# ESSAYS ON PUBLIC POLICY AND POPULATION AGING IN DEVELOPING ECONOMIES

A Dissertation

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**DOCTOR OF PHILOSOPHY IN PUBLIC ECONOMICS**

**by**

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# Abstract

This dissertation developed a two-sector general-equilibrium overlapping generations (OLG) model with endogenous fertility and education choices. We considered an emerging economy with a large informal sector and a trend of rapid population aging. In the model, individuals also choose to allocate labor between formal and informal sector. We used Thailand as an example for the quantitative analysis because of its dramatic decline in fertility to below the replacement rate. Moreover, roughly 60% of its workers are in the informal sector, and it has recently developed public pension and the universal-health insurance systems. We quantitatively investigated the impacts of aging and assessed the population and fiscal policies by their effects on economic performance and social welfare. We also discussed population and fiscal policies on taxation in an aging economy with informal employment. Our study found that while childcare subsidies (subsidies on time cost and lump-sum child allowances) do encourage fertility and improve age structure, they worsen the already low human-capital level and hurt social welfare in the long run, which possibly slows economic growth. Furthermore, if a consumption tax were available, we found that it was the best tax tool for aging economy, as it causes fewer distortions of labor allocation, saving, and education investment. We also found that capital income tax should not be zero in an economy with a large informal sector. Even if the informal sector does not exist, a labor tax still distorts the decision of education investment and indicates the necessity of a positive capital income tax. We found that reducing pay-as-you-go government pension can be a welfare improvement if the government considered fiscal burdens and capital crowding out among a young generation. Finally, we found that if the government could improve its tax-collection system and be able to tax the informal sector, it could reduce the labor income-tax rate. Moreover, there would be less relocation between the formal and informal sector. We revisited the fiscal experiment by assuming that the government could collect 100% of all tax revenue to ensure the robustness of the results. We found that the consumption tax was still the best tax tool.

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# CHAPTER 1

## Introduction

In this chapter, we first highlight the motivation and policy background of the studies in this dissertation. Then, we provide our research objective and discuss the methodology used in this dissertation, as well as the representative for quantitative analysis. Finally, we briefly talk about the organization of this dissertation.

## 1.1 Motivation

This dissertation investigates fiscal and population policies in an emerging economy with a large informal sector and a trend of rapid population aging. Population aging has been observed in the developed world, and it is expected to happen at a more rapid speed in many developing countries soon.[1] According to the population forecasts made by the United Nations, the global elderly population (60+) will double to 2 billion in 2050, and 80% of them will be from developing countries. Moreover, in contrast to past decades, fertility rates have declined sharply in many developing countries. Lee, Mason, and members of the NTA Network (2014) have studied population policy across countries and have shown that the average total fertility rate (TFR) in upper-middle-income countries was already below replacement, about 2.1 births per woman for 2005 to 2010. Table 1-1 presents average TFRs for countries from three income groups and selected sample countries.[2]

TFRs in some middle-income countries are even lower than those in the United States. Low fertility worsens the problem of population aging and implies that parents cannot expect much support from children in their retirement. Therefore, international organizations keep encouraging developing countries to establish social-security programs, such as public-pension and universal health-insurance systems, to maintain the standard of life

[1] See United Nations (2013), page 13.

[2] Income groups are based on World Bank classification for 2014. There are 82 economies in the lower-income group, 53 economies in the upper-middle-income and 80 economies in the high-income.

for the elderly. Many developing countries are also moving in this direction (e.g., Brazil, China, India, Mexico, Thailand, and Vietnam).

However, from the experience of developed countries, it is challenging to sustain such social programs in the presence of population aging because there will be fewer tax payers, more pension/social-welfare receivers, and higher costs of medical care. Even worse, the speed of aging is expected to be faster in those middle-income developing countries, which will be encountering the aging problem soon.

In addition, the large rate of informal employment ($>$40%) in emerging economies is a differing feature from developed economies and further constrains governments' abilities to collect income taxes in order to sustain social-security programs and maintain fiscal balance. Figure 1-1 presents the estimation of ratios of informal employment to total employment in the non-agriculture sector for some selected emerging economies from the International Labor Organization. Turkey, which has the highest income level among middle-income countries, is shown at lower bound of 30%, and several countries have an informal employment ratio higher than 70%. The ratio will be even higher (generally greater than 50%) if the agricultural sector is included. However, the implications of the large informal sector on fiscal and population policies are not fully studied in the literature.

## 1.2 Policy Background

### 1.2.1 Population Policy

Population aging has been observed in the developed world, and it is expected to happen at a more rapid speed in many developing countries soon (United Nations, 2013). Mortality decline, followed by fertility reduction, trigger the process of demographic transition and population aging (Kalemli-Ozcan, Ryder,& Weil, 2000). Many studies have observed fertility reduction below replacement rates in many countries in Europe and East Asia (Goldstein, Sobotka, & Jasilioniene, 2009). Moreover, given the current low fertility rates in many developed and developing countries, economists realized it is worth rein-

vestigating the demographic transition and population policy because there are significant challenges in terms of economic development and growth. Fertility is related to three channels, which are physical capital, human capital accumulation, and dependency ratio (Doepke, 2004). Mortality decline is beyond human control; therefore, efforts have been made to find any possible avenues for increasing fertility rates.

China reconsidered changing its one-child policy, which has been in place for more than 30 years, to a two-child policy since it began to observe an aging society. By 2030, people aged over 65 will make up a quarter of the population. This policy was introduced by the communist party to control a high birth rate (four children per family) and stabilize food and water consumption[3]. Moreover, many developed countries have already started population policies to increase fertility; for example, Singapore introduced a baby bonus scheme in 2001, which includes a monetary gift and a Children Development Account (CDA) for a new child. The monetary gift is a policy designed to encourage parents to have more children. The government will give 8,000 Singapore dollars for the first and second children and then 10,000 Singapore dollars for the third and subsequent children[4]. The CDA is a special savings account where the government will match a parents contribution until the child is 6 years old. Canada also provides an allowance for newborn children. The government gives 8,000 Canadian dollars for a child after birth.

In Thailand, the Thai government provides an education subsidy: free basic education from primary school to senior high school; however, a childcare subsidy is still uncertain. In 2015, the Thai government introduced a childcare subsidy project for the first time. The project mainly help women who are likely to give birth between October 1, 2015, and September 30, 2016 by providing them 400 baht per month for 12 months, with the conditions that they must earn less than 3,000 baht per month and cannot access to any social supports[5].

[3]see:http://www.independent.co.uk/life-style/health-and-families/health-news/chinas-one-child-policy-to-change-in-the-new-year-9028601.html

[4]see:http://app.msf.gov.sg/Policies/Strong-and-Stable-Families/Supporting-Families/Baby-Bonus-Scheme

[5]see:http://www.nationmultimedia.com/national/Bt400-a-month-subsidy-for-poor-mothers-from-Octobe-30265231.html

### 1.2.2 Fiscal Policy

According to the encouraging reports form the international organization for developing countries, which guides the establishment of social-security programs, such as public pensions and health-insurance system, to maintain the quality of life for the elderly. In general, social programs are costly, especially among low-fertility-rate countries, as they have a smaller of young population who will be able to pay taxes and bear the social-subsidy costs for a larger number of elderly people. Therefore, there are many studies try to find alternative tax tools, such as consumption tax and capital income tax for financing excess social-security costs and reducing fiscal burden from a high level of labor income tax.

Japan is also currently concerned about low birth rates and a high old-age dependency ratio. With high aging-related expenditure pressures along with public debt, the government decided to raise its consumption to finance the excess costs of social welfare, which is linked to its aging structure. The consumption tax (sales tax) was slated to be increased from 5% to 8% by April 2014 and will be increased further to 10% by April 2017. In Thailand, there have been some discussions about increasing the sales tax from 7% to 10%; however, the government concerned that the action will slow down the economy as well as increase inflation. Thailands official sales tax was actually 10%, but it was reduced to 7% after the 1997 crisis.

The topic of public pensions is also widely discussed in terms of the long-term financial viability of the government pension system for elderly people (Lindbeck & Persson, 2003) as well as the optimal pension replacement rate (Imrohoroglu, Imrohoroglu & Joines, 1995). The United Kingdom's government has sought ways to finance the cost of its pension, which is forecasted to hit over 8% of economic output by 2060. Therefore, a new British pension system, with a higher flat-rate state pension (a flat-rate payment of 144 pounds a week), was introduced in 2016. Workers need to work at least 35 years to receive full pensions, which is five years longer than the previous requirement[6].

[6]see:http://uk.reuters.com/article/uk-pension-savings-britain-idUKLNE92I01G20130319

According to the 2014 Pension Stainability Index compiled by Allianz Asset Management, Thailand got the lowest Retirement Income Adequacy (RIA)[7]. The index indicated the difficulty that the elderly face in maintaining their living standards. Moreover, with a high rate of poverty in Thailand, the government needs to provide more social welfare, which eventually leads to a higher fiscal burden. Therefore, the public pension system is suggested to be reformed to deal with the rapid demographic changes, fertility reduction and longer life expectancy.

## 1.3 Research Objective

Considering the significance of population aging, this dissertation attempts to study the impacts of population and fiscal policy on increasing fertility, social welfare, and fiscal burdens. First, developing countries used to spend efforts on reducing fertility in the past decades. The literature that examined demographic changes and economic growth also discussed the benefit of fertility reduction in the early stages of development, because it lowers the dependency ratio and increases education investment.[8] However, given the current low fertility rates in many developing countries, it is worth reinvestigating the population policy. We particularly focus on whether policies encouraging fertility, such as subsidies based on the number of children or education, can help the aging economy.

Second, we investigate fiscal burdens and tax policies in an aging economy with the presence of increased informal employment, which represents a situation that middle-income emerging economies are facing now or will face in the near future. We would like to understand the impact of aging on governments' fiscal balance, given the challenges of a shrinking labor force and a large informal sector. The arrangement of taxation among consumption, labor income, and capital income will be particularly discussed in response to the conventional issues in the public-finance and macroeconomic literature, including

[7] see:http://www.nationmultimedia.com/business/Thailand-advised-to-raise-retirement-age-30273718.html

[8] For example, Becker, Murphy and Tamura (1990), Galor and Weil (1996).

optimal taxation of factor incomes (e.g., capital/labor) and the adoption of a consumption tax to replace income tax. The former issue was raised by several previous studies, which found that capital income should not be taxed in the long run.[9] The latter issue is from proposals to replace the complicated income-tax system with a flat consumption tax.[10]

Regarding the fiscal burden, the pension program for elders is costly. Therefore, we would like to investigate a possible pension reform for the government to maintain its budget and provide better social welfare. This issue is mentioned by several previous studies that investigated potential social security reform, including privatization and a fully funded system.[11]

We also would like to discover the role of the informal sector and study its implications regarding fiscal policies. The income of workers in the informal sector is generally not taxed, and a higher income-tax rate might push labor forces to switch from formal positions to informal positions, which can worsens the government's fiscal condition and likely lowers aggregate productivity.

## 1.4 Methodology and Target

For the above purposes, we adopted a structural approach and developed a two-sector general equilibrium overlapping generations model with endogenous fertility and education choices. In the model, individuals choose to allocate labor between formal and informal sectors. The life cycle is characterized by three stages: child, young adult, and old adult. In the model, parents (young adults) care for children and decide how many children to have, how to invest in children's education, their own labor supply, and consumption/savings. Human-capital accumulation is modeled in a discrete way, in which children will become skilled laborers if parents invest in their education. We assume labor-market friction that cause voluntary and involuntary informal employment to exist.

[9] See, for example, Chamley (1985, 1986), Judd (1985, 1999), and Lucas (1990)

[10] A summary can be found in Correia (2010)

[11] see, for example, Conesa and Krueger (1998), Fuster, Imrohoroglu and Imrohoroglu (2007), Kitao (2014)

We intend to provide both qualitative and quantitative analyses. We use Thailand as a representative to set up a benchmark economy and perform quantitative exercises. Thailand was selected for the following reasons:

(1) It has experienced a dramatic transition in fertility (compared to developed countries). Its TFR has declined from above 6 in the 1960s to below 2 currently, and its old-age dependency ratio is expected to experience a sharp increase in the next few decades to a level close to Japan's and higher than those in France and the United States (Figure 1-2).

(2) The informal sector comprises a stable 60% of the workforce (Figure 1-3).

(3) Thailand has recently developed public-pension and universal health-insurance systems.

## 1.5 Organization

This dissertation proceeds as follows. In chapter 2, we briefly review the literature on demographic transition and previous studies of population and fiscal policy in terms of aging. Then, we provide the contribution of this dissertation. In chapter 3, we quantitatively investigate the impacts of aging in a developing country in terms of fiscal burden and human-capital accumulation. Also, we discuss some population policies, such as time-cost subsidy, child allowance, and education subsidy, in search of a better policy for fertility stimulation. In chapter 4, we investigate a better tax tool to finance the excess social-security cost of elders. We also investigate social-security reform and a counterfactual experiment in the informal sector. In chapter 5, we summarize the results and provide some policy implications for a broader perspective. Finally, we briefly mention the potential directions for future studies.

# 1.A Main Table

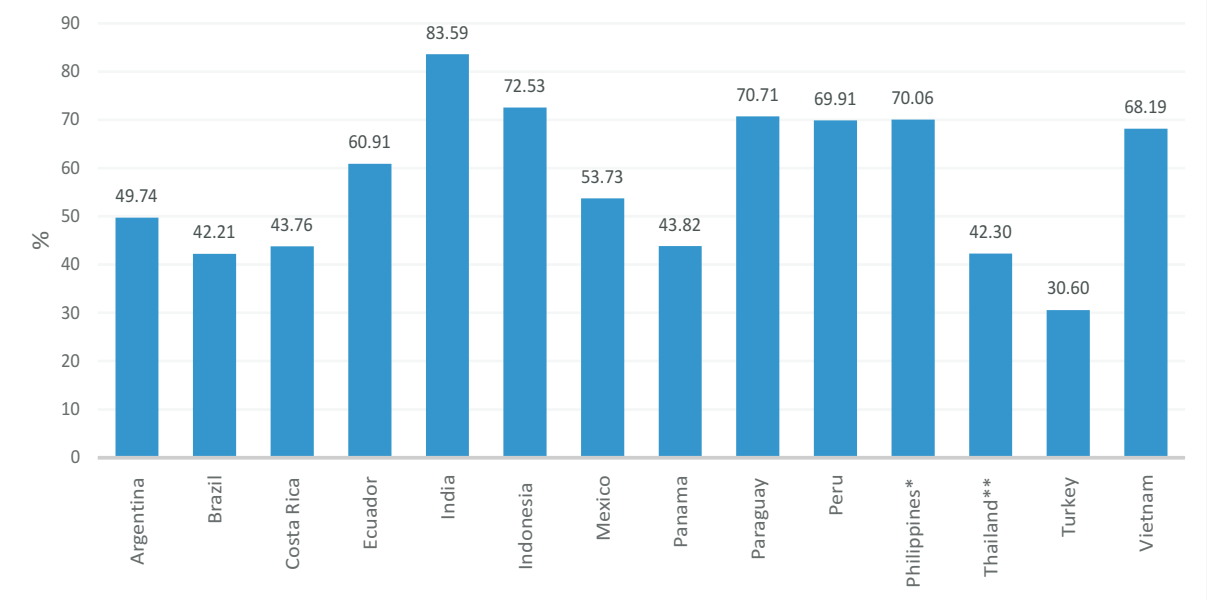
Table 1-1: Average Total Fertility Rate 2005-2010

| Lower income (<$4125) | | | | |
|---|---|---|---|---|
| Average | India | Indonesia | Philippines | Vietnam |
| 4.03 | 2.66 | 2.50 | 3.27 | 1.89 |
| Upper-middle income ($4125-12735) | | | | |
| Average | Brazil | China | Mexico | Thailand |
| 2.09 | 1.90 | 1.63 | 2.37 | 1.49 |
| High income (>$12735) | | | | |
| Average | Australia | Japan | UK | US |
| 1.65 | 1.89 | 1.34 | 1.88 | 2.06 |

Source: Lee et al. (2014)/United Nations.

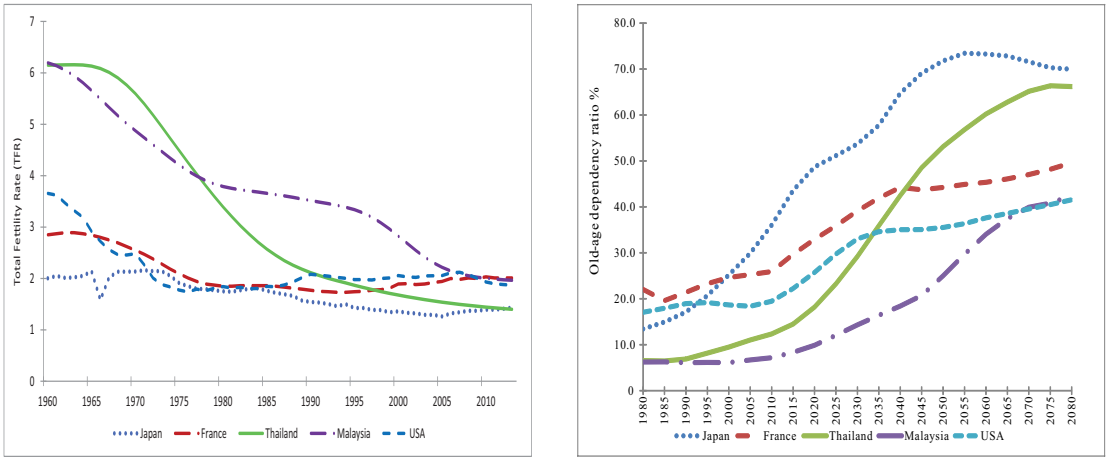
# 1.B Main Figures

Figure 1-1: Informal Employment Share (non-agriculture 2009)




Note: *data of 2008; **data of 2010. Source: International Labor Organization

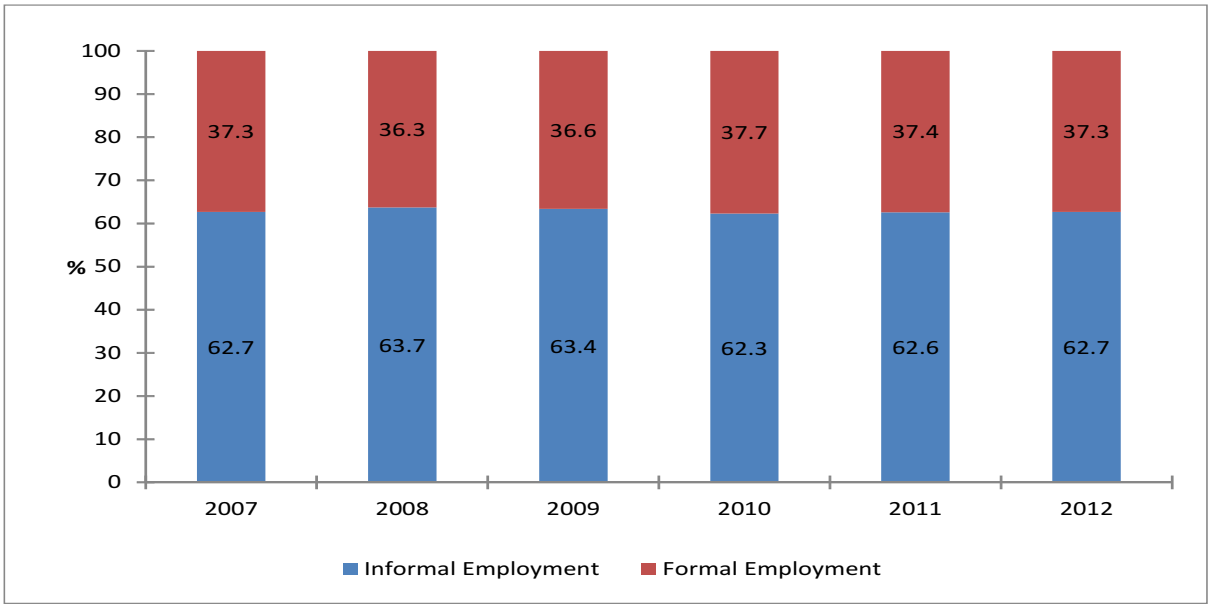
Figure 1-2: Demographic change (selected developed and developing countries)




(a) Transition in fertility

(b) Old-age dependency ratio

Figure 1-3: Ratio of informal employment (Thailand)



# CHAPTER 2

## Literature Review

This chapter will briefly review the general literature on demographic transition. Then, we concisely review the literature associated with population policy and fiscal policies in aging economies, respectively. Finally, we highlight the contributions of each study in this dissertation.

## 2.1 Overview of Demographic Transition

Demographic transition is known as a discussion of the changes in human-population structure (Teitelbaum, 1975). Mortality decline, followed by fertility reduction, trigger the process of demographic transition and population aging (Kalemli-Ozcan, Ryder,& Weil, 2000). This phenomenon has important implications for economic growth. Lee (2003) found that the transition began in Europe around 1800 before spreading through many other countries. Forecasts project a 50-fold increase in the elderly population by 2100. On the other hand, there will be a mere five-fold increase in the number of children. Therefore, the old-age dependency ratio will rise by a factor of 10.

### 2.1.1 Mortality

The mortality decline began due to the public-health and medical improvements, especially the development of vaccines in the late 18th century, which played a major role in preventing contagious and infectious diseases and led to declining mortality in Europe (Lee, 2003). Another reason for increased life expectancy was improvements in nutrition, which increased immune systems' abilities to resist diseases (Riley, 2001). Moreover, Soares (2001) also emphasized the improvement of the medical process and people's ability to adhere to a more nutritious diet because of higher incomes as the major factors for mortality decline.

### 2.1.2 Fertility

As life expectancy has lengthened, there has been a significant change in fertility patterns, which reveal not only a fall in birth rates but also a growing tendency to put off having children (Blackburn & Cipriani, 2002). Coale and Watkins (1986) observed that in the late 1800s, marital fertility began to decline in most European countries; this trend spread throughout the rest of the world during the post-transitional period. In order to sustain the standard living costs of old age, people may no longer want to have many children, different from the early 1800s. Instead of investing in children, young adults save for retirement, which leads to fertility reduction and eventually exacerbates population aging.

## 2.2 Population and Fiscal Policy

### 2.2.1 Quality-quantity trade-off framework

The theoretical framework in this dissertation builds on literature that studies the quantity-quality trade-off of fertility choice, demographic change, and economic growth. The concept was pioneered by Backer (1960), who introduced endogenous choices of fertility and education investment in children. Following studies, such as Becker, Murphy and Tamura (1990), Doepke (2004), Doepke and Zilibotti (2005), Galor and Weil (1996), and Liao (2011), have linked fertility, demographic change, and economic growth based on the mechanism of the quantity-quality trade-off. These studies typically focused on the early stage of economic development, with a demographic transition from high fertility to low fertility. However, our dissertation studies developing economies in a post-stage of development with low fertility. Precisely, parents may provide higher education investment if they have fewer children (Tamura, 2006). Therefore, parents experience a trade-off to find the optimum number of children and level of education investment (Kalemli-Ozcan, 2003).

### 2.2.2 Population policy

Regarding population policy, Lee et al.'s (2014) study is most similar to this dissertation. They used a static model, given current population structures and fiscal conditions, to investigate optimal fertility rated in 40 economies. They found that to improve living standards/fiscal burdens, the fertility rates should be even lower in some countries, even though their current fertility rates are already below replacement rates, such as in Brazil and Thailand. They assumed that fertility was exogenously determined and focused on the current situation without touching future demographic changes. We developed a richer model that allow endogenous fertility choices and took into account the demographic dynamics. Therefore, we are able to assess alternative population policies and examine their effects on fertility, human-capital development, long-run economic performance, and social welfare.

There are other studies regarding population policy. Blau (2003) suggested that child-care policies can be used to facilitate the employment of mothers and enhance the development of young children. Oguro, Oshioa, and Takahata (2013) investigated how education subsidies, childcare allowances, and family allowances affected economic growth and income distribution. Childcare and family allowances, along with education subsidies helped boost economic growth and reduced income inequality. Zhang (1997) suggested that child benefits increase fertility and decrease human capital.

### 2.2.3 Fiscal policy

This dissertation also sheds light on understanding the implication of informal employment on optimal taxation and fiscal policies. There are few studies that consider informal employment, since most studies target developed countries. A few exceptions include Penalosaa and Turnovsky (2005), who studied optimal taxation on labor and capital incomes in a standard growth model with the existence of an informal sector. They also suggested a positive capital-income tax. Dekle (2004) studied aging and the social-security system in Japan and suggested that the benefits of the current retirees should be funded by an increased consumption tax. There are many existing literatures that investigate pension reform (partial pension subsidy or privatization) to make social security sustainable for the aging: Conesa and Krueger (1998), Fuster, Imrohoroglu and Imrohoroglu (2007), and Kitao (2014). Jung and Tran (2012) studied the potential effects of the extension of social security to informal workers in developing countries to reduce the poverty problem for the elderly. We extend this literature to further discuss the implications of aging and population policy in developing countries by allowing endogenous fertility and education choices.

## 2.3 Contribution

This dissertation contributes to the existing literature, we extend an assessment of population and fiscal policy on developing countries with a trend of rapid population aging.

First, it contributes to the literature studying demographic change and economic growth. We extend the models of Doepke (2004), Doepke and Zilibotti (2005), and Liao (2011, 2013) to incorporate the informal sector and fiscal policies on taxation arrangements. The unique feature of developing countries, different from developed countries, is the existence of the informal sector. There are few studies focused on both the aging problem in developing countries and the issues of the informal sector.

The second contribution of this dissertation is to offer quantitative analyses on the impacts of aging and population policy in developing countries. Lee et al. (2014) provided a cross-country analysis on fertility and population policy. They used a static model and focused on current demographic and fiscal structures. We further consider the trend of aging and investigate more realistic population policies within a dynamic framework.

The third contribution of this dissertation is providing a better understanding on the design of fiscal policy in developing countries, taking into account the large informal sector. There are few studies in the literature considering optimal taxation and fiscal policy among developing countries, since most of studies target developed countries. Turnovsky and Basher (2009) developed a two-sector model for developing countries to determine the ability of a government to increase tax revenue with the presence of the informal sector. We further consider population aging, human-capital investment, and fertility choices in an OLG framework.

# CHAPTER 3

## Population Policy in a Developing Economy with Aging

This chapter discusses the impacts of population policy on population aging. Over the past few years, many studies on demographic change and economic growth have discussed the benefit of fertility reduction in early stages of economic development because it lowers the dependency ratio and increases investments in education.[12] However, given the current low fertility rates in many developing countries, it is worth reinvestigating the population policy. We particularly focus on whether policies encouraging fertility, such as subsidies for the number of children a family has, child care, or education, can help an aging economy.

We will first discuss the impacts of population aging and how the government can manage the costs of aging. Then, we introduce three different population policies that may increase fertility: (a) a subsidy on the time cost for child rearing, since most countries ensure at least three months of paid leave for mothers, such as a Government-Paid Maternity Leave (GPML) program in Singapore[13]; (b) a lump-sum subsidy on each child, such as the childbirth and childcare lump-sum grant in Japan and baby-bonus scheme in Australia; and (c) a subsidy on children's educational costs. Our study found that while childcare subsidies (subsidies on time cost and lump-sum child allowances) do encourage fertility and improve age structure, they worsen the already low human-capital level and hurt social welfare in the long run, which possibly slows economic growth.

[12] For example, Becker, Murphy and Tamura (1990), Galor and Weil (1996).

[13] According to the current rules implemented by the Singapore government, working mothers, including self-employed, are entitled to 16 weeks of Government-paid Maternity Leave at the birth of their Singapore Citizen child. Please see the details: https://www.ecitizen.gov.sg/Topics/Pages/Maternity-leave-How-to-apply.aspx.

In this chapter, we develop a two-sector general equilibrium overlapping generations (OLG) model with endogenous fertility and education choices to provide a structural analysis. We also model the informal sector to represent the labor market in developing countries; thus, individuals also choose labor allocation between formal and informal sectors in the model. We further use Thailand as a representative for calibration and quantitative analysis. Thailand has experienced a dramatic transition in fertility; the TFR has declined from above 6 in 1960s to below the replacement rate today. The old-age dependency ratio is also expected to increase sharply in the coming decades. Therefore, it is very important for Thailand to start considering which policy is good for the upcoming trend of population aging to help improve the low fertility rate.

## 3.1 The Model

The human life cycle is characterized by three stages: child, young adult, and old adult. A child relies on parents without making any decisions. Parents (young adults) care for their children and make decisions on the number of children to have, the investment they make in their children's education, their own labor supply, and consumptions/savings. Old adults retire and use their savings and pension benefits for consumption and medical care. Human-capital accumulation is modeled in a discrete way: Children will become skilled laborers if parents invest in their education. Labor allocations between formal and informal sectors are endogenized and both voluntary and involuntary informal employments are modeled. We assume that the total factor productivity (TFP) differs between the two sectors and that there exists some friction (constraint) preventing completely free movement between formal and informal sectors to match (a) the large wage gap between the two sectors and (b) the large informal-labor employment share in developing countries.

### 3.1.1 Demographics

Total population $N$ at a given time consists of the population of children $N^c$, young adults $N^y$, and old adults $N^o$:

$$N = N^c + N^y + N^o. \tag{1}$$

Population dynamics are determined by fertility choices (endogenous) and survival rates (exogenous) in the model. The total number of children is determined by the fertility decisions made by current young adults. Let $n$ denote the average fertility per young adult, $N^c$ can be expressed by:

$$N^c = nN^y. \tag{2}$$

We assume that young adults can survive to old age with a probability $\pi^y$. Therefore, the old population next period $N^{o\prime} = \pi^y N^y$.

### 3.1.2 Education Investment and Human-Capital Development

If parents invest in children's education beyond a fundamental level (with a cost $\bar{e}$), children will become skilled laborers. Children who receive higher education do not become unskilled laborers when they become young adults. We use $N_s^y$ to denote the population of skilled young adults and $N_u^y$ to denote the population of unskilled young adults. Human-capital development is represented by the increase in the ratio of skilled labor to the total labor force ($N_s^y/N^y$).

### 3.1.3 Production and Labor Market

There are two production sectors - the formal sector and informal sector and one type of final goods in this economy. We use superscript $f$ to denote variables in the formal sector and superscript $x$ to denote variables in the informal sector. We assume that in both sectors, competitive firms operate a standard constant return to scale (CRS) production technology using three input factors, physical capital ($K$), skilled labor ($L_s$), and unskilled labor ($L_u$), to produce the final goods.

The production function is given by:

$$Y^f = A^f (K^f)^{\alpha_1} (L_s^f)^{\alpha_2} (L_u^f)^{\alpha_3} \tag{3}$$

$$Y^x = A^x (K^x)^{\gamma_1} (L_s^x)^{\gamma_2} (L_u^x)^{\gamma_3}. \tag{4}$$

The total production is determined by the production from both sector:

$$Y = Y^f + Y^x \tag{5}$$

To capture the existence of both voluntary and involuntary informal workers, we assume there are constraints on labor mobility for both types of labor moving from the informal sector to the formal sector due to market frictions and/or policy distortions (e.g., minimum-wage regulation in the formal sector).

### 3.1.4 Government

We assume that the government taxes consumption, labor income, and capital income with rates $\tau_C$, $\tau_L$, and $\tau_K$, respectively. Thus, total government tax revenue is a sum of revenues from the consumption tax ($T_C$), labor income tax ($T_L$), and capital income tax ($T_K$). The government uses total revenue to finance public health care expenditures ($M_g$) and other public expenditures ($G$). The government cannot monitor/tax the labor income from the informal sector. We assume that the financial industry is in the formal sector, and therefore, the total capital income is monitored and taxed by the government.

The public medical care system covers a fraction $\omega$ of total household medical expenditure, $M$. The government medical expenditure $M_g$:

$$M_g = \omega M. \tag{6}$$

The government is required to maintain budget balance every period. The budget constraint for the government is given by:

$$M_g + G = T_C + T_L + T_K. \tag{7}$$

### 3.1.5 Individual's Problem

Each young adult is endowed one unit of time. Child-rearing activities cost a fraction of the parent's total time per child ($\phi$). The rest of the parent's time $(1-\phi)$ can be supplied to labor markets for earnings in the formal and/or informal sectors. We assume that during their lifetimes, individuals experience working in both sectors, and to some extent, they can decide the allocation of working time between the two sectors. To capture the features of involuntary informal workers and institutional distortions on the labor markets (e.g., minimum-wage regulation in the formal sector), we adopted a reduced form constraint on labor mobility: an upper bound of labor allocated in the formal sector.

An young adult with skill level $i = \{s, u\}$ chooses current consumption $c_i^y$, assets to carry to old age $a_i'$, number of children $n_i$, education investment $e_i = \{0, \bar{e}\}$ and proportion of formal labor supply $\theta_i$ to maximize her lifetime utility. We assume period utility function is a constant relative risk aversion utility function:

$$u(c_i^y) = \frac{c_i^{y\,1-\sigma}}{1-\sigma} \tag{8}$$

$$u(c_i^{o\prime}) = \frac{c_i^{o\prime\,1-\sigma}}{1-\sigma} \tag{9}$$

$$0 < \sigma < 1 \tag{10}$$

The problem can be defined and expressed by the following value function:

$$V_i = \max_{\{c_i^y, a_i', n_i, e_i, \theta_i\}} \left\{ u(c_i^y) + \beta \pi^y u(c_i^{o\prime}) + \psi n_i^{-\varepsilon} [n_i V_j'] \right\}, \tag{11}$$

subject to

$$(1+\tau_C)c_i^y + \pi^y a_i' + e_i n_i = (1-\phi n_i)[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x]; \tag{12}$$

$$(1+\tau_C)c_i^{o\prime} = [1+(1-\tau_K)r']a_i' - (1-\omega)m'; \tag{13}$$

$$j = s, \text{ if } e_i = \bar{e};\ j = u, \text{ if } e_i = 0 \tag{14}$$

$$0 \leq \theta_i \leq \bar{\theta_i}; \tag{15}$$

where $w^g$ is the wage rate for sector $g$; $\theta$ is the proportion of total working time allocated in the formal sector; $m'$ is medical expenditures in old age. We assume perfect annuity. The young adult pays $\pi^y a_i'$ for the annuity (as savings) and receives $(1+r')a'$ next period if she/he survives. We assume educational cost is a function of skilled wage in the formal sector $\bar{e} = \phi_s w_s^f$.

### 3.1.6 Equilibrium Features

We focus on an equilibrium in which both skilled and unskilled workers exist with an upward intergenerational mobility: Skilled parents always invest in children's education, and some unskilled parents invest in education while others do not. Thus, in this equilibrium, unskilled parents are indifferent about investing in their children's education:

$$\frac{V_{s,e=\bar{e}}}{P_s^{1-\varepsilon}} = \frac{V_{u,e=0}}{P_u^{1-\varepsilon}} \tag{16}$$

where $V_{s,e=\bar{e}}$ is the value of a skilled parent who chooses to invest on children's education (so his/her children will become skilled labor),

$V_{u,e=0}$ is is the value of a unskilled parent who chooses not to invest on children's education (so his/her children will become unskilled labor),

$P_s = \phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x] + \bar{e}$ is the total cost for having an educated child, and

$P_u = \phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x]$ is the total cost for an un-(low-)educated child.

Optimal decision rules are determined as follows:

- Savings($\pi_y a'$): An adult needs to trade off between today consumption and future consumption. Thus, the optimal decision is a marginal utility of today consumption equals to a marginal utility of tomorrow consumption (old-adult period).

$$u_{c^y} = \beta(1+(1-\tau_K)r')u_{c^{o\prime}} \tag{17}$$

- Fertility (number of children): To satisfy the optimal number of children, it implies a marginal utility of children equals to a marginal cost spending on raising a child.

$$\psi(1-\varepsilon)(n_i)^{-\varepsilon}V_j' = u_{c^y}\{\phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x] + e_i\} \tag{18}$$

where $w_i^f$ is the formal sector wage rate and $w_i^x$ is the informal sector wage rate

- Formal labor supply:

  if not binding

$$(1-\tau_L)w_i^f = w_i^x; \quad \theta_i < \bar{\theta_i} \tag{19}$$

  if binding

$$(1-\tau_L)w_i^f > w_i^x; \quad \theta_i = \bar{\theta_i} \tag{20}$$

Given the big wage gap between formal and informal sectors, it is not possible if none of the formal labor supply constraints are binding. Hence, there are two possible cases:

- Case 1: unskilled binding; skilled not binding

  Skilled:

$$\begin{aligned} &(1-\tau)w_s^f = w_s^x; \quad \theta_s < \bar{\theta_s} \\ \Rightarrow &(1-\tau)\frac{A^f(K^f)^{\alpha_1}\alpha_2(L_s^f)^{\alpha_2-1}(L_u^f)^{\alpha_3}}{A^x(K^x)^{\gamma_1}\gamma_2(L_s^x)^{\gamma_2-1}(L_u^x)^{\gamma_3}} = 1 \\ \Rightarrow &\frac{L_s^f}{L_s^x} = (1-\tau)\frac{A^f(K^f)^{\alpha_1}\alpha_2(L_s^f)^{\alpha_2}(L_u^f)^{\alpha_3}}{A^x(K^x)^{\gamma_1}\gamma_2(L_s^x)^{\gamma_2}(L_u^x)^{\gamma_3}} \end{aligned}$$

  Unskilled: $\theta_u = \bar{\theta_u}$

- Case 2: both binding $\Rightarrow \theta_u = \bar{\theta_u}$ and $\theta_s = \bar{\theta_s}$.

  This is not a preferred case because voluntary informal workers do not exist.

In this dissertation we focus on case 1 for all the analysis.

## 3.2 Parameter Selection and Benchmark Economy

As we mentioned in the introduction, we selected Thailand as a representative economy for quantitative analysis. We set up parameters by calibrating our model to match Thailand's demographics and some key economic variables in 2000s, including fertility, life expectancy, skilled-labor share, capital-output ratio, formal-employment ratio, and skill-unskilled wage ratio in the formal sector. We used the calibrated model as a benchmark and performed quantitative experiments based on it.

### 3.2.1 Parameters

Table 3-1 summarizes the parameters used to calibrate the benchmark in a steady state. We assumed one period in the model is 30 years. In the calibration, we chose $\pi^y = 0.47$ to match life expectancy at birth in 2012 (74.18).[14] Preference parameters for the first steady state were chosen as follows. We chose the annual discount factor to be 0.9517 to match the capital-output ratio (1.90) in 2012[15]. We followed Liao (2011), using $\sigma = 0.5$ to match relative consumption at its peak to middle age, which is the age of 40. The elasticity of altruism with respect to the number of children, $\varepsilon$ was 0.5.[16] The final preference parameter was the altruism coefficient, $\psi$. We made it equal 0.234 so that we could match the TFR (1.54).[17]

In terms of informal employment and production parameters, we focused on the case that unskilled labor in the formal sector is binding ($\bar{\theta_u} = 0.3$). On the other hand, skilled laborers have more freedom to work in either the formal or informal sector. Therefore, the probability that skilled labor work in formal sector and pay labor income tax is unbinding. We assume the skilled labor in the formal sector is not binding ($\bar{\theta_s} = 1$). In the formal sector, we targeted $A^x = 6.5$ to match the fraction of time of skilled workers in the formal

[14] Estimated by the Population Division of the United Nations Department of Economic and Social Affairs of the United Nations Secretariat.

[15] Beta is 0.2265 (Beta = Annual discount factor$^{30}$)

[16] Estimated by Liao (2011) about 5 percent of children have parents educated at or above the college level in 1975; Data source: Macroeconomics Database, DGBAS, Executive Yuan, Taiwan in 1975.

[17] Data source: United Nations Population Division. World Population Prospects.

sector $\theta_s$. Additionally, in the production sector, we pinned down $\alpha_1$ to be 0.67, $\alpha_2$ to be 0.09 and $\alpha_3$ to be 0.24 from the total labor per capita income in the formal sector. Moreover, for the informal sector, $\gamma_1$, $\gamma_2$ and $\gamma_3$ are also required. We assume capital income share in the informal sector is equal to the formal sector ($\alpha_1 = \gamma_1$)[18]. Then, to get $\gamma_2$ and $\gamma_3$, we needed to match the average income share between the formal and informal sectors, which was 3.3.

There are two costs associated with children: time cost ($\phi$) and education time cost for one children ($\phi_s$). According to the data, the full cost (net of a child's own labor income) of raising a child from birth until age 24 was about 1.156 million Baht in 2004. So, we get a 0.234 time cost per children from the ratio of the amount parents need to spend on one child to average income until high school.[19] Therefore, we used 0.243 as the time cost. We chose $\phi_s = 0.16$ to match skilled-labor share in the formal sector (17.34%).

In addition to the household parameters, to calibrate the benchmark, we also considered some fiscal parameters. According to the Organisation for Economic Co-operation and Development (OECD), the component of a consumption tax includes indirect tax topics, such as value-added tax/goods and services tax (VAT/GST) and excise duty rates. In the case of Thailand, we used a 10% consumption tax rate, a 7% value-added tax (VAT), and we assumed another 3% excise duty rate. The corporate income tax (CIT) in Thailand stands at 20% on net profit[20] and will be applied to the tax rate on capital income. For the labor income tax, we considered personal income tax (PIT), which is a direct tax levied on a person's income. The progressive tax rates applicable to taxable income range from 0% to the maximum 35%. We chose 15% to represent labor income tax in our calibration as the rate is in the middle of the range.[21] We found the ratio of general government expenditure on health per capita in 2012 was approximately 0.675. Therefore, for the elderly, the government will provide a partial subsidy of 67.5% for medical expenditures.

[18]We assume $\alpha_1$ and $\gamma_1$ are the same; however, we provided a sensitivity analysis in 4.B
[19]Data source: National Statistical Office, Thailand.
[20]Data source: Revenue Department, Thailand
[21]Data source: Revenue Department, Thailand

### 3.2.2 Benchmark Economy

Table 3-2 compares the real data and benchmark results. There are two parts: calibrated and non-calibrated results. In terms of calibrated results, we found all target variables; fertility, life expectancy, skilled-labor share, skilled workers in the formal economy ratio ($\theta_s$), and average income share between formal and informal sector ($w^f/w^x$), were perfectly matched with the real data. Therefore, it can be implied that the model is highly effective and can represent Thailand's current demographic and real economic situation very well. Although the income inequality $w_s^f/w_u^f$ was not calibrated, it turned out to be close to the data. The model also simulated fertility for $n_{ij}$ which can be summarized as follows: the fertility rate of skilled parents ($n_{ss}$) was 0.3528, the fertility rate of unskilled parents with skilled children ($n_{us}$) was 0.2963, and the fertility rate of unskilled parents with unskilled children $n_{uu}$ was 0.9208.

## 3.3 Impacts of Population Aging

To study the impacts of aging, we considered that (a) life expectancy is forecasted to increase from 74 to 83 by 2065 and (b) total medical expenditures will increase from 3.65% of GDP to 7.47% of GDP, which was estimated by using a simple linear regression of medical expenditures and life-expectancy.

As a baseline, we used labor income tax to ensure fiscal balance in the aging economy (new steady state). Table 3-3 presents the results of aging, which can be summarized by three main effects. First, people live longer in aging societies; therefore, they require more assets to secure their retirement. People tend to increase their savings, and the capital-output ratio increases by 18.42%. Second, we observed significant increases in labor income tax burdens. The government needs to increase the labor income tax from 15% to 32% to sustain social programs and other government expenditures. Skilled laborers tend to switch from the formal sector to the informal sector to avoid higher tax burdens. The proportion of skilled laborers working in the formal economy decreases by 6.1 percentage

point. Third, parents have fewer incentives to invest in children's education when the tax rate increases, as the return on education becomes lower. We found that the fertility rate of skilled parents and the fertility rate of unskilled parents with skilled children declined slightly from 0.353 to 0.346 and 0.296 to 0.275, respectively. The fertility rate of unskilled parents with skilled children declines more, as unskilled parents receive a lower income compared to skilled parents, but their skilled children need to face a higher labor income tax once they grow up and become skilled laborers. As a result of increases in the labor income tax and decreases in education investment, the skilled-labor share in the formal sector declined by 3.1 percentage point.

## 3.4 Population Policy – Subsidy on Childcare/Education

We considered three types of population policies to encourage fertility: time cost subsidy, child allowance (lump-sum subsidy on each child), and education subsidy.

### 3.4.1 Subsidy on Time Cost

Child rearing is time consuming, so we first considered a policy providing compensation for parents' time cost, such as Government-Paid Maternity Leave (GPML). For our quantitative experiment, our study treats the subsidy as a percentage of time cost that parents need to spend to raise one child. The results presented in table 3-4 introduce subsidy on time cost ranging from 5% to 20%. We observed that a subsidy can successfully stimulate fertility, as it showed an increasing trend from 1.512 to 1.679 and 2.395 when we increased child care subsidy from 5% to 20%, respectively. Precisely, the fertility rate of all types of parents (skilled parents and the unskilled parents with skilled and unskilled children) increased. Labor income tax decreased from 31.5% to 29.55% with 10% rate of subsidy and then increased again to 31.47%. It shows the lowest burden if the government exercises a 10% subsidy on time cost.

However, there are two negative effects caused by a time-cost subsidy, which eventually brings the price of unskilled children down. One is the crowding out effect on saving. While our results supported the findings of previous literatures regarding using a time-cost subsidy, we expanded the analysis in terms of economic performance and labor force. The key novelty here is that, to have more children, people need to transfer their savings to child-raising costs; children are substitutable for savings, which is reflected in the continuous decrease in the capital-output ratio. Another is a distortion of investment in children's education. We noticed that parents switch from having skilled children to unskilled children with a cheaper time cost after receiving the subsidy. Therefore, the ratio of skilled-labor share in the formal sector decreases slightly from 13.87% to 13.79% with a 5% subsidy and keeps declining to 12.82% with 20% subsidy.

### 3.4.2 Child Allowance

Another experiment involves the government providing a lump-sum subsidy to every child, such as the child allowance in Japan. For our quantitative experiment, we assumed that a lump-sum subsidy was proportional to the after-tax wage of unskilled laborers spending their time cost for one child. The results presented in table 3-5 show that the average TFR increased from 1.512 to 1.671, and 2.348 if we increase the proportion of subsidy from 5% to 20%, accordingly. We observed that a fixed subsidy made skilled children very expensive in terms of time cost, since parents received a subsidy as though their children were unskilled children but they need to pay a higher time cost because they actually had skilled children. Therefore, parents will have more unskilled children, which eventually decreases the skilled-labor share in the formal sector even further than the time-cost subsidy in the first policy-experiment case.

### 3.4.3 Education Subsidy

As we mentioned, the time-cost subsidy has some drawbacks. Therefore, we considered an education subsidy for the third policy experiment. For this quantitative experiment, we assumed that the government would proportionally subsidize the cost of education from a range of 5% to 20%. We found in table 3-6 that the education subsidy also raised the TFR from 1.512 to 1.515, and 1.529 when we increased the education subsidy from 5% to 20%, respectively. The fertility rate of skilled parents and the fertility rate of unskilled parents with skilled children kept increasing. However, the fertility rate of unskilled parents with unskilled children remained unchanged. We observed that this policy may not be a successful policy for population stimulation, as it causes only a slight increase in fertility rates. Moreover, the policy also generated the highest tax burden for young people. However, there were some comparative advantages compared to the other two subsidies. We observed that the education subsidy did not crowd out savings, as the capital-output ratio experience nearly stable growth. Also, we found an increasing trend of the skilled-labor share in the formal economy, which is significant for economic development.

## 3.5 Conclusion

In this chapter, we discussed the impacts of population policy on population aging by developing a two-sector general equilibrium overlapping generations model with endogenous fertility and education choices. The model also captured the informal sector, which is an important feature in developing countries. We used Thailand as a representative for calibration and quantitative analysis.

We first discussed the impact of aging by considering life expectancy and total medical-expenditure increases, as forecasted for 2065. We used a labor income tax to ensure fiscal balance in the aging economy. We found that in the aging economy, people needed to save more to sustain their lifestyles after retirement. The government also needed to increase the labor income tax to ensure that it was possible to maintain the social security

programs, which tended to cause skilled laborers to switch from the formal to the informal sector. Parents also had fewer incentives to provide education to their children, as the return on education decreased.

Second, we discussed three different policies to stimulate fertility: a subsidy on time cost (childcare subsidy), a lump-sum child allowance subsidy, and an education subsidy. Comparing the three types of population subsidies, we observed that the time-cost subsidy and child allowance subsidy could successfully stimulate average TFR. Moreover, we observed a U shape pattern as labor income tax increased again if the time-cost subsidy and child allowance subsidy are higher than 10% rate. This is because a higher level of childcare subsidy (time-cost subsidy and child allowance subsidy) increased fertility rate and followed by a demographic structure change with a higher number of young generation, who will be able to pay taxes and bear the social subsidy costs. Therefore, labor income tax decreased. On the other hand, both subsidy distort human-capital investment and capital-output ratio, which imply a lower GDP per capita. Therefore, government needs to increase labor tax. The conclusion is the distortion effects out weighted the benefit of fertility increased after 10% subsidy. Therefore, labor income tax increased again as a U shape after 10% subsidy. However, we found education subsidy was the best policy. The education subsidy at least provided a small social-welfare improvement; for example, with a 10% education subsidy increased lifetime consumption by around 0.5%, unlike the other two subsidies, which caused social welfare to decline. Also, the education subsidy does not encourage parents to have more unskilled children, which decrease the skilled-labor share in the formal sector. Moreover, the old-age dependency ratio was not affected by implementing the education subsidy.

# 3.A Main Table

Table 3-1: Parameters

| **Parameters** | **Value** | **Source/Target** |
|---|---|---|
| *Survival Rates* | | |
| $\pi^y$ | 0.47 | life expectancy 74.18 |
| *Preference* | | |
| $\beta$ | 0.9517 | capital-output ratio 1.90 |
| $\psi$ | 0.234 | a half of TFR 0.77 |
| *Informal employment and production* | | |
| $\overline{\theta}_s$ | – | not binding |
| $\overline{\theta}_u$ | 0.3 | binding; data $L_u^f/(L_u^f+L_u^x)=0.3$ |
| $A^f$ | 10 | normalization |
| $A^x$ | 6.5 | data $L_s^f/(L_s^f+L_s^x)=0.726$ |
| $(\alpha_1,\alpha_2,\alpha_3)$ | (0.67, 0.09, 0.24 ) | data income shares (formal sector) |
| $(\gamma_1,\gamma_2,\gamma_3)$ | (0.67, 0.045, 0.285 ) | $w^f/w^x=3.3$ |
| *Child Schooling/Rearing Costs* | | |
| $\phi_s$ | 0.16 | skilled labor share 17.34% |
| $\phi$ | 0.243 | child-rearing cost (to high school) 2004 |
| *Tax Rates* | | |
| $\tau_C$ | 10% | Tax rate on consumption |
| $\tau_K$ | 20% | Tax rate on capital income |
| $\tau_L$ | 15% | Tax rate on labor income |
| *Government Subsidy* | | |
| $\omega$ | 67.5% | public medical expenditure share |

Table 3-2: Model Benchmark

| | Data | Model (benchmark) |
|---|---|---|
| **Calibrated** | | |
| Average TFR | 1.54 | 1.53 |
| Life expectancy | 74 | 74 |
| Skilled labor share (formal) | 17% | 17% |
| Capital-output ratio | 1.90 | 1.90 |
| $\theta_s \ (L_s^f/L_s)$ | 0.73 | 0.73 |
| $\theta_u \ (L_u^f/L_u)$ | 0.30 | 0.30 |
| $w^f/w^x$ | 3.3 | 3.3 |
| **Not calibrated** | | |
| $w_s^f/w_u^f$ | 1.79 | 1.83 |
| $(G/Y)$ / (Total Govt Exp/Y) | –/ 11.71% | 19.88% / 22.34% |
| $n_{ss}$ | | 0.3527 |
| $n_{us}$ | | 0.2963 |
| $n_{uu}$ | | 0.9208 |
| Average TFRs | | 0.71 |
| Average TFRu | | 1.70 |

Table 3-3: Impact of Aging

| | Benchmark (2000s) | Aging (2065) |
|---|---|---|
| $n_{ss}$ | 0.353 | 0.346 |
| $n_{us}$ | 0.296 | 0.275 |
| $n_{uu}$ | 0.921 | 0.910 |
| Average TFR | 1.527 | 1.512 |
| Average TFRs | 0.706 | 0.692 |
| Average TFRu | 1.699 | 1.684 |
| Life expectancy | 74.1 | 83.1 |
| Skilled labor share (formal) | 17.0% | **13.9%** |
| $w_s^f/w_u^f$ | 1.83 | 2.31 |
| $w_s^f/w_s^x$ | 1.18 | 1.46 |
| Capital-output ratio | 1.90 | 2.25 |
| Annual return on capital | 8.2% | 7.6% |
| $(L_s^f/L_s)$ | 0.726 | **0.665** |
| Labor income tax | 15.0% | **31.50%** |

Table 3-4: Subsidy on Time Cost

| | Baseline | 5% Child care | 10% Child care | 15% Child care | 20% Child care |
|---|---|---|---|---|---|
| $n_{ss}$ | 0.346 | 0.384 | 0.429 | 0.483 | 0.548 |
| $n_{us}$ | 0.275 | 0.302 | 0.333 | 0.369 | 0.411 |
| $n_{uu}$ | 0.910 | 1.010 | 1.127 | 1.265 | 1.430 |
| Average TFR | 1.512 | 1.679 | 1.877 | 2.112 | 2.395 |
| Average TFRs | 0.692 | 0.768 | 0.859 | 0.966 | 1.096 |
| Average TFRu | 1.684 | 1.871 | 2.091 | 2.353 | 2.668 |
| Skilled labor share | **13.87%** | **13.79%** | **13.60%** | **13.28%** | **12.82%** |
| $w_s^f/w_u^f$ | 2.308 | 2.323 | 2.361 | 2.426 | 2.528 |
| $w_s^f/w_s^x$ | 1.46 | 1.43 | 1.42 | 1.43 | 1.46 |
| Capital-output ratio | 2.25 | 2.14 | 2.02 | 1.90 | 1.78 |
| $(L_s^f/L_s)$ | 0.665 | 0.670 | 0.671 | 0.669 | 0.662 |
| Labor income tax | **31.5%** | **30.16%** | **29.55%** | **29.89%** | **31.47%** |
| Social welfare | 1.54 | **1.49** | **1.43** | **1.36** | **1.29** |
| | | **CEV=-5.26%** | **CEV=-10.99%** | **CEV=-17.14%** | **CEV=-29.70%** |
| Welfare (skilled) | 2.69 | 2.60 | 2.51 | 2.41 | 2.30 |
| Welfare (unskilled) | 1.47 | 1.42 | 1.37 | 1.30 | 1.23 |
| Old/Young ratio | 94.78% | 85.22% | 76.14% | 67.55% | 59.45% |

Table 3-5: Child Allowance Subsidy

| | Baseline | 5% Lump-sum | 10% Lump-sum | 15% Lump-sum | 20% Lump-sum |
|---|---|---|---|---|---|
| $n_{ss}$ | 0.346 | 0.368 | 0.391 | 0.417 | 0.447 |
| $n_{us}$ | 0.275 | 0.301 | 0.332 | 0.368 | 0.410 |
| $n_{uu}$ | 0.910 | 1.010 | 1.127 | 1.265 | 1.430 |
| Average TFR | 1.512 | 1.671 | 1.858 | 2.081 | 2.348 |
| Average TFRs | 0.692 | 0.735 | 0.783 | 0.834 | 0.891 |
| Average TFRu | 1.684 | 1.868 | 2.084 | 2.342 | 2.654 |
| Skilled labor share | **13.87%** | **13.72%** | **13.46%** | **13.07%** | **12.54%** |
| $w_s^f/w_u^f$ | 2.308 | 2.336 | 2.389 | 2.470 | 2.591 |
| $w_s^f/w_s^x$ | 1.46 | 1.43 | 1.42 | 1.43 | 1.46 |
| Capital-output ratio | 2.25 | 2.14 | 2.03 | 1.91 | 1.79 |
| $(L_s^f/L_s)$ | 0.665 | 0.669 | 0.671 | 0.669 | 0.661 |
| Labor income tax | **31.5%** | **30.22%** | **29.64%** | **29.94%** | **31.42%** |
| Social welfare | 1.54 | **1.49** | **1.43** | **1.36** | **1.28** |
| | | **CEV=-5.25%** | **CEV=-10.97%** | **CEV=-17.11%** | **CEV=-23.61%** |
| Welfare (skilled) | 2.69 | 2.60 | 2.52 | 2.42 | 2.30 |
| Welfare (unskilled) | 1.47 | 1.42 | 1.37 | 1.30 | 1.23 |
| Old/Young ratio | 94.78% | 85.42% | 76.48% | 67.89% | 59.90% |

Table 3-6: Education Subsidy

| | Baseline | 5% Education | 10% Education | 15% Education | 20% Education |
|---|---|---|---|---|---|
| $n_{ss}$ | 0.346 | 0.349 | 0.354 | 0.359 | 0.365 |
| $n_{us}$ | 0.275 | 0.285 | 0.296 | 0.308 | 0.320 |
| $n_{uu}$ | 0.910 | 0.910 | 0.910 | 0.910 | 0.910 |
| Average TFR | 1.512 | 1.515 | 1.519 | 1.524 | 1.529 |
| Average TFRs | 0.692 | 0.699 | 0.709 | 0.718 | 0.729 |
| Average TFRu | 1.684 | 1.687 | 1.689 | 1.693 | 1.697 |
| Skilled labor share | **13.87%** | **14.34%** | **14.85%** | **15.39%** | **15.97%** |
| $w_s^f/w_u^f$ | 2.308 | 2.219 | 2.131 | 2.043 | 1.955 |
| $w_s^f/w_s^x$ | 1.46 | 1.46 | 1.46 | 1.47 | 1.47 |
| Capital-output ratio | 2.25 | 2.25 | 2.25 | 2.25 | 2.24 |
| $(L_s^f/L_s)$ | 0.665 | 0.666 | 0.666 | 0.667 | 0.668 |
| Labor income tax | **31.5%** | **31.62%** | **31.74%** | **31.88%** | **32.04%** |
| Social welfare | 1.54 | **1.55** | **1.55** | **1.55** | **1.56** |
| | | **CEV=0.23%** | **CEV=0.46%** | **CEV=0.69%** | **CEV=0.93%** |
| Welfare (skilled) | 2.69 | 2.64 | 2.59 | 2.55 | 2.51 |
| Welfare (unskilled) | 1.47 | 1.48 | 1.48 | 1.48 | 1.49 |
| Old/Young ratio | 94.78% | 94.72% | 94.65% | 94.57% | 94.48% |

# CHAPTER 4

## Fiscal Policy in a Developing Economy with Aging

In this chapter, we discuss fiscal policies in a developing country with population aging. We will first discuss the costs of aging and alternative tax tools for the government to use to finance the costs of aging, such as a consumption tax and capital income tax. Second, we study the impacts of pension reform in terms of social welfare and capital accumulation. Third, we discuss a counterfactual scenario in an informal sector if the government can improve its tax-collection system. Our study suggests that a consumption tax is the best tax tool in an aging economy, compared to a labor income tax and capital income tax, because it distorts on labor allocation, saving, and education investment less. We found that a low pension-replacement rate was a good method if the government considered fiscal burdens and capital crowding out among a young generation. Moreover, we observed that taxing the informal sector may reduce savings, although it would help reduce income tax rates and increase the number of children.

According to the encouraging reports form the international organization for developing countries, which guides the establishment of social-security programs, such as public pensions and health-insurance system, to maintain the quality of life for the elderly. We realized the importance of the social-security programs and would like to emphasize the significance of the programs for retired people as they cannot expect much support from their children for their retirement. Many developing countries, including Thailand, are moving in this direction.

We used a similar framework and incorporated some assumptions extended from chapter 3. In the previous chapter, we incorporated health insurance into the model. However, to investigate a government's financial burden in an aging society, a pension system should be considered. In chapter 4, therefore, we introduce a pay-as-you-go pension program as an extension of social security from chapter 3 to capture a wider range of government subsidies for the elderly. We also conducted a quantitative discussion re-

garding how the government could finance the excess costs of aging. In general, social programs are costly, especially among low-fertility-rate countries, as they have a smaller of young population who will be able to pay taxes and bear the social-subsidy costs for a larger number of elderly people.

## 4.1 The Model

This chapter uses a similar framework as chapter 3; therefore, we refer to some basic structures of the model, including demographic structure, education investment, and production function:

(1) Demographic structure (3.1.1): We still have three generations in our framework, which are children, young adults, and old adults.

(2) Education investment and human-capital development (3.1.2): There are two types of populations, skilled and unskilled adults, which are determined by their education investment decided by their parents.

(3) Production function and labor market (3.1.3): We also have two separate production sectors for the formal and informal sector with a standard constant return to scale.

However, this chapter highlights the significance of social-security programs and how the government finances the excess costs of aging; thus, we modified government constraints, individual's problem, and equilibrium features as follows.

### 4.1.1 Government

In this chapter, the government uses total revenue to finance not only public health-care expenditures ($M_g$) and other public expenditures ($G$) but also public pension ($P_g$; equation 9). The government still cannot monitor/tax the labor income from the informal sector.

The government runs a pay-as-you-go pension system with a replacement rate ($\rho$) of registered (taxable) wage income. Let $\theta_s$ denote the proportion of skilled labor allocated in the formal sector and $\theta_u$ denote the proportion of unskilled labor allocated in the formal sector. Total pension payment $P_g$ can be defined as

$$P_g = \rho(\theta_s w_s^f L_s^f + \theta_u w_u^f L_u^f). \tag{21}$$

The government is required to maintain budget balance every period. The budget constraint for the government is given by:

$$P_g + M_g + G = T_C + T_L + T_K. \tag{22}$$

### 4.1.2 Individual's Problem

Each young adult is endowed one unit of time. Child-rearing activities cost a fraction of the parent's total time per child ($\phi$). The rest of the parent's time $(1-\phi)$ can be supplied to labor markets for earnings in the formal and/or informal sectors. We assume that during their lifetimes, individuals experience working in both sectors, and to some extent, they can decide the allocation of working time between the two sectors. To capture the features of involuntary informal workers and institutional distortions on the labor markets (e.g., minimum-wage regulation in the formal sector), we adopted a reduced form constraint on labor mobility: an upper bound of labor allocated in the formal sector.

An young adult with skill level $i = \{s, u\}$ chooses current consumption $c_i^y$, assets to carry to old age $a_i'$, number of children $n_i$, education investment $e_i = \{0, \bar{e}\}$ and proportion of formal labor supply $\theta_i$ to maximize her lifetime utility. We assume period utility function is a constant relative risk aversion utility function:

$$u(c_i^y) = \frac{c_i^{y\,1-\sigma}}{1-\sigma} \tag{23}$$

$$u(c_i^{o\prime}) = \frac{c_i^{o\prime\,1-\sigma}}{1-\sigma} \tag{24}$$

$$0 < \sigma < 1 \tag{25}$$

The problem can be defined and expressed by the following value function:

$$V_i = \max_{\{c_i^y, a_i', n_i, e_i, \theta_i\}} \left\{ u(c_i^y) + \beta \pi^y u(c_i^{o\prime}) + \psi n_i^{-\varepsilon} [n_i V_j'] \right\}, \tag{26}$$

subject to

$$(1+\tau_C)c_i^y + \pi^y a_i' + e_i n_i = (1-\phi n_i)[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x]; \tag{27}$$

$$(1+\tau_C)c_i^{o\prime} = [1+(1-\tau_K)r']a_i' - (1-\omega)m' + P_{g,i}; \tag{28}$$

$$j = s, \text{ if } e_i = \bar{e};\ j = u, \text{ if } e_i = 0 \tag{29}$$

$$0 \leq \theta_i \leq \bar{\theta_i}; \tag{30}$$

where $w^g$ is the wage rate for sector $g$; $\theta$ is the proportion of total working time allocated in the formal sector; $m'$ is medical expenditures in old age. We assume perfect annuity. The young adult pays $\pi^y a_i'$ for the annuity (as savings) and receives $(1+r')a'$ next period if she/he survives. We assume educational cost is a function of skilled wage in the formal sector $\bar{e} = \phi_s w_s^f$.

### 4.1.3 Equilibrium Features

We focus on an equilibrium in which both skilled and unskilled workers exist with an upward intergenerational mobility: Skilled parents always invest in children's education, and some unskilled parents invest in education while others do not. Thus, in this equilibrium, unskilled parents are indifferent about investing in their children's education:

$$\frac{V_{u,e=\bar{e}}}{P_s^{1-\varepsilon}} = \frac{V_{u,e=0}}{P_u^{1-\varepsilon}} \tag{31}$$

where $V_{s,e=\bar{e}}$ is the value of a skilled parent who chooses to invest on children's education (so his/her children will become skilled labor),

$V_{u,e=0}$ is is the value of a unskilled parent who chooses not to invest on children's education (so his/her children will become unskilled labor),

$P_s = \phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x] + \bar{e}$ is the total cost for having an educated child, and

$P_u = \phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x]$ is the total cost for an un-(low-)educated child.

Optimal decision rules are determined as follows:

- Savings($\pi_y a'$): An adult needs to trade off between today consumption and future consumption. Thus, the optimal decision is a marginal utility of today consumption equals to a marginal utility of tomorrow consumption (old-adult period).

$$u_{c^y} = \beta(1+(1-\tau_K)r')u_{c^{o\prime}} \tag{32}$$

- Fertility (number of children): To satisfy the optimal number of children, it implies a marginal utility of children equals to a marginal cost spending on raising a child.

$$\psi(1-\varepsilon)(n_i)^{-\varepsilon}V_j' = u_{c^y}\{\phi[\theta_i(1-\tau_L)w_i^f + (1-\theta_i)w_i^x] + e_i\} \tag{33}$$

where $w_i^f$ is the formal sector wage rate and $w_i^x$ is the informal sector wage rate

- Formal labor supply:

  if not binding

$$\left[(1-\tau_L)+(\frac{\pi_y}{1+r})\rho\right] w_i^f = w_i^x; \quad \theta_i < \bar{\theta_i} \tag{34}$$

  if binding

$$\left[(1-\tau_L)+(\frac{\pi_y}{1+r})\rho\right] w_i^f > w_i^x; \quad \theta_i = \bar{\theta_i} \tag{35}$$

Given the big wage gap between formal and informal sectors, it is not possible if none of the formal labor supply constraints are binding. Hence, there are two possible cases:

- Case 1: unskilled binding; skilled not binding

  Skilled:

$$\begin{aligned}
&\left[(1-\tau)+(\frac{\pi_y}{1+r})\rho\right] w_s^f = w_s^x; \quad \theta_s < \bar{\theta_s} \\
\Rightarrow &\left[(1-\tau)+(\frac{\pi_y}{1+r})\rho\right] \frac{A^f(K^f)^{\alpha_1}\alpha_2(L_s^f)^{\alpha_2-1}(L_u^f)^{\alpha_3}}{A^x(K^x)^{\gamma_1}\gamma_2(L_s^x)^{\gamma_2-1}(L_u^x)^{\gamma_3}} = 1 \\
\Rightarrow &\frac{L_s^f}{L_s^x} = \left[(1-\tau)+(\frac{\pi_y}{1+r})\rho\right] \frac{A^f(K^f)^{\alpha_1}\alpha_2(L_s^f)^{\alpha_2}(L_u^f)^{\alpha_3}}{A^x(K^x)^{\gamma_1}\gamma_2(L_s^x)^{\gamma_2}(L_u^x)^{\gamma_3}}
\end{aligned}$$

  Unskilled: $\theta_u = \bar{\theta_u}$

- Case 2: both binding $\Rightarrow \theta_u = \bar{\theta_u}$ and $\theta_s = \bar{\theta_s}$.

  This is not a preferred case because voluntary informal workers do not exist.

In this dissertation we focus on case 1 for all the analysis.

## 4.2 Parameters and Benchmark

Thailand was selected as a representative economy for our quantitative analysis. We set up parameters by calibrating our model to match similar targets as in chapter 3, including fertility, life expectancy, skilled-labor share, capital-output ratio, formal-employment ratio, and skilled-unskilled wage ratio in the formal sector. We used the calibrated model as a benchmark and performed quantitative experiments based on it.

### 4.2.1 Parameters

Table 4-1 summarizes the parameters used to calibrate the benchmark in a steady state. In the calibration, most parameters were similar to the one in chapter 3 (table 3-1). There were some that were slightly different: (a) we chose the annual discount factor to be 0.9383 to match the capital-output ratio (1.90) in 2012. (b) we made the altruism coefficient equal to 0.233 so that we could match TFR (1.54).[22] (c) in the formal sector, we targeted $A^x = 6.53$ to match the proportion of skilled workers in formal economy ($\theta_s$). (d) in terms of pay-as-you-go pension benefits, we assumed that pension benefits would be provided only for workers who paid their income tax during the working period, with a 25% pension-replacement rate.

### 4.2.2 Benchmark Economy

Table 4-2 compares the real data and benchmark results. There are two parts: calibrated and non-calibrated results. In terms of calibrated results, we found all target variables; fertility, life expectancy, skilled-labor share, skilled workers in the formal economy ratio ($\theta_s$), and average income share between formal and informal sector ($w^f/w^x$), were perfectly matched with the real data. Therefore, it can be implied that the model is highly effective and can represent Thailand's current demographic and real economic situation very well. Although the income inequality $w_s^f/w_u^f$ was not calibrated, it turned out to be

[22] Data source: United Nations Population Division. World Population Prospects.

close to the data. The model also stimulated fertility for $n_{ij}$ which can be summarized as follows: the fertility rate of skilled parents ($n_{ss}$) was 0.3547, the fertility rate of unskilled parents with skilled children ($n_{us}$) was 0.2973, and the fertility rate of unskilled parents with unskilled children $n_{uu}$ was 0.9253.

## 4.3 Cost of Aging and Tax Policy

We compared alternative tax tools, such as a consumption tax and capital income tax for financing government expenditures in the aging economy. We assumed that the government-consumption-to-GDP ratio was fixed, as in the benchmark, and used labor income tax, consumption tax, or capital income tax to balance the government budget.

We used labor income tax to ensure fiscal balance in the aging economy. First, in an aging society, people are required to save more assets to secure their retirement; therefore, capital-output ratio increases by 14.88%. Second, we observed significant increases in labor-income tax burdens, income tax rate increases from 15% to 34%. The government needs to increase the labor income tax to sustain social programs and other government expenditures. Skilled labors tend to switch from the formal sector to the informal sector to avoid higher tax burdens. Therefore, the skilled-labor share in the formal sector declined from 17.02% to 13.81%. Moreover, we found that the average TFR and social welfare slightly increased from 1.533 to 1.538 and 1.38 to 1.52, respectively.

The results in table 4-3 also present the impacts on alternative policies. We observed that both consumption and capital income tax have minor impacts on the average TFR. Fertility increased slightly from 1.533 to 1.540 and 1.538. Moreover, we found three main effects on using a consumption tax and capital income tax for financing government expenditures in the aging economy. First, unlike income tax, we found neither consumption tax and capital income tax distorted human-capital investment. The skilled-labor share in the formal sector increased from 17.02% to 17.19% and 17.33%, respectively. Second, people tend to decrease their saving if the government increases the capital income tax.

This means that an increase in the capital income tax will distort savings. If the government would like to use the capital income tax to finance the exceeding costs of aging, the tax rate needs to be increased by 6.7 percentage point from 20% to 26.7%. On the other hand, if the government uses a consumption tax to balance the expenditures, we can observe the highest capital-output ratio (2.367), since people need to save more money for future consumption. Third, people can enjoy the best social-welfare benefits if the government finances the excess cost of aging by increasing the consumption tax. One possibility is that all age of groups be required to pay the consumption tax equally.

## 4.4 Potential Social-Security Reform

The results in table 4-4 present the potential social-welfare reform. We discuss pension reform to see whether the government can improve social welfare and the average TFR by adjusting different pension replacement rates from 0% to 40%. We observed that the average TFR slightly increased according to an increase in the pension-replacement rate. On the other hand, the social welfare decreased. We found that lower pension-replacement rate or pension repayment is better because of two possible factors.

(1) Fiscal burden: The government needed to tax young people to finance old people. With the population declining, at some point, the number of old people will surpass the number of young people. Therefore, the burden on young people to maintain social security will be higher.

(2) Capital crowding out: We observed that people will reduce saving if they realize that they receive a higher pension, which decrease the capital-output ratio.

## 4.5 Role of the Informal Sector

We will first discuss a counterfactual scenario in which the government improves its tax-collection technology, allowing the informal sector to be taxed. We demonstrate a case in which there is a 50% probability that workers' income in the informal sector will be taxed. Table 4-5 presents the result; the labor income tax decreases by over 10% from 33.9% to 23.6%. Therefore, there is no benefit for workers to relocate from the formal to informal sector to avoid increased tax burdens. We observed a smaller distortion on skilled-labor allocation and education investment, as skilled-labor share in the formal economy increased by 2.77%. However, the result showed a negative welfare change, as the government also needed to provide more pension benefits by increasing fiscal burdens for young generations. Moreover, people reduce saving as they rely more on the government pension, which lowers the capital-output ratio.

Table 4-6 shows the results of fiscal policy with formalization (i.e., no informal sector). We revisited the fiscal-policy experiment again by assuming the government can collect 100% of all tax revenue from every tax-income channel. In this case, there was no distortion from the informal sector that we mention earlier. We found that the consumption tax was still the best compared to the other two tax tools. Similarly, even though there was no informal sector, labor income tax showed some distortion on education investment, and capital income tax showed some distortion on saving.

## 4.6 Conclusion

In this chapter, we discussed the impacts of fiscal policy on population aging by developing a two-sector general equilibrium overlapping generations model with endogenous fertility and education choices. The model also captured the informal sector, which is an important feature in developing countries. We used Thailand as a representative for calibration and quantitative analysis. We realized the significance of social programs in developing countries to maintain the quality of life for the elderly. We incorporated a pay-as-you-go pension plan into the model to capture a wider range of government subsidies.

We first discussed the impact of aging and fiscal burden on society. We found that there was a significant increase in income taxes to sustain social programs. Moreover, when comparing the use of consumption and capital income taxes to finance to excess costs of aging, we observed that the consumption tax was the best tax tool in this aging economy scenario, as it causes fewer distortions of labor allocation, saving, and education investment.

Second, we discussed potential social-security reform. We adjusted the pension-replacement rate to figure out whether the government could improve social welfare. The model implies that privatization of public pensions is a good way to improve social welfare. A PAYG pension system mainly relying on intergradation transfer is not good for an aging society. The government should encourage people to prepare enough savings for themselves. However, we do not consider any risk or uncertainty that can occur if they do not have enough saved resources. Therefore, any pension reform should take this concern into consideration.

Third, we studied a counterfactual scenario in the informal sector if the government could improve its tax-collection system in which there is a 50% probability that workers' income in the informal sector will be taxed. This improvement could reduce the income tax rate. Moreover, there was no benefit for workers to relocate from the formal to the informal sector to avoid tax payment in this scenario. Therefore, in this scenario, we observed a higher number of skilled-labor share. We also revisited the fiscal experiment by assuming the government could collect 100% of all tax revenue from every income-tax channel to ensure the robustness of the results. We observed the same pattern; the consumption tax was still the best compared to labor income and capital income taxes.

# 4.A Main Table

Table 4-1: New Parameters

| **Parameters** | **Value** | **Source/Target** |
|---|---|---|
| *Survival Rates* | | |
| $\pi^y$ | 0.47 | life expectancy 74.18 |
| *Preference* | | |
| $\beta$ | 0.9528 | capital-output ratio 1.9 |
| $\psi$ | 0.233 | a half of TFR 0.77 |
| *Informal employment and production* | | |
| $\bar{\theta}_s$ | – | not binding |
| $\bar{\theta}_u$ | 0.3 | binding; data $L_u^f/(L_u^f+L_u^x)=0.3$ |
| $A^f$ | 10 | normalization |
| $A^x$ | 6.53 | data $L_s^f/(L_s^f+L_s^x)=0.726$ |
| $(\alpha_1,\alpha_2,\alpha_3)$ | (0.67, 0.09, 0.24 ) | data income shares (formal sector) |
| $(\gamma_1,\gamma_2,\gamma_3)$ | (0.67, 0.045, 0.285 ) | $w^f/w^x=3.3$ |
| *Child Schooling/Rearing Costs* | | |
| $\phi_s$ | 0.16 | skilled labor share 17.34% |
| $\phi$ | 0.243 | child-rearing cost (to high school) 2004 |
| *Tax Rates* | | |
| $\tau_C$ | 10% | Tax rate on consumption |
| $\tau_K$ | 20% | Tax rate on capital income |
| $\tau_L$ | 15% | Tax rate on labor income |
| *Government Subsidy* | | |
| $\omega$ | 67.5% | public medical expenditure share |
| $\rho$ | 25% | pension replacement rate |

Table 4-2: New Model Benchmark

| | Data | Model (benchmark) |
|---|---|---|
| **Calibrated** | | |
| Average TFR | 1.54 | 1.53 |
| Life expectancy | 74 | 74 |
| Skilled labor share (formal) | 17% | 17% |
| Capital-output ratio | 1.90 | 1.91 |
| $\theta_s \ (L_s^f/L_s)$ | 0.73 | 0.73 |
| $\theta_u \ (L_u^f/L_u)$ | 0.30 | 0.30 |
| $w^f/w^x$ | 3.26 | 3.28 |
| **Not calibrated** | | |
| $w_s^f/w_u^f$ | 1.79 | 1.81 |
| $(G/Y)$ / (Total Govt Exp/Y) | –/ 11.71% | 18.89% / 22.59% |
| $n_{ss}$ | | 0.3547 |
| $n_{us}$ | | 0.2973 |
| $n_{uu}$ | | 0.9253 |
| Average TFRs | | 0.71 |
| Average TFRu | | 1.71 |

Table 4-3: Tax Policy

| | Fiscal Policies - Aging economy | | | |
|---|---|---|---|---|
| Financing tool | Benchmark | Labor tax | Consumption tax | Capital tax |
| $\tau_L$ | 15% | **33.9%** | 15.0% | 15.0% |
| $\tau_C$ | 10% | 10% | **15.8%** | 10.0% |
| $\tau_K$ | 20% | 20% | 20.0% | **26.7%** |
| Average TFR | 1.533 | 1.538 | 1.540 | 1.538 |
| Average TFRs | 0.709 | 0.705 | 0.719 | 0.715 |
| Average TFRu | 1.706 | 1.714 | 1.712 | 1.710 |
| Skilled labor share (formal) | 17.02% | **13.81%** | 17.19% | 17.33% |
| $w_s^f/w_s^x$ | 1.16 | 1.47 | 1.15 | 1.15 |
| Capital-output ratio | 1.908 | 2.192 | **2.367** | 2.288 |
| Annual return on capital | 8.2% | 7.7% | 7.4% | 7.5% |
| Social welfare | 1.38 | 1.52 | **1.72** | 1.70 |
| Welfare (skilled) | 2.27 | 2.64 | 2.83 | 2.79 |
| Welfare (unskilled) | 1.32 | 1.45 | 1.64 | 1.62 |

Table 4-4: Government Pension Reform

| | Baseline | 0% | 10% | 20% | 30% | 40% |
|---|---|---|---|---|---|---|
| $n_{ss}$ | 0.352 | 0.345 | 0.348 | 0.351 | 0.354 | 0.356 |
| $n_{us}$ | 0.276 | 0.279 | 0.278 | 0.277 | 0.276 | 0.274 |
| $n_{uu}$ | 0.927 | 0.902 | 0.912 | 0.923 | 0.932 | 0.942 |
| Average TFR | 1.538 | 1.499 | 1.515 | 1.531 | 1.546 | 1.561 |
| Average TFRs | 0.075 | 0.690 | 0.696 | 0.702 | 0.707 | 0.713 |
| Average TFRu | 1.714 | 1.669 | 1.687 | 1.705 | 1.722 | 1.739 |
| Skilled labor share | **13.81%** | **14.63%** | **14.30%** | **13.97%** | **13.65%** | **13.33%** |
| $w_s^f / w_s^x$ | 1.47 | 1.36 | 1.40 | 1.45 | 1.49 | 1.54 |
| Capital-output ratio | 2.19 | 2.38 | 2.30 | 2.23 | 2.16 | 2.09 |
| Labor income tax | **33.96%** | **26.64%** | **29.64%** | **32.55%** | **35.36%** | **38.08%** |
| Social welfare | 1.52 | **1.67** | **1.61** | **1.55** | **1.50** | **1.44** |
| Welfare (skilled) | 2.64 | 2.87 | 2.77 | 2.68 | 2.59 | 2.51 |
| Welfare (unskilled) | 1.45 | 1.59 | 1.53 | 1.48 | 1.43 | 1.38 |

Table 4-5: Role of Informal Sector-Income tax

| | Baseline | Taxing informal |
|---|---|---|
| Average TFR | 1.538 | 1.752 |
| Average TFRs | 0.705 | 0.705 |
| Average TFRu | 1.714 | 1.971 |
| Skilled labor share (formal) | 13.81% | **16.58%** |
| $w_s^f / w_s^x$ | 1.47 | 1.14 |
| Capital-output ratio | 2.19 | 2.02 |
| Labor income tax | **33.9%** | **23.6%** |
| Social welfare | **1.52** | **1.45 (CEV:-8.18%)** |
| Welfare (skilled) | 2.64 | 2.44 (CEV:-14.51%) |
| Welfare (unskilled) | 1.45 | 1.38 (CEV:-9.93%) |

Table 4-6: Fiscal Policy with a Formalization

| | | Aging economy | | |
|---|---|---|---|---|
| Financing tool | Baseline | Labor tax | Consumption tax | Capital tax |
| $\tau_L$ | 33.9% | **18.9%** | 15.0% | 15.0% |
| $\tau_C$ | 10% | 10% | **16.7%** | 10.0% |
| $\tau_K$ | 20% | 20% | 20.0% | **27.4%** |
| Skilled labor share (formal) | 13.81% | **18.2%** | 18.4% | 18.4% |
| Capital-output ratio | 2.192 | 1.93 | **2.04** | 1.96 |
| Social welfare | 1.52 | 1.39 | **1.46** | 1.44 |
| Welfare (skilled) | 2.64 | 2.31 | 2.39 | 2.36 |
| Welfare (unskilled) | 1.45 | 1.33 | 1.39 | 1.37 |

## 4.B Sensitivity Analysis

In this dissertation, the capital share of output between the formal and informal section is assumed to be the same. Therefore, we provide a sensitivity test with alternative values of capital share in the informal sector production function and redo the fiscal policy experiments ($\gamma_1$, from 0.67 to 0.5 and 0.8). The results in table 4-3 (a) and table 4-3 (b) show the same patterns as that in the 4.3.

Moreover, we observed that a lower $\gamma_1$, capital return in the informal sector will be lower and more capital will be allocated in the formal sector (more efficient) and so the aggregate productivity will be higher and lead to higher output per capital. This improvement in output/income reduces the tax burden.

Table 4-7: Tax Policy with a Lower Informal Sector Capital Share ($\gamma_1 = 0.5$)

| | Fiscal Policies - Aging economy | | |
|---|---|---|---|
| Financing tool | Labor tax | Consumption tax | Capital tax |
| $\tau_L$ | **29.60%** | 15.0% | 15.0% |
| $\tau_C$ | 10% | **14.9%** | 10.0% |
| $\tau_K$ | 20% | 20.0% | **25.9%** |
| Average TFR | 1.570 | 1.564 | 1.571 |
| Average TFRs | 0.743 | 0.746 | 0.755 |
| Average TFRu | 1.744 | 1.736 | 1.742 |
| Skilled labor share (formal) | **15.74%** | 18.64% | 18.39% |
| Capital-output ratio | 2.388 | **2.528** | 2.446 |
| Social welfare | 1.71 | **1.87** | 1.84 |
| Welfare (skilled) | 2.78 | 2.92 | 2.89 |
| Welfare (unskilled) | 1.64 | 1.79 | 1.76 |

Table 4-8: Tax Policy with a Higher Informal Sector Capital Share ($\gamma_1 = 0.8$)

| | Fiscal Policies - Aging economy | | |
|---|---|---|---|
| Financing tool | Labor tax | Consumption tax | Capital tax |
| $\tau_L$ | **39.83%** | 15.0% | 15.0% |
| $\tau_C$ | 10% | **17.1%** | 10.0% |
| $\tau_K$ | 20% | 20.0% | **27.5%** |
| Average TFR | 1.477 | 1.492 | 1.491 |
| Average TFRs | 0.652 | 0.678 | 0.676 |
| Average TFRu | 1.650 | 1.663 | 1.662 |
| Skilled labor share (formal) | **11.98%** | 16.28% | 16.22% |
| Capital-output ratio | 1.904 | **2.138** | 2.057 |
| Social welfare | 1.21 | **1.47** | 1.45 |
| Welfare (skilled) | 2.35 | 2.63 | 2.59 |
| Welfare (unskilled) | 1.14 | 1.38 | 1.36 |

# CHAPTER 5

# Conclusion

In this chapter, we first gather and summarize the main findings from chapters 3 and 4. Then, we discuss the policy implications from a broader perspective. Finally, we briefly mention the possible directions for the further studies.

## 5.1 Summary of Studies

This dissertation concentrated on evaluating population and fiscal policies in a developing economy with aging. In particular, we first investigated the impacts of aging on different population policies, which were a subsidy on time cost, child allowance, and an education subsidy, responding to the average total fertility rate (TFR) stimulation. Second, we investigated the excess burdens on social-security programs to finance elders by discussing the possible alternative tax tools for fiscal balance, adjusting pension-replacement rates for social security reform, and conducting counterfactual scenarios in the informal sector.

To address these concerns, we developed a two-sector general equilibrium OLG model with endogenous fertility and education choices. We used Thailand as an example for the quantitative analysis because of its dramatic decline in fertility to below the replacement rate. Moreover, roughly 60% of its workers are in the informal sector, and it has recently developed public-pension and the universal-health insurance systems. The model was calibrated to match some key factors of the Thai economy and demographic variables in 2000s. We quantitatively investigated the impacts of aging and assessed the population and fiscal policies by their effects on economic performance and social welfare.

Our quantitative analysis first suggested that in an emerging economy like Thailand, if the life expectancy increases to 83, as forecasted for 2065, and the labor income tax is used to balance the government's budget, the labor income tax has to increase to 32%, up from the current 15%. We also observed a distortion in education and labor allocation between the formal and informal sectors as a higher labor income tax rate will lower the return on education.

Second, in addition to aging, the time-cost subsidy and child allowance will lead to a worsened social-welfare level because they distort the relative price between skilled and unskilled labor and reduce education investments, although they successfully raise the average TFR and improve the old-age dependency ratio. Instead, we suggested an education subsidy to improve long-run economic performance and welfare.

Third, we found that capital income taxes should not be zero in an economy with a large informal sector. Even if the informal sector does not exist, a labor tax still distorts the decision of education investment and indicates the necessity of a positive capital income tax. If a consumption tax were available, we found that it was the best tax tool for an aging economy. Redistribution is the main concern about using a consumption tax to replace income taxes in the literature. Although we do not characterize detailed income/wealth inequalities in this model to discuss redistribution in this aspect, a consumption tax has a redistribution effect between young and old generations, which is preferred in an aging economy with a negative population growth.[23]

Fourth, we found that reducing pay-as-you-go government pension can be a welfare improvement because it generates a lower labor income tax burden while maintaining the capital-output ratio. However, we do not consider any risk or uncertainty that can occur if people do not have enough financial or saved resources.

[23]Correia (2010) shows that consumption tax also has a preferred redistribution effect over income groups.

Finally, we found that if the government could improve its tax-collection system and be able to tax the informal sector, it could reduce the labor income tax rate. We observed that doing so may reduce savings and increases the number of children, which could lead to a lower capital-output ratio. Moreover, there would be less relocation between the formal and informal sectors, as there would be no benefit to moving from one sector to the other. We revisited the fiscal experiment by assuming that the government could collect 100% of all tax revenue from every income-tax channel to ensure the robustness of the results. We found that the consumption tax was still the best tax tool.

## 5.2 Policy implications

This dissertation investigates the impacts of aging in a developing country with population and fiscal policy in chapter 3 and chapter 4, respectively.

Chapter 3 investigated population policy in a developing country with aging; our empirical studies provided some policy implications. First, a time cost subsidy and child allowance can help improve the fertility rate and age-structure. However, they lessened both physical and human-capital investment and eventually increased fiscal burdens and lowered economic growth in the long run. Therefore, they may not be good policy suggestions for developing countries with an already low human-capital level.

Second, we found that the education subsidy encouraged human-capital investment. Therefore, if the government would like to increase the fertility rate without lowering human-capital investment, the possible solution is an education subsidy with some other childcare policy.

Chapter 4 investigated fiscal policy in a developing country with aging; our empirical studies provided several policy implications. First, concerning taxation, our results were consistent with Dekle (2004), suggesting that the benefits of current retirees should be covered by increased consumption taxes. We found that the consumption tax was the best tax tool in an aging economy because it distorted on labor allocation, saving, and education investment less than any other taxes. In terms of labor allocation, workers will see no benefit in moving from the formal sector to the informal sector in order to avoid paying labor income taxes.

Second, according to the experiments related with the public pension system, our results imply that a privatization or a fully-funded system will improve social welfare in an aging economy. Since our model does not consider any income risk that limits the ability of saving for retirement, although we suggest that the government should not provide too generous pay-as-you-go pension system with a trend of rapid population aging. It is necessary to consider associated social insurances that ensure a certain living standard for poor people in old ages.

## 5.3 Future Studies

Population aging is a much broader concept than what we have discussed here; our studies in this dissertation suggest several possible research directions that deserve further exploration in the future.

Concerning population policy, we could further explore other developing countries and conduct a cross-country comparison. Another possible idea would be to consider Lee et al.'s (2014) study of population policies across countries, which showed the optimal fertility for three different groups classified by income level, which were high-income, medium-income, and low-income countries. They observed the optimal replacement rate to maximize per capita consumption, standard of living, and the most beneficial government budgets in the long-run. However, the study did not concern the aging issue. Therefore, investigating the optimal fertility in an aging economy can be an extension of our study.

Concerning fiscal policy, a potential research direction would introduce a social public pension for elderly informal sector workers in developing countries. In this dissertation, we assumed that only formal sector workers who paid taxes would receive social pensions after they retired. However, in reality, the government should show concern for informal sector workers, as they have a higher potential to have difficulties sustaining their lifestyles after they retire.

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