new features the mandatory retirement age and the child allowance policy are introduced in standard OLG models of Cipriani (2016). First, the mandatory retirement age policy is introduced. Address in a long-term perspective the following questions. Is a mandatory postponement of the retirement age really beneficial for pension system (i.e. for pension benefits paid to pensioners)? Second, to study the child allowance policy, which is the government has been to provide incentives for child care and to facilitate fertility recovery is investigated under this analysis. To do so, extended models with endogenous fertility by household is separated into three generations; child, working-age, and elderly.

1.2 Research questions

1.What are the impact of population aging on macroeconomic variables (saving, capital and output)?

2.Can the lengthening of retirement age enhance the Thai pension system?

3.Can the child allowance policy enhance the Thai pension system?

1.3 Objectives of the study

The objectives of the study are as follows

1.To study the effect of longevity shock on macroeconomic variables in Thailand.

2.To analyze the effect of a lengthening retirement age policy on macroeconomic variables in Thailand.

3.To analyze the effect of the adoption of child allowance policy on macroeconomic variables in Thailand.

1.4 Significance of the study

Analysis of the macroeconomic impact of population aging in Thailand. By looking at these two factors separately the consequences of lower fertility and greater longevity, brings about important implications for policy makers use planning employability and social security of aging society. For these reasons, this dissertation being conducted focuses on government policies in relation to a lengthening retirement age programs from 60 to 63 years and a raising of the child allowance (the fixed percentage of wage income entitled to each young parent as a subsidy for each additional newborn). The main purpose of this dissertation is to indicated whether the policy variable shocks have affected the macroeconomic variables.

1.5 Scope and limitation of the study

This study employs the DSGE model with the OLG framework to achieve all objectives. The OLG model based on the study of Cipriani (2016) is modified to incorporate key features of a lengthening retirement age (scenario 1) and the policy of a raising the child allowance (scenario 2). The model is a close economy model of the Thai economy which consists of representative households, firms, government sector and social security system. Parameters in this study are calibrated by using the Thai data. The macroeconomic variables consist of saving, capital, and output.

1.6 Research hypotheses

This dissertation will study the impact of population aging as it relates to the economic policy of Thailand. Thus, the hypotheses of this study will be seen as follows:

1.The longevity has a positive effect on macroeconomic variables (saving, capital and output), except for pension payouts is negative effect.

2.The policy of a lengthening retirement age has a negative effect on macroeconomic variables (saving, capital and output), except for pension payouts is positive effect.

3.The policy of a raising the child allowance has a negative effect on macroeconomic variables (saving, capital and output), except for pension payouts is positive effect.

1.7 Organization of the study

The outline of this study is as follows: Chapter 1 states the significances, motivations and background of this study. Chapter 2 is the review of the related literatures. Chapter 3 discusses model environment and parameter calibration. Chapter 4 provides results of the models. Finally, conclusions and some policy implications are discussed in Chapter 5.

CHAPTER 2

REVIEW OF LITERATURE AND RELEVANT POLICY IN THAILAND

The purpose of this chapter is to review related literatures which consist of 3 major parts. The first part is to overview theories and concepts which are used for analyzing the overlapping generations model (in Chapter 3). The second part is to review the empirical and theoretical research applying OLG model related to these research questions. The last part is to shed some light on involving the topic of public policy of Thai aging economy.

2.1 Theoretical Literature

The consequences of population aging have been theoretically analyzed under the overlapping generations (OLG) framework. This type of model can be used to investigate the aggregate implications of lifecycle hypothesis, which departs from the assumption of infinite-lived household agent. This OLG model states the overlapped heterogeneous household to examine the intra and inter generation effects.

2.1.1 Basic lifecycle model

The lifecycle model is initially developed by Ando and Modigliani (1963) and extended by Merton (1969, 1971). The Lifecycle model (LCM) is based on the idea of a rational and well-informed representative individual who plans consumption over entire lifecycle with lifetime of income. According to the Lifecycle model, the principal motivation for saving is to accumulate assets in order to support consumption in retirement for elderly. It builds on the empirical observation that aggregate consumption per capita is smoother than aggregate income per capita.

In a lifecycle model, it suggests that individuals will try to smooth their consumption over time. The model is where an individual's life is divided into two periods generations, a period of young age (and work), and a period of old age (and retirement). In the absence of a pension system, the individual will experience a fall in living standards if young age has not saved adequately for retirement. It will be hard for the individual to borrow from others to support the future consumption for old age, if elderly has no prospect of future earnings to repay the loan. Consequently, young age must reduce the current consumption expenditure below income when income is relatively high. In order to old age enjoy higher future consumption than income when income is relatively low. This is called saving for retirement and as a consequence of this saving, consumption will be smoother than income. Savings retirement of elderly leads to the accumulation of financial assets. Then, the OLG framework has fruitfully been applied because it enables the aggregate implication of lifecycle hypothesis and introduces the heterogeneous household to examine the intra and inter generation effect.

2.1.2 Fundamental the two-period OLG model

The original overlapping generations model was proposed by Samuelson (1958) and Diamond (1965). In the overlapping generations model, individuals are allocated to finitely lived generations (with certain lifetimes) according to their date of birth, and at any one time more than one generation will be alive. Each generation will trade with two the generations (young and old age) ahead of it and the generation behind it at different stages in its lifecycle. The model can be used to study the consequences of lifecycle saving during their working period to finance their consumption during retirement. In these models, capital is the only asset that savings can be held. The net capital stock increases over time as a result of bequests to the next generation. This framework is simple (the two-period overlapping generations model of young and old age) and feasible to solve for numerical solution.

The OLG model is a powerful vehicle for analyzing pension systems. The key state variable in the Diamond-Samuelson OLG model is the physical capital stock, and it explicitly shows the dynamic path of the economy. When labor supply and retirement are exogenous in the Diamond-Samuelson model and when a fully funded pension system is introduced. There will be no change to the dynamic path of the economy. So long as the fund invests in the capital stock and so generates the same rate of return as on private savings. Instead, if an unfunded pay-as-you-go (PAYG) pension system is introduced, the outcome will be non-neutral (Blinder, 1982). The unfunded scheme will be superior to the funded scheme if the Aaron (2014) condition holds, i.e., the economy invests more than it is earning profit. The growth rate of population exceeds the rate of return on the capital stock. These conditions implied that the economy is dynamically inefficient. There is too much capital in the economy and welfare would be increased if the capital stock was reduced and consumption was increased. In practice, Abel et al. (1989) showed that developed economies are not dynamically inefficient. So that funded schemes are superior to unfunded schemes. However, with an exogenous labor supply, it is impossible to move from an unfunded to a funded pension scheme without making the transition generation worse off (which has to pay both for own funded pension and the pay-as-you-go (PAYG) pension of the previous generation) (Breyer, 1989). When labor supply and retirement are endogenous (Feldstein, 1974), and respond to the taxes, it is possible to move gradually from an unfunded to a funded scheme in a Pareto improving manner, so long as non-distortionary lump sum taxes are used during the transition phase (Belan & Pestieau, 1999; Breyer & Straub, 1993; Homburg, 1990).

2.2 Empirical and theoretical research applying OLG model

2.2.1 Impact of demographic change on macroeconomic

There is a vast literature exploring the link between demographic composition and economic activity. Starting with the work by Auerbach and Kotlikoff (1987), the large-scale OLG model improves the period under the two-period OLG because the whole population can be separated into any age groups along the year since birth. Additionally, it departs the finite household from the assumption of infinite life in a representative household by assuming that the last group is restricted to die. Although this framework is more realistic than the two-period OLG, the yearly period provides so little frequency that details of analyzing temporary shocks is not represented under this framework. The model is used to evaluate the impact of demographic transitions on economic activity in the United States economy. They demonstrate that the OLG model is considered to be the workhorse model for analyzing the economic consequences of demographic transitions and the associated fiscal policy. Miles (1999) also utilizes an OLG model to explore demographic impact, focusing on the United Kingdom and European countries. Within a growth accounting framework, for instance, Maddaloni et al. (2006) analyze the effects of population aging on economic growth, financial markets and public finance in the Euro area, considering the fertility rate, longevity, and immigration.

In case of Japan, the population aging by using has been investigated an OLG model in two strands of literature. The one strand focuses on movements in the saving rate in Japan. The Japanese saving rate has displayed a downward trend since the 1990s, while it was much higher than the United States saving rate in the past. Chen et al. (2007) and Braun, Ikeda, and Joines (2009) demonstrate that this can partially be population aging. Other things being equal, since a lower saving rate results in less capital accumulation, the saving rate decline associated with population aging may cause output to decline. A more recent work such as, Ikeda and Saito (2014) studied the implications of demographic changes for real interest rate dynamics in post-war Japan by using the DSGE model base on OLG framework. From a different perspective, Fujiki, Hirakata, and Shioji (2012) conducted an empirical investigation of how population aging affects households' asset portfolio allocations, particularly between stocks and other assets, in Japan.

Then other study, Ihori et al. (2006, 2011), focuses on the effects of population aging with OLG model on the fiscal policy including public pension system and health care insurance systems, as well as on debt sustainability. These studies showed that if deficits in these systems are to some extent financed by the general government policy through distortional taxes, then population aging may severely affect to private sector.

In addition, Heer, Rohrbacher, and Scharrer (2016) employed the large-scale OLG framework to investigate the driving forces behind the Great Moderation in 1985 to 2005. This study found out that the pure demographic occurs when the two main factors are driving force and the shift effect when many older workers who supply low volatility of labor increased. The shift effect is the volatility of labor supply of all age reduces. They found that low volatility of aggregate output at that time was mainly driven by the shift effect but pure demographic effect plays a marginal role.

2.2.2 PAYG pensions and retirement age

Much has been written on PAYG pensions in an overlapping generation framework. Fanti and Gori (2012) showed that a falling fertility rate does not necessarily cause a fall of pensions in the steady state in a standard overlapping generation model with log utility and Cobb-Douglas production function. The result also stated that pension reforms may not be necessary to face the fertility drop. In case of Cipriani (2014), the study showed that the effects of demographic change on PAYG pensions in OLG model with exogenous fertility rate and then a model with endogenous fertility. In both cases, found that population aging due to increased longevity implies a reduction in pensions sector.

Moreover, Miles (2002) employed this framework to examine the interest rate effects in the aging economy. Miles also looks at the different pension schemes to investigate these effects which influence the individuals' saving pattern. The study applied the partial equilibrium OLG model with portfolio allocation to examine the effects of the interest rate and the transmission mechanism of monetary policy on the aging economy. In this model, individuals face portfolio choices between a safe asset with known return and a risky asset with volatile return. The result showed that aging economy causes a decline in the interest rate under all pension schemes and the more generosity of pension schemes is, the more incentive to reduce saving becomes. In other words, less generosity of pension schemes may increase saving incentive, thereby amplifying a decline in the interest rate in the aging economy. According to the interest rate effect, the result is as same as that of the first model. The transmission mechanism of monetary policy effect, a wealth channel is more powerful because there are more older people who hold many financial assets while a credit channel is less powerful because there are few young cohorts who are more prevalent to credit constraint.

However, while the literature has largely developed (especially in the framework of the two-period OLG model) a normative analysis of the optimal retirement age (Hu, 1979; Michel & Pestieau, 2013) as well as models of political games for voting on the age of retirement (Casamatta, Cremer, & Pestieau, 2005; Conde-Ruiz & Galasso, 2004), what seems to be less extensively investigated is a positive analysis of the effects of the often advocated mandatory postponement of the retirement age on both economic growth and sustainability of PAYG pension systems. In most countries, especially in Europe and Japan, retirement is compulsory (i.e. workers must retire at the fixed age by law to obtain a pension transfer). But, in the United States, old agents can contemporaneously work and receive a pension transfer. Jorgensen and Jensen (2010) employed the DSGE model with OLG framework to studied a policy rule for the retirement age aiming at offsetting the effects on the supply of labor following fertility changes in the context of the Brazil aging. This study found that the retirement age should increase more than proportionally to the direct fall in labor supply caused by a fall in fertility.

Recently, the effect of raising the retirement age policy on economic growth and sustainability of PAYG pension system have drawn a lot of attention from researchers. Fanti (2014) studied the effects of raising the mandatory retirement age by using in OLG model. This study found that early retirement reduces economic growth (i.e. GDP) and poses a threat to the PAYG pension system. Viability is really warranted, obtaining the following result: when the capital share is sufficiently high, a reduction in the retirement mandatory age may favour economic growth and even pension payments. Indeed, it is shown that short-run and long-run effects may be of opposite sign. The postponement of retirement age increases the GDP in the short run but this positive effect has an impact on the generation which is young at the time of postponement. For any subsequent generation, the GDP is reduced, approaching rapidly the lower long-run level. Thus, one policy implication is that in developed countries beset by strong population aging the compulsory raising of the retirement age might not in the long run be the appropriate policy to keep the PAYG pension budget balanced.

Hsu (2017) investigated the effects of four reform programs aiming to enhance the sustainability of the pension system in Taiwan by using multigenerational OLG model. Scenarios of this study were 1) an increase in pension contribution, 2) a reduction in pension benefit, 3) an extension of mandatory retirement age, and 4) a combination of program a reduction in pension benefit and an extension of mandatory retirement age. As a result, an extension of mandatory retirement age harms less on the current generations' lifetime utility but the extension gradually improves future generations' life time utility. On the contrary, an increase in pension contribution reduces lifetime utility of the current generation without benefitting future generation.

In contrast to Cipriani (2016), also studied endogenous retirement decisions when there is a PAYG social security system in an aging economy in the OLG model. As a result, the effects of aging on pensions may not be negative if the elderly are free to choose their retirement age. From a different perspective, Cipriani (2014)'s result also showed that aging has always a negative effect on pension benefits. The negative effect on pensions in the specifically case of full retirement. Like, H.-J. Chen (2016) employed exogenous retirement age in OLG framework. This study found that an increase in the fertility rate may raise pensions when the output elasticity of capital is low.

2.2.3 Fertility incentives

A theoretical literature based on OLG models with endogenous adult mortality, based on Blackburn and Cipriani (2002) and Chakraborty (2004). The former considered a general equilibrium OLG model with endogenous fertility and endogenous longevity with three-period overlapping generations. Households accumulate human capital through education, which is the main determinant of the probability of adult survival. Households produce and consume output, invest in education and spend a fraction of their lifetime taking care of their children. It increases labor productivity by increasing the return of capital accumulation. Blackburn and Cipriani (2002) showed that chain of events promotes human capital accumulation which then leads to a reduction in both adult mortality and population growth. The study found that the former characterized by low income, high fertility rate and a relatively short life-span, the latter by high income, low fertility rate and a relatively long life-span.

Chakraborty (2004) introduced endogenous lifetime into Diamond (1965)'s model with exogenous fertility rate. The probability of surviving from work to retirement is a function of an individual's health status, which is provide by public health investments. An increased in health taxes to finance health expenditure may lead to individuals living longer, which in turn provides an impetus to capital accumulation together with a higher life span. This study found that improving the health status of people can be beneficial for growth and development. It directly reduces the risk of adult mortality, which in turn causes an impetus to higher capital accumulation together with lower adult mortality rate. Chakraborty (2004) also found that, when the output elasticity of capital in Cobb-Douglas production function is relatively high, endogenous mortality rate may cause development traps. This is turn means that low-income high mortality rate and high-income low mortality rate societies can exist.

In developed countries, Germany, Italy, Spain and Japan, have experienced a seriously drop in fertility, which has reduced the number of children below the replacement rate. Also, cause declining ratio of economically active to retired people. The response to labour force of many governments has been to implement child support programs. The government to provide incentives for child care and to facilitate fertility recovery (such as a direct money transfer to families with newborn children). Especially in northern Europe, other policies have also been adopted such as child care facilities and child tax credits. The government invests in infrastructure for day care centers and schools. For instance, Fanti and Gori (2014) studied the effects of child policies in OLG model with endogenous fertility and endogenous longevity determined by public health investments (Chakraborty, 2004). This study emphasized the important role of family policies which consists of either a tax or subsidy on children. The result showed that the aforementioned policy can play on both the transitional dynamics and economic outcomes in the very long term. This study found the second-best optimal child tax policy exists that can be used to maximize steady state welfare.

This is because the increase in longevity and consumption by young age. In contrast to old age, the negative welfare effects of the reduction in fertility rate and consumption amongst elderly.

In addition, Cipriani and Fioroni (2021) studies retirement and child support policies with a small open economy in three periods overlapping generations model. In this model setting the three policies that consists of: (1) the fixed retirement age and implementing a child subsidy. (2) the policy of a subsidy on labour supply of elderly workers and fertility, and (3) a policy mix that includes both a child allowance and a subsidy for the labour supply of elderly workers under a flexible retirement regime. The model set up OLG with endogenous retirement and endogenous fertility decisions. This study found that young age (parents) do not make fertility and retirement choices that coincide with social optimum because in PAYG pension system and the external social effects of both fertility and the labour supply in elderly workers. In particular, the result is that in an economy initially characterized by a mandatory early retirement system, a policy which introduces a child allowance scheme and either a mandatory increase in retirement age or a free retirement scheme combined with a subsidy for elderly labor supply is found to be a Pareto improvement. By contrast, in an economy initially characterized by retirement scheme, a policy which introduces both a child benefit plan and a subsidy to incentivize the elderly labour supply does not lead to a Pareto improvement. This is consistent with a study conducted by van Groezen et al. (2003) and Groezen and Meijdam (2008) showed that the optimal policy in an economy with public PAYG pensions under fixed contributions and endogenous fertility rate comes from the adoption of child allowances policy to eliminate the external effects of children. A raising child is costly for young parents, and the amount of resources needed to take care of a child is given by a monetary cost per child. This study found that when longevity and fertility rate are endogenous, a child tax can be used to maximize steady state welfare also when a public PAYG pensions is in place. Irrespective of whether PAYG pensions are in place, there exists a couple child tax and health tax that can be used as a second-best optimum policy.

2.2.4 Review of research applying OLG model in Thailand

Cheewatrakoolpong and Boonprakaikawe (2010) studied the best pension system for Thai economic growth. This study employed the two-period OLG model with three different scenarios of pension systems simulation are 1) informal support system 2) mandatory public pension system and 3) the combination of the two systems. The study was to invest pension tax in public education in order to build up human capital accumulation. Parameters in this study are calibrated from the Thailand's data during 1980-2008. Then, the model is numerically simulated to look at the effect of several pension systems on the economic variables. This study found that the mandatory public pension system yields the highest economic growth, saving, output per effective labor, and capital per effective labor in the balanced growth path. Also, the study clearly showed that the mandatory public pension system is the best for economic growth. This is the because the informal family supports that the elderly in the other systems lower amount of saving and capital accumulation which in turn brings about lower economic growth and output per capita. Finally, if the economy transits to aging society, the mandatory public pension system gains even more output per capital than the informal one.

Moreover, Bisonyabut and Panpiemras (2012) studied impacts of moving forward to an aging society on Thai economic growth with an emphasis on the technological progress plays during the transitional period. The model study employed the OLG model that incorporates both age-specific productivity of labor and technological progress for improving productivity of all labor regardless of age. The results showed that the transitional period, aggregate labor supply in effective units, aggregate capital, and aggregate output continuously increase throughout the period. This was mainly due to the technological progress which helps to improve the aggregate productivity to offset the decline in the number of workers and work hours. Without the technological progress, the economy will be slowed down throughout the period. Therefore, it can be proclaimed that the technological progress plays an important role in buffering the negative impact that would happen. The higher rate of technological progress would result in the higher growth rate of the aggregate output during the transitional period.

CHAPTER 3
METHODOLOGY

This chapter describes the model employed in this study and the solution method. To capture the characteristics of the Thai economy, the study uses parameter values model based on Tanboon (2008). The model in this study based on the study of Cipriani (2016) to support the study of population aging are the uncertainty of the time of death (longevity) and retirement. The key features initially introduced in this model of the policy of a lengthening the mandatory retirement age (scenario 1) and the policy of a raising the child allowance (scenario 2).

3.1 The model

In this section, aging in closed economy overlapping generation model with the aging feature. The overlapping generation model is derived from microeconomic foundation. Most of equations are derived as a solution of economic agent's optimization problems. The model in this study is based on Cipriani (2016). Then, the model is modified by introducing longevity to be able to presents an OLG model with aging resulting from changes in fertility and longevity. Its structure is closed economy model of the Thai economy approach which consists of representative agents whom are households, firms, government sector and social security system. The figure 1 below illustrates the conceptual framework of the study.

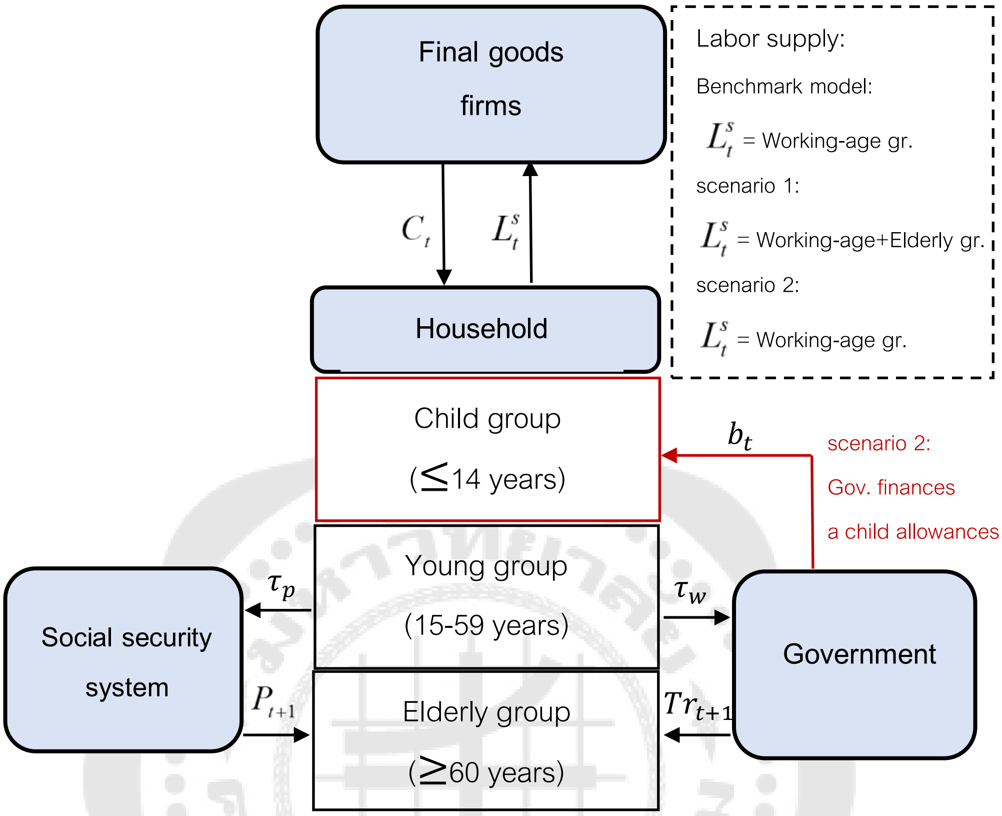

Figure 1 The conceptual framework of the study

Source: Author's illustration

As shown in the figure 1, there are four economic agents in the economy; households, final goods firms, government, and social security system.

The benchmark model illustrates the interaction among economic agents in the model. Firstly, the household is separated into two-period overlapping generations (young and old), all of which consume final goods, and supply of labor. Since, a benchmark model will also assume that the labor supply and retirement decisions are exogenous. In addition to assuming that retirement age 60 years with full retirement. Secondly, final goods firms produce using labour and physical capital from households as inputs factor. Then, firms sell their products in a perfectly competitive market.

Thirdly, the government, partly, collects income tax to finance its expenditures on government transfers some living allowance to elderly people. Finally, the social security system run a defined contribution pay-as-you-go social security scheme with a balanced budget. The model is a one-country closed economy model, where both the goods market and factor markets are assumed to be perfectly competitive.

Table 2 Two-period overlapping generations

	Time period					
Generation	0	1	2	3	4	5
-1	Old					
0	Young	Old				
1		Young	Old			
2			Young	Old		
3				Young	Old	
4					Young	Old
5						Young

Source: McCandless, G. T., & Wallace, N. (1991)

To study the impact of population aging, this research will have two scenarios.

Scenario 1: To be able to capture the extended mandatory retirement age, the model is lengthening of the mandatory retirement age from 60 to 63 years to conform with the government policy. Therefore, the labor force consists of young group plus elderly group. This model will also assume that the labour supply and retirement decisions are exogenous.

Scenario 2: To be able to capture the extended models with the child allowance. The government has been to provide incentives for child care and to facilitate fertility recovery. In this model set up the household is separated into three-period overlapping generations with endogenous fertility. Three generations consist of child, young, and old. The life of the typical agent is divided into child and young age. As a children does not make economic decisions. Children consumes resources directly from parents and survives to the end of youth with certainty (assumed that no child mortality). As parents works and takes care of newborn children when young age, and retires when old age. Hence, the labor force consists of young group only. (as illustrated in table 3)

Table 3 Three-period overlapping generations

	Time period					
Generation	0	1	2	3	4	5
-1	Old					
0	Young	Old				
1	Child	Young	Old			
2		Child	Young	Old		
3			Child	Young	Old	
4				Child	Young	Old
5					Child	Young
6						Child

Source: McCandless, G. T., & Wallace, N. (1991)

Sector	Cipriani (2016)	Benchmark model	Scenario 1	Scenario 2
Household	▪ Agents live through first stage of life with certainty, and face some probability to live until old age (the probability of survival to the last period of life (longevity))	/	/	/
	▪ Two-period OLG	/	/	Three-period OLG
	▪ PAYG income tax	Adjust features: Income tax and pension contribution rate	Adjust features: Income tax and pension contribution rate	Adjust features: Income tax and pension contribution rate
	▪ Full retirement vs endogenous labor supply	Full retirement	Adjust features: raising the mandatory retirement age policy (exogenous labor supply)	Full retirement
	▪ No children	x	x	children
	▪ Exogenous fertility	/	/	Endogenous fertility
Firm	▪ using Cobb-Douglas production function. ▪ perfect competitive markets	/	/	/
Government	x	Gov. transfers payment for elderly	Gov. transfers payment for elderly	Gov. transfers payment for elderly and child allowance
Social security system	PAYGO	/	/	/

Note: 1. / represents straightforward features from Cipriani (2016)
2. x represents excluded features from Cipriani (2016)

Figure 2 Different features between Cipriani (2016) and this model

Source: Author's interpretation

3.1.1 Population aging in overlapping generation model (benchmark model)

The model presented in this section is a stochastic two-period OLG model that allow us to analyze the effect of population aging on macroeconomic variables (saving, capital formation and output).

There are four sectors in the economy: households, firms, the government, and social security system. There is representative individual for each generation in the household sector. It is assumed that each individual has a fixed life time up to age 80. Each individual with age less than 14 is nurtured by parents and receives education. The individual starts working at the age of 15 and retires at age 60 (to conform with labour force survey obtained from the National Statistical Office (2019)). Each individual earns wage income and builds up savings for old age. The representative agent maximizes intertemporal utility function with consumption. Firms maximize profits. Then, firms use labour and capital from households as inputs factor. The government collects taxes with a balanced budget. Social security system is pension sector collects social security contributions rate and runs a balanced budget.

A period, t, in the model corresponds to one year. At each time period, a new generation of households is born. These models consider only the working and retired generations. Newborns have a real life age of 15, corresponding to working-age group in the model. So, retire at age 60 and lives up to a maximum age of 80, corresponding to elderly group in the model. Since age from 61 to 80 years, there are 20 different generations coexist. At t, all agents of age φ survive until age $\varphi+1$ with probability $\pi_{\varphi t}$, where $\pi_{60t}=1$ and $\pi_{80t}=0$, $\varphi=61,62,...,80$. This study uses the officially published survival probability of Thailand estimated by United Nations (2017).

1) The representative households

Now, let us look at the preferences of individuals. Each individual derives utility from the consumption of goods throughout lifetime, or in the first and second period. The consumption for a generation born in period t is ($c_{1,t}$, $c_{2,t+1}$), where $c_{1,t}$ is the consumption in young age and $c_{2,t+1}$ is consumption when old. The utility function of this agent is as follows

$$U=\ln c_{1,t}+\beta\pi_t\left(\ln c_{2,t+1}\right) \tag{3.1}$$

where β is a utility discount factor, π_t is the probability of survival to the last period of life (longevity).

In the first period, when the households are young and have to decide how much to consume and save for retirement. When retired, agents receive a pension (P_{t+1}) financed by the social security system that runs a pay as you go retirement scheme. Households also get the government transfer payment for elderly (Tr_{t+1}). Individuals are assumed to have no bequest motives.

The first period budget constraint is

$$c_{1,t} + s_t = \left(1 - \tau_w - \tau_p\right) w_t \tag{3.2}$$

where w_t is wage at period t, s_t is savings of an individual belonging to generation t, τ_w is income tax rate, and τ_p is the social security tax rate.

The second period budget constraint is

$$c_{2,t+1} = \frac{R_{t+1}}{\pi_t} s_t + P_{t+1} + Tr_{t+1} \tag{3.3}$$

The first and second period constraints are combining the lifetime budget constraint of the individual can be written as,

$$\left(1 - \tau_w - \tau_p\right) w_t + \frac{\pi_t P_{t+1}}{R_{t+1}} + \frac{\pi_t Tr_{t+1}}{R_{t+1}} = c_{1,t} + \frac{\pi_t}{R_{t+1}} c_{2,t+1} \tag{3.4}$$

where P_{t+1} is pension received in period $t+1$ by an old individual, Tr_{t+1} is government transfers for elderly people, and $\frac{R_{t+1}}{\pi_t}$ is the rate of return on savings. This rate of return assumes the presence of financial intermediaries operating under perfect competition who must take into account the risk form uncertain lifetimes. Hence, R_{t+1} is the risk-free interest rate.

The number of new adults at time t is $N_t = \left(1 + g_{t-1}\right) N_{t-1}$ where g_{t-1} is the exogenous fertility rate. Since, a benchmark model, we also assume in this section with full retirement. Therefore, labor force is given by $L_t = N_t = (1 + g_{t-1})N_{t-1}$, where N_t represents young worker and N_{t-1} represents old worker.

2) The representative firms

On the production side, the market is assumed to be perfectly competitive. Thus, the aggregate production technology can be specified as the following Cobb-Douglas production function.

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{3.5}$$

In equation (3.5), Y_t, K_t, and L_t respectively stand for aggregate output, capital stock and labor in the economy in period t, and α is capital income share, $0 < \alpha < 1$. The labor force can be written as $L_t = N_t$, where N_t is the number of young workers in period t. Assuming full capital depreciation after on period. The production per worker can be rewritten as

$$y_t = A_t k_t^{\alpha} \tag{3.6}$$

where the capital stock per worker, $k_t = \frac{K_t}{L_t}$, and the exogenous process for the technology productivity A_t is

$$\ln A_t = \rho_A \ln A_{t-1} + \upsilon_{A,t} \qquad , \upsilon_{A,t} \sim N\left(0, \sigma_A^2\right) \tag{3.7}$$

where ρ_A measure the persistence of shock, and $\upsilon_{A,t}$ is $i.i.d., \sim N\left(0, \sigma^2\right)$.

The firm decides the demand for physical capital and labour to maximize profits with given factor prices. The factor prices, wage w_t and interest rate R_t , are determined in the perfect competitive markets.

Profit maximization problem is written as

$$\max_{\{K_t, L_t\}} \Pi_t = A_t K_t^{\alpha} L_t^{1-\alpha} - R_t K_t - W_t L_t \tag{3.8}$$

The first-order conditions for maximization are

$$\left(1-\alpha\right) A_t k_t^{\alpha} = w_t \tag{3.9}$$

$$\alpha A_t k_t^{\alpha-1} = R_t \tag{3.10}$$

Equation (3.9) shows the marginal product of labour is equal to the wage, and equation (3.10) shows the marginal product of capital is equal to rental rate.

3) Government sector

The government collects income tax from households to finance its expenditures on government transfers for elderly people (Tr_{t+1}). The government's tax revenues (T_t) are given by

$$T_t = \tau_w w_t L_t \tag{3.11}$$

$$T_t = \tau_w w_t \left(1 + g_{t-1}\right) N_{t-1} \tag{3.12}$$

And the government transfer payment for elderly (Tr_{t+1}) is given as

$$Tr_t \pi_{t-1} N_{t-1} = \tau_w w_t N_t \tag{3.13}$$

Equation (3.13) shows that the government transfer payment for elderly is equal to the tax receipts.

$$Tr_t = \frac{\tau_w w_t \left(1 + g_{t-1}\right) N_{t-1}}{\pi_{t-1} N_{t-1}} \tag{3.14}$$

From equation (3.14), government transfer can be written as,

$$Tr_{t+1} = \frac{\tau_w w_{t+1}\left(1+g_t\right)}{\pi_t} \tag{3.15}$$

where τ_w is labor income tax rate, w_t is wage, and labor force is given by $L_t = N_t = \left(1+g_{t-1}\right)N_{t-1}$, when N_t represents young worker and N_{t-1} represents old worker. In addition, g_{t-1} is the exogenous fertility rate and π_t is the probability of survival to the last period of life (longevity).

It is assumed that the government runs the balanced budget and can be written as:

$$Tr_t \pi_{t-1} N_{t-1} = T_t \tag{3.16}$$

4) Social security system

The pension sector adopts the social security system in a pay-as-you-go style. The pension system grants a pension to the retired generations while the pension contribution is collected from the working generations. Assume that the pension system runs a defined contribution pay-as-you-go social security scheme with a balanced budget. Therefore, pensions benefits are:

$$P_t \pi_{t-1} N_{t-1} = \tau_p w_t N_t \tag{3.17}$$

Equation (3.17) shows that the social security expenditure is equal to the tax receipts. This scheme leads to the following formula for pension benefits:

$$P_t = \frac{\tau_p w_t \left(1+g_{t-1}\right)}{\pi_{t-1}} \tag{3.18}$$

or it can be written in period $t+1$ as

$$P_{t+1} = \frac{\tau_p w_{t+1}\left(1+g_t\right)}{\pi_t} \tag{3.19}$$

In this case, the pension contribution rate (τ_p) has to be adjusted in order to balance the social security budget. Equation (3.18) shows that the pension system is that total pension contribution received from period $t-1$ equals to the current periods' pension benefit payments (period t).

5) The equilibrium and model solution

The household maximizes (3.1) subject to budget constraint (3.2) and (3.3) taking wage, the interest rate, and the pensions benefit as given. After substituting for P_{t+1} from (3.19), the first order conditions with respect to savings.

The Lagrangean is given as

$$\Gamma = \ln c_{1,t} + \beta\pi_t \ln c_{2,t+1} + \lambda_t\left(\left(1-\tau_w-\tau_p\right)w_t + \frac{\pi_t P_{t+1}}{R_{t+1}} + \frac{\pi_t Tr_{t+1}}{R_{t+1}} - c_{1,t} - \frac{\pi_t}{R_{t+1}}c_{2,t+1}\right)$$

The FOCs for lifetime utility maximization are

$$\frac{\partial\Gamma}{\partial c_{1,t}} : \frac{1}{c_{1,t}} - \lambda_t = 0$$

$$\frac{\partial\Gamma}{\partial c_{2,t+1}} : \beta R_{t+1}\left(\frac{1}{c_{2,t+1}}\right) = \lambda_t$$

FOCs can be combined to give the consumption Euler equation:

$$\beta\left(\frac{c_{1,t}}{c_{2,t+1}}\right) = \frac{1}{R_{t+1}}$$

$$c_{2,t+1} = \beta R_{t+1} c_{1,t} \tag{3.20}$$

By substituting equation (3.2) and (3.3) in equation (3.20), the following equation can be obtained as

$$\frac{R_{t+1}}{\pi_t} s_t + P_{t+1} + Tr_{t+1} = \beta R_{t+1} \left(\left(1 - \tau_w - \tau_p \right) w_t - s_t \right) \tag{3.21}$$

$$s_t = \frac{\beta R_{t+1} \left(1 - \tau_w - \tau_p \right) w_t - P_{t+1} - Tr_{t+1}}{\frac{R_{t+1}}{\pi_t} \left(1 + \beta \pi_t \right)} \tag{3.22}$$

Equation (3.22) is the saving function, and it has the following implications:

Firstly, $s_w = \dfrac{\partial s_t}{\partial w_t} \in (0,1)$, savings is a normal good: an increase in wage income increases savings.

Secondly, $s_R = \dfrac{\partial s_t}{\partial R_{t+1}} > 0$, savings to changes in the rate of interest. A rise in R_{t+1} reduces the relative price of future consumption. The individual to substitute future for current consumption ($c_{1,t}$) by increasing savings. Future consumption ($c_{2,t+1}$) is now cheaper (in present value terms) than current consumption and so the substitution effect of an increase in R_{t+1} is always positive. But, a rise in R_{t+1} induces individuals to increase consumption in both periods (young age and old age) and reduce savings. This implies that the income effect on savings is negative effect.

Finally, savings has a positive relationship on the longevity. If longevity is increased, young individuals will reduce their consumption both current and future consumption and increasing savings. $s_\pi = \dfrac{\partial s_t}{\partial \pi_t} > 0$.

In addition, the capital market equilibrium is given by

$$K_{t+1} = N_t S_t \tag{3.23}$$

or, in per worker terms, the dynamic of capital is written as

$$k_{t+1} = \frac{s_t}{\left(1 + g_t\right)} \tag{3.24}$$

which shows how future capital is linked to current savings with a PAYG system.
By substituting equation (3.22) into equation (3.24), the following equation can be written as

$$k_{t+1} = \frac{\beta R_{t+1}\left(1 - \tau_w - \tau_p\right) w_t - P_{t+1} - Tr_{t+1}}{\frac{R_{t+1}}{\pi_t}\left(1 + \beta\pi_t\right)\left(1 + g_t\right)} \tag{3.25}$$

By assuming perfect foresight, the steady state implies $k_{t+1} = k_t = k^*$. We can get the steady state value of k^* from equation (3.25) as

$$k^* = \left(\frac{\alpha\left(1-\alpha\right)\left(1 - \tau_w - \tau_p\right)\pi\beta A}{\left(1+g\right)\left(\alpha\left(1+\beta\pi\right) + \left(1-\alpha\right)\left(\tau_p + \tau_w\right)\right)}\right)^{\frac{1}{1-\alpha}} \tag{3.26}$$

Hence, population aging, either because of a fall in g or an increase in π, increases the per capital stock. Given the social security system budget constraint, and the steady state level of capital, k^*, the long run pension benefits can be written as a function of the demographic variables $p^* = p\left(g, \pi\right)$.

Therefore, what are the effects of aging on the pension payouts in the current model. To do so, let's first derive the pension payout in the steady state when agents fully retire, because τ_p is higher than the threshold defined above

$$P^* = \frac{\tau_p(1-\alpha)A}{\pi}\left(\frac{\alpha(1-\alpha)(1-\tau_w-\tau_p)\pi\beta A}{\alpha(1+\beta\pi)+(1-\alpha)(\tau_p+\tau_w)}\right)^{\frac{\alpha}{1-\alpha}}(1+g)^{\frac{1-2\alpha}{1-\alpha}} \tag{3.27}$$

From equation (3.27), it is shows that if $\alpha < \frac{1}{2}$ aging reduces pensions in the steady state since $\frac{\partial P^*}{\partial g} > 0$ and $\frac{\partial P^*}{\partial \pi} < 0$. In general, aging reduces pension because it increases the number of pensioners.

From equation (3.26), the corner solution is obtained with full retirement, and it implies that population ageing increases the level of capital per worker in steady state. Moreover, the social security tax increases (τ_p), labor participation in the last period of life declines and becomes zero when τ_p is sufficiently high. At this point, capital per worker in the steady state starts declining with τ_p.

The steady state value of output is written as

$$y^* = A\left(\frac{\alpha(1-\alpha)(1-\tau_w-\tau_p)\pi\beta A}{(1+g)\left(\alpha(1+\beta\pi)+(1-\alpha)(\tau_p+\tau_w)\right)}\right)^{\frac{\alpha}{1-\alpha}} \tag{3.28}$$

The steady state value of saving is written as

$$s^* = (1+g)\left(\frac{\alpha(1-\alpha)(1-\tau_w-\tau_p)\pi\beta A}{(1+g)\left(\alpha(1+\beta\pi)+(1-\alpha)(\tau_p+\tau_w)\right)}\right)^{\frac{1}{1-\alpha}} \tag{3.29}$$

The steady state value of government transfers from equation (3.15) is written as

$$Tr^{*} = \frac{\tau_{w}\left(1+g\right)}{\pi}\left(1-\alpha\right)Ak^{*\alpha} \tag{3.30}$$

or it can be written as

$$Tr^{*} = \frac{\tau_{w}\left(1+g\right)}{\pi}\left(1-\alpha\right)A\left(\frac{\alpha\left(1-\alpha\right)\left(1-\tau_{w}-\tau_{p}\right)\pi\beta A}{\left(1+g\right)\left(\alpha\left(1+\beta\pi\right)+\left(1-\alpha\right)\left(\tau_{p}+\tau_{w}\right)\right)}\right)^{\frac{\alpha}{1-\alpha}} \tag{3.31}$$

From equation (3.26), (3.29), and (3.28) shows that the increased longevity has a positive impact on capital stock, saving, and output in steady state. On the contrary, the longevity has negative impact on pension system and the government transfers for the elderly in steady state, as illustrated in equation (3.27) and (3.31).

3.1.2 The lengthening mandatory retirement age model

The first scenario presents an extended benchmark model with the mandatory retirement age policy. The benchmark model is modified by increasing the mandatory retirement age from 60 to 63 years. To analyze the effect of a lengthening of the mandatory retirement age policy on macroeconomic variables (saving, capital formation and output). It can be done by setting the labor supply and retirement decisions exogenously determined.

1) The representative households

Young population N_t grows at a constant fertility rate g_{t-1}. The household is separated in two period overlapping generations between young and old age. Individuals belonging to generation t have a conventional the logarithmic utility function defined over young age ($c_{1,t}$) and old age consumption ($c_{2,t+1}$). Each person born at (the beginning of period) t lives for two periods and provides one unit of labor per period.

In the first period, t, he or she works full time, earning a wage income of w_t while paying a labor income tax rate (τ_w) and a social security tax (τ_p) according to the contribution rate (see equation 3.33).

In the second period, $t+1$, he or she works a fraction of the time (l), and then retires (i.e. when $l = 0$ each person is retired for the whole second period of life, which is the assumption of the conventional OLG model of Diamond (1965)). During old age, agents' earnings therefore consist of (1) the savings (s_t) plus the accrued interest at the rate $\frac{R_{t+1}}{\pi_t}$, (2) the net wage income of $\left(1-\tau_w-\tau_p\right)w_{t+1}l$, (3) the pension of $\left(1-l\right)P_{t+1}$, which is publicly provided and financed at a balanced budget by the social security system, and (4) the government transfers for elderly (Tr_{t+1}) (see equation 3.34). The length of the retirement period ($1-l$) is mandatory fixed by the government.

Thus, the representative individual faces the following the utility function as

$$U = \ln c_{1,t} + \beta\pi_t\left(\ln c_{2,t+1} + \gamma\ln\left(1-l\right)\right) \tag{3.32}$$

The first period budget constraint is

$$c_{1,t} + s_t = \left(1-\tau_w-\tau_p\right)w_t \tag{3.33}$$

The second period budget constraint is

$$c_{2,t+1} = \frac{R_{t+1}}{\pi_t}s_t + \left(1-\tau_w-\tau_p\right)w_{t+1}l + \left(1-l\right)P_{t+1} + Tr_{t+1} \tag{3.34}$$

By combining constraints in the first and second period, the lifetime budget constraint of the individual is

$$\left(1-\tau_w-\tau_p\right)w_t+\frac{\pi_t\left(1-\tau_w-\tau_p\right)w_{t+1}l}{R_{t+1}}+\frac{\pi_t\left(1-l\right)P_{t+1}}{R_{t+1}}+\frac{\pi_t Tr_{t+1}}{R_{t+1}}=c_{1,t}+\frac{\pi_t}{R_{t+1}}c_{2,t+1} \quad (3.35)$$

2) The representative firms

Concerning the production sector, competitively firms have the Cobb-Douglas technology of production is

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \quad (3.36)$$

where Y_t, K_t, and L_t denote aggregate output, capital stock and labor in the economy in period t, respectively, A_t is the exogenous process for the technology productivity and α is the capital share of output, $0<\alpha<1$.

The time t labor force (labor input) is $L_t = N_t + \pi_{t-1}N_{t-1}l$, consists of working-age group plus elderly group. It can be written as

$$L_t = N_t + \pi_{t-1}N_{t-1}l \quad (3.37)$$

$$L_t = \left(1+g_{t-1}+\pi_{t-1}l\right)N_{t-1} \quad (3.38)$$

Population N_t grows at a constant fertility rate g_{t-1} or $N_t = \left(1+g_{t-1}\right)N_{t-1}$.

The intensive form production function may be written as $y_t = A_t k_t^{\alpha}$. As usual, it is assumed that physical capital totally depreciates at the end of each period and that the price of the final output in normalized to one. Profit maximization then leads to following marginal conditions for capital and labour, respectively:

$$\left(1-\alpha\right)A_t k_t^{\alpha} = w_t \quad (3.39)$$

$$\alpha A_t k_t^{\alpha-1} = R_t \quad (3.40)$$

3) Government sector

The government collects income tax from households to finance its expenditures on government transfers for elderly people (Tr_{t+1}). The government's tax revenues (T_t) are given by

$$T_t = \tau_w w_t L_t$$

$$T_t = \tau_w w_t N_t + \tau_w w_t \pi_{t-1} l N_{t-1}$$

$$T_t = \tau_w w_t \left(1 + g_{t-1} + \pi_{t-1} l\right) N_{t-1} \tag{3.41}$$

And the government transfer for elderly people (Tr_{t+1}) is given as

$$Tr_t \pi_{t-1} N_{t-1} = \tau_w w_t N_t + \tau_w w_t \pi_{t-1} l N_{t-1}$$

$$Tr_t = \frac{\tau_w w_t \left(1 + g_{t-1} + \pi_{t-1} l\right)}{\pi_{t-1}} \tag{3.42}$$

Also, the government transfer can be written in period $t+1$ as

$$Tr_{t+1} = \frac{\tau_w w_{t+1} \left(1 + g_t + \pi_t l\right)}{\pi_t} \tag{3.43}$$

where τ_w is labor income tax rate, w_t is wage, and labor force is given by $L_t = \left(1 + g_{t-1} + \pi_{t-1} l\right) N_{t-1}$, when N_t represents young worker and N_{t-1} old worker. In addition, g_{t-1} is the exogenous fertility rate and π_t is the probability of survival to the last period of life (longevity).

By assuming that the government runs the balanced budget and can be written as:

$$Tr_t \pi_{t-1} N_{t-1} = T_t \tag{3.44}$$

4) Social security system

The pension sector runs a defined contribution pay-as-you-go social security scheme with a balanced budget. Hence, social security tax (τ_p), both for the young and the old individuals, and to pay a pension for the retired (P_{t+1}). Therefore, pensions benefits are

$$(1-l) P_t \pi_{t-1} N_{t-1} = \tau_p w_t N_t + \tau_p w_t \pi_{t-1} l N_{t-1} \tag{3.45}$$

or it can be written as

$$(1-l) P_t \pi_{t-1} N_{t-1} = \tau_p w_t (1 + g_{t-1} + \pi_{t-1} l) N_{t-1} \tag{3.46}$$

Concerning equation (3.46) shows the left-hand side represents the social security expenditure and the right-hand side the tax receipts. This scheme leads to the following formula for pension benefits:

$$P_t = \frac{\tau_p w_t (1 + g_{t-1} + \pi_{t-1} l) N_{t-1}}{\pi_{t-1} (1-l) N_{t-1}}. \tag{3.47}$$

or it can be written as

$$P_{t+1} = \frac{\tau_p w_{t+1} (1 + g_t + \pi_t l)}{\pi_t (1-l)} \tag{3.48}$$

5) The equilibrium and model solution

The household maximizes (3.32) subject to budget constraint (3.33) and (3.34) taking wage, the interest rate and the pensions benefit as given. After substituting for P_{t+1} from (3.48), the first order conditions with respect to savings.

The Lagrangean is given as

$$\Gamma = \ln c_{1,t} + \beta\pi_t \left(\ln c_{2,t+1} + \gamma \ln\left(1 - l\right)\right)$$
$$+\lambda_t \left(\left(1 - \tau_w - \tau_p\right) w_t + \frac{\pi_t \left(1 - \tau_w - \tau_p\right) w_{t+1} l}{R_{t+1}} + \frac{\pi_t \left(1 - l\right) P_{t+1}}{R_{t+1}} + \frac{\pi_t Tr_{t+1}}{R_{t+1}} - c_{1,t} - \frac{\pi_t}{R_{t+1}} c_{2,t+1}\right)$$

The FOCs for lifetime utility maximization are

$$\frac{\partial \Gamma}{\partial c_{1,t}} : \frac{1}{c_{1,t}} - \lambda_t = 0$$

$$\frac{\partial \Gamma}{\partial c_{2,t+1}} : \beta R_{t+1} \left(\frac{1}{c_{2,t+1}}\right) = \lambda_t$$

FOCs can be combined to give the consumption Euler equation:

$$\beta \left(\frac{c_{1,t}}{c_{2,t+1}}\right) = \frac{1}{R_{t+1}}$$

$$c_{2,t+1} = \beta R_{t+1} c_{1,t} \tag{3.49}$$

By substituting equation (3.33) and (3.34) in equation (3.49), the following equation can be obtained as

$$\frac{R_{t+1}}{\pi_t} s_t + \left(1 - \tau_w - \tau_p\right) w_{t+1} l + \left(1 - l\right) P_{t+1} + Tr_{t+1} = \beta R_{t+1} \left(\left(1 - \tau_w - \tau_p\right) w_t - s_t\right)$$

(3.50)

$$s_t = \frac{\left(1-\tau_w-\tau_p\right)\left(\beta R_{t+1} w_t - w_{t+1} l\right) - \left(1-l\right) P_{t+1} - Tr_{t+1}}{\frac{R_{t+1}}{\pi_t}\left(1+\beta\pi_t\right)} \tag{3.51}$$

Using equation (3.43) and (3.48) to substitute in equation (3.51), the first order conditions with respect to savings (s_t) is written as

$$s_t = \frac{\left(1-\tau_w-\tau_p\right)\left(\beta R_{t+1} w_t - w_{t+1} l\right) - \frac{\left(\tau_p+\tau_w\right) w_{t+1}\left(1+g_t+\pi_t l\right)}{\pi_t}}{\frac{R_{t+1}}{\pi_t}\left(1+\beta\pi_t\right)} \tag{3.52}$$

Equation (3.52) shows the effect of a lengthening of the working period on savings. A lengthening of the working period (i.e. a mandatory increase in the retirement age) reduces savings (as regards wage and interest rate), $s_l = \frac{\partial s_t}{\partial l} = -\frac{1-\tau_w-\tau_p \;\; w_{t+1}}{1+\beta\pi_t \;\; R_{t+1}} < 0$. The rational of this is when the working period in old age is reduced individuals' saving is higher in order to better sustain consumption for retirement. Indeed, the length of such a period is increased jointly with the reduction in old age wage income.

In addition, the capital market equilibrium is given by

$$K_{t+1} = N_t S_t \tag{3.53}$$

or, in per worker terms, the dynamic of capital is written as

$$\frac{K_{t+1}}{L_{t+1}} = \frac{N_t S_t}{L_{t+1}} \tag{3.54}$$

$$k_{t+1} = \frac{N_t s_t}{\left(1 + g_t + \pi_t l\right) N_t} \tag{3.55}$$

$$k_{t+1} = \frac{s_t}{1 + g_t + \pi_t l} \tag{3.56}$$

By substituting s_t from (3.51) in equation (3.56), we can get the dynamic of k_{t+1} the following equation can be written as

$$k_{t+1} = \frac{\left(1 - \tau_w - \tau_p\right)\left(\beta R_{t+1} w_t - w_{t+1} l\right) - \left(1 - l\right) P_{t+1} - Tr_{t+1}}{\frac{R_{t+1}}{\pi_t}\left(1 + \beta \pi_t\right)\left(1 + g_t + \pi_t l\right)} \tag{3.57}$$

$$k_{t+1} = \frac{\left(1 - \tau_w - \tau_p\right)\left(\beta R_{t+1} w_t - w_{t+1} l\right) - \left(\tau_p + \tau_w\right) \frac{w_{t+1}\left(1 + g_t + \pi_t l\right)}{\pi_t}}{\frac{R_{t+1}}{\pi_t}\left(1 + \beta \pi_t\right)\left(1 + g_t + \pi_t l\right)} \tag{3.58}$$

By assuming perfect foresight, the steady state implies $k_{t+1} = k_t = k^*$. We can get the steady state value of k^* from equation (3.59) as

$$k^* = \left(\frac{\alpha\left(1 - \alpha\right)\pi \beta A}{\left(\alpha\left(1 + \beta \pi\right) + \tau_p + \tau_w\right)\left(1 + g + \pi l\right) + \left(1 - \alpha\right)\pi l}\right)^{\frac{1}{1-\alpha}} \tag{3.59}$$

Equation (3.59) shows that the capital stock is always reduced by raising the mandatory retirement age.

The steady state value of output is written as

$$y^{*} = A\left(\frac{\alpha\left(1-\alpha\right)\pi\beta A}{\left(\alpha\left(1+\beta\pi\right)+\tau_{p}+\tau_{w}\right)\left(1+g+\pi l\right)+\left(1-\alpha\right)\pi l}\right)^{\frac{\alpha}{1-\alpha}} \tag{3.60}$$

Equation (3.60) recalling from equation (3.59), $\frac{\partial k^{*}}{\partial l} < 0$ that an increase in the retirement age may reduce output in steady state.

The steady state value of saving is written as

$$s^{*} = \left(1+g+\pi l\right)\left(\frac{\alpha\left(1-\alpha\right)\pi\beta A}{\left(\alpha\left(1+\beta\pi\right)+\tau_{p}+\tau_{w}\right)\left(1+g+\pi l\right)+\left(1-\alpha\right)\pi l}\right)^{\frac{1}{1-\alpha}} \tag{3.61}$$

Equation (3.61) shows that savings is reduced by raising the mandatory retirement age.

The steady state value of pension can be derived from equation (3.48) as

$$P^{*} = \frac{\tau_{p}\left(1-\alpha\right)A}{\pi\left(1-l\right)}\left(\frac{\alpha\left(1-\alpha\right)\pi\beta A}{\alpha\left(1+\beta\pi+g\right)+\tau_{p}+\tau_{w}+\pi l}\right)^{\frac{\alpha}{1-\alpha}}\left(1+g+\pi l\right)^{\frac{1-2\alpha}{1-\alpha}} \tag{3.62}$$

Equation (3.62) reveals that the effect of an increase in the retirement age on the pension payment in steady state. Depends on two things (1) a direct effect due to the length of the retirement period and (2) an indirect effect due to wage.

We can get the steady state value of government transfers from equation (3.43) as

$$Tr^{*} = \frac{\tau_{w}\left(1+g+\pi l\right)}{\pi}\left(1-\alpha\right)Ak^{*\alpha} \tag{3.63}$$

or it can be written as

$$Tr^{*} = \frac{\tau_{w}\left(1+g+\pi l\right)}{\pi}\left(1-\alpha\right)A\left(\frac{\alpha\left(1-\alpha\right)\pi\beta A}{\left(\alpha\left(1+\beta\pi\right)+\tau_{p}+\tau_{w}\right)\left(1+g+\pi l\right)+\left(1-\alpha\right)\pi l}\right)^{\frac{\alpha}{1-\alpha}}$$

(3.64)

Equation (3.64) shows that the effect of an increase in the retirement age on government transfers in steady state depending on the length of the retirement period.

This equation (3.59), (3.61), and (3.60) shows that a higher mandatory retirement age has a negative impact on capital stock, saving, and output in steady state. On the contrary, the policy has positive impact on pension system and the government transfers for the elderly in steady state, as illustrated in equation (3.62) and (3.64).

3.1.3 The raising child allowance model

The second scenario presents an extended benchmark model with the child allowance policy. The government adopts the policy to provide incentives for child care.

1) The representative households

In this model set up the household is separated into three-period overlapping generations with endogenous fertility. Three generations consist of child, young, and old. The life of the typical agent is divided into childhood and adulthood. As children does not make economic decisions. Children consumes resources directly from parents and survives to the end of young with certainty (assume that no child mortality). As parents, an individual works and takes care of children when young age, and retires when old age. The young members of a generation t are endowed with one unit of labor inelastically and supply labor to firms, while earning a wage income of w_t. When an adult, an individual of a generation t draws utility from consumption when young, $c_{1,t}$, consumption when old, $c_{2,t+1}$, is to put the number of children (n_t) directly to the utility function. It is called altruism towards children (Zhang and Zhang, 1998).

The individual representative of generation t chooses how many children to have and how much to save from disposable income, in order to maximize the expected lifetime utility function. The utility function of this agent is as follows

$$U = \ln c_{1,t} + \beta \pi_t \left(\ln c_{2,t+1} \right) + \varepsilon \ln n_t \tag{3.65}$$

where $\varepsilon > 0$ captures the parents' relative desire to have children.

This representative also faces the same budget constraint as of the previous model. By combining equation (3.66) and (3.68), the first period budget constraint is

$$c_{1,t} + s_t + \left(q - b_t \right) w_t n_t = \left(1 - \tau_w - \tau_p \right) w_t \tag{3.66}$$

The left-hand side of the equation (3.66) represents the expenditure consist of consumption when young ($c_{1,t}$) saving (s_t) and the (net) cost of raising children (n_t). The right-hand side of the equation (3.66) is the wage income (net of contributions paid to income tax rate (τ_w) and social security tax rate (τ_p)).

With regard to child care activities, it is assumed that raising children is costly for young parents, and the amount of resources needed to take care of a child is given by a monetary cost $q\, w_t$ per child, where q is the percentage of the cost of children of the parents' working income and $0 < q\, n_t < 1$. This element captures all needs required for the upbringing of children, included food, schooling and so on. In addition, it is also assumed that in every period the government finances a child allowance program at a balanced budget through wage income taxes.

$$b_t w_t n_t = \tau_w w_t \tag{3.67}$$

Equation (3.67) shows that the left-hand side being the child allowance expenditure, and the right-hand side, the tax receipt, where b_t is the fixed percentage of wage income entitled to each young parent as a subsidy for each additional newborn, $0 < b_t < q$. The income tax rate is $0 < \tau_w < 1$ and n_t is the average number of children at time t.

When old, individuals are retired and live uniquely with the amount of resources saved when young plus the expected interests accrued from time t to time $t+1$ at the rate, R_{t+1}. It is assumed that a perfect market for annuities exists, so that the second period budget constraint is

$$c_{2,t+1} = \frac{R_{t+1}}{\pi_t} s_t + P_{t+1} + Tr_{t+1} \tag{3.68}$$

where P_{t+1} is pension received in period $t+1$ by an old individual, Tr_{t+1} is government transfers for elderly people, and $c_{2,t+1}$ is consumption when old.

Thus, the lifetime budget constraint of the individual is

$$\left(1-\tau_w-\tau_p\right)w_t - \left(q - b_t\right)w_t n_t + \frac{\pi_t P_{t+1}}{R_{t+1}} + \frac{\pi_t Tr_{t+1}}{R_{t+1}} = c_{1,t} + \frac{\pi_t}{R_{t+1}} c_{2,t+1} \tag{3.69}$$

2) The representative firms

On the production side, the market is assumed to be perfectly competitive. Thus, the production per worker can be rewritten as

$$y_t = A_t k_t^{\alpha} \tag{3.70}$$

In that equation (3.70), A_t is the exogenous process for the technology productivity and α is the capital share of output, $0 < \alpha < 1$. The capital stock per worker, $k_t = \frac{K_t}{L_t}$. The time t labor force (labor input) is $L_t = N_t$, where N_t is the number of young workers in period t. Assuming full capital depreciation after on period.

The firm decides the demand for physical capital and labour to maximize profits with given factor prices. The factor prices, wage (w_t) and interest rate

(R_t), are determined in the perfect competitive markets. Thus, the first-order conditions for maximization are

$$\left(1-\alpha\right)A_t k_t^{\alpha} = w_t \tag{3.71}$$

$$\alpha A_t k_t^{\alpha-1} = R_t \tag{3.72}$$

3) Government sector

The government collects income tax from households to finance its expenditures on government transfers for elderly people (Tr_{t+1}) and subsidies the child allowance for young parent each additional newborn. The government's tax revenues (T_t) are given by

$$T_t = \tau_w w_t N_t \tag{3.73}$$

$$T_t = \tau_w w_t n_{t-1} N_{t-1} \tag{3.74}$$

And the government transfers for elderly people (Tr_{t+1}) is given as

$$Tr_t \pi_{t-1} N_{t-1} = \tau_w w_t N_t \tag{3.75}$$

$$Tr_t = \frac{\tau_w w_t N_t}{\pi_{t-1} N_{t-1}} \tag{3.76}$$

$$Tr_t = \frac{\tau_w w_t n_{t-1}}{\pi_{t-1}} \tag{3.77}$$

Also, the government transfer can be written in period $t+1$ as

$$Tr_{t+1} = \frac{\tau_w w_{t+1} n_t}{\pi_t} \tag{3.78}$$

where τ_w is labor income tax rate, w_t is wage, and labor force is given by $L_t = N_t = n_{t-1}N_{t-1}$, when N_t represents young worker and N_{t-1} represents old worker. In addition, n_{t-1} is the number of children (newborn) at time $t-1$.
and π_t is the probability of survival to the last period of life (longevity).

By assuming that the government runs the balanced budget, the government budget constraint can be written as:

$$Tr_t \pi_{t-1} N_{t-1} + b_t w_t n_t N_t = T_t \tag{3.79}$$

4) Social security system

The pension sector adopts the social security system in a pay-as-you-go style. The pension system grants a pension to the retired generations while the pension contribution is collected from the working generations. Assume that the pension system runs a defined contribution pay-as-you-go social security scheme with a balanced budget. Therefore, pensions benefits are:

$$P_t \pi_{t-1} N_{t-1} = \tau_p w_t N_t \tag{3.80}$$

Equation (3.80) shows the left-hand side represents the social security expenditure and the right-hand side the tax receipts. This scheme leads to the following formula for pension benefits:

$$P_t = \frac{\tau_p w_t N_t}{\pi_{t-1} N_{t-1}} \tag{3.81}$$

where $N_t = n_{t-1}N_{t-1}$ or it can be written as

$$P_t = \frac{\tau_p w_t n_{t-1}}{\pi_{t-1}} \tag{3.82}$$

Also, it can be written in period $t+1$ as

$$P_{t+1} = \frac{\tau_p w_{t+1} n_t}{\pi_t} \tag{3.83}$$

5) The equilibrium and model solution

Model solution by taking as given the pension budget, the other child policy variables and factor prices, the maximization of the expected lifetime utility function equation (3.65) by the representative individual subject to budget constraint equation (3.66) and (3.68) gives the demand for children and savings as follows:

The Lagrangean is given as

$$\Gamma = \ln c_{1,t} + \beta\pi_t\left(\ln c_{2,t+1}\right) + \varepsilon \ln n_t$$
$$+\lambda_t\left(\left(1-\tau_w-\tau_p\right)w_t - \left(q - b_t\right)w_t n_t + \frac{\pi_t P_{t+1}}{R_{t+1}} + \frac{\pi_t Tr_{t+1}}{R_{t+1}} - c_{1,t} - \frac{\pi_t}{R_{t+1}}c_{2,t+1}\right)$$

The FOCs for lifetime utility maximization are

$$\frac{\partial\Gamma}{\partial c_{1,t}} : \frac{1}{c_{1,t}} - \lambda_t = 0$$

$$\frac{\partial\Gamma}{\partial c_{2,t+1}} : \beta R_{t+1}\left(\frac{1}{c_{2,t+1}}\right) = \lambda_t$$

$$\frac{\partial\Gamma}{\partial n_t} : \frac{\left(q - b_t\right)w_t n_t}{\varepsilon} = \frac{1}{\lambda_t}$$

FOCs can be combined to give the consumption Euler equation:

$$\beta\left(\frac{c_{1,t}}{c_{2,t+1}}\right)=\frac{1}{R_{t+1}}$$

Thus, the lifetime budget constraint equation (3.69) can be written as

$$\left(1-\tau_w-\tau_p\right)w_t-\left(q-b_t\right)w_t n_t+\frac{\pi_t P_{t+1}}{R_{t+1}}+\frac{\pi_t Tr_{t+1}}{R_{t+1}}=c_{1,t}+\frac{\pi_t}{R_{t+1}}c_{2,t+1}$$

$$\left(1-\tau_w-\tau_p\right)w_t-\left(q-b_t\right)w_t n_t+\frac{\pi_t P_{t+1}}{R_{t+1}}+\frac{\pi_t Tr_{t+1}}{R_{t+1}}=\frac{1}{\lambda_t}+\frac{\pi_t}{R_{t+1}}\left(\frac{\beta R_{t+1}}{\lambda_t}\right)$$

$$\left(1-\tau_w-\tau_p\right)w_t-\left(q-b_t\right)w_t n_t+\frac{\pi_t P_{t+1}}{R_{t+1}}+\frac{\pi_t Tr_{t+1}}{R_{t+1}}=\frac{1}{\lambda_t}\left(1+\beta\pi_t\right) \qquad (3.84)$$

$$\left(1-\tau_w-\tau_p\right)w_t-\left(q-b_t\right)w_t n_t+\frac{\pi_t P_{t+1}}{R_{t+1}}+\frac{\pi_t Tr_{t+1}}{R_{t+1}}=\frac{\left(q-b_t\right)w_t n_t}{\varepsilon}\left(1+\beta\pi_t\right)$$

(3.85)

$$\varepsilon\left(1-\tau_w-\tau_p\right)w_t+\frac{\varepsilon}{R_{t+1}}\left(\pi_t P_{t+1}+\pi_t Tr_{t+1}\right)=\left(q-b_t\right)w_t n_t\left(1+\beta\pi_t+\varepsilon\right) \qquad (3.86)$$

By substituting equation (3.78) and (3.83) into equation (3.86), the following equation can be obtained as

$$\varepsilon\left(1-\tau_w-\tau_p\right)w_t+\frac{\varepsilon}{R_{t+1}}\left(\tau_p w_{t+1}n_t+\tau_w w_{t+1}n_t\right)=\left(q-b_t\right)w_t n_t\left(1+\beta\pi_t+\varepsilon\right) \qquad (3.87)$$

$$\varepsilon\left(1-\tau_w-\tau_p\right)w_t+\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}n_t=\left(q-b_t\right)w_t n_t\left(1+\beta\pi_t+\varepsilon\right) \qquad (3.88)$$

$$\varepsilon\left(1-\tau_{w}-\tau_{p}\right)w_{t}=n_{t}\left[\left(q\ -b_{t}\right)\left(1+\beta\pi_{t}+\varepsilon\right)w_{t}-\varepsilon\left(\tau_{p}+\tau_{w}\right)\frac{w_{t+1}}{R_{t+1}}\right] \quad (3.89)$$

The demand for children (n_t) can be written as

$$n_{t}=\frac{\varepsilon w_{t}\left(1-\tau_{w}-\tau_{p}\right)}{w_{t}\left(\left(q\ -b_{t}\right)\left(1+\beta\pi_{t}+\varepsilon\right)\right)-\varepsilon\left(\tau_{p}+\tau_{w}\right)\frac{w_{t+1}}{R_{t+1}}} \quad (3.90)$$

In addition, the savings can be written as

$$c_{2,t+1}=\beta R_{t+1}c_{1,t} \quad (3.91)$$

By substituting equation (3.66) and (3.68) into equation (3.91), the following equation can be obtained as

$$\frac{R_{t+1}}{\pi_{t}}s_{t}+P_{t+1}+Tr_{t+1}=\beta R_{t+1}\left(\left(1-\tau_{w}-\tau_{p}\right)w_{t}-s_{t}-\left(q\ -b_{t}\right)w_{t}n_{t}\right) \quad (3.92)$$

$$s_{t}=\frac{\beta\pi_{t}R_{t+1}\left(\left(1-\tau_{w}-\tau_{p}\right)w_{t}-\left(q\ -b_{t}\right)w_{t}n_{t}\right)-\pi_{t}P_{t+1}-\pi_{t}Tr_{t+1}}{\left(1+\beta\pi_{t}\right)R_{t+1}} \quad (3.93)$$

By substituting equation (3.78) and (3.83) into equation (3.93), the following equation can be obtained as

$$\left(1+\beta\pi_{t}\right)R_{t+1}s_{t}=\beta\pi_{t}R_{t+1}\left(\left(1-\tau_{w}-\tau_{p}\right)w_{t}-\left(q\ -b_{t}\right)w_{t}n_{t}\right)-\tau_{p}w_{t+1}n_{t}-\tau_{w}w_{t+1}n_{t}$$

(3.94)

$$\left(1+\beta\pi_{t}\right)s_{t}=\beta\pi_{t}\left(1-\tau_{w}-\tau_{p}\right)w_{t}-\left[\beta\pi_{t}\left(q\ -b_{t}\right)w_{t}+\left(\tau_{p}+\tau_{w}\right)\frac{w_{t+1}}{R_{t+1}}\right]n_{t} \quad (3.95)$$

By substituting equation (3.90) into equation (3.95), the following equation can be obtained as

$$\left(1+\beta\pi_t\right)s_t = \beta\pi_t\left(1-\tau_w-\tau_p\right)w_t - \left(\beta\pi_t\left(q-b_t\right)w_t + \left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}\right) \cdot \left(\frac{\varepsilon w_t\left(1-\tau_w-\tau_p\right)}{w_t\left(\left(q-b_t\right)\left(1+\beta\pi_t+\varepsilon\right)\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}}\right) \tag{3.96}$$

$$\left(1+\beta\pi_t\right)s_t = \frac{\left(1+\beta\pi_t\right)\left(1-\tau_w-\tau_p\right)w_t\left(\beta\pi_t w_t\left(q-b_t\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}\right)}{\left(\left(q-b_t\right)\left(1+\beta\pi_t+\varepsilon\right)w_t\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}} \tag{3.97}$$

The savings (s_t) is written as

$$s_t = \frac{w_t\left(1-\tau_w-\tau_p\right)\left(\beta\pi_t w_t\left(q-b_t\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}\right)}{w_t\left(q-b_t\right)\left(1+\beta\pi_t+\varepsilon\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}} \tag{3.98}$$

The capital market equilibrium is given by

$$K_{t+1} = N_t S_t \tag{3.99}$$

or, in per worker terms, the dynamic of capital is written as

$$k_{t+1} = \frac{s_t}{n_t} \tag{3.100}$$

By substituting equation (3.90) and (3.98) into equation (3.100), the following equation can be obtained as

$$k_{t+1} = \frac{w_t\left(1-\tau_w-\tau_p\right)\left(\beta\pi_t w_t\left(q-b_t\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}\right)}{w_t\left(q-b_t\right)\left(1+\beta\pi_t+\varepsilon\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}} \cdot \left(\frac{w_t\left(\left(q-b_t\right)\left(1+\beta\pi_t+\varepsilon\right)\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}}{\varepsilon w_t\left(1-\tau_w-\tau_p\right)}\right) \tag{3.101}$$

$$k_{t+1} = \frac{\beta\pi_t w_t\left(q-b_t\right)-\varepsilon\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}}}{\varepsilon} \tag{3.102}$$

$$k_{t+1} = \frac{\beta\pi_t w_t\left(q-b_t\right)}{\varepsilon}-\left(\tau_p+\tau_w\right)\frac{w_{t+1}}{R_{t+1}} \tag{3.103}$$

By substituting w_{t+1} and R_{t+1} into equation (3.103), the following equation can be obtained as

$$k_{t+1} = \frac{\beta\pi_t}{\varepsilon}\left(q-b_t\right)\left(1-\alpha\right)A_t k_t^{\alpha}-\left(\tau_p+\tau_w\right)\frac{\left(1-\alpha\right)A_t k_{t+1}^{\alpha}}{\alpha A_t k_{t+1}^{\alpha-1}} \tag{3.104}$$

The dynamic of capital is written as

$$k_{t+1} = \left(\frac{\alpha}{\alpha+\left(\tau_p+\tau_w\right)\left(1-\alpha\right)}\right)\frac{\beta\pi_t}{\varepsilon}\left(q-b_t\right)\left(1-\alpha\right)A_t k_t^{\alpha} \tag{3.105}$$

By assuming perfect foresight, the steady state implies $k_{t+1} = k_t = k^*$. We can get the steady state value of k^* from equation (3.105) as

$$k^* = \left(\frac{A\alpha\beta\pi(q-b)(1-\alpha)}{\varepsilon(\alpha + (1-\alpha)(\tau_p + \tau_w))} \right)^{\frac{1}{1-\alpha}} \tag{3.106}$$

Equation (3.106) shows that the capital stock is always reduced by raising the child allowance policy.

The steady state value of output is written as

$$y^* = A\left(\frac{A\alpha\beta\pi(q-b)(1-\alpha)}{\varepsilon(\alpha + (1-\alpha)(\tau_p + \tau_w))} \right)^{\frac{\alpha}{1-\alpha}} \tag{3.107}$$

Equation (3.107) recalling from equation (3.106) shows that raising the child allowance policy may reduce output in steady state.

The steady state value of demand for children (newborn) is written as

$$n^* = \frac{\varepsilon(1-\tau_w-\tau_p)(\alpha + (1-\alpha)(\tau_p + \tau_w))}{(q-b)((1+\varepsilon)(\alpha + (1-\alpha)(\tau_p + \tau_w)) + \alpha\beta\pi)} \tag{3.108}$$

Equation (3.108) shows that demand for children (newborn) is increased by raising the child allowance policy.

The steady state value of saving is written as

$$s^* = \frac{\varepsilon(1-\tau_w-\tau_p)(\alpha + (1-\alpha)(\tau_p + \tau_w))}{(q-b)((1+\varepsilon)(\alpha + (1-\alpha)(\tau_p + \tau_w)) + \alpha\beta\pi)} \left(\frac{A\alpha\beta\pi(q-b)(1-\alpha)}{\varepsilon(\alpha + (1-\alpha)(\tau_p + \tau_w))} \right)^{\frac{1}{1-\alpha}}$$

(3.109)

Equation (3.109) shows that savings is reduced by raising the child allowance policy. The steady state value of pension from equation (3.83) as

$$P^* = \frac{\tau_p(1-\alpha)A}{\pi}\frac{\varepsilon(1-\tau_w-\tau_p)(\alpha+(1-\alpha)(\tau_p+\tau_w))}{(q-b)((1+\varepsilon)(\alpha+(1-\alpha)(\tau_p+\tau_w))+\alpha\beta\pi)}k^{*\alpha} \tag{3.110}$$

Equation (3.110) shows that pension is increased by raising the child allowance policy. The steady state value of government transfers from equation (3.78) as

$$Tr^* = \frac{\tau_w n^*}{\pi}(1-\alpha)Ak^{*\alpha} \tag{3.111}$$

or it can be written as

$$Tr^* = (1-\alpha)A\frac{\tau_w}{\pi}\frac{\varepsilon(1-\tau_w-\tau_p)(\alpha+(1-\alpha)(\tau_p+\tau_w))}{(q-b)((1+\varepsilon)(\alpha+(1-\alpha)(\tau_p+\tau_w))+\alpha\beta\pi)}\left(\frac{A\alpha\beta\pi(q-b)(1-\alpha)}{\varepsilon(\alpha+(1-\alpha)(\tau_p+\tau_w))}\right)^{\frac{\alpha}{1-\alpha}} \tag{3.112}$$

Equation (3.112) shows that the government transfers for the elderly is increased by raising the child allowance policy.

From equation (3.106), (3.109), and (3.107) shows that raising the child allowance policy has a negative impact on capital stock, saving, and output in steady state. On the contrary, the policy has positive impact on pension system and the government transfers for the elderly in steady state, as illustrated in equation (3.110) and (3.112).

3.1.4 Exogenous process

The random variations in A_t, π_t, l_t, b_t capture respectively shocks to the technology productivity, the probability of survival rate, the policy of a lengthening of retirement age and the policy of a raising of the child allowance respectively. These shocks follow the stochastic processes as follow:

$$\ln A_t = \rho_A \ln A_{t-1} + \upsilon_{A,t} \qquad , \upsilon_{A,t} \sim N\left(0, \sigma_A^2\right) \qquad (3.113)$$

$$\ln \pi_t = \rho_\pi \ln \pi_{t-1} + \upsilon_{\pi,t} \qquad , \upsilon_{\pi,t} \sim N\left(0, \sigma_\pi^2\right) \qquad (3.114)$$

$$\ln l_t = \rho_l \ln l_{t-1} + \upsilon_{l,t} \qquad , \upsilon_{l,t} \sim N\left(0, \sigma_l^2\right) \qquad (3.115)$$

$$\ln b_t = \rho_b \ln b_{t-1} + \upsilon_{b,t} \qquad , \upsilon_{b,t} \sim N\left(0, \sigma_b^2\right) \qquad (3.116)$$

where ρ_A, ρ_π, ρ_l, ρ_b measure the persistence of those shocks, and $\upsilon_{A,t}, \upsilon_{\pi,t}, \upsilon_{l,t}, \upsilon_{b,t}$ are $i.i.d., \sim N\left(0, \sigma^2\right)$.

3.2 Solution method of solve this model

The method employed in the research is based on Dynare user guide (Griffoli, 2013) and has consists of following steps:

Step 1: Construct a population aging in overlapping generation model with the features and solution.

- First-order conditions and policy rules.
- Exogenous processes.
- Market clearing conditions.

Step 2: Computing the steady-state of the model.

Step 3: Calibrate model with parameters representing Thai economy.

Step 4: Simulation model.

- Start from the steady state.
- Perturb the model by introducing shocks.
- Solve for transition paths toward the post-shock steady state.

We did this with the stochastic simulation tools of the program “Dynare” developed by Juillard (2003) and (2001).

Step 5: Study impulse response behaviors and steady state analysis.

3.3 Calibration and data description

This study selects the values of parameters based on empirical findings of Thai economy and other developing countries if it deems necessary. Most parameters, otherwise specified, follow Tanboon (2008) which corresponds firmly to stylized facts of the Thai economy, and many studies relevant to OLG model and thus provides a strongly consistent basis for policy analysis in Thailand economic environment. Their value can be summarized in the Table 4 below.

A number of parameters are excluded from the estimation and need to be calibrated. This is because they are either notoriously difficult to estimate or better be identified by using other information.

Firstly, the calibration of aging parameters is based on period one year. Agents are born at real lifetime age 15 which corresponds to $t = 1$. They work $T = 45$ years corresponding to a real lifetime age of 59. They live a maximum life of 60 years ($T^R = 20$) so that agents do not become older than real lifetime age 80. We use the same survival probabilities that are presented by United Nations (2017), π is set equal to 0.473.

Secondly, the discount factor for households (β) is fixed at 0.9926 which implies to annual interest rate of 3% in line with Tanboon (2008). For the household's elasticity of labor supply is calibrated by Tanboon (2008), γ is set equal to 3.0303. In addition, ε or the parameter of preference to choose the quantity of children is set equal to 0.369 according to Pattamasiriwat, Hengpatana and Phanthunane (2012). Moreover, the parameter of the child rearing cost (q) is assumed to be a fixed proportion of adult income. q is fixed at 0.32 according to Pattamasiriwat, Hengpatana and Phanthunane (2012)'s calculation based on costly for parents to take care of a child is given by expenditures for schooling and food.

Thirdly, the capital income share (α) is set equal to 0.328 according to Cheewatrakoolpong and Boonprakaikawe (2010)'s calculation based on data from the National Statistical Office and the National Economic and Social Development Board 2003 to 2008.

Fourthly, for government sector, parameter τ_w or the labor income tax rate is set equal to 0.10 which is the rate for middle-class taxpayer in Thailand. In addition, the parameter l represents the mandatory retirement age policy. In this study, it is set equal to 0.066 for raising retirement age 3 year according to Office of the Civil Service Commission (2018). Assume he/she works a fraction l of the time, we may interpret $1+l$ as the total time devoted to labor over the life-cycle while, of course, the length of retirement is $(1-l)$. This also means that, for instance, by assuming conventionally one period of 45 year and an age of entry in adult life (i.e. in the labor market) of about 15 years, then the age of retirement would be 60 years when l = 0, 63 years when l = 0.066, 65 years when l = 0.110, and so on as in Fanti (2014). Moreover, the parameter of child allowance rate is assumed to be a fixed proportion at b = 0.1 as in Child Support Grant policy (Ministry of Social Development and Human Security, 2016).

Finally, the social security system (τ_p) represents degree of pension contribution rate is set equal to 6 percent from employer and employee each pay equal contributions of 3 percent of the worker's salary according to the Social Security Act, B.E. 2533 (1990), provides mandatory insurance (Section 33). (Social security office, 2018)

Table 4 Calibration of the model

Parameter	Value	Interpretation	Reference
Aging parameters			
π	0.473	the probability of survival rate	United Nations (2017)
Household			
β	0.9926	discount factor	Tanboon (2008)

Table 4 (Continued)

Parameter	Value	Interpretation	Reference
Household			
γ	3.0303	the parameter measuring preference for leisure or retirement	Tanboon (2008)
ε	0.369	preference to choose the quantity of children	Pattamasiriwat, Hengpatana and Phanthunane (2012)
q	0.32	the child rearing cost, assumed to be a fixed proportion of adult income	Pattamasiriwat, Hengpatana and Phanthunane (2012)
Firm			
α	0.328	capital income share	Cheewatrakoolpong and Boonprakaikawe (2010)
Government			
τ_w	0.10	labor income tax rate	The revenue department (2018)
l	0.066	raising retirement age 3 year (fraction of the work times)	Office of the Civil Service Commission (2018)
b	0.10	child allowance rate	Ministry of Social Development and Human Security (2016)
Social security system			
τ_p	0.06	social security tax (or pension contribution rate)	Social security office (2018)

Source: Author’s study

3.4 Estimation of the exogenous shocks processes

The study estimated the exogenous shock processes based on annual calculations conducted by the National Statistical Office (2019) on yearly demography population and housing statistics between 2007-2017 through an $AR(1)$ process to determine the probability of survival rate shock. $AR(1)$ is estimated on the relative deviation of the probability of surviving from 60 to 80 years (Solow residual) from its average level on the period and on the relative deviations of the growth rate of the model from its average on the period. As the Solow residual is contaminated by shock with imperfect competition (Hall, 1989), it is, thus, the proxy for the probability of survival rate shock, with autocorrelation coefficients 0.8816 (ρ_π).

The shock of the retirement age policy is persistent, with autocorrelation coefficients of 0.9758 (ρ_l) which was used to estimate parameters using data of elderly workers on a yearly informal employment survey from 2007-2018 obtained from the National Statistical Office (2019).

The persistence parameter for child allowance policy shock is equal to 0.1832 (ρ_b) which was used to estimate the parameter used on the yearly data on the budget of Child Support Grant from 2016-2020 provided by the Ministry of Social Development and Human Security (2018). The 2019 and 2020 data are based on data forecasts cited in TDRI (2015).

The technological growth parameter A_t is equal to 2.4 percent per year according to Sutthasri's (2007) calculation based on data from 1978 to 2006. This value is consistent with Chuenchoksan and Nakornthab's (2008) finding that Thailand's total factor productivity (TFP) growth is 1.8% between 1987-1996, and 2.0% between 2000-2007 (the average TFP growth during the financial crisis years was registered at -6.7%). Therefore, for this study, the persistence parameter for productivity shock was established to be at 0.794 (ρ_A) following Alp and Elekdag (2012).

CHAPTER 4
RESULTS AND DISCUSSION

The results of this study are divided into 4 sections. Given the demographic and macroeconomic scenarios in Thailand, the first section of this chapter investigates the transition path of some macroeconomic variables with the impacts of population aging. It is acknowledged that population aging consequently causes aging of the labor force and reduces the proportion of the working-age population in the economy. It is also recognized that promoting technological progress can mitigate the adverse effect of a shrinking working-age population on aggregate output. Therefore, this chapter will initially address the macroeconomic outcomes of the economy from the impact on population aging. Models are described by analysis of the impulse response function under the effects of a probability of survival rate shock. The timing of the model is based on a quarterly period and the size of the positive probability of survival rate shock is assumed to be 1% standard deviation.

The second section of this chapter studies the macroeconomic outcomes of the economy with technological progress. Models are described by analysis of the impulse response function under the positive productivity shock. The timing of the model is based on a quarterly period and the size of the positive productivity shock is assumed to be 1% standard deviation.

The third section, studies the effect of the policy of extending the working life of the working-age population from 60 years to 63 years on macroeconomic variables, by analyzing the impulse response function under the effects of a lengthening of retirement age policy shock. The timing of the model is based on a quarterly period and the size of the retirement age policy shock is assumed to be 1% standard deviation.

The last section studies the effects of the policy raising the child allowance on macroeconomic variables where the model defined the child allowance rate to be at 0.10% (Ministry of Social Development and Human Security, 2016). Analyze the impulse response function under the positive child allowance shock. The timing of the model is based on a quarterly period and the size of a positive child allowance shock is assumed to be 1% standard deviation.

4.1 Effects of population aging

The result of the impulse response analysis was to consider the response of the change in the standard deviation of the variable of interest when 1 unit of shock occurs. The vertical axis (Y-axis) represents the percentage change from the steady-state and the horizontal axis (X-axis) represents the duration. The study looked at changes that occurred over a period of 10 years, or 40 quarters.

Figure 3 shows the effects of a probability of survival rate shock, i.e. increasing longevity of Thailand's population. The result shows that an increase in longevity has a positive effect on capital stock. Capital increased sharply to 0.0015% during the third quarter and then slowly decreased for more than 40 quarters. Longevity had a positive impact on savings, following the shock, the savings rose sharply to 0.0018% during the third quarter, then gradually declined until the 40^{th} quarter.

The increase in the life expectancy has an effect on the factor prices in the business sector including interest rates and wages based on the marginal product of capital and labor, that is, the increase of capital per capita directly caused the interest rate to drop sharply to 0.014% in the third quarter and thereafter gradually increase until the 40^{th} quarter. Wages rose sharply to 0.0028% in the third quarter and gradually declined through the 40^{th} quarter. The longevity affects output positively where after the shock, it caused the output to rise sharply to 0.004% in the third quarter and then gradually declined until the 40^{th} quarter.

In addition, the sudden increase in the population's life expectancy also contributes to an increase in lifetime consumption, where young age consumption and savings are dependent on wages. Therefore, when wages increased, it consequently, increased the young age consumption to 0.005% in the third quarter and then gradually declined until the 40^{th} quarter. Old age consumption is derived from their savings and pension, as well as, from the government transfers for the elderly. This will lead to an increase in the number of the elderly which will negatively affect the overall government sector as it has to increase its budget for the government transfers for the elderly. However, longevity will also indirectly affect the wage rates resulting in an income increase for young age workers and increased payment of labor income tax, causing government transfers for the elderly to increase by 0.0015% continuously until the 40^{th} quarter. As with pensions, longevity has a direct negative impact on the overall pension system due to the growing number of the elderly population, but the rate of newborns remains either constant or decreases. However, after the shock, pensions continued to increase by 0.001% through to the 40^{th} quarter. Therefore, the increase in savings, pensions, and state transfers will result in a continuous increase in old age consumption by 0.01% until the 40^{th} quarter, as illustrated in Figure 3.

From Figure 3, whenever there is a probability of survival rate shock, the transmission mechanism can be summarized, as follows: starting from after the shock, it will have an effect where the capital stock and saving increases. This increase in the capital stock directly affects the firms' sector output in a positive manner, whereby, as output increases, it increases wages, while reducing interest rates. Secondly, the increase in wages also affects the pension sector as it increases the contribution towards the pension fund, thus increasing pension benefits. Thirdly, the increase in wages also affects the increase in government transfer payments for the elderly through the income tax rate mechanism. And finally, the aftermath of the shock also affects the household sector by increasing young age consumption due to higher wages. Additionally, old age consumption also increases due to increased savings, pension benefits, and increased government transfer payments for the elderly. Therefore, it can be concluded that an increase in young and old age consumption inevitably results in an increase in lifetime consumption.

From such changes, it can be seen that changes to the interest rates is an important factor in changing economic processes, which can be described in two ways; a decrease in interest rates will lead to capital stock increases, and an increase in productivity resulting in increased employment and an increase in wages. Secondly, rises in wages result in a shift in consumption for both the young and the elderly, whereby savings are increased and a positive effect on pensions and the government transfers for the elderly. Therefore, wage increases that are substantial enough has the capability to offset the negative effects resulting from an increase in the longevity of the aging population. This is consistent with a study conducted by Cipriani (2014) which indicated that population aging adversely affects the pension system in the long run.

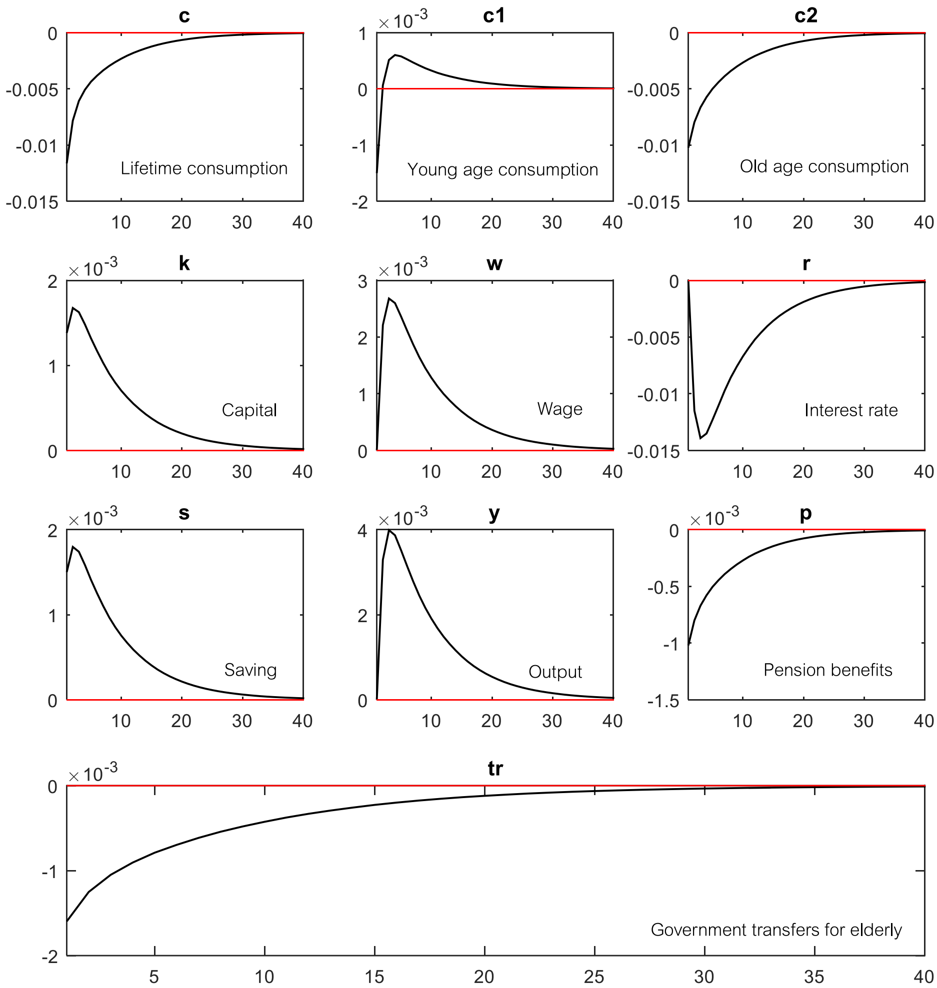

Figure 3 Response to the probability of survival rate shock

Source: Author's illustration

4.2 Effects of the technological shock

The result of the impulse response analysis was to consider a temporary positive technological productivity shock is depicted in Figure 4. As a result of the shock, the factor prices in the sector were impacted, which includes interest rates and wages based on the marginal product of capital, and the marginal product of labor, in other words, if the capital per capita increases, the interest rate will drop 0.02% in the third quarter and gradually rise to the original equilibrium during the 20^{th} quarter. Wages rose sharply to 0.013% in the third quarter and gradually declined until the 40^{th} quarter. The marginal product of capital decreases, which enables the production and output to increase by as much as 0.018% in the third quarter and then declined gradually until the 40^{th} quarter.

A positive technological shock also results in capital accumulation, as the economy's capital accumulation was found to be at the same level as household savings. Therefore, when the capital rose to 0.0025% in the third quarter and gradually declined until the 40^{th} quarter, savings consequently also increased to 0.0025% during the third quarter and then gradually declined until the 40^{th} quarter.

Additionally, lifetime consumption has increased due to young age consumption and savings. Therefore, when wages increased, it resulted in an increase in young age consumption by 0.007% in the third quarter and then gradually declined until the 40^{th} quarter. Old age consumption is derived from savings plus pension combined with government transfers for the elderly. Thus, when a technological productivity shock results in an increase in wages, the income of young workers thus increases and directly leads to an increase in their contribution towards paying more labor income tax, causing government transfers for the elderly to increase to 0.0028% in the third quarter and then gradually declining through to the 40^{th} quarter. Pensions also increased to 0.0018% in the third quarter and then gradually declined until the 40^{th} quarter. Therefore, the increase in savings, pensions, and state transfers, are the main factors that drive old age consumption to increase to 0.018% in the third quarter and then gradually declined until the 40^{th} quarter, as shown in Figure 4.

From Figure 4, when a positive technological productivity shock occurs, the transmission mechanism can be summarized, as follows: starting from after the shock, the capital stock and savings increases. This increase in capital stock has a positive effect on the firms' sector, where output also increases, and results in more employment and increased wages, while reducing interest rates. Secondly, the increase in wages also affects the pension sector as the contribution to the pension fund increases, thus, causing pension benefits to increase. Thirdly, the increase in wages also affects the government transfer payment for the elderly in a positive manner through the income tax rate mechanism. Finally, the aftermath of the shock also affects the household sector by increasing young age consumption due to higher wages. Additionally, old age consumption also increases due to increased savings, pension benefits, and increased government transfer payments for the elderly. Therefore, it can be concluded that an increase in young and old age consumption inevitably results in an increase in lifetime consumption.

The changes caused by a positive technological productivity shock can be seen to have a positive impact on all macroeconomic variables by means of the transmission mechanism of productivity shock through the key variable, i.e. the declining interest rate. This contributes to the economic process changes which can be described in two ways; lower interest rates affect investment causing increases in capital stock and production, resulting in increased employment and an increase in wages. Second, when wages increase, there is a shift in consumption for both young and old alike where an increase in savings is also evident. In addition, higher wage rates will have a positive impact (increases) on pensions and government transfers for the elderly. This is consistent with the study conducted by Bisonyabut and Panpiemras (2012), which found that technological developments are a major cause of the increase in total productivity. Due to technological developments, the productivity of labor is increased to compensate for the shortage of the working-age population and the decrease in working hours. If no such development occurs, the total labor supply in the efficiency unit, the total capital amount, and the total output will continue to decline in an aging society. Moreover, technological development is an important mechanism in helping to alleviate the negative impacts on the economy in the elderly society. If the country has a high rate of technological expansion, the total output growth rate will also be higher.

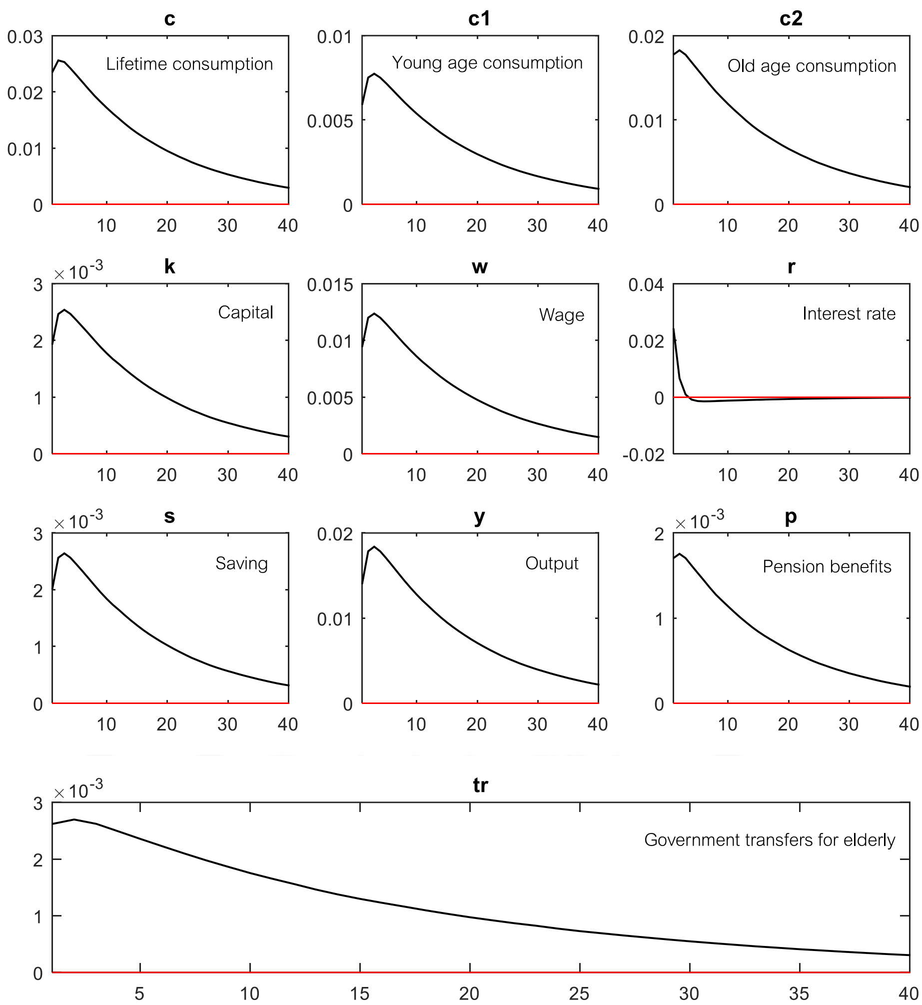

Figure 4 Responses to the technological shock

Source: Author's illustration

4.3 Effects of a lengthening of the mandatory retirement age policy

The effects of a lengthening of retirement age policy shock are shown in Figure 5. A positive shock in the retirement age will tend to directly increase labor supply and lower the length of the retirement period. As a result, workers need to save less for a shorter retirement period. Figure 5 shows the saving reduction until it reaches 0.0001% in the third quarter and continues to gradually increase until the 40^{th} quarter. The capital stock and output also show decreases as well. The capital stock showed a decrease until it reaches 0.00015% in the third quarter, while output displayed a similar trend where it decreased until it reaches 0.00039% in the third quarter and then gradually increased. The net effect on the capital is negative if the retirement age is increased. In such a case, the net effect on capital returns remains positive and the wage rate will fall (a negative factor price effect for workers and a positive factor price effect for retirees). The interest rate rises to 0.0013% in the third quarter and eventually gradually decreased until the 40^{th} quarter. The wage rate dropped as low as 0.00025% during the third quarter and then gradually increased until the 40^{th} quarter. (Mattayaphutron, Tam, & Jariyapan, 2021)

For the consumption effect, the future generations enjoy more income and consumption than the current generation does. With delayed retirement, it has a direct effect on labor supply and a time effect on the delayed payment of pension benefits by the pension system. Figure 5 illustrates that old-age consumption is positively affected after the shock and slowly decreases for more than 40 quarters (old-age consumption dropped 0.0005%). The young age consumption is negatively affected, as the consumption declines immediately after the shock until it reaches 0.0001% in the third quarter and then increases until the 40^{th} quarter. The delayed retirement age policy measure causes a noticeable positive effect on the overall lifetime consumption. However, lifetime consumption declined to 0.0006% after the shock and slowly decreases until the 40^{th} quarter. (Mattayaphutron, Tam, & Jariyapan, 2021)

As mentioned earlier, the government transfers for the elderly are based on the collection of income tax, therefore with an increased labor supply (which includes both the young and old generation), the government collects more tax and spend more on budgeting the money transfers for the elderly. Overall, the government sector has a significantly positive effect. However, the government transfers decline immediately after the shock in the 5^{th} quarter. (Mattayaphutron, Tam, & Jariyapan, 2021)

Studying the effect of this shock on the PAYG social security system, it is pertinent to note that the social security expenditure is based on the collection of social security tax (or pension contribution rate). The effects of a lengthening of the retirement age policy results in an increased number of elderly workers. With the higher supply of labor, the pension benefit is a significantly positive effect. The pension declines slowly after the shock until it reaches 0.0001% in the third quarter and lasts for more than 40 quarters. This is consistent with a study by H.-J. Chen (2016) which employed exogenous retirement age in the OLG framework. This study found that an increase in the retirement age may raise pensions if the tax rate is sufficiently high.

From Figure 5, when a lengthening of the mandatory retirement age policy occurs, the transmission mechanism can be summarized, as follows: starting from after the shock, there will be a decline in capital stock and savings. The decline in the firms' sector results in lower output and declining employment and directly causes wages to fall. An additional effect of the shock is the rise in interest rates. Secondly, it also affects the pension sector as the lengthening of the mandatory retirement age policy increases the labor supply. Thus, pension increases, resulting in an increase in pension benefits and then thereafter, gradually decreases. Thirdly, after the shock, government transfer payments for the elderly increased and eventually gradually decreases through the income tax rate mechanism resulting from the young and elderly workers who are still working. Finally, the shock will also have an effect on the household sector, causing old age consumption to increase and then gradually decreases, due to the increase in interest rates, the elderly earns more from their work, higher pension benefits and higher government transfer payments for the elderly. On the other hand, the shock will cause a decrease in young age and lifetime consumption.

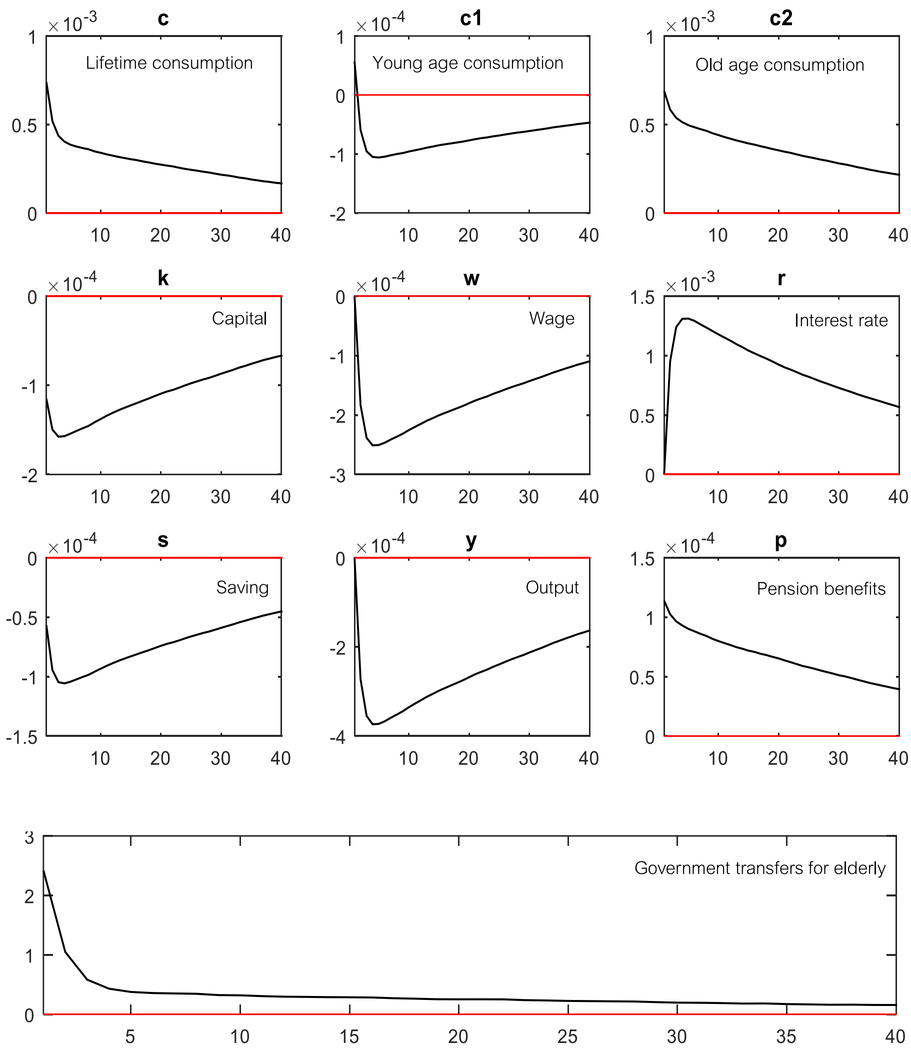

Figure 5 Responses to retirement age policy shock

Source: Author's illustration

4.4 Effects of raising the child allowance policy

The effects of the child allowance policy shock are shown in Figure 6. A positive shock in the child allowance will tend to directly decrease the child cost which has a positive impact on the demand for having children. Child allowance increased will be family has more children in the period of the shock then later the no of children declines. Demand for having children declined sharply to 0.005% in the second quarter and gradually declined from the third quarter to the fourth quarter. The saving reduction reached 0.003% in the second quarter and gradually increased until the 6^{th} quarter.

The capital stock will be drop first and increased later by 0.01% in the 6^{th} quarter. The net effect on the capital is negative if demand for newborns increases. In such a case, the net effect on capital returns remains positive and the wage rate will fall. The interest rate rises until it reaches 0.08% in the second quarter and gradually declines until the 6^{th} quarter. The wage rate declined to 0.015% in the second quarter and then gradually increased through to the 6^{th} quarter. Output dropped to 0.025% in the second quarter and then gradually increased until the 6^{th} quarter.

For the consumption effect, the future generations enjoy more consumption than the current generations do. The old-age consumption is positively affected after the shock and declined sharply from 0.035% in the second and third quarters. However, after the third quarter, it is likely that old-age consumption will rise due to the increase in pension benefits and government transfers for the elderly. The economy will adjust to its original equilibrium during the 6^{th} quarter. The young age consumption is negatively affected, as the consumption declines immediately after the shock until it reaches 0.025% in the second quarter and increases for more than 6 quarters. The child allowance policy measure causes a noticeable negative effect on the overall lifetime consumption. However, the lifetime consumption will gradually increase from 0.02% after the shock and will slowly increase for more than 6 quarters.

Studying the effect of this shock on the government transfers for the elderly, overall, the government sector has a significantly positive effect. However, the government transfers declines immediately by 0.005% after the shock in the second quarter to the third quarter, but after the third quarter, it can be seen that the government transfers for the elderly will increase due to the increase in the wage rate and the economy will adjust to its original equilibrium in the 6^{th} quarter.

Finally, regarding the effect of this shock on the PAYG social security system, it is pertinent to note that the pension benefit has a significantly positive effect whereby the pension declines slowly after the shock by 0.003% in the second and third quarters.

However, after the third quarter, the pension benefit will rise due to the increase in wage rates rise and the economy will settle into its original equilibrium in the 6^{th} quarter. This is consistent with a study conducted by Cipriani (2014), showing that as the child-rearing cost increases, it will have a positive effect on capital in the steady-state, but will show a negative effect on demand for children and PAYG pension system in the steady-state. The child allowance policy to encourage young people to have more children would have the opposite effect: i.e. it could increase the fertility rate of the newborn population and positively affect the pension system in the long term.

Figure 6, illustrates the transmission mechanism when a child allowance policy shock occurs, which can be summarized, as follows: starting from after the shock, the demand for having children increases and thereafter, gradually decreases. This occurrence directly affects and causes an increase in capital stock adjustment. The shock also affects the firms' sector, whereby the output is reduced and results in less employment causing wages to decline, but a decline in interest rates. Secondly, the aftermath of the shock also affects the pension sector, where the pension benefits increases and thereafter, gradually decreases as the number of newborn children increases (or in other words, causes an increase in the endogenous fertility rate). Thirdly, the shock also increases the government transfer payments for the elderly, and then gradually decreases. Finally, the child allowance policy shock also has an effect that contributes to reduced savings and affects the household sector, in which young age consumption declines as wages are reduced. Old age consumption increases and gradually declines due to an increase in interest rates, pension benefits, and increased government transfer payments for the elderly. The aftershock also increases overall lifetime consumption.

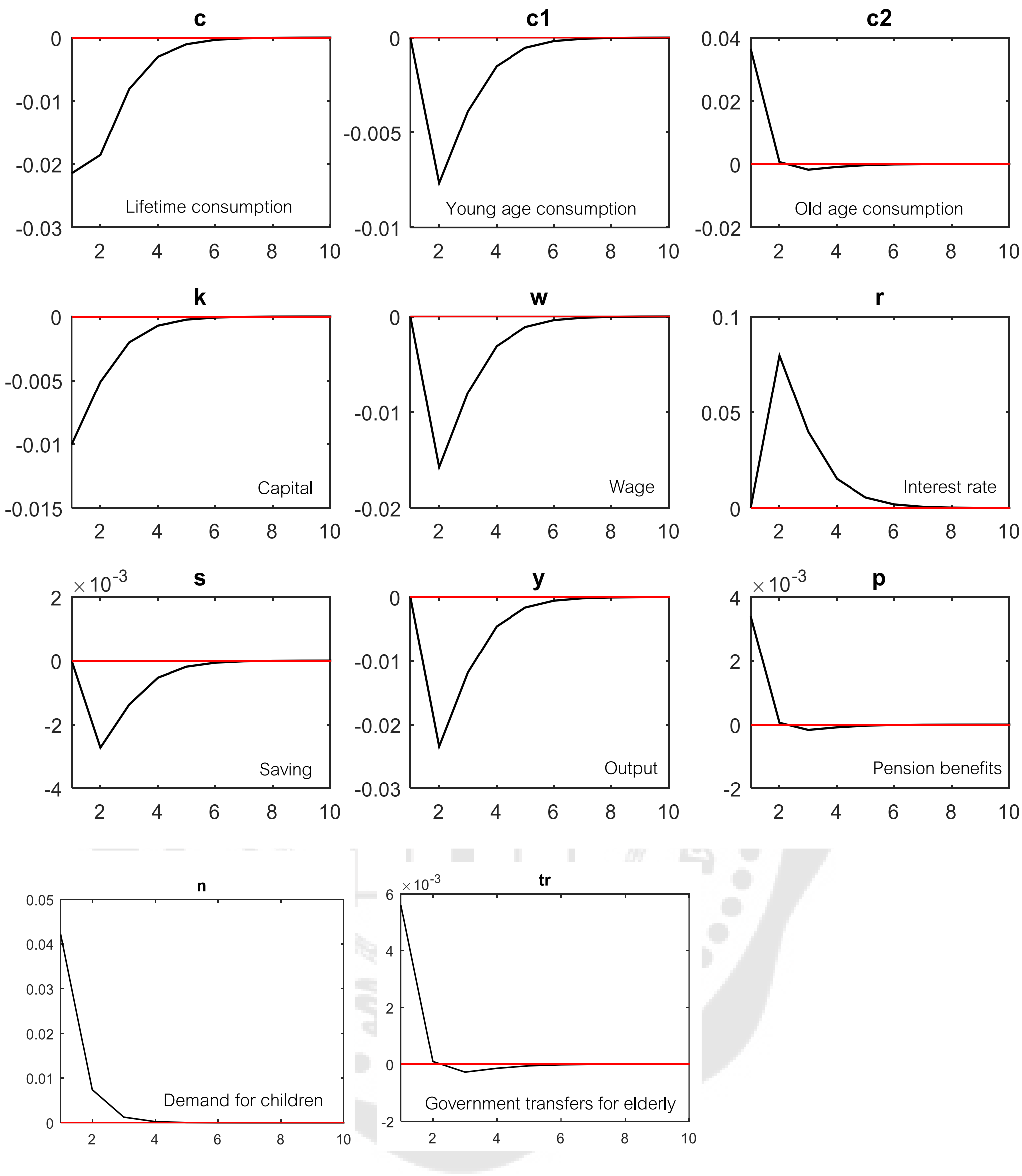

Figure 6 Responses to the child allowance shock

Source: Author’s illustration

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

In this study employs DSGE model augmented with the OLG framework. To achieve three objectives (1) To study the effect of longevity shock on macroeconomic variables (2) To analyze the effect of a lengthening retirement age policy on macroeconomic variables and (3) To analyze the effect of the adoption of child allowance policy on macroeconomic variables. The OLG model based on the study of Cipriani (2016) is modified to incorporate key features of the model. The keys feature of the model are the policy of extending the retirement age and the policy of a raising the child allowance. Model structure is close economy model of the Thai economy. There are representative households, firms, government sector and social security system. The set of calibrated parameters used in the model satisfies the characteristics of Thai economy to study the aforementioned objectives. The results show that impulse response behaviors of macroeconomy responses to policy shock, as follows:

5.1 Conclusions

Firstly, the increased longevity of the Thai population sends a negative impact on the pension system and lifetime consumption, where both young and old age consumption are negatively affected. On the contrary, a longer life expectancy has a positive impact on capital stock, savings, and output. This is consistent with research hypotheses of study. The impulse response is caused by the key variable, which is the interest rate adjustment, or in other words, a decrease in interest rates contributes toward an expansion in investments, savings, and productivity. While on the other hand, the increase in wages will lead to a shift in consumption among the young and elderly, pensions, and government transfers for the elderly.

Secondary, technological productivity has a positive effect on every macroeconomic variable, which includes capital stock, savings, output, and pension payouts. It also has a positive impact on lifetime consumption for both young and old age consumption. The transmission mechanism of the technological productivity shock with an impulse response occurring in an increasing trend across all economic variables except for the interest rate which displays a downward trend.

Third, a higher mandatory age of retirement is always beneficial in the long run for PAYG pension budgets, government transfers for the elderly, and lifetime consumption. In this way, the future generations can enjoy increased consumption than the current generations. On the contrary, the policy of increasing the mandatory age has a negative impact on capital stock, savings, and output. This is consistent with research hypotheses of study. Thus, the policy of increasing the mandatory age may be harmful not only in the long run, in terms of the capital accumulation, but also in terms of the output. The mechanisms for driving this are twofold: (1) there is a direct positive effect consisting of an increase in labor supply and a lower length of the retirement period, and (2) there is an indirect effect due to the negative change in the wage. This is consistent with a study conducted by Mattayaphutron, Tam, and Jariyapan (2021).

Lastly, the policy of a raising the child allowance has a positive effect on PAYG pension system. The child's allowance is always beneficial in the long run for PAYG pension budgets, government transfers for the elderly, and the demand for having more children (newborns). In this way, the future generations can enjoy increased consumption than the current generation. On the contrary, the policy of raising the child allowance has a negative impact on capital stock, savings, and output. This is consistent with research hypotheses of study. Therefore, the policy of raising the child allowance may be harmful not only in the long run in terms of capital accumulation but also in terms of output, as the net effect on capital returns remains positive and results in a fall in the wage rate.

Therefore, from the study, it can be concluded that entering into an aging society (where the general population experiences a longer life expectancy) negatively affects the long-term pension system and lifelong consumption plans for both the young and elderly. Mitigating the impact of entering an aging society by implementing policies, such as extending the retirement age, applying technology to increase productivity, and implementing the policy to increase child allowance, have a positive impact on the long-term pension system. When a policy shock is implemented in the economy, the impulse response to such policies, particularly with regard to extending the retirement age and applying technology to increase productivity, will have a long-term effect before the economy returned to its original steady-state equilibrium (adjustments occur for more than 40 quarters). While on the other hand, a sudden implementation of the policy to increase child allowance results in a short-term impulse response where the economy will adjust to its original steady-state equilibrium in the 6th quarter. However, caution is warranted as implementing either the retirement age extension or increasing child allowance will have a long-term negative impact on capital stock, savings, and output, which could inevitably lead to a slowdown in the economy.

5.2 Policy implications

From this study, it can be clearly seen that the approach to mitigating the impact of an aging society in Thailand should be to support policies on technology development, whereby the government should support and encourage the firms' sector to apply an increased use of technology to improve labor productivity which should make it possible to replace the reduced labor force without causing a slowdown in the economy. As technological development is promoted and increases, capital stocks, output, and savings will inevitably increase. Therefore, the government should set up incentives for firms to invest more in technology, such as tax cuts on machinery imports that can enhance production processes, or measures to provide low-interest loans for technology-related investments of business operators, etc.

In addition to technology policies, government policymakers should also implement other supporting policies that can mitigate the effects of an aging society. For instance, the planning of labor force policies in an aging society, such as (1) establishing a policy of extending the working life to increase the labor force in the economy for certain types of businesses that cannot use machinery or technology to replace the workforce; and (2) policies to increase newborns which will eventually be developed into Thailand's future labor force. The details are as follows.

(1) Extending the population's working life to help alleviate labor shortage problems. There is currently a disparity in the current policy on working life in Thailand in the public and private sectors. In the government sector, there is a law that clearly defines the retirement age of 60 years with some exceptions for certain highly skilled jobs. While in the private sector, the retirement age is currently established at 55 years in accordance with the Social Security Act 2010. In actual practice, continuing employment is based purely on the voluntary arrangement between the employers and employees. Therefore, many workers tend to drop out of the labor force before the age of 55. In 2018, the government has set a policy to extend the compulsory working age, which is the country's plan to prepare for entering an aging society, whereby the mandatory retirement age for government and state enterprise officials will be extended from 60 to 63 years under a national reform plan that took effect in Thailand and is intended to address issues associated with being an aging society (referred from the Office of the Civil Service Commission (2018)).

Therefore, in this study, the research is thus targeting the policy of extending the retirement age to 63 years. The results clearly show that extending the population's working life can have a positive effect on the pension system and on lifetime consumption. By comparison, old age consumption benefits the policy more than young age consumption. However, the government's enforcement of the retirement age extension policy may be just limited to full-time working hours, which may prove to be restrictive for seniors. Therefore, in the effort to increase the elderly workforce, they should be provided with a more flexible working policy, i.e. the number of working hours that are more suitable for the elderly in each age group. In addition, the sole application of the employment extension policy alone is cautionary as it negatively affects capital stock, savings, and output, which may result in a slowdown in the economy.

(2) Measures to support the increase of the newborn population in the aging society. In this study, the use of universal child allowance policies was found to motivate

young people to have more children. The policy also has a positive impact on the pension system. However, on the other hand, it has a negative impact on lifetime consumption where consumption by the elderly will benefit more from this policy than the younger generation, but this is just a short-term effect (1-6 quarters). Additionally, caution must be exercised in the sole use of the child allowance policy as it negatively affects capital stock, savings, and productivity (output), which may result in a slowdown in the economy.

However, the decision to have more children among young adults depends on other factors as well. In addition to a family's economic factors, such as balancing work and childcare, and support for raising pre-school children. Therefore, the government's policy to incentivize young people to motivate them to have more children should be supported by measures with regards to time and providing pre-school child care services, such as the right to take time off to care for preschool children, or the provision of child care services at their workplace, etc.

5.3 Limitations and suggestions for further study

There are some limitations with respect to the model and suggestions for further study. Firstly, the model assumes that the labor efficiency is not different for each age group. But in reality, the labor efficiency will vary according to different age ranges. Therefore, future research should be carried out to conduct studies in the workforce according to the different age ranges which affect the household income (the age-efficiency profile in accordance with the age-earning profile of a representative household). This additional analysis may affect different macroeconomic variables.

Secondly, as entering an aging society affects the stability of the pension system, therefore, the study of reforming the structure of the pension system in Thailand should be conducted by studying the different pension contribution rates which will have an effect on macroeconomic variables.

In addition, due to data limitations, the parameter estimation of this study required an establishment of the parameters through calibrations, i.e. conducting a review of past research studies in Thailand. Therefore, future studies may estimate the parameters by using the Bayesian method, in which the Prior function is added to weight the parameter estimation probability function, and utilize a technique to estimates Posterior parameter through the use of the Metropolis-Hasting method, where it will prove useful in the analysis and forecasting process.

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Appendix

1. Solving rational expectations models at first order approximation in Dynare

In the following Villemot (2011), first define the deterministic steady state of the model as the vector $(\bar{y}, \bar{u}, \bar{\varepsilon})$ satisfying:

$$\bar{\varepsilon} = 0$$
$$\bar{u} = P(\bar{u}, \bar{\varepsilon})$$
$$f(\bar{y}^+, \bar{y}, \bar{y}^-, \bar{u}) = 0$$

Finding the deterministic steady state involves the resolution of a multivariate nonlinear system. Then, finding the rational expectation solution of the model means finding the policy functions (also known as decision rules), which give current endogenous variables as a function of state variables:

$$y_t = g(y^-_{t-1}, u_t)$$

by definition of the deterministic steady state, we have $\bar{y} = g(\bar{y}^-, \bar{u})$.

The function g is characterized by the following functional equation:

$$\mathbb{E}_t f\left[g^+(g^-(y^-_{t-1}, u_t), u_{t+1}), g(y^-_{t-1}, u_t), y^-_{t-1}, u_t\right] = 0 \tag{1A}$$

where g^+ (resp. g^-) is the restriction of g to forward (resp. backward) endogenous variables. In the general case, this functional equation cannot be solved exactly, and one has to resort to numerical techniques to get an approximated solution. The remainder of this paper describes the first order perturbation technique implemented in Dynare. Let:

$$f_{y^+} = \frac{\partial f}{\partial y^+_{t+1}}, \; f_{y^0} = \frac{\partial f}{\partial y_t}, \; f_{y^-} = \frac{\partial f}{\partial y^-_{t-1}}, \; f_u = \frac{\partial f}{\partial u_t}$$
$$g_y = \frac{\partial g}{\partial y^-_{t-1}}, \; g_u = \frac{\partial g}{\partial u_t}$$
$$P_u = \frac{\partial P}{\partial u_{t-1}}, \; P_\varepsilon = \frac{\partial P}{\partial \varepsilon_t}$$

where the derivatives are taken at $\bar{y}$, $\bar{u}$ and $\bar{\varepsilon}$.

The first order approximation of the policy function is therefore:

$$\hat{g}(y^-_{t-1}, u_t) = \bar{y} + g_y \hat{y}^-_{t-1} + g_u \hat{u}_t$$

where $\hat{y}^-_{t-1} = y^-_{t-1} - \bar{y}^-$, $\hat{u}_t = u_t - \bar{u}$, and g_y and g_u are unknowns at this stage.

A first order approximation of (1A) around $\bar{y}$ and $\bar{u}$ gives:

$$f(\bar{y}^+, \bar{y}, \bar{y}^-, \bar{u}) + f_{y^+}[g^+_y(g^-_y \hat{y}^-_{t-1} + g^-_u \hat{u}_t) + g^+_u \mathbb{E}_t[P_u \hat{u}_t + P_\varepsilon \varepsilon_{t+1}]]$$
$$+ f_{y^0}(g_y \hat{y}^-_{t-1} + g_u \hat{u}_t) + f_{y^-}\hat{y}^-_{t-1} + f_u \hat{u}_t = 0$$

where g^+_y, g^-_y, g^-_u, g^+_u are the derivatives of the restrictions of g with obvious notation. Computing the expectancy term, taking into account the property of the deterministic steady state, and reorganizing the terms, we obtain:

$$(f_{y^+} g^+_y g^-_y + f_{y^0} g_y + f_{y^-})\hat{y}^-_{t-1} + (f_{y^+} g^+_y g^-_u + f_{y^+} g^+_u P_u + f_y g_u + f_u)\hat{u}_t = 0 \qquad (2A)$$

In the next step, we exploit this equation in order to recover the unknown coefficients g_y and g_u.

Recovering g_y, taking into account the term multiplying $\hat{y}^-_{t-1}$, equation (2A) imposes:

$$f_{y^+} g^+_y g^-_y + f_{y^0} g_y + f_{y^-} = 0$$

This amounts to:

$$f_{y^+} \hat{y}^+_{t+1} + f_{y^0} \hat{y}_t + f_{y^-} \hat{y}^-_{t-1} = 0 \qquad (3A)$$

Let S be the $n \times n^S$ submatrix of f_{y^0} where only the columns for static endogenous variables are kept, i.e. $S_{i,j} = f_{y^0,i,\zeta_j^s}$. A QR decomposition gives $S = QR$ where Q is an $n \times n$ orthogonal matrix and R an $n \times n^S$ upper triangular matrix.

For the model to be identified, we assume that:

$$rank(R) = n^s. \tag{4A}$$

Thus, equation (3A) can be rewritten as:

$$A^+ \hat{y}_{t+1}^+ + A^0 \hat{y}_t + A^- \hat{y}_{t-1}^- = 0 \tag{5A}$$

where $A^+ = Q' f_{y^+}$, $A^0 = Q' f_{y^0}$ and $A^- = Q' f_{y^-}$. By construction, columns of static endogenous variables in A^0 are zero in their lower part: $\forall i > n^s, \forall j \leq n^s,\ A_{i,\zeta_j^s}^0 = 0$. Non-static endogenous variables, taking only the n^d lower rows of system (5A), we get:

$$\tilde{A}^+ \hat{y}_{t+1}^+ + \tilde{A}^{0+} \hat{y}_t^+ + \tilde{A}^{0-} \hat{y}_t^- + \tilde{A}^- \hat{y}_{t-1}^- = 0 \tag{6A}$$

where $\tilde{A}^+$ (resp. $\tilde{A}^-$) contains the last n^d rows of A^+ (resp. A^-). Matrices $\tilde{A}^{0+}$ and $\tilde{A}^{0-}$ can be defined in two ways, depending on where we deal with mixed endogenous variables:

$\tilde{A}^{0+}$ is a submatrix of A^0 where only the last n^d rows and the columns for forward endogenous variables are kept ($\tilde{A}_{i,j}^{0+} = A_{n^s+i,\zeta_j^+}^0$), $\tilde{A}^{0-}$ is such that purely backward columns are taken from A^0 ($\tilde{A}_{i,\pi_j^-}^{0-} = A_{n^s+i,\zeta_j^{--}}^0$), and the rest is zero.

$\tilde{A}^{0-}$ is a submatrix of A^0 where only the last n^d rows and the columns for forward endogenous variables are kept ($\tilde{A}_{i,j}^{0-} = A_{n^s+i,\zeta_j^-}^0$), and $\tilde{A}^{0+}$ is such that purely forward columns are taken from A^0 ($\tilde{A}_{i,\pi_j^+}^{0+} = A_{n^s+i,\zeta_j^{++}}^0$) and the rest is zero.

The structural state space representation of (6A) is:

$$\underbrace{\begin{pmatrix} \tilde{A}^{0-} & \tilde{A}^{+} \\ I^{-} & 0 \end{pmatrix}}_{D} \begin{pmatrix} \hat{y}_t^{-} \\ \hat{y}_{t+1}^{+} \end{pmatrix} = \underbrace{\begin{pmatrix} -\tilde{A}^{-} & -\tilde{A}^{0+} \\ 0 & I^{+} \end{pmatrix}}_{E} \begin{pmatrix} \hat{y}_{t-1}^{-} \\ \hat{y}_t^{+} \end{pmatrix}$$

where I^{-} is an $n^{m} \times n^{-}$ selection matrix for mixed endogenous variables, such that $I^{-}_{i,\beta_i^-} = 1,$ and zero otherwise. Similarly, I^{+} is an $n^{m} \times n^{+}$ matrix, such that $I^{+}_{i,\beta_i^+} = 1,$ and zero otherwise.

Therefore, D and E are square matrices of size $n^{++} + n^{--} + 2n^{m}$.

Using the fact that $\hat{y}_{t+1}^{+} = g_y^{+} \hat{y}_t^{-}$, this can be rewritten as:

$$D \begin{pmatrix} I_{n^-} \\ g_y^{+} \end{pmatrix} \hat{y}_t^{-} = E \begin{pmatrix} I_{n^-} \\ g_y^{+} \end{pmatrix} \hat{y}_{t-1}^{-} \tag{7A}$$

where I_{n-} is the identity matrix of size n^{-}.

A generalized Schur decomposition (also known as the QZ decomposition) of the pencil (D, E) is performed:

$$\begin{cases} D &= QTZ \\ E &= QSZ \end{cases}$$

where T is upper triangular, S quasi upper triangular, and Q and Z are orthogonal matrices.

The decomposition is done is such a way that stable generalized eigenvalues (modulus less than 1) are in the upper left corner of T and S.

Matrices T and S are block decomposed so that the upper left block of both matrices is square and contains generalized eigenvalues of modulus less than 1, and the lower right block is square and contains generalized eigenvalues of modulus strictly greater than 1. From equation (7A) can be rewritten as:

$$\begin{pmatrix} T_{11} & T_{12} \\ 0 & T_{22} \end{pmatrix} \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_{n^-} \\ g_y^{+} \end{pmatrix} \hat{y}_t^{-} = \begin{pmatrix} S_{11} & S_{12} \\ 0 & S_{22} \end{pmatrix} \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_{n^-} \\ g_y^{+} \end{pmatrix} \hat{y}_{t-1}^{-} \tag{8A}$$

where T_{11} and S_{11} are square and contain stable generalized eigenvalues, while T_{22} and S_{22} are square and contain explosive generalized eigenvalues.

To exclude explosive trajectories, we impose:

$$\begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_{n^-} \\ g_y^+ \end{pmatrix} = \begin{pmatrix} X \\ 0 \end{pmatrix} \tag{9A}$$

which implies:

$$g_y^+ = -(Z_{22})^{-1} Z_{21}$$

the squareness of Z_{22} is the Blanchard and Kahn (1980) *order* condition (i.e. the requirement to have as many explosive eigenvalues as forward or mixed endogenous variables), and the non-singularity of Z_{22} is the Blanchard and Kahn (1980) *rank* condition.

Using equation (9A) and the fact that $\hat{y}_t^- = g_y^- \hat{y}_{t-1}^-$, equation (8A) implies:

$$\begin{pmatrix} T_{11} & T_{12} \\ 0 & T_{22} \end{pmatrix} \begin{pmatrix} X \\ 0 \end{pmatrix} g_y^- = \begin{pmatrix} S_{11} & S_{12} \\ 0 & S_{22} \end{pmatrix} \begin{pmatrix} X \\ 0 \end{pmatrix}$$

Then, using the fact that solving equation (9A) for X gives $X = (Z'_{11})^{-1}$, the upper part of this system gives the solution for g_y^-:

$$g_y^- = X^{-1} T_{11}^{-1} S_{11} X = Z'_{11} T_{11}^{-1} S_{11} (Z'_{11})^{-1}$$

Note that mixed variables appear in both g^+ and g^-: the corresponding lines will be equal across the two matrices by construction.

Static endogenous variables, the n^S upper lines of equation (5A) can be written as:

$$\breve{A}^{+}\hat{y}_{t+1}^{+} + \breve{A}^{0d}\hat{y}_{t}^{d} + \breve{A}^{0s}\hat{y}_{t}^{s} + \breve{A}^{-}\hat{y}_{t-1}^{-} = 0 \qquad (10A)$$

where $\breve{A}^{+}$ (resp. $\breve{A}^{-}$) contains the first n^{S} rows of A^{+} (resp. A^{-}). Matrix $\breve{A}^{0S}$ (resp. $\breve{A}^{0d}$) contains the first n^{S} rows and only the static (resp. non-static) columns of A^{0}. Recall that $\breve{A}^{0S}$ is a square upper triangular matrix by construction, and it is invertible because of assumption (4A). From equation (10A) can be rewritten as:

$$\breve{A}^{+}g_{y}^{+}g_{y}^{-}\hat{y}_{t-1}^{-} + \breve{A}^{0d}g_{y}^{d}\hat{y}_{t-1}^{-} + \breve{A}^{0s}\hat{y}_{t}^{s} + \breve{A}^{-}\hat{y}_{t-1}^{-} = 0$$

where g_{y}^{d}, the restriction of g_{y} to non-static endogenous variables, is obtained by combining g_{y}^{+} and g_{y}^{-}. We therefore have:

$$g_{y}^{s} = -\left[\breve{A}^{0s}\right]^{-1}\left(\breve{A}^{+}g_{y}^{+}g_{y}^{-} + \breve{A}^{0d}g_{y}^{d} + \breve{A}^{-}\right)$$

Recovering g_{u}, from equation (2A) restricted to $\hat{u}_{t}$ imposes:

$$f_{y^{+}}g_{y}^{+}g_{u}^{-} + f_{y^{+}}g_{u}^{+}P_{u} + f_{y}g_{u} + f_{u} = 0,$$

and be rewritten as:

$$(f_{y^{+}}g_{y}^{+}J^{-} + f_{y})g_{u} + f_{y^{+}}J^{+}g_{u}P_{u} + f_{u} = 0$$

where J^{-} (resp. J^{+}) is an $n^{-} \times n$ matrix (resp. $n^{+} \times n$ matrix) selecting only the backward (resp. forward) endogenous variables. In the particular case solved by Dynare, where $P_{u} = 0$, the solution to this equation is:

$$g_{u} = -(f_{y^{+}}g_{y}^{+}J^{-} + f_{y})^{-1}f_{u}$$

2. Review of children and elderly policy in Thailand

In this section, to capture the child and elderly public policies in Thailand. The review literature based on Office of the Civil Service Commission (2018) and Paitoonpong, Tasee, and Waisuriya (2016) as follows.

2.1 Child support policy

The Thai government has to implemented the child support programs mainly based on the provision of child subsidies (e.g., free education and child allowance) to provide incentives for child care.

2.1.1 Free Education

Under the 2007 constitution, children in Thailand are entitled to 12 years of free education. Under the National Education Act, B.E. 2542 (1999) and Amendment No. 2, B.E. 2545 (2002), children age from 6 to 15 years were required to take nine years education. That requirement was extended to 15 years in 2009, with free education provided from preschool to the high school level or vocational education, covering formal, non-formal, and informal education applicable to all children, including stateless and ethnic minority children and children of migrants. The policy covers payment of tuition fees (100 percent for public schools and subsidies for private schools), textbook, learning materials, school uniforms, and activities that promote quality improvement among students.

2.1.2 Universal child allowance

A person insured under the Social Security System (SSS) is entitled to a child allowance of 400 baht per child age 0-6 years, for a maximum of two children. In addition, the government in 2015 conducted a pilot project involving a non-contributory child allowance of 400 baht per month for a child from birth to one year of age, from 1 October 2015 to 30 September 2016. Eligible families are the income of not more than 30,000 baht a year (Pisitpaiboon, 2015). On 22 March 2016, the Cabinet decided to extend the child allowance from one year to three years and increase the allowance from 400 baht to 600 baht (Ministry of Social Development and Human Security, 2016).

2.2 Retirement benefits

The retirement benefits policy is focused on private sector employees (formal sector) and elderly persons as follows.

2.2.1 Private sector employees

1) Social security fund

Private sector employees are protected by the Social Security System (SSS) and the Workmen's Compensation Fund (WCF). The Social Security System established by the Social Security Act, B.E. 2533 (1990), provides mandatory insurance (Section 33) for employees in the private sector and regular migrant workers. The Social Security System also provides voluntary insurance (Section 39) for workers previously covered by SSS Section 33 and who are willing to continue the insurance (e.g. newly self-employed or retired persons) and voluntary insurance (Section 40) covering self-employed or informal economy workers.

Section 33 of SSS covers workers employed in non-agricultural establishments who are 15 years of age and older. Under the scheme, employers who have at least one employee must register their employee. The insured are entitled to benefits for non-occupational injury or illness (health care), maternity, becoming an invalid, death, unemployment, old age, and child allowance. The employer and employee each pay equal contributions of 5% of the worker's salary, whereas the government contributes an additional 2.75% to make a total contribution of 12.75% of the worker's salary. As a temporary measure to cope with the impact of the 2011 floods, the government in 2012 reduced workers and employer contributions from 5% to 3% for the first six months and from 5% to 4% for the last six months of 2012 (Social security office, 2018).

The Social Security System Section 39 covers individuals previously insured under Section 33 who have paid contributions for not less than 12 months, or ceased to be employees but wish to continue being insured. For a contribution of 432 baht per month (9% of the reference salary set at 4,800 baht), to be increased since the minimum wage is higher than 4,800 baht per month. The insured are entitled to six types of benefits (e.g. for non-occupational injury or illness, maternity, becoming an invalid, death, old age, and as a child allowance) (Social security office, 2018).

2) Workmen's compensation fund

Paitoonpong, Tasee, and Waisuriya (2016) studied Workmen's Compensation Act, B.E. 2537 (1994) mandates any employer who has at least one employee in any type of business to contribute to the Workmen's Compensation Fund (WCF). The scheme covers employees in the formal private sector and regular migrant workers. The insured are entitled to benefits in case of work-related injuries, death, illness, and disappearance (Social security office, 2018). The benefits provided by Workmen's Compensation Fund include monthly indemnities, medical and rehabilitation expenses, and funeral expenses.

3) Provident funds

The Provident Funds Act was enacted in 1987 to encourage private sector employees to save for their retirement. The fund is a voluntary benefit scheme between employers and employees who set up a fund committee to oversee the provident fund. The committee is composed of representation from the employer and elected representatives of the employee, with a fund manager selected by the committee. The Securities and Exchange Commission is the regulatory authority of the scheme. Employee's contributions are not lower than 3% but do not exceed 15% of their wages (Section 10 in Provident Funds Act of 1987). The employer's contributions must not be less than the employee's contributions. This requirement was revised through the amendment in 2015 of the Provident Funds Act of 1987. (Provident Fund Act No. 4, 2015) (International Labour Organization, 2015).

Employees received lump sum at the termination of their employment or upon retirement. Segregation of the fund as a distinct legal entity from the company is required. Contributions to the provident fund were tax deductible and the benefit payment is tax exempted (Provident Fund Act No. 4, 2015).

4) Private school teacher's welfare fund

The Private School Teacher's Welfare Fund (PSTWF) was introduced in 1974 through an amendment to the Private School Act of 1954. In 2008, the government enacted the Private School Act in which the PSTWF became a private entity run by a board of directors chaired by the permanent secretary of the Ministry of Education. The PSTWF provides a provident fund, welfare benefits, and financial assistance to private school directors, teachers, and staff. Monthly contributions (not exceeding 3% of the member's salary) are paid by the teacher, the school (equal to the member's contribution) and the Ministry of Education (twice the member's contribution) as the studied by Paitoonpong, Tasee, and Waisuriya (2016).

2.2.2 Elderly persons

The government policy promoting the quality of life of the elderly and their appropriate employment or activities include promoting home care, nursing homes and hospital care through cooperation involving the public sector, private sector, community and family as well as the fiscal system. (Bureau of empowerment for older persons, 2015)

1) Old-age living allowance

The old-age living allowance (OAA) is a universal non-contributory social assistance payment made by the government since 1993, on a temporary basis, to provide income for poor elderly persons. The allowance was later provided through the Old-age Act, B.E. 2546 (2003), which came into effect through the regulation on disbursement of Old-age Allowance, B.E. 2552 (2009). The scheme grants 500 baht per month to persons who are 60 years old. The elderly has registered and submitted an application to the local government to receive the old-age allowance. The elderly have their domicile registered in the local government district where they applied for the allowance, and who receive no other regular benefits from the government, including pension, care in a government welfare shelter, or other income or benefits (except persons with disabilities or living with HIV/AIDS). Since October 2011, the government has applied a stepwise program to increase the monthly allowance to 600 baht for those aged 60-69 years, to 700 baht (70-79 years), to 800 baht (80-89 years), and to 1,000 baht (90 years and older) (Schmitt, Sakunphanit, & Prasitsiriphol, 2013).

2) National savings fund

The National Savings Fund Act, B.E. 2554 (2011) started operations in August 2015 with the status of a juristic person, an independent entity which is not a government agency or a state enterprise. The fund is aimed at encouraging workers in the informal sector to save, with contributions coming from the government in amounts determined by the members' contribution and the member's age. Financing comes from the government and members' contributions. The intended beneficiaries are citizens aged 15-60 years old, not enrolled in other funds receiving contributions from the government and not under the pension systems of the government or the private sector (National Saving Fund, 2018). The fund covers workers in the informal sector, workers employed on a daily or weekly basis, temporary state enterprise employees, temporary government employees, students, and local politicians. Workers enrolled under Social Security System Section 40 (informal workers) can be transferred to the National Savings Fund on a voluntary basis (National Saving Fund, 2018).

A member has to save at least 50 baht at a time, but total savings may not exceed 13,200 baht per year. The government contributes progressively based on the age of the member consist of 50% of the savings but not exceeding 600 baht per year for members aged 15-30 years, 80% but not exceeding 960 baht per year for those aged 31-50 years, and 100% but not exceeding 1,200 baht per years for those more than 50 years old. The NSF member will obtain the following benefits lifetime pension upon reaching the age of 60. Firstly, a lump sum payment composed of own savings and interest in case elderly becomes disabled before the age of 60. Secondly, the government's contribution and interest upon reaching the age of 60. It accumulated savings and interest in case the member quits before reaching the age of 60, and the member's beneficiaries. Lastly, the member's savings plus the government's contribution and interest in the case of death (National Saving Fund, 2018).

2.3 Mandatory retirement age policy

The mandatory retirement age for government and state enterprise officials will be extended from 60 to 63 under a national reform plan that took effect on Thailand addresses problems associated with being aging society (Office of the Civil Service Commission, 2018). The move is part of a plan that will also see measures put in place to encourage elderly state officials to continue their duties until later life. However, policy is taken six years to fully implement the later retirement age. This will not be in full effect until 2024. “Under the plan, civil servants who turn 60 in 2019 or 2020 will continue to work for one more year. Those who were due to retire at age 60 in 2021 or 2022 will stay on in office until they reach 61, while those who turn 60 in 2023 or 2024 will be able to work until they are 63. “After 2024, the mandatory retirement age for all government officials will be 63. The plan will not impact the recruitment of new officials to replace those who are set to retire. The Office of the Civil Service Commission and the Office of the Public Sector Development Commission are responsible for implementing the plan. Thus, the policy maker will conduct a study to determine which civil service positions should be granted the extension and amend the law governing their pension plans. The measures were published in the Royal Gazette on 6 April 2018, one year after the latest charter was promulgated (Office of the Civil Service Commission, 2018).

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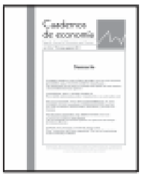

ARTÍCULO

Macroeconomic Impact of Mandatory Retirement Age Policy to Population Aging in Thailand

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Abstract: This paper develops a stochastic overlapping generations (OLG) model to investigate the effects of mandatory retirement age policy in an aging economy. The model has been constructed using a calibration and simulation approach with a view to analyze the impact of extending the retirement age on macroeconomic variables in Thailand. The results show that a higher mandatory age of retirement is always beneficial in the long run for PAYG pension budgets, government transfers for the elderly, and lifetime consumption. In this way, the future generations enjoy more consumption than the current generations. On the contrary, the policy of increasing the mandatory age may be harmful not only in the long run-in terms of capital accumulation but also in terms of the output. The mechanisms for driving this are two-fold: (1) there is a direct positive effect consisting in an increase of labor supply and lower the length of the retirement period and (2) there is an indirect effect due to the negative change in the wage.

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1. Introduction

In recent years, much attention has been paid to the macroeconomic consequences of population aging across the world. Low fertility rates and high life expectancy are two primary determinants influencing this global trend. These have shifted the age structure toward a greater share of the elderly. In 2017, some ASEAN members, i.e., Singapore, Thailand, and Vietnam are qualified as aged societies. It has been estimated that the elderly population (age 60 or over) is increasing at the rate of 4% per year, and the share of the oldest cohort (age 80 or over) is increasing at an even faster rate (6% per year ((TGRI), 2018)((TGRI), 2018) The rapid change in the demographic structure of the Thai population poses major challenges to the country's economic development (National Statistical Office, 2016) In general, the rise in the dependency ratio stems from two factors: (1) a decline in the fertility rate, and (2) an increase in longevity. The aforementioned factors have highly deteriorated the Thai population's aging. By looking at these two factors separately (Table1), the consequences of lower fertility and greater longevity, the study has been able to offer key implications for policymakers.

Population projections for Thailand conducted by the (NESDB, 2013) predicted that the total fertility rate of Thai people will be declining further from 1.6 in 2015 to 1.3 in the next 20 years. Life expectancy will, in all likelihood, be in an upward trend from 74 years at present to 80 years in the next twenty years (NESDB, 2013) Combined with the fact that people born between 1963 and 1983 are now becoming elderly, a precipitous increase in the rate of population aging in the near future can be expected (Prasartkul, 2013)The dependency ratios of the elderly population in Thailand will reach 54% in 2050, which will be above the average for Southeast Asian countries (26.6%), and the country will be ranked 24th in the highest old-age dependency ratios in the world (Scherbov et al., 2018)

Table 1 Total fertility rate and elderly survival rates in Thailand

Year	Total fertility rate (Per woman)	The survival rate of 60-80 age (percentage)	Life expectancy (years)
1950-1955	6.4	-	52.0
1975-1980	4.0	-	61.4
2000-2005	2.0	36.0	70.8
2025-2030	1.9	49.5	76.8
2045-2050	1.9	56.4	79.1

Source: Population Division, DESA, United Nations (2017)

Thailand's total fertility rate has now reached an extremely low level (Jones, 2011)This has resulted in a change in the population age structure which will significantly lessen the size of the labor force of the country in the next two decades. In 2018, there were 10.67 million people who were part of the elderly population (60 years and over) and remained working in the labor market at 4.36 million people (Offic, 2019) This number is likely to increase continuously (Table 2). Among Thai workers, when people reach a retired age (mostly at the age of 60) they will most likely exit the labor force, so it will be difficult for them to earn their own income. The rapid increase in the number of the elderly and monetary inflation may lead to a situation of dire poverty for a large portion of the elderly in the future (Prasartkul et al., 2019) Thus, Thailand needs to initiate measures to mitigate the impact of a shrinking labor force with other policy options, which can be undertaken feasibly. At present, Thailand already has a pension scheme for retired officials, while for some retired workers in higher-paid private sectors, a social security fund has been established. Recently, the government has set up the old-age living allowance to provide a welfare allowance of around 600-1,000 baht per month to elderly individuals. To receive this allowance, those aged 60 years and above must register at the local administrative organization where they are residents. Those who are eligible must be neither governmental nor non-governmental organization retirees (Gazette., 2018)

Another policy is retaining the elderly in the labor force. Recently, the government will be reforming the mandatory retirement age by lengthening the retirement age from 60 years to 63 years for government and state enterprise officials. This policy was adopted in 2019 (Commission, 2018). In this study, we will only focus on the effect of retirement age policy reform

Table 2 Number of older workers (60 years and over) in Thailand.
Unit: million persons

Year	Total population aged 60 years and over*	Total older workers**	Formal employment	Informal employment
2007	6.71	2.77	0.26	2.51
2008	6.90	2.80	0.25	2.55
2009	7.18	3.07	0.28	2.80
2010	7.49	3.05	0.27	2.78
2011	7.81	3.24	0.31	2.92
2012	8.17	3.40	0.35	3.06
2013	8.73	3.45	0.32	3.13
2014	9.11	3.84	0.38	3.46
2015	9.46	3.91	0.43	3.48
2016	9.80	4.02	0.45	3.56
2017	10.23	4.06	0.48	3.59
2018	10.67	4.36	0.51	3.85

Source: *Department of Provincial Administration, Ministry of Interior (2019)
**The Informal Employment Survey, National Statistical Office, Ministry of Digital Economy and Society (2019)

Based on the background that has been described by the author, the purpose of this paper is to investigate the impact of mandatory retirement age policy on the macroeconomy in Thailand. Given the population aging in Thailand, this paper develops a dynamic stochastic general equilibrium (DSGE) model with the OLG framework to explore the effects. The OLG model based on the study of Cipriani (2016) to support the study of population aging are the uncertainty of the time of death (longevity) and retirement. With the OLG model at hand, this paper first obtains the simulated impact of a lengthening of retirement age on the economy and sets the simulated do-nothing policy as the benchmark model (full retirement). This paper then obtains a sensitivity analysis of the length of the retirement period and compares the results with that of the benchmark model to draw conclusions.

2. Literature Review

There is a vast amount of literature exploring the link between demographic composition and economic activity. Starting with the work by Auerbach (1987), the large-scale OLG model improves the period under the two-period OLG because the whole population can be separated into any age group along the year since birth. Additionally, it departs from the finite household from the assumption of infinite life in a representative household by assuming that the last group is restricted to die. Although this framework is more realistic than the two-period OLG, the yearly period provides such little frequency that details of analyzing temporary shocks are not represented under this framework. Their model is used to evaluate the impact of demographic transitions on economic activity in the U.S. economy. They demonstrate that the OLG model is considered to be the workhorse model for analyzing the economic consequences of demographic transitions and the associated fiscal policy. Miles (1999) also utilizes an OLG model to explore the demographic impact, focusing on the U.K. and European countries. Within a growth accounting framework, for instance, Angela Maddaloni et al. (2006) analyzes the effects of population aging on economic growth, financial markets, and public finance in the Euro area, taking into consideration the fertility rate, longevity, and immigration.

However, while the literature has developed (especially in the framework of the two-period OLG model) a normative analysis of the optimal retirement age (Hu, 1979; Michel & Pestieau, 2013) as well as models of political games for voting on the age of retirement (Casamatta et al., 2005; Conde-Ruiz & Galasso, 2004). However, what seems to be less extensively investigated is a positive analysis of the effects of the often-advocated mandatory postponement of the retirement age on both economic growth and sustainability of PAYG pension systems. In most countries, especially in Europe and Japan, retirement is compulsory (i.e. workers must retire at the fixed age by law to obtain a pension transfer). But, in the U.S., old agents can contemporaneously work and receive a pension transfer. Jorgensen and Jensen (2010) employed the DSGE model with the OLG framework to study a policy rule for the retirement age aiming at offsetting the effects on the supply of labor following fertility changes in the context of Brazilian population aging. This study found that the retirement age should increase more than proportionally to the direct fall in labor supply caused by a fall in fertility.

Recently, the effect of raising the retirement age policy on the economic growth and sustainability of the PAYG pension system has drawn a lot of attention from researchers. Fanti (2014) studied the effects of raising the mandatory age in the OLG model. This study found that early retirement reduces economic growth (i. e. GDP) and poses a threat to the PAYG pension system viability is warranted, obtaining the following result: when the capital share is sufficiently high, a reduction in the retirement mandatory age may favour economic growth and even pension payments. Indeed, it is shown that short-run and long-run effects may be of opposite sign: a postponement of retirement increases the GDP in the short run, but this positive effect considers only the generation which is young at the time of postponement. For any subsequent generation, the GDP is reduced, rapidly approaching the lower long-run level. Thus, one policy implication is that in developed countries beset by strong population aging, the compulsory raising of the retirement age might not, in the long run, be the appropriate policy to keep the PAYG pension budget balanced.

Hsu (2017) studied the multigenerational OLG model to investigate the effects of four reform programs aiming to enhance the sustainability of the pension system in Taiwan. Scenario simulations were 1) an increase in pension contribution, 2) a reduction in pension benefit, 3) an extension of mandatory retirement age, and 4) a combination of program 2) and 3). As a result, an extension of mandatory retirement age does less harm to the current generations' lifetime utility, but the extension gradually improves future generations' lifetime utility. On the contrary, an increase in pension contribution reduces the lifetime utility of the current generation without benefitting the future generation.

In addition, Cipriani (2016) also studied endogenous retirement decisions when there is a PAYG social security system in an aging economy with the OLG model. As a result, the effects of aging on pensions may not be negative if the elderly are free to choose their retirement age. The negative effect on pensions in the specific case of full retirement. Like, Chen (2016) employed exogenous retirement age in the OLG framework. This study found that an increase in the fertility rate may raise pensions when the output elasticity of capital is low. From a different perspective, Cipriani (2014) showed that aging has always had a negative effect on pension benefits.

Thailand's population aging has been investigated by using the OLG model in past works. The first study we consider focuses on technological progress which helps to improve the aggregate productivity to offset the decline in the number of workers and work hours. Technological progress plays an important role in providing a buffer against the negative impact of what would happen (Bisonyabut, 2012). The second, Cheewatrakoolpong and Boonprakaikawe (2010) focuses on the effects of population aging on economic growth with the reform pension system. The study called for investing in pension tax in public education in order to build up human capital accumulation. The numerical method simulated the effect of several pension systems on the economic variables and is calibrated with Thailand's data during 1980-2008. This study found that the mandatory public pension system yields the highest economic growth, saving, output per effective labor, and capital per effective labor in the balanced growth path. Also, the mandatory public pension system is the best for economic growth because informal family support for the elderly in other systems leads to a lower amount of saving and capital accumulation which in turn brings about lower economic growth and output per capita.

Furthermore, Hsu et al. (2015)applied the DSGE model with the OLG framework to examine the effects of population aging and informal employment across three tax options for financing the universal health insurance coverage (UHI) in Thailand. The simulated numerical method found that when labor income tax is used to finance the cost of UHI, an additional 11-15% of labor tax will be required with the 2050 population age structure compared with the 2005 benchmark economy. As results showed, an expansion of income tax base to the informal sector could substantially alleviate the tax burden. Based on welfare comparisons across alternative tax options, the labor income tax will be the most preferred because the informal labor sector was large. If the informal sector could not avoid labor income tax, the capital tax will be preferred over labor and consumption taxes.

Another empirical study, for example, Adhikari, (Adhikari et al., 2011) studied the factors affecting labor force participation among the elderly in Thailand. The analysis was used to the logistic regression model with the data from the survey of older persons in 2007. Study results found that place of residence, functional status, and the number of chronic diseases were the most significant predictors. The health status of the elderly was necessary to encourage employment among older persons. Like, Chansarn (2013)investigated the determinants of the economic preparation for retirement by utilizing binary logistic regression analysis. This study found that, on average, the working-age population aged 50 - 59 years old in Thailand had moderate economic preparation for retirement. Moreover, the finding also revealed that age, income, income sufficiency, year of schooling, and health condition had positive influences on the opportunity to have above-average economic preparation for retirement. These studies have recommended the government to carry out an effective campaign for promoting the awareness of the necessity of economic preparation for retirement in order to encourage working-age people to prepare for retirement in advance. By doing so, Thailand will be able to enjoy the economic benefit from the increasing proportion of the old-age population who will become the source of sustainable economic growth of the nations in an aging society.

In summary, the prime question in the investigation of the effects of mandatory retirement age on the economy is as follows; "Is a mandatory postponement of the retirement age really beneficial for the pension system? If so, how could it happen?" The OLG model has been applied intensively in the search for answers to the key research question of this study. Usually, it is used to explore the impacts of population aging on the pension system (e.g. see Cipriani (2016) for an introduction) However, not much of the existing literature on the subject investigates the effect of a lengthening of retirement age on macroeconomic variables. The paper aims to bridge this gap by incorporating exogenous retirement decisions into an OLG model setting and uses this approach to investigate the effects of retirement age policy reform.

3. The Model

The model presented in this section is a stochastic OLG model that allows us to analyze the effect of a lengthening of the mandatory retirement age policy on macroeconomic variables. There are four sectors in the economy: households, firms, the government, and the social security system. There is a representative individual for each generation in the household sector. Each individual has a fixed lifetime up to the age of 80. Each individual with an age less than 14 is nurtured by parents and receives education. The individual starts working at the age of 15 and retires at age 60. Each individual earns wage income and builds up savings for old age. The representative agent maximizes the intertemporal utility function with consumption. Firms maximize profits. The government collects taxes with a balanced budget. The social security system, that is, the pension sector collects social security contributions rate and runs a balanced budget.

A period, t, in the model corresponds to one year. At each time period, a new generation of households is born. These models consider only the working and retired generations. Newburn's have a real-life age of 15, corresponding to the working-age group in the model. So, retire at age 60 and lives up to a maximum age of 80, corresponding to the elderly group in the model. From age 60 to 79 years, 20 different generations coexist. At t, all agents of age j survive until age $j+1$ with probability p_{jt}, where $p_{60t}=1$ and $p_{80t}=0$, $j=60,61,\ldots,80$. This study uses the officially published survival probability of Thailand estimated by the Nations. (2017)

The policy of a lengthening of the mandatory retirement age model presents an extended retirement age from 60 to 63 years. This study has been conducted under labor supply and retirement decisions exogenously determined.

4. Households

The young population N_t grows at a constant fertility rate g_{t-1} and agents are assumed to belong to an OLG structure with finite lifetimes. Adult life is separated into two periods: young and old age. Individuals belonging to generation t have a conventional logarithmic utility function defined over young age (c_{1t}) and old age consumption $(c_{2,t+1})$. Each person born at (the beginning of period) t lives for two periods and provides one unit of labor per period.

In the first period, t, he or she works full time, earning a wage income of w_t while paying a labor income tax rate t_{wt} and a social security tax according to the contribution rate t_{pt} (Equation 2).

In the second period, $t+1$, he or she works a fraction of the time (l_t), and then retires (i.e. when $l_t=0$ each person is retired for the whole second period of life, which is the assumption of the conventional OLG model of Diamond (1965) During old age, agents' earnings, therefore, consist of (1) the savings (s_t) plus the accrued interest at the rate $\frac{R_{t+1}}{p_t}$, (2) the net wage income of $(1-t_{wt}-t_{pt})w_{t+1}l_t$, (3) the pension of $(1-l_t)P_{t+1}$, which is publicly provided and financed at a balanced budget by the social security system, and (4) the government transfers for elderly (Tr_t) (Equation 3). The length of the retirement period $(1-l_t)$ is mandatory fixed by the government.

Thus, the representative individual faces the following utility function as

$$U=\ln c_{1t}+bp_t\left(\ln c_{2,t+1}+g\ln(1-l_t)\right) \tag{1}$$

The first period budget constraint is

$$c_{1t}+s_t=(1-t_{wt}-t_{pt})w_t \tag{2}$$

The second period budget constraint is

$$c_{2,t+1}=\frac{R_{t+1}}{p_t}s_t+(1-t_{wt}-t_{pt})w_{t+1}l_t+(1-l_t)P_{t+1}+Tr_t \tag{3}$$

By combining constraints in the first and second period, the lifetime budget constraint of the individual is

$$(1-t_{wt}-t_{pt})w_t+\frac{p_t(1-t_{wt}-t_{pt})w_{t+1}l_t}{R_{t+1}}+\frac{p_t(1-l_t)P_{t+1}}{R_{t+1}}+\frac{p_tTr_t}{R_{t+1}}=c_{1t}+\frac{p_t}{R_{t+1}}c_{2,t+1} \tag{4}$$

Firms

Concerning the production sector, competitively firms have the Cobb-Douglas technology of production is

$$Y_t=A_tK_t^{a}L_t^{1-a} \tag{5}$$

where Y_t, K_t, and L_t denote aggregate output, capital stock, and labor in the economy in the period t, respectively, A_t is the exogenous process for the technology productivity and α is the capital share of output, $0 < \alpha < 1$.

The time t labor force (labor input) is $L_t = N_t + p_{t-1}N_{t-1}l_t$, consists of the working-age and elderly group. It can be written as

$$L_t = \left(1 + g_{t-1} + p_{t-1}l_t\right)N_{t-1} \tag{6}$$

Population N_t grows at a constant fertility rate g_{t-1} or $N_t = \left(1 + g_{t-1}\right)N_{t-1}$.

The intensive form production function may be written as $y_t = A_t k_t^{\alpha}$. As usual, it is assumed that physical capital totally depreciates at the end of each period and that the price of the final output is normalized to one. Profit maximization problem is written as

$$\max_{\{K_t, L_t\}} \Pi_t = A_t K_t^{\alpha} L_t^{1-\alpha} - R_t K_t - W_t L_t \tag{7}$$

Profit maximization then leads to the following marginal conditions for capital and labor, respectively:

$$f\left(k_t\right) - k_t f'\left(k_t\right) = w_t \tag{8}$$

$$\left(1 - \alpha\right)A_t k_t^{\alpha} = w_t \tag{9}$$

$$f'\left(k_t\right) = R_t \tag{10}$$

$$\alpha A_t k_t^{\alpha - 1} = R_t \tag{11}$$

Equation (9) shows that the marginal product of labor is equal to the wage, and equation (11) shows that the marginal product of capital is equal to the rental rate.

5. Government Sector

The government collects income tax to finance its expenditures on government consumption $\left(G_t\right)$ and transfers for elderly people $\left(Tr_t\right)$. The government's tax revenues $\left(T_t\right)$ are given by

$$T_t = t_{wt} w_t L_t \tag{12}$$

$$T_t = t_{wt} w_t \left(1 + g_{t-1} + p_{t-1}l_t\right)N_{t-1} \tag{13}$$

And the government transfer for elderly people $\left(Tr_t\right)$ is given as

$$Tr_{t-1} p_{t-1} N_{t-1} = t_{wt} w_t L_t \tag{14}$$

Equation (14) shows that the left-hand side represents the government expenditure for transfer payment for the elderly and the right-hand side the tax receipts. This scheme leads to the following:

$$Tr_{t-1} = \frac{t_{wt} w_t \left(1 + g_{t-1} + p_{t-1}l_t\right)}{p_{t-1}} \tag{15}$$

Also, the government transfer can be written in the period t as

$$Tr_t = \frac{t_{wt+1} w_{t+1} \left(1 + g_t + p_t l_t\right)}{p_t} \tag{16}$$

where t_{wt} is the labor income tax rate, w_t is wage, and labor force is given by $L_t = \left(1 + g_{t-1} + p_{t-1}l_t\right)N_{t-1}$, when N_t represents young worker and N_{t-1} old worker.

In addition, g_{t-1} is the exogenous fertility rate and p_t is the probability of survival to the last period of life (longevity).

By assuming that the government runs the balanced budget, it can be written as:

$$G_t + Tr_t = T_t \tag{17}$$

Social Security System

The pension sector runs a defined contribution pay-as-you-go social security scheme with a balanced budget. Hence, social security tax $\left(t_{pt}\right)$, both for the young and the old individuals, and to pay a pension for the retired $\left(P_{t+1}\right)$. Therefore, pension benefits are

$$\left(1 - l_t\right)P_t p_{t-1} N_{t-1} = t_{pt} w_t L_t \tag{18}$$

or it can be written as

$$\left(1 - l_t\right)P_t p_{t-1} N_{t-1} = t_{pt} w_t \left(1 + g_{t-1} + p_{t-1}l_t\right)N_{t-1} \tag{19}$$

Concerning equation (19), as shown, the left-hand side represents the social security expenditure, and the right-hand side represents the tax receipts. This scheme leads to the following formula for pension benefits:

$$P_t = \frac{t_{pt} w_t \left(1 + g_{t-1} + p_{t-1}l_t\right)N_{t-1}}{p_{t-1}\left(1 - l_t\right)N_{t-1}} \tag{20}$$

or it can be written as

$$P_{t+1} = \frac{t_{pt+1} w_{t+1} \left(1 + g_t + p_t l_t\right)}{p_t\left(1 - l_t\right)} \tag{21}$$

Equation (21) shows the rate of return on the PAYG pension system is equal to $\dfrac{\left(1 + g_t + p_t l_t\right)}{p_t\left(1 - l_t\right)}$.

Market Equilibrium and Model Solution

The household maximizes (1) subject to the budget constraint (2) and (3) taking wage, the interest rate, and the pensions benefit as given. After substituting for P_{t+1} from (21), the first order condition with respect to savings is

$$c_{2,t+1} = bR_{t+1}c_{1,t} \tag{22}$$

Equation (22) is the consumption Euler equation. It can be written as $\dfrac{c_{2,t+1}}{bc_{1,t}} = R_{t+1}$, where the left-hand side of the equation is the *marginal rate of intertemporal substitution* between consumption in old age and consumption in young age (MRIS ($c_{2,t+1}, c_{1,t}$)) and the right-hand side is the *marginal rate of intertemporal transformation* (and measures the rate at which one unit of currency can be transferred into the future; in other words, it measures the return on savings).

By substituting equation (2) and (3) in equation (22), the following equation can be obtained as

$$\frac{R_{t+1}}{p_t}s_t + \left(1 - t_{wt} - t_{pt}\right)w_{t+1}l_t + \left(1 - l_t\right)P_{t+1} + Tr_t = bR_{t+1}\left(\left(1 - t_{wt} - t_{pt}\right)w_t - s_t\right) \tag{23}$$

$$s_t = \frac{\left(1 - t_{wt} - t_{pt}\right)\left(bR_{t+1}w_t - w_{t+1}l_t\right) - \left(1 - l_t\right)P_{t+1} - Tr_t}{\dfrac{R_{t+1}}{p_t}\left(1 + bp_t\right)} \tag{24}$$

Using equation (16) and (21) to substitute in equation (24), the first order conditions with respect to savings (s_t) is written as

$$s_t = \frac{(1-\tau_{wt}-\tau_{pt})(bR_{t+1}w_t - w_{t+1}l_t) - \frac{(\tau_{pt}+\tau_{wt})w_{t+1}(1+g_t+p_t l_t)}{p_t}}{\frac{R_{t+1}}{p_t}(1+bp_t)} \qquad (25)$$

Equation (25) shows the effect of a lengthening of the working period on savings. A lengthening of the working period (i.e. a mandatory increase in the retirement age) reduces savings (as regards wage and interest rate), $s_{lt} = \frac{\partial s_t}{\partial l_t} < 0$.

The rationale behind this is that when the working period in old age is reduced, individuals' saving is higher allowing him or her better sustain consumption for retirement. Indeed, the length of such a period is increased jointly with the reduction in old age wage income.

In addition, the market-clearing condition in goods as well as in capital markets is expressed by the equality

$$K_{t+1} = N_t S_t \qquad (26)$$

or, in per worker terms, the dynamic of capital is written as

$$\frac{K_{t+1}}{L_{t+1}} = \frac{N_t S_t}{L_{t+1}} \qquad (27)$$

$$k_{t+1} = \frac{N_t s_t}{(1+g_t+p_t l_t)N_t} \qquad (28)$$

$$k_{t+1} = \frac{s_t}{1+g_t+p_t l_t} \qquad (29)$$

while equation (29) shows how future capital is linked to current savings with a PAYG system.

By substituting s_t from (24) into equation (29), exploiting (9) and (11), and assuming that households have perfect foresight, the dynamic equilibrium sequence of capital is determined by

$$k_{t+1} = \frac{(1-\tau_{wt}-\tau_{pt})(bR_{t+1}w_t - w_{t+1}l_t) - (1-l_t)P_{t+1} - Tr_t}{\frac{R_{t+1}}{p_t}(1+bp_t)(1+g_t+p_t l_t)} \qquad (30)$$

$$k_{t+1} = \frac{(1-\tau_{wt}-\tau_{pt})(bR_{t+1}w_t - w_{t+1}l_t) - (\tau_{pt}+\tau_{wt})\frac{w_{t+1}(1+g_t+p_t l_t)}{p_t}}{\frac{R_{t+1}}{p_t}(1+bp_t)(1+g_t+p_t l_t)} \qquad (31)$$

We can get the dynamic of capital as

$$k_{t+1} = \frac{1}{(1+bp_t)}\left[\begin{array}{l} bp_t(1-\tau_{wt}-\tau_{pt})(1-\alpha)A_t k_t^{\alpha}\left(\frac{1}{1+g_t+p_t l_t}\right) \\ -k_{t+1}\frac{(1-\alpha)\left((1-\tau_{wt}-\tau_{pt})p_t l_t + (\tau_{pt}+\tau_{wt})(1+g_t+p_t l_t)\right)}{\alpha(1+g_t+p_t l_t)} \end{array}\right] \qquad (32)$$

Assuming perfect foresight, the steady state implies $k_{t+1} = k_t = k^*$. We can get the steady-state value of k^* from equation (32) as

$$k^* = \left[\frac{\alpha(1-\alpha)pbA}{\left(\alpha(1+bp)+\tau_p+\tau_w\right)(1+g+pl_t)+(1-\alpha)pl_t}\right]^{\frac{1}{1-\alpha}} \qquad (33)$$

Equation (33) shows that capital accumulation is always reduced by raising the mandatory retirement age.

The steady-state value of output is written as

$$y^* = A\left[\frac{\alpha(1-\alpha)pbA}{\left(\alpha(1+bp)+\tau_p+\tau_w\right)(1+g+pl_t)+(1-\alpha)pl_t}\right]^{\frac{\alpha}{1-\alpha}} \qquad (34)$$

Equation (34) recalling from equation (33), $\frac{\partial k^*}{\partial l_t} < 0$ that an increase in the retirement age may reduce long-run output.

The steady-state value of saving is written as

$$s^* = (1+g+pl_t)\left[\frac{\alpha(1-\alpha)pbA}{\left(\alpha(1+bp)+\tau_p+\tau_w\right)(1+g+pl_t)+(1-\alpha)pl_t}\right]^{\frac{1}{1-\alpha}} \qquad (35)$$

Equation (35) shows that savings is reduced by raising the mandatory retirement age.

We can get the steady-state value of pension from equation (21) as

$$P^* = \frac{\tau_p w^*(1+g+pl_t)}{p(1-l_t)} \qquad (36)$$

or it can be written as

$$P^* = \frac{\tau_p(1-\alpha)A}{p(1-l_t)}\left[\frac{\alpha(1-\alpha)pbA}{\alpha(1+bp+g)+\tau_p+\tau_w+pl_t}\right]^{\frac{\alpha}{1-\alpha}}(1+g+pl_t)^{\frac{1-2\alpha}{1-\alpha}} \qquad (37)$$

Equation (36) and (37) reveal that the effect of an increase in the retirement age on the long-run pension payment depends on two things (1) a direct effect due to the length of the retirement period and (2) an indirect effect due to wage.

We can get the steady-state value of government transfers from equation (16) as

$$Tr^* = \frac{\tau_w(1+g+pl_t)}{p}(1-\alpha)Ak^{*\alpha} \qquad (38)$$

or it can be written as

$$Tr^* = \frac{\tau_w(1+g+pl_t)}{p}(1-\alpha)A\left[\frac{\alpha(1-\alpha)pbA}{\left(\alpha(1+bp)+\tau_p+\tau_w\right)(1+g+pl_t)+(1-\alpha)pl_t}\right]^{\frac{\alpha}{1-\alpha}} \qquad (39)$$

Equation (39) shows the effect of an increase in the retirement age on the long-run government transfers depending on the length of the retirement period.

Exogenous Process

The random variation in l_{u} capture respectively shock to the policy of a lengthening of retirement age. This shock follows the stochastic processes:

$$\ln Z_{u,t} = \rho_{l} \ln Z_{u,t-1} + u_{u,t}$$

$$, u_{u,t} \sim N\left(0, s_{u}^{2}\right) \quad (40)$$

where r_{u} measures the persistence of those shocks, and $u_{u,t}$ is $i.i.d., \sim N\left(0, s^{2}\right)$.

6. Calibration and Simulation

This study selects the values of parameters based on empirical findings of the Thai economy and other developing countries it deems necessary. Most parameters, otherwise specified, follow Tanboon (2008a) which corresponds firmly to stylized facts of the Thai economy, and many studies relevant to the OLG model provide a strongly consistent basis for policy analysis in Thailand's economic environment. Their value can be summarized in Table 3 below.

A number of parameters are excluded from the estimation and need to be calibrated. This is because they are either notoriously difficult to estimate or can be better identified using other information.

Firstly, the calibration of aging parameters is based on a period of one year. Agents are born at the real lifetime age of 15 which corresponds to $t = 1$. They work $T = 45$ years corresponding to a real lifetime age of 59. They live a maximum life of 60 years $\left(T^{*} = 20\right)$ so that agents do not become older than real lifetime age 80. We use the same survival probabilities that are presented by United Nations (2017), p which is set equal to 0.473.

Secondly, the discount factor for households $\left(b\right)$ is fixed at 0.9926 which implies an annual interest rate of 3% in line with Tanboon (2008a). The household's elasticity of labor supply is calibrated by Tanboon (2008b) g is set equal to 3.0303.

Thirdly, the capital income share $\left(a\right)$ is set equal to 0.328 according to Cheewatrakoolpong and Boonprakaikawe (2010)'s calculation based on data from the National Statistical Office and the National Economic and Social Development Board for 2003 to 2008.

Fourthly, for the government sector, the parameter t_{w} or the labor income tax rate is set equal to 0.10 which is the rate for the middle-class taxpayer in Thailand. In addition, the parameter l_{i} represents the mandatory retirement age policy. In this study, it is set equal to 0.066 for raising the retirement age to 3 years according to the Office of the Civil Service Commission (2018). Assume he/she works a fraction l_{i} of the time, we may interpret $1 + l_{i}$ as the total time devoted to labor over the life-cycle while, of course, the length of retirement is $\left(1 - l_{i}\right)$. This also means that, for instance, by assuming conventionally one period of 45 years and an age of entry in adult life (i.e. in the labor market) of about 15 years, then the age of retirement would be 60 years when $l_{i} = 0$, 63 years when $l_{i} = 0.066$, 65 years when $l_{i} = 0.110$, and so on as in Fanti (2014).

Finally, the social security system $\left(t_{p}\right)$ represents the degree of pension contribution rate is set equal to 6 per cent from employer and employee each paying equal contributions of 3 per cent of the worker's salary according to the Social Security Act, B.E. 2533 (1990), provides mandatory insurance (Section 33) (Paitoonpong et al. (2016)

We do estimate standard Solow's procedure to obtain the shock from the residual with retirement age policy. This is done to estimate the use of data on the number of older workers (60 years and over) from the Thai Informal Employment Survey. This is done by taking the log values for the older workers at annual frequencies for 2007-2018 (Offic, 2019) We obtained a value of standard deviation which is equal to 0.0881 and the autocorrelation coefficient which is equal to 0.9758 $\left(r_{A}\right)$. The technological growth parameter A_{t} is equal to 2.4 per cent per year according to Sutthasri's (2007) calculation based on data from 1978 to 2006. This value is comparable with Chuenchoksan and Nakornthab (2008) finding that Thailand's total factor productivity (TFP) growth is 1.8 per cent over 1987-1996 and 2.0 per cent over 2000-2007 (the average TFP growth during the financial crisis years registers -6.7 per cent).

Table 3 Calibration of the model

Parameter	Value	Interpretation	Reference
Aging parameter			
p	0.473	the probability of survival rate	Thai data, UN (2017)
Household			
b	0.9926	discount factor	Tanboon (2008a)
g	3.0303	the parameter measuring preference for leisure or retirement	Tanboon (2008a)
Firm			
a	0.328	capital income share	Cheewatrakoolpong and Boonprakaikawe (2010)
Government			
t_{w}	0.10	labor income tax rate	Thai policy (2018)
l_{i}	0.066	raising retirement age 3 year	Thai policy (2018)
		(fraction of the work times)	
Social security system			
t_{p}	0.06	social security tax (or pension contribution rate)	Thai policy (2018)

Source: Author's study

7. Results and Discussions

7.1 Long-Run Effects

In this section, we compare the long run of a mandatory retirement economy with a lengthening of the retirement age from 60 to 63 years by aggregate outcomes. Aggregate variables and factor prices for steady states are presented in Table 4.

Table 4 shows that the length of the retirement period assumes a rather complicated role. In particular, postponement of the retirement age has (1) a direct effect consisting of an increase in pension benefits first because pensions must be paid for a shorter period and secondly, because the composite number of contributions (which includes both the young and old generation) is raised due to the increased number of old workers and (2) an indirect effect due to the negative change in the wage induced by such a postponement. In regard to the latter effect, a change in the retirement period affects wages through two channels: (1) the effects on the capital stock input and (2) the effects on the labor input. Regarding the former, since savings are reduced when the retirement age increases (consumption in young age is decreased and consumption in old age is increased), the capital stock and output will decrease as well. Interest rate increases in the long run depending on the marginal rate of intertemporal substitution between consumption in old age and consumption in young age (MRIS ($c_{2,t+1}, c_{1,t}$)). Government transfers for the elderly increased because tax receipts are raised due to the increased number of old workers.

In reference to the latter point, an increase in the retirement age clearly entails a higher labor supply and thus, through this channel, a tendency towards a lower wage. Therefore, the overall effect on wages will be even more negative than that on sole capital accumulation.

Table 4: Long-run effects of lengthening the mandatory retirement age

	Aging economy (full retirement)	Mandatory retirement economy	% D from Aging. econ.
Aggregate Outcomes			
Capital	0.2100	0.1924	-8.3810
Output	1.4385	1.3978	-2.8293
Life-time consumption	1.9244	1.9671	2.2189
Young age consumption	0.5999	0.5887	-1.8670
Old age consumption	1.3378	1.3922	4.0664
Saving	0.2121	0.2004	-5.5163
Factor prices			
Wage	0.9667	0.9393	-2.8344
Interest rate	2.2466	2.3826	6.0536
PAYG pension system			
Pension benefits	0.1238	0.1328	7.2698
Government			
Government transfers for elderly	0.2064	0.2068	0.1938

Source: Calculated

8. Transitional Effects

The effects of a lengthening of the retirement age policy shock are shown in Figure 1 where the x-axis represents time on an annual basis, and the y-axis depicts percentage deviation from the steady state. A positive shock in the retirement age will tend to directly increase labor supply and lower the length of the retirement period. As a result, workers need to save less for a shorter retirement period. Figure 1 shows the saving reduction in 3 periods and increases to reach steady-state values for about 40 periods. The capital stock and output will be decreased as well. The net effect on the capital is negative if the retirement age has increased. In that case, the net effect on capital returns remains positive and the wage rate will fall (a negative (positive) factor price effects for workers (retirees)). The interest rate rises until 1.3 in 3 periods and declines to reach steady-state values for about 40 periods.

For the consumption effect, the future generations enjoy more income and consumption than the current generations do. With delayed retirement, this reform has a direct effect on labor supply and a time effect on the delayed payment of pension benefits by the pension system. Figure 1 illustrates that old-age consumption is positively affected after the shock and slowly decreased for more than 40 periods. The young age consumption is negatively affected, as the consumption declines immediately after the shock in 3 periods and increases to reach steady-state values for about 40 periods. The delayed retirement age policy measure causes a noticeable increase in the overall lifetime consumption.

As mentioned earlier, the government expenditure is based on the collection of income tax, therefore with an increased labor supply (which includes both the young and old generation), the government can spend more on consumption and the transfers for the elderly. Overall, the government sector has a significantly positive effect. However, the government consumption and government transfers decline immediately after the shock in 5 periods.

Studying the effect of this shock on the PAYG social security system, it is pertinent to note that the social security expenditure is based on the collection of social security tax (or pension contribution rate). The effects of a lengthening of retirement age policy are increased number of old workers. With the higher supply of labor, the pension benefit is a significantly positive effect. The pension declines slowly after the shock and lasts more than 40 periods.

9. Sensitivity Analysis

Numerical steady-state sensitivity analysis gauges the effects of raising the retirement age upon the long-run values of capital, output, and pension payments. Table 5 below clearly shows that the higher the retirement age (i.e. from 60 years to 65 years), the lower the long-run capital and output. Moreover, the effects of a postponement of retirement, starting from the beginning of old age (conventionally 60 years) to 65 years, on the level of pension benefits. The final effect of an increase in the retirement age upon the pension benefit depends on the level of the existing age of retirement. For instance, when the retirement age is fixed in the early years of the second period of life, a further increase in the mandatory retirement age will have the effect of raising the future pension benefit (a positive effect on the pension).

Table 5: Effects of an increase in the retirement age on the equilibrium capital, output, and pension

Age of retirement (in terms of l_i)	Capital	Output	Pension
60 years (i.e. $l_i = 0$)	0.2100	1.4385	0.1238
61	0.2039	1.4246	0.1267
62	0.1980	1.4110	0.1297
63	0.1924	1.3978	0.1328
64	0.1871	1.3850	0.1361
65	0.1862	1.3828	0.1368

Source: Calculated

10. Conclusions

This paper presents a four-sector, two-period overlapping generation (OLG) model to explore the effects of mandatory retirement age policy on macroeconomic variables. The four sectors of the model are the households' sector, the private sector, the government sector, and a pay-as-you-go (PAYG) pension system. The economic data and institutional setting of Thailand are used for the purpose of this study. According to the results of the simulated model, we found that:

The mechanisms driving a change in the retirement period, are the following two channels: (1) a direct positive effect consisting in an increase of labor supply and lower the length of the retirement period and (2) an indirect effect due to the negative change in the wage.

A higher mandatory age of retirement is always beneficial in the long run for PAYG pension budgets, government transfers for the elderly, and lifetime consumption. The future generations enjoy more consumption than the current generations. On the contrary, the policy of postponing the mandatory age may be harmful not only for capital accumulation in the long run but also for the output.

However, we are aware of the limitations of the present analysis, especially those resulting from the absence of human capital. Indeed, an increase in the compulsory retirement age extends the work-life planning of individuals, which provides an incentive to accumulate human capital, and this human capital accumulation could potentially reverse the results obtained in the present paper. Future research works are encouraged to overcome the present study limitations

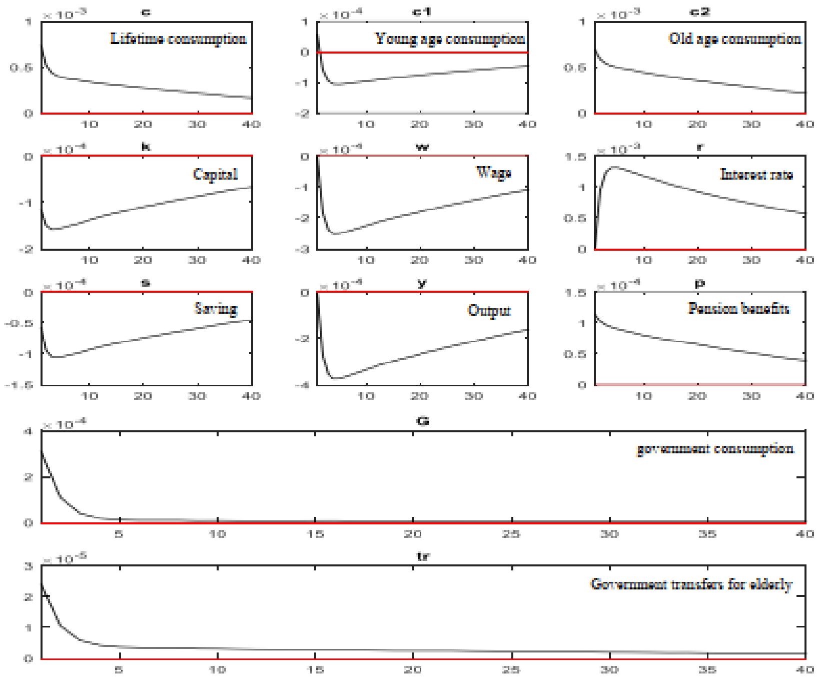

Figure 1 Responses to retirement age policy shock
Source: Author's illustration

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