The Development of Universal Health Insurance

Coverage in Thailand: Challenges of Population Aging and Informal Economy

Minchung Hsu*  Xianguo Huang†  Somrasri Yupho‡ §

ABSTRACT

This paper quantitatively investigates the sustainability of the universal health insurance coverage (UHI) system in Thailand while taking into account the country’s rapidly aging population and large informal labor sector. We examine the effects of population aging and informal employment across three tax options for financing the UHI. A modern dynamic general equilibrium framework is utilized to conduct policy experiments and welfare analysis. In the case of labor income tax being used to finance the cost of UHI, an additional 11–15% of labor tax will be required with the 2050 population age structure, compared with the 2005 benchmark economy. We also find that an expansion of income tax base to the informal sector (formalization) can substantially alleviate the tax burden. Based on welfare comparisons across the alternative tax options, the labor income tax is the most preferred because the informal labor sector is large. If the informal sector cannot avoid labor income tax, capital tax will be preferred over labor and consumption taxes.

Keywords: Universal Health Insurance, Informal Employment, Population Aging.

*Corresponding author. National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan. E-mail: minchunghsu@grips.ac.jp. 7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, Japan
†National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan. E-mail: phd09008@grips.ac.jp.
‡Fiscal Policy Office, Ministry of Finance, Thailand. E-mail: somrasri@gmail.com.
§Hsu is grateful for the financial support from GRIPS policy research center and JSPS Grant-in-Aid for Young Scientists (B) 26780173. Huang would like to thank the research support from Global Leadership Program, the University of Tokyo and from the Australian Research Council Centre of Excellence in Population Aging Research (project CE110001029).
1 Introduction

Most developed countries provide universal health insurance (UHI) to their residents. In developing countries, health care is distributed unequally across the population. Those with low income or living in rural areas usually have limited access to medical resources. Therefore, the World Health Organization (WHO) encourages developing countries to improve the equity and the affordability of health care by establishing UHI. The goal is for all people to have access to medical services without suffering financial hardship to pay for these services (WHO, 2010).

To achieve this goal, a sufficient financing system is crucial. A public provision of UHI, which is financed/subsidized by government revenue, is a shortcut. However, such a provision is not easy for developing countries, particularly those with lower income levels, due to its potentially high financing burden. This study focuses on Thailand because it has been viewed as a successful case in terms of middle- and low-income countries achieving UHI. Thailand implemented the Universal Coverage Scheme (UCS) in 2002 to cover the previously uninsured population. Two then-existing insurance schemes – the Medical Welfare Scheme (MWS), which covered the elderly, the children, and the poor, and the Voluntary Health Card Scheme (VHCS), which targeted farmers and workers in the informal sector – were merged into the UCS. Both the MWS and VHCS were underfunded and provided ineffective insurance coverage. In addition to the UCS, Thailand’s health-care system includes the Social Security Scheme (SSS), which covers workers in the formal private sector, and the Civil Servant Health Benefit Scheme (CSMBS), which provides health care to government employees and their direct relatives. The effect of the 2002 health-care system reform is significant, with the coverage of health insurance increasing from 70% in 2001 to 95% in 2003. The total health insurance
Table 1: The Health-Care Reform in Thailand

<table>
<thead>
<tr>
<th>Insurance scheme in 2001</th>
<th>Group</th>
<th>Effects of UHI reform</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSS &amp; CSMBS</td>
<td>Formal sector workers, civil servants &amp; families</td>
<td>no formal change</td>
<td>20%</td>
</tr>
<tr>
<td>MWS</td>
<td>Poor, elderly (&gt; 60), and children (&lt; 15)</td>
<td>merged to UCS</td>
<td>30%</td>
</tr>
<tr>
<td>VHCS</td>
<td>Voluntary participation</td>
<td>merged to UCS</td>
<td>20%</td>
</tr>
<tr>
<td>Uninsured</td>
<td></td>
<td>covered by UCS</td>
<td>30%</td>
</tr>
</tbody>
</table>

coverage was 98% in 2011. Table 1 summarizes the development of universal coverage in Thailand. Compared with previous insurance schemes, UCS provides better insurance coverage. The co-payment for any covered item is set at 30 baht (around 0.9 USD), and the average out-of-pocket health expenditure ratio was reduced from 33% in 2001 to 14% in 2011. Although the total health expenditure grew, on average, by 6.3% annually between 2001 and 2010, its ratio to gross domestic product (GDP) was only 3.5–4% during this period. However, the cost remains much lower than that of developed countries. See Hanvoravongchai (2013) for more detailed information about the universal health insurance coverage reform in Thailand.

However, some potential threats to the sustainability of the current health-care system exist. In particular, the trend of rapid population aging and the large informal sector in Thailand might be the two most important challenges to financing the health-care system. The former increases the cost of UHI sharply and reduces the tax base. The latter further constrains the government’s ability to raise its tax revenue.

According to the United Nations population forecast, Thailand will soon face a severe issue of population aging. The old-age dependency ratio (ratio of population aged 65+ per 100 population aged 15–64) was 12.4 in 2010, but it is expected to increase quickly and reach 53.1 in 2050, even higher than those of the US (35.5) and France (42.2). Figure 1
shows the trends in the old-age dependency ratio for Thailand and some selected countries. The effects of population aging on the health-financing system are twofold. First, because elderly people need significantly more health care than young people and the rapid population aging indicates an imminent increase in their numbers in the total population, significant increases in the aggregate medical cost and in the financing burden of the UHI system cannot be avoided. Table 2 presents the average medical costs for young and old people in several countries, and it is obvious that the average annual cost for the old is at least twice as much as that for the young. Figure 2 further shows trends in aging and per-capita medical cost in several countries with similar universal health insurance coverage. Both factors clearly increased during the studied time period. Second, aging implies a shrinking working-age population/tax base, such that the government finds it difficult to finance the extra burden of UHI using its original tax revenue.

While population aging increases the total medical cost and reduces the tax base, the presence of the informal economy further constrains the government’s ability to collect taxes. This issue has not been well discussed in the literature because most previous
Table 2: Estimated average annual medical costs for young and old

<table>
<thead>
<tr>
<th>Country (data year; currency)</th>
<th>Young</th>
<th>Old</th>
<th>Old/Young ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan (2007; Yen)</td>
<td>122,000</td>
<td>591,000</td>
<td>4.84</td>
</tr>
<tr>
<td>Taiwan (2004; TWD)</td>
<td>13,779</td>
<td>85,279</td>
<td>6.19</td>
</tr>
<tr>
<td>Thailand (2005; baht)</td>
<td>4873</td>
<td>9653</td>
<td>1.98</td>
</tr>
<tr>
<td>USA (2003; USD)</td>
<td>2640</td>
<td>6425</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Source: US – Hsu (2013); Taiwan – Hsu and Liao (2015); Japan – Hsu and Yamada (2013); Thailand–authors’ calculation (see Table 5)

studies have focused on developed countries. However, in developing countries, informal sectors are typically greater. According to estimates made by the National Statistical Office of Thailand, the share of informal employment was stably around 62–63% between 2007 and 2012 (see Fig. 3; source: http://web.nso.go.th/en/survey/lfs/imp/imp09.htm).

Informal workers are not protected by social security, and they do not pay tax. They have low education levels (65–70% had an elementary school education or below and only 5–7% had a level of education higher than secondary school during the 2007–2012 period), and they tend to work in the agriculture sector (around 60%). If the size of the informal sector remains the same, the financing of UHI will be even more difficult in the near future when the population becomes more aged.

To quantitatively analyze the sustainability of Thailand’s universal health insurance system and to assess potential reforms of its financing (taxation) scheme, we adopt a modern dynamic general equilibrium framework that includes a large number of heterogeneous agents who face income/employment and medical expenditure shocks every period, a production sector with formal and informal laborers, and a government that collects taxes and provides universal health insurance and social security. This theoretical framework takes individuals’ responses to a policy/environment change over time into account, and it allows us to investigate the long-term consequence of the change.
Figure 2: Trends of aging and per-capita medical cost

Figure 3: Percentage of informal employment 2007–2012
It also enables a comprehensive welfare analysis that considers the effects on both the aggregate economy and individuals. Similar models have been used in recent studies on health insurance systems and public finance issues. For example, Jeske and Kitao (2009) study the effect of the US tax subsidy on health insurance, Hsu (2013) analyzes individuals’ choices of health insurance/saving and the effects of some US welfare programs, Hsu and Liao (2015) study the financing issue focusing on the National Health Insurance in Taiwan, and Hansen et al. (2014) analyze the corresponding impacts and financing burden of a potential health insurance reform in the US. Heathcote (2005) and Hsu and Yang (2013) also use this framework to discuss fiscal policy and income taxation and the corresponding welfare effects.

We estimate the shocks of medical expenditures and transitions of employment in the model according to Thai survey data and, we set up parameters for the benchmark model to match some key features of the current Thai economy. Then, we use simulations to investigate the effects of population aging and alternative financing schemes. Our simulation results suggest that although the Thai UHI is currently inexpensive, an additional 11% labor income tax would be needed to finance the UHI in 2050 when the population is more aged. If we adopt the medical price inflation of the US, that is, 0.6% per year on top of GDP growth, an additional 15% labor tax will be needed in 2050. We also find that the existence of the informal sector largely constrains the government’s ability to collect labor income tax in the aging economy. If the economy can be fully formalized (i.e., the government is able to tax labor income in the informal sector), the additional labor tax needed to finance the UHI will be reduced to 8% in 2050 in the scenario of an annual medical price inflation of 0.6%.

We find that the existence of a large informal sector with high inequality has an im-
important implication for fiscal policy. Labor income tax has a significant redistribution
effect among informal (poor) and formal (rich) workers that is most preferred in terms
of social welfare. By contrast, if the informal sector can no longer avoid income tax,
capital income tax will be most preferred.

This study contributes to the literature that analyzes health/social insurance and gov-
ernment fiscal policy issues while considering effects on both individuals and the aggre-
gate economy, as pioneered by Auerbach and Kotlikoff (1987). Among the recent studies,
the study by Attanasio et al. (2010) is similar to the current study. These authors analyze
the effect of population aging on financing Medicare, a public health insurance program
covering the elderly in the US. As most studies in this literature have focused on the
US and other developed countries, the current paper studies the features of health and
financing systems in developing economies, and it particularly uses the UHI develop-
ment of Thailand as an example. Furthermore, it focuses on the trend of rapid aging and
the large informal employment sector, which are two main factors in this paper.

The remainder of the paper is organized as follows. In section 2, the theoretical
model is introduced. In section 3, the income and medical expenditure uncertainties
are estimated and the choice of model parameters for quantitative analysis is explained.
In section 4, the quantitative analysis on the effects of aging and alternative financing
schemes is presented. The conclusion is presented in section 5.

2 Model

We apply a modern dynamic stochastic general equilibrium model with heterogeneous
agents for the investigation. The model economy consists of a large number of individ-
uals who own/supply labor and capital, competitive firms that hire labor and capital to produce final goods, and a government that collects tax revenue and provides social insurance programs. A more detailed description of the theoretical model is provided in the appendix.

2.1 Demographics

The economy is populated by a large number of individuals, and the total population measure is normalized to be one. The population consists of two types of agents in terms of age – working (young) and retired (old). As described by Castaneda et al. (2003), Jeske and Kitao (2009), and Hsu (2013), the life cycle is modeled as a stochastic transition from young age to old age. An individual enters the economy as an young adult and makes decisions about saving and consumption every period until he/she experiences retirement shock with a probability $\pi_o$. Then the agent retires from the labor market and becomes an old agent. An old agent can survive to the next period with a probability of $\left(1 - \pi_d\right)$, where $\pi_d$ is the probability of death. In each period, newborn young agents replace the deceased such that the measure of the total population remains unchanged. The demographic setting implies that 1) the young work for $1/\pi_o$ years on average and the old survive for $1/\pi_d$ years on average, and 2) the fraction of the old is $\pi_o/(\pi_o + \pi_d)$ and the fraction of the young is $\pi_d/(\pi_o + \pi_d)$. Population aging in the model is represented by a decline in the young/old ratio.

We also consider an ex ante heterogeneity of the education level of individuals, because it has significant effects on the determination of employment and income. We assume that an individual enters the economy with an (permanent) education level $e$, which can be high or low.
2.2 Employment, Economic Informality, and Income Uncertainty

The large informal economy is a feature of developing countries different from developed countries. In this paper, economic informality is defined as tax and regulation avoidance as in the literature (see Rauch (1991), Fortin et al. (1997), and De Paula and Scheinkman (2007), for example). In the model economy, workers in the formal sector have to pay labor income tax, and they are covered by the social security. By contrast, workers in the informal sector can avoid labor tax, and they do not participate in social security.

Young agents face employment shocks that determine their job positions and employment statuses. A job position can be in the formal labor sector or in the informal labor sector.

In addition to the uncertainty of employment status, workers face labor productivity shocks that determine effective labor and levels of earnings. We assume that the transition of labor productivity is correlated with employment and follows a joint first-order Markov process.

2.3 Health Expenditure Risk and Universal Health Insurance

In addition to income uncertainty, all agents face the risk of health expenditures $x$, which is age dependent, $x = x_g, x_o$. Their evolutions follow first-order Markov processes with transition probabilities $\Pi^y_x$ and $\Pi^o_x$, respectively. Health expenditures are treated as necessary costs for recovery from illness.

Because of the provision of UHI, all individuals can have health insurance to cover their medical expenditures $x$. Individuals pay $(1 - \omega^h)x$ out of their pocket, and the proportion $\omega^h$ is paid by UHI. In reality, some treatments are not covered by the public
health-care system and individuals have to pay the full prices; for covered treatments, the co-payments may be low but the treatments that are covered might vary over time due to government policy and budget limitation. We adopt this simplified setting without distinguishing between covered and uncovered treatments, because we focus on the aggregate financing issue and simply use the average coverage ratio to prevent unnecessary complexity.

2.4 Production

We assume that there exists a continuum of competitive firms hiring labor and capital to produce final goods with a general Cobb–Douglas production technology. The aggregate production can be summarized as follows:

\[ Y = AK^\alpha L^{1-\alpha} \]  

where \( A \) is the total factor productivity, \( \alpha \) is the capital income share, \( K \) is the aggregate capital per capita, and \( L \) is the effective labor per capita employed by the firms. The capital has a constant depreciation rate of \( \delta \) each period. For simplicity, we assume that firms hire both informal and formal workers.

2.5 Government and Social Programs

The government collects its revenue through consumption tax (with a rate \( \tau_c \)), capital income tax (with a rate \( \tau_k \)), and labor income tax (with a rate \( \tau_l \)) on taxable labor income (net after social security tax). A wage-based social security tax \( T_{sc}(wz) \) is also collected by the government to provide social security, including unemployment and
medical care benefits (included in UHI), to workers in the formal sector although it is not self-financed.

In addition to the UHI system, unemployment insurance and social assistance for maintaining a consumption floor are also provided for in the economy.

We assume that the government will ensure a balanced budget at each period. The mathematical details of the government’s budget balance constraint are defined in the appendix.

2.6 Individuals’ Problem of Decision Making

Based on information of the current economic status, individuals make decisions about consumption and asset holdings (savings) to maximize their expected lifetime utility. A standard constant relative risk aversion (CRRA) period utility function is assumed.

2.6.1 Young agents’ problem

A young individual faces the problem of optimally allocating income (which is uncertain) on consumption $c$ and savings/asset holdings $k'$, given the realization of medical expenditures (which are also uncertain) and the expectation of future income pattern. We assume that individuals face a borrowing constraint and therefore cannot insure themselves against these income/expenditure uncertainties through borrowing and lending.

2.6.2 Old agents’ problem

Retired agents do not supply labor and have no labor income. Therefore, old agents only face medical expenditure shocks. Except labor income, an old agent’s decision making
is similar to the young agent’s.

A detailed and technical description of young and old individuals’ decision-making problems is provided in the appendix. The definition of model equilibrium is also described in the appendix.

3 Data, Estimation, and Parameter Selection

The strategy of numerical analysis that we use first establishes a reasonable benchmark model economy that characterizes some key features of the current economy. It is crucial to set up model parameters appropriately. This section describes our parameter selection and some Thai data used here. To estimate the employment, income, and medical expenditure shocks in the benchmark model, we mainly use the panel data of the Household Socio-Economic Survey (HSES) from the Thai National Statistics Office. The survey has been regularly conducted every 2 years since 1987, and the data are basically cross-sectional. A smaller-scale panel survey was conducted annually from 2005 to 2007; it included 6000 households and >20,000 individuals. Our estimates of transitions of health expenditures and employment statuses are based on the 2005–2007 panel survey. General information about the dataset can be found on the website – http://web.nso.go.th/eng/stat/socio/socio.htm. Ethics approval is not required because we only use public data in this paper.

3.1 Preference and Production

The model period is 1 year. The discount factor $\beta$ was selected such that the capital–output ratio of the model matches the Thai data. Based on data of the National Economic
and Social Development Board of Thailand, we match the capital–output ratio of 3.51, which was the ratio in 2005 and was approximately the average ratio during the 2000–2010 period. The risk aversion parameter in the utility $\sigma$ is set at 2, which is in the middle of the range of micro-estimates in the literature (see Attanasio, 1999, for a survey). Regarding the production function, the total factor productivity $A$ is normalized to unity. The capital income share $\alpha$ is 0.3144, as estimated by Ahuja et al. (2004), and the annual capital depreciation rate $\delta$ is set at 4.2% according to Tanboon (2008).

3.2 Demographics

In the model, $1/\pi_o$ implies an individual’s average years of working. In Thailand, the official working ages are from 15 to 59 years, and the working population accounts for 67% of the total population in 2006. We also estimate the average years of working in the HSES household samples. First, we estimate the initial working age by calculating the average (expected) age of initial labor market participation in the age group of 15–29 years. Second, we estimate the average retirement age by calculating the average in the age group of 50–64 years. According to the 2005 HSES data, the expected initial age of working is 17.88 years, and the average retirement age is 61.89 years. Although these ages slightly differ from the legal regulation, the average years of working is roughly the same. Therefore, we use 45 years as the average years of working for young agents, and we set the retirement probability $\pi_o$ at $1/45$.

The old-age dependency ratio was 13% in Thailand in 2005. We choose the death probability $\pi_d$ such that the old-age dependency ratio in the benchmark model economy (i.e., the old–young ratio $\pi_o/\pi_d$) matches 13%. 
3.3 Education, Employment, and Labor Productivity

Regarding education level, \( e \), tertiary level (including vocational school) and above is defined as “high education” \((e = h)\), and secondary school and below is defined as “low education” \((e = l)\). The ratios of population with high and low educations are estimated directly from the HSES data (variable “d5”). The high-education population share is 25%, and the low-education population share is 75%. We estimate the transitions of employment and labor productivity for high- and low-education levels separately.

The HSES data provide direct information on the average wage per month, which is used to measure the labor productivity \( z \) in the model. The variable “g1” in the HSES provides this information. Note that it does not include other additional income such as overtime pay and bonuses, or workplace welfare. However, the HSES neither classifies individuals into formal and informal workers nor provides individual social security/tax payment information. To identify formal/informal workers, we use a strategy similar to Wagstaff and Manachotphong (2012), as follows: (1) Those working for the government, state-owned enterprises, and private companies with regular monthly payment are classified as formal workers. (2) Those, who are self-employed without employees, work for a household business without payment, or work in private companies without regular monthly payment are classified as informal workers. In HSES, the variables “a_1” and “f5_1” are used to represent work status and employer status, respectively. Those who identify themselves as “employer” in the sample are excluded. If a worker is employed in a private company, additional information about type of wage “f9_1” is used to determine payment regularity.

Table 3 presents the distribution of labor income (in monthly wage) during the 3 years from 2005 to 2007. In each group, individuals are classified into the following three wage
income levels: low (bottom 40%), middle (next 35%), and high (top 25%). We find that, even when the education level is conditional, the gap between high income and low income is large. The high-income level is roughly 600% higher than the low-income level. Table 4 shows the mean wage income by education and by employment. The wage gaps between those with high and low education levels and between formal and informal workers are obvious. The average monthly wage of those with a low education level is less than one-third of that of workers with a high education level. Similarly, the average monthly wage of informal workers is less than one-third of that of formal workers.

In the model, we consider three wage income levels (low, middle and high) as shown in Table 3 of each education group as possible labor productivities conditional on education $z_e \in [z_{e1}, z_{e2}, z_{e3}]$. The possible values of $z$ are normalized as ratios to the social average of wage income during the period from 2005 to 2007 (shown in the last column in Table 3). For those unemployed $j = um$, the productivity is zero regardless of the education level. Hence, within the same education level, both formal and informal workers face a labor productivity/wage uncertainty with three possible levels for $z$.

We assume that labor productivity $z$ and employment status $j$ are correlated. Following the method used by Jeske and Kitao (2009) and Hsu (2013), we estimate a joint transition probability matrix of $(z, j)$ for each education group ($\Psi^e$) directly from the panel data between 2005 and 2007. The seven-by-seven transition matrices ($\Psi^h$ and $\Psi^l$) are constructed based on the weighted average of the transitions in the 2005–2006 period and in the 2006–2007 period from the HSES data. The transition probabilities are adjusted such that their invariant distributions imply a 62% informal employment share, as mentioned in the introduction. Please see the details of the adjustment in the appendix.
Table 3: Wage Income Distribution by Education

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low e = h</td>
<td>4482</td>
<td>4736</td>
<td>5194</td>
<td>0.5607</td>
<td>0.5614</td>
<td>0.5682</td>
<td>0.5635</td>
</tr>
<tr>
<td>Mid</td>
<td>11,777</td>
<td>11,814</td>
<td>12,362</td>
<td>1.4734</td>
<td>1.4004</td>
<td>1.3524</td>
<td>1.4087</td>
</tr>
<tr>
<td>High</td>
<td>30,494</td>
<td>30,015</td>
<td>32,896</td>
<td>3.8150</td>
<td>3.5581</td>
<td>3.5988</td>
<td>3.6573</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low e = l</td>
<td>1885</td>
<td>2166</td>
<td>2524</td>
<td>0.2358</td>
<td>0.2568</td>
<td>0.2761</td>
<td>0.2562</td>
</tr>
<tr>
<td>Mid</td>
<td>4349</td>
<td>4648</td>
<td>5115</td>
<td>0.5441</td>
<td>0.5510</td>
<td>0.5596</td>
<td>0.5516</td>
</tr>
<tr>
<td>High</td>
<td>9620</td>
<td>9709</td>
<td>10,409</td>
<td>1.2035</td>
<td>1.1510</td>
<td>1.1388</td>
<td>1.1644</td>
</tr>
</tbody>
</table>

Note: Low–bottom 40%, Middle–40%-75%, and High–top 25% of the income distribution conditional on education.

Table 4: Wage by Education and Employment

<table>
<thead>
<tr>
<th>Group</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social average</td>
<td>7993</td>
<td>8436</td>
<td>9141</td>
</tr>
<tr>
<td>High education</td>
<td>13,173</td>
<td>13,528</td>
<td>14,401</td>
</tr>
<tr>
<td>Low education</td>
<td>4650</td>
<td>4913</td>
<td>5242</td>
</tr>
<tr>
<td>Formal workers</td>
<td>12,531</td>
<td>12,724</td>
<td>13,169</td>
</tr>
<tr>
<td>Informal workers</td>
<td>3677</td>
<td>3928</td>
<td>4235</td>
</tr>
</tbody>
</table>

Table 14 in the appendix presents the estimation result. We find that workers with high education level have lower probabilities of transiting to informal positions. Even if they are currently informal workers, they have a high probability of switching to formal positions in the next year. By contrast, workers with low education level have a much higher probability of transiting to or remaining in informal positions.

3.4 Health Expenditure Shocks

In the model, we simply use two levels of health expenditures (before insurance coverage) for the young and the old separately. This simplified categorization is used because most of the people in the dataset do not spend a substantial amount of money on health care. For example, the average medical cost for 95% of the young (working-age) population is only 137 baht per month (after the above adjustment) or 1.7% of the average
### Table 5: Status of Health Expenditures

<table>
<thead>
<tr>
<th>Status</th>
<th>Expenditures (baht)</th>
<th>% of average labor income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bottom 95%</td>
<td>137.48</td>
<td>1.72</td>
</tr>
<tr>
<td>High top 5%</td>
<td>3871.81</td>
<td>48.44</td>
</tr>
<tr>
<td>Low bottom 95%</td>
<td>260.57</td>
<td>3.26</td>
</tr>
<tr>
<td>High top 5%</td>
<td>7821.95</td>
<td>97.86</td>
</tr>
</tbody>
</table>

### Table 6: Transition Probabilities of \( X \)

<table>
<thead>
<tr>
<th>Young (( \Pi^y_x ))</th>
<th>Old (( \Pi^o_x ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>0.950</td>
</tr>
<tr>
<td>High</td>
<td>0.942</td>
</tr>
</tbody>
</table>

income. However, the average medical cost of the top 5% of spenders is much higher, that is, 3872 baht per month or 48% of the average income. Therefore, we define a “low” expenditure level as the average cost of the lower 95% of health expenditure distribution and a “high” expenditure level as the average cost of the top 5%. Table 5 shows the medical costs (adjusted) for the young, \( X^y \), and for the old, \( X^o \). The results show that the medical cost old people is roughly twice as high as that of young people. The corresponding transition probabilities (adjusted) of \( X^y (\Pi^y_x) \) and of \( X^o (\Pi^o_x) \) are shown in Table 6.

### 3.5 Social Security System

**Unemployed benefits**

Workers in the formal sector are entitled to unemployment benefits. In practice, the unemployed receives 50% of the average monthly salary during the past 5 years for a maximum duration of 6 months. Because the model period is 1 year, the replacement ratio \( \tau_{um} \) in the model is set at 25%. 

18
Consumption floor

The government guarantees a minimum consumption level for all agents. The HSES data provide the information on monetary or goods assistance from the government, which can be used to approximate the guaranteed minimum consumption level. See the variable “g18” in HSES. Our estimation shows that the guaranteed minimum consumption is 8.45% of the average wage income during 2005–2007.

Health-care system

The UHI system is developed to make health care affordable for everyone. It contains three insurance programs, SSS, CSMBS, and UCS, which cover nearly the entire population. In the model, we use the out-of-pocket ratio of medical expenditures $\omega^h$ to measure the general benefit provided by the whole health-care system. Based on the World Bank’s estimate in 2005, we set $\omega^h$ at 27.23%.

3.6 Government

In Thailand, the tax revenues consist of direct income taxes and indirect taxes. The direct income taxes include personal income tax, corporate income tax, and petroleum income tax. We treat the sum of corporate income and petroleum income as capital income, and personal income tax as labor income tax. Indirect taxes excluding export–import-related taxes are treated as consumption tax because they are eventually borne by consumers. According to the 2005 Thai fiscal budget, using the definition above, the corresponding tax revenues from consumption, capital income, and labor income are 9.38%, 4.44% and 1.95%, of GDP, respectively. We calibrate the corresponding tax rates in the model to target these tax revenue to GDP ratios. The tax rates are 13.05%, 26.10%, and 4.64% for consumption, capital income, and labor income taxes, respectively.
Table 7: Features of Benchmark Economy

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>K/Y</td>
<td>3.5099</td>
<td>3.5000</td>
</tr>
<tr>
<td>X/Y</td>
<td>3.49%</td>
<td>3.50%</td>
</tr>
<tr>
<td>Informal share</td>
<td>62.00%</td>
<td>62.00%</td>
</tr>
<tr>
<td>T_l/Y</td>
<td>1.95%</td>
<td>1.95%</td>
</tr>
<tr>
<td>T_k/Y</td>
<td>4.40%</td>
<td>4.40%</td>
</tr>
<tr>
<td>T_c/Y</td>
<td>9.38%</td>
<td>9.38%</td>
</tr>
</tbody>
</table>

In the benchmark economy, the government expenditure G is determined endogenously to balance the government’s budget.

4 Analysis

In this section, we first present the features of the benchmark model economy, which is constructed to be consistent with the Thai economy in 2005. Based on the benchmark model, we quantitatively investigate the effects of population aging (with the 2050 population age structure) and medical price inflation on tax burden under alternative financing methods. The role of informal employment is also discussed. Finally, we perform welfare analysis to compare the alternative financing methods in an aging economy with a large informal labor sector.

4.1 Benchmark Economy

The benchmark economy represents some key features of the Thai economy in 2005. As shown in Table 7, the model is calibrated to match the capital–output ratio (K/Y), the health expenditure–output ratio (X/Y), the informal employment share and the tax revenue to GDP ratios for labor income tax (T_l/Y), capital income tax (T_k/Y), and consumption tax (T_c/Y).
4.2 Impacts of Population Aging

Thailand is one among the various countries facing rapid population aging. In Southeast Asia, Thailand has the second highest speed of population aging, following Singapore. Furthermore, its old-age dependency ratio is expected to increase from 13% in 2005 to 45% in 2050, which might be even higher than the ratios in France and the US.

Population aging implies the following: 1) an increase in medical cost per capita because old people need more health care and 2) a decline in tax base because the working-age population shrinks. Both of these factors increase the burden of financing the UHI system. In addition, in the benchmark economy, the UHI of medical expenditures is lower because it represents the condition in 2005. The average out-of-pocket medical expenditure ratio in 2005 was 27%, but it gradually decreased to 14% in 2011. We assume that the government is targeting a long-term out-of-pocket ratio of 15% under UHI.

Based on the benchmark economy, we then simulate the model economy by adjusting the old-age dependency ratio to the 2050 level and introducing alternative financing schemes to quantitatively investigate the potential burden of the UHI in an aging economy. Technically, we adjust the old-age dependency ratio by changing the death probability $\pi_d$ for the old. The results are reported in Table 8.

In the policy experiment in column/scenario (2) of Table 8, the government raises labor income tax to finance the extra cost of UHI and balance the budget with all other policies being equal. The labor income tax must increase from 4.64% in the benchmark to 15.75% in the 2050 population age structure scenario. The health-expenditure-to-output ratio ($X/Y$) increases from 3.49% to 5.25% as the economy is populated with more old people. Because people live longer after retirement in the aging economy, they need to save more, and therefore the capital–output ratio ($K/Y$) increases from 3.51 to 4.67. The
increased $K/Y$ ratio reduces the interest rate and increases the wage rate.

If consumption tax is used to finance the extra burden due to population aging, as shown in scenario (3) of Table 8, the consumption tax will increase from 13.05% to 20.96%.

Finally, scenario (4) of Table 8 is an economy in which capital income tax is used to finance the extra burden due to aging. The capital income taxes must increase sharply from 26.10% to 75.41% to raise sufficient revenue.

### 4.2.1 Discussion on medical cost

**Medical price inflation**

The literature reveals that the medical price may increase faster than average consumption price. For example, Attanasio et al. (2010) suggest that medical price inflation is 0.6% on top of GDP growth per year. We adopt the same scenario together with population aging to investigate the effects on financing the UHI system. Scenarios (5)–(7) of Table 9 present the results. In this case, if labor income tax is used as the financing tool, it must increase to 19.42% from 4.64% in the benchmark (scenario (5)). For the con-
Table 9: Aging + Medical Price Inflation with various financing schemes

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benchmark (2005)</th>
<th>Aging+ Medical Inflation (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Labor tax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\tau_l)</td>
</tr>
<tr>
<td>Labor tax</td>
<td>4.64%</td>
<td>4.64%</td>
</tr>
<tr>
<td>Cons. tax</td>
<td>13.05%</td>
<td>13.05%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>26.10%</td>
<td>26.10%</td>
</tr>
<tr>
<td>(r)</td>
<td>4.75%</td>
<td>2.61%</td>
</tr>
<tr>
<td>(w)</td>
<td>1.2197</td>
<td>1.3831</td>
</tr>
<tr>
<td>(K/Y) ratio</td>
<td>3.5099</td>
<td>4.6200</td>
</tr>
<tr>
<td>(X/Y) ratio</td>
<td>3.49%</td>
<td>6.87%</td>
</tr>
</tbody>
</table>

Note: Medical price inflation is assumed to be 0.6% per year.

Table 10: Aging economy with various medical inflation scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benchmark (2005)</th>
<th>Aging+ Medical Inflation (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Labor tax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\tau_l)</td>
</tr>
<tr>
<td>Labor tax</td>
<td>4.64%</td>
<td>15.75%</td>
</tr>
<tr>
<td>Cons. tax</td>
<td>13.05%</td>
<td>13.05%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>26.10%</td>
<td>26.10%</td>
</tr>
<tr>
<td>(r)</td>
<td>4.75%</td>
<td>2.53%</td>
</tr>
<tr>
<td>(w)</td>
<td>1.2197</td>
<td>1.3899</td>
</tr>
<tr>
<td>(K/Y) ratio</td>
<td>3.5099</td>
<td>4.6718</td>
</tr>
<tr>
<td>(X/Y) ratio</td>
<td>3.49%</td>
<td>5.25%</td>
</tr>
</tbody>
</table>

Note: Only the labor income tax financing scheme is shown.

Consumption tax financing scheme, scenario (6), consumption tax has to increase to 23.85%.

If capital income tax is used, it has to dramatically increase to 92.84%.

**Medical cost for the elderly**

In the earlier analysis, the medical cost of old agents is estimated based on the average of the medical expenditures of individuals aged 60 years and above in the data. In fact, the medical cost increases with age, and it becomes expensive for those above the age of 75 years. We treat all those aged 60 years and above as a group to simplify the model and reduce the computational burden. In addition, very few people aged 75 years are included in the Thai survey data as the life expectancy in Thailand is currently below
Table 11: Impacts of Population Aging – higher medical costs for old people who have lived longer

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benchmark (2005)</th>
<th>Aging + $X_y$ increases by 30% (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\tau_l$ (1)</td>
<td>$\tau_c$ (9)</td>
</tr>
<tr>
<td>Labor tax</td>
<td>4.64%</td>
<td>17.53%</td>
</tr>
<tr>
<td>Consumption tax</td>
<td>13.05%</td>
<td>13.05%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>26.10%</td>
<td>26.10%</td>
</tr>
<tr>
<td>Interest rate ($r$)</td>
<td>4.75%</td>
<td>2.54%</td>
</tr>
<tr>
<td>Wage rate ($w$)</td>
<td>1.2196</td>
<td>1.3892</td>
</tr>
<tr>
<td>$K/Y$ ratio</td>
<td>3.5099</td>
<td>4.6663</td>
</tr>
<tr>
<td>$X/Y$ ratio</td>
<td>3.49%</td>
<td>5.99%</td>
</tr>
</tbody>
</table>

Note: $X_y$ is assumed to be the same as in 2005.

75. However, according to the data of other countries, for example, the US data Medical Expenditure Panel Survey (MEPS), the average medical cost of those aged 75+ is $>50\%$ higher than that of those aged 60–64 years and $>20\%$ higher than that of those aged 65–74 years. In this sense, we underestimated the medical cost of the elderly in an aged society (represented by 2050), which is the same as in the 2005 benchmark economy, in our previous quantitative exercises. This is because the underlying assumption for the simplified setting is that the population age distribution of old people (60+) in 2050 is the same as in 2005. The Thai life expectancy is expected to be longer with more people being aged 75 and above in 2050. Hence, the average medical cost of all of the old people (defined as 60 years and above) will be higher than the number we currently use. In this regard, the effect of aging on medical cost and the government’s financing burden will be even higher than our estimation. Table 11 shows the scenario in which the average medical cost of old people (age 60+) in 2050 is 30% higher than that in 2005 because of a longer life expectancy in 2050. Compared with the simulation results in Table 8, the government must collect more tax revenue to finance the UHI system in 2050 if we consider that old people will live longer and need more medical care at that time.
4.2.2 Discussion on informal employment

One distinguishing feature of Thailand and other developing countries is their large informal labor sector. To investigate the effect of informal employment on the financing of UHI, we perform a counterfactual experiment and assume that the government can fully monitor/tax all workers’ labor income, that is, a full formalization of the informal labor sector. With this additional assumption, we perform the same policy experiment as that in column (5) of Table 9 with the same aged population. In this experiment, all workers must pay labor income tax and social security tax. Column (8) of Table 9 shows the result; the burden of labor income tax can be reduced from 19.42% (with the informal labor sector) to 12.37%.

4.3 Welfare Analysis on Financing Policies

We further investigate which financing scheme is better based on the aging population. We use a standard welfare measure by calculating the consumption equivalent variation (CEV) of the baseline economy. The CEV measure represents the percentage change in consumption each period that is required for an individual to be as prosperous, in terms of expected lifetime utility, in the alternative economy as he/she is in the baseline economy. The CEV can be calculated as follows:

$$\int_i E_0 \left[ \sum_{t=0}^{\infty} \beta^t u(c^a_{i,t}) \right] = \int_i E_0 \left[ \sum_{t=0}^{\infty} \beta^t u((1 + \zeta)c^b_{i,t}) \right],$$

where $c^a_{i,t}$ is agent $i$’s consumption chosen at time $t$ in the economy with alternative policy, and $c^b_{i,t}$ is agent $i$’s corresponding choice in the baseline economy. $\zeta$ represents the CEV. A positive $\zeta$ implies the welfare improved compared with the baseline economy; a
negative $\zeta$ represents a welfare loss.

### 4.3.1 Economy with informal employment

The baseline is chosen to be the aging economy with the labor income tax for financing the UHI as in Column (2) of Table 8. Alternative financing policies are consumption tax and capital income tax as in Columns (3) and (4) of Table 8, respectively. Table 12 reports the welfare comparisons. We find that both consumption tax and capital tax financing schemes lead to welfare losses compared with the labor tax financing scheme – both CEV measures (for all population) are negative. This is because labor income tax is only imposed on formal workers, who have much higher income than informal workers in Thailand, while consumption tax and capital tax are imposed on the entire population. Using labor tax to finance the extra cost of the UHI in the aging economy will have less impact on those who are relatively poor and financially constrained. As shown in the lower panel of Table 12, all of the CEV measures are negative for those with a low-education level, those who have a higher chance of working in informal positions when they are young, and those who cannot save enough for their retirement. Extra consumption tax or capital tax will worsen the financial constraint for the poor, and therefore it is not preferred.

### 4.3.2 Economy without informal employment

If the government develops an improved technique to tax labor income and enforces the full formalization of the informal labor sector, the result of welfare comparisons among the three financing schemes mentioned earlier reverses. Table 13 shows the result. In this case, the advantage of labor tax financing, redistribution between formal (rich) and
informal (poor) workers, is no longer apparent. The capital tax financing scheme, case $\tau_k$ in Table 13, is preferred (CEV for the entire population is highest). However, individuals with a high education level now prefer the labor tax financing scheme because the extra labor tax burden is shared by those who were previously informal workers. Their burden with the consumption tax and capital tax financing schemes was higher than that with the labor tax scheme. In particular, the capital tax scheme is not popular because poor people do not save much and the rich have a greater extra capital tax burden.

This experiment presents an important policy implication – the existence of a large informal labor sector does change the optimal choice of government fiscal policy.
5 Conclusions

Although the Thai UHI is currently inexpensive, challenges to its sustainability exist. We construct a dynamic general equilibrium model while taking the risks of income/health expenditures, social programs, and the large informal labor sector in Thailand into account. Our simulation results suggest that an additional 11% labor income tax, 8% consumption tax, or 49% capital income tax will be needed to finance the UHI with the 2050 population age structure. If the excess medical price inflation is 0.6% per year, an additional 15% labor tax, 11% consumption tax, or 67% capital tax will be needed in the aging economy. We also find that informal employment has a significant effect on the financing issue. If the informal labor sector is fully formalized, the government’s ability to finance UHI in the aging economy can be largely improved, and the labor tax burden can be reduced by >40%.

Welfare analysis on alternative financing options is also performed. We find that the existence of a large informal labor sector and the large wage gap between formal and informal workers have important implications for fiscal policy. We find that the labor income tax financing scheme has a significant redistribution effect between informal (poor) and formal (rich) workers that is most preferred in terms of social welfare. By contrast, if the government is able to monitor and tax labor incomes in the informal sector (formalization), capital income tax will be most preferred.

References


Appendix (Not for publication)

A.1 Model – Employment, Economic Informality, and Income Uncertainty

The large informal economy is a feature of developing countries different from developed countries. In this paper, economic informality is defined as tax and regulation avoidance as in the literature (see Rauch (1991), Fortin et al. (1997), and De Paula and Scheinkman (2007), for example). In the model economy, workers in the formal sector have to pay labor income tax, and they are covered by the social security. By contrast, workers in the informal sector can avoid labor tax, and they do not participate in social security.

Young agents face employment shocks that determine their job positions and employment statuses. A job position can be in the formal labor sector or in the informal labor sector. We assume that the transition of employment status follows a Markov chain, and we use data to identify the transition probabilities according to education level. We adopt this simple setting because the data show that the employment status largely depends on education level and the majority of informal workers have low education levels. Therefore, an individual’s employment, denoted by $j$, is stochastic and has three possible statuses:

$$j = \begin{cases} 
  f, & \text{formal;} \\
  nf, & \text{informal;} \\
  um, & \text{unemployed.}
\end{cases} \quad (2)$$

In addition to the uncertainty of employment status, workers face labor productivity shocks, $z$. The realization of $z$ leads to an ex post individual heterogeneity on earnings.
A worker’s labor income is given by $wz$, where $w$ is the market wage rate per effective labor.

The values of $z$ are finite and dependent on education level $e$, that is, $z = z^{e,j} \in [z_1^e, z_2^e, ..., z_n^e]$. We assume that the transition of $z$ is correlated with employment $j$, and $(z, j)$ follow a joint first-order Markov process with transition probabilities $\Psi^e(z', j' | z, j)$.

### A.2 Model – Health Expenditure Risk and Universal Health Insurance

In addition to income uncertainty, all agents face the risk of health expenditures $x$, which is age dependent, $x = x_y, x_o$. The values of $x^y$ and $x^o$ are also assumed to be finite $(x^i \in [x_1^i, x_2^i, ..., x_m^i], i = y, o)$, and their evolutions follow first-order Markov processes with transition probabilities $\Pi^y_x$ and $\Pi^o_x$, respectively. Health expenditures are treated as necessary costs for recovery from illness.

Because of the provision of UHI, all individuals can have health insurance to cover their medical expenditures $x$. Individuals pay $(1 - \omega^h)x$ out of their pocket, and the proportion $\omega^h$ is paid by UHI. In reality, some treatments are not covered by the public health-care system and individuals have to pay the full prices; for covered treatments, the co-payments may be low but the treatments that are covered might vary over time due to government policy and budget limitation. We adopt this simplified setting without distinguishing between covered and uncovered treatments, because we focus on the aggregate financing issue and simply use the average coverage ratio to prevent unnecessary complexity.
A.3 Model – Production

We assume that there exists a continuum of competitive firms hiring labor and capital to produce final goods with a general Cobb–Douglas production technology. The aggregate production can be summarized as follows:

\[ Y = AK^a L^{1-a} \]  

where \( A \) is the total factor productivity, \( a \) is the capital income share, \( K \) is the aggregate capital per capita, and \( L \) is the effective labor per capita employed by the firms. The capital has a constant depreciation rate of \( \delta \) each period. For simplicity, we assume that firms hire both informal and formal workers. The market wage rate \( w \) and the net-of-depreciation capital return rate \( r \) can be derived from the firm’s profit maximization conditions:

\[ w = (1 - a)AK^a L^{-a} \]  
\[ r = aAK^{a-1}L(1-a) - \delta. \]

A.4 Model – Government and Social Programs

The government collects its revenue through consumption tax (with a rate \( \tau_c \)), capital income tax (with a rate \( \tau_k \)), and labor income tax (with a rate \( \tau_l \)) on taxable labor income (net after social security tax). A wage-based social security tax \( T_{sc}(wz) \) is also collected by the government to provide social security, including unemployment and medical care benefits (included in UHI), to workers in the formal sector although it is not self-financed.
The social security tax function $T_{sc}(wz)$ is defined as

$$T_{sc}(wz) = \begin{cases} \\
\tau_{sc}wz, & \text{if } wz \leq \bar{y}_{sc}; \\
\tau_{sc}\bar{y}_{sc}, & \text{if } wz > \bar{y}_{sc}, \\
\end{cases} \quad (6)$$

where $\bar{y}_{sc}$ is the salary cap for the social security tax.

In addition to the UHI system, unemployment insurance and social assistance for maintaining a consumption floor are also provided for in the economy. If an individual worked in the formal sector in the previous period $j_{-1} = f$, and currently unemployed $j = um$, he/she can receive a transfer from the government $TR_{um}$, which is assumed to be a proportion $\tau_{um}$ of the average labor income in the formal sector $\bar{y}_f$.

We also assume a minimum consumption level $\zeta$ guaranteed by the government to prevent an individual from encountering bad income and medical expenditure shocks and being unable to afford a positive consumption level. A transfer $TR_{\zeta}$ will be made to a poor individual such that he/she is able to just maintain the consumption level $\zeta$.

We assume that the government will ensure a balanced budget at each period:

$$\int \left[ \tau_c c + \tau_k (k + b) + \tau_l (wz - T_{sc}(wz)) + T_{sc}(wz) \right] d\Phi(s),$$

$$\quad = \int \left[ TR_{\zeta} + TR_{um} + (1 - \omega^h) x \right] d\Phi(s) + G. \quad (7)$$

In the above equation, the left side is the government revenue, and the right side is government expenditures on the social programs and its consumption $G$, which is a residual. $b$ is a lump-sum transfer of accidental bequests, which are collected and equally distributed to all survivals by assumption. It is determined by $b = (\frac{\pi^d}{\pi_o + \pi_d}) \bar{k}_o$ in the stationary equilibrium, where $\bar{k}_o$ is the average asset holdings among the elderly. $\Phi(s)$ is
the distribution of total population over the state space $s$.

**A.5 Model – Individuals’ decision-making problems**

Based on the information of the current economic state, which can be summarized by a state vector $s = (k, j, j_{-1}, z, x)$, individuals make decisions on consumption and asset holdings to maximize their expected lifetime utility. A standard constant relative risk aversion (CRRA) period utility function is assumed: $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, where $\sigma$ is the inter-temporal elasticity of substitution for consumption.

**A.5.1 Young agents’ problem**

A young individual faces the problem of optimally allocating income (which is uncertain) on consumption $c$ and savings/asset holdings $k'$, given the realization of medical expenditures (which are also uncertain) and the expectation of future income pattern. The budget constraint for the young can be defined by 1) net wealth after tax payments and medical expenditures ($Wel$), 2) government transfer for maintaining minimum consumption ($TR_{c}$), and 3) unemployment benefit ($TR_{um}$):

\begin{align*}
(1 + \tau_c)c + k' &= Wel + TR_c + TR_{um} \quad (8) \\
Wel &\equiv wz(I_{j \neq um}) + (1 + (1 - \tau_k)r)(k + b) - [T_{sc} + \tau_i(wz - T_{sc})](I_{j=f}) - \omega^h x^f \quad (9) \\
TR_c &= \begin{cases} 
(1 + \tau_c)L - Wel, & \text{if } Wel < (1 + \tau_c)L \\
0, & \text{otherwise} 
\end{cases} \quad (10) \\
TR_{um} &= \begin{cases} 
\tau_{um}y_f, & \text{if } j_{-1} = f \text{ and } j = um \\
0, & \text{otherwise} 
\end{cases} \quad (11)
\end{align*}
where $I_{j \neq um}$ is an indicator that is one if the agent is not unemployed and zero otherwise, $I_{j = f}$ is an indicator that is one if the agent is employed in the formal sector and zero otherwise, $\zeta$ is the guaranteed minimum consumption level in (15), and the unemployment insurance payment $TR_{um}$ is defined in (11). It will be made if the agent worked in the formal sector in the previous period, $j_{-1} = f$, where $j_{-1}$ represents the previous state of employment, and he/she is currently unemployed, $j = um$. We assume that individuals face a borrowing constraint and therefore cannot insure themselves against these income/expenditure uncertainties through borrowing and lending.

The problem for a young agent with education level $e$ and state $s$ can be expressed recursively as follows:

$$V_y(s) = \max_{c, k'} \left\{ u(c) + \beta \{(1 - \pi_o)E^e[V_y(s')|s] + \pi_a E[V_o(s')|s]\} \right\},$$

subject to

$$(1 + \tau_c)c + k' = Wel + TR_e + TR_{um}$$

$$Wel = wz(I_{j \neq um}) + (1 + (1 - \tau_k)r)(k + b) - [T_{sc} + \tau_l(wz - T_{sc})](I_{j = f}) - \omega^h x^y$$

$$TR_e = \begin{cases} (1 + \tau_c)\zeta - Wel, & \text{if }Wel < (1 + \tau_c)\zeta \\ 0, & \text{otherwise} \end{cases}$$

$$TR_{um} = \begin{cases} \tau_{um} y_f, & \text{if }j_{-1} = f \text{ and } j = um \\ 0, & \text{otherwise} \end{cases}$$

$$k' \geq 0$$

where $\beta$ is the discount factor; $I_{j \neq um}$ is an indicator, which is one if the agent is not
unemployed and zero otherwise; $I_{j=f}$ is an indicator, which is one if the agent are employed in the formal sector and zero otherwise; and $V_0$ is the value when the agent becomes old/retired. We assume that individuals face a borrowing constraint as in (??), and therefore they cannot insure themselves against these income/expenditure uncertainties through borrowing and lending.

A.5.2 Old agents’ problem

Retired agents do not supply labor and have no labor income. The labor productivity $z$ is fixed at zero. Therefore, old agents only face medical expenditure shocks. An old agent chooses consumption and asset holdings to solve the following maximization problem:

$$V_0(s) = \max_{c, k'} \{ u(c) + \beta (1 - \pi_d) E[V_0(s') | s] \},$$

subject to (15), the same borrowing constraint and

$$ (1 + \tau_c) c + k' = Wel + TR_{\ell} $$

$$ Wel \equiv (1 + (1 - \tau_k)r)(k + b) - \omega^k x^o. $$

A.6 Recursive Competitive Equilibrium of the Model

In this paper, we emphasize the long-run effects of population aging and social insurance policies, and therefore we focus on the features of the economy’s stationary recursive competitive equilibrium.

A stationary recursive competitive equilibrium for the benchmark economy consists of individual decision rules for asset holdings $k'$ and consumption $c$, a set of firm decision
rules with regard to capital rented $K$ and effective labor employed $L$, a price system of $w$ and $r$, and a stationary distribution of individuals over the state variables $\Phi(s)$, under a set of government policies of taxation and social insurance $\{\tau_c, \tau_l, \tau_k, \tau_{sc}, \tau_{um}, \theta, \xi\}$ such that:

a) Given the price system, the decision rules regarding $K$ and $L$ maximize the firm’s profit and satisfy equations (4) and (5);

b) Given the price system and the policies of tax rates and social insurance, the decision rules regarding $(k', c)$ solve the problems of young and old individuals;

c) The government budget constraint (7) is satisfied;

d) All markets are cleared: $L = \int (z) d\Phi(s)$ and $K = \int (k + b) d\Phi(s)$;\(^1\)

e) The resource feasibility condition is satisfied:

$$Y = C + G + I + X;$$

where $C = \int (c) d\Phi(s)$ is the aggregate consumption, $I = K' - (1 - \delta)K = \delta K$ in the stationary equilibrium, and $X = \int (x) d\Phi(s)$ is the aggregate medical expenditures.

\(^1\) The aggregate labor market clearing condition can be expressed as

$$L = \int (z) d\Phi(s) = \frac{\pi_I}{\pi_o + \pi_q} \int (z) d\Phi_y(s),$$

where $\Phi_y$ is the stationary distribution of young individuals over state variables.
A.7 Estimation of Labor and Medical Shocks

A.7.1 The Transitions of Labor and Employment

A joint seven-by-seven transition matrix of $z$ and $j$ is based on the Thai HSES data for each education group:

$$
\Psi(z', j')(z, j) = \begin{cases}
\Psi(z', j' = f)(z, j = f) & \Psi(z', j' = f)(z, j = nf) & \Psi(z', j' = f)(z, j = um) \\
\Psi(z', j' = nf)(z, j = f) & \Psi(z', j' = nf)(z, j = nf) & \Psi(z', j' = nf)(z, j = um) \\
\Psi(z', j' = um)(z, j = f) & \Psi(z', j' = um)(z, j = nf) & \Psi(z', j' = um)(z, j = um)
\end{cases}
$$

(21)

The share of informal sector is underestimated in the transition matrices constructed from the 3-year SES panel data. We assume a transitory bias from the estimation with the short-term data, and therefore an adjustment with a multiplier $\epsilon_1$ is imposed:

$$
\Psi(z', j')(z, j) = \begin{cases}
(1 - \epsilon_1)\Psi(z', j' = f)(z, j = f) & (1 + \epsilon_1)\Psi(z', j' = f)(z, j = nf) & \Psi(z', j' = f)(z, j = um) \\
(1 - \epsilon_1)\Psi(z', j' = nf)(z, j = f) & (1 + \epsilon_1)\Psi(z', j' = nf)(z, j = nf) & \Psi(z', j' = nf)(z, j = um) \\
\Psi(z', j' = um)(z, j = f) & \Psi(z', j' = um)(z, j = nf) & \Psi(z', j' = um)(z, j = um)
\end{cases}
$$

(22)

In addition, each row has to be normalized to one after the adjustment. To match the target informal employment share, the calibrated value of $\epsilon_1$ is 0.1155.

Table 14 presents the estimation result of transition probabilities of labor shocks. The upper panel in the table is the transition matrix of employment/productivity for the high-education $\Psi^h$, and the lower panel is that for the low-education $\Psi^l$. We find that
workers with high education level have lower probabilities of transiting to informal positions. Even if they are currently informal workers, they have a high probability of switching to formal positions in the next year. By contrast, workers with low education level have a much higher probability of transiting to or remaining in informal positions.

### A.7.2 Transitions of Health Expenditure

The reported health expenditures in the data are out-of-pocket expenditures. The model health expenditures ($x$) are the total costs of medical care. We first use the reported expenditures to estimate the distribution and transitional dynamics of health expenditures. The variable “h22” in the HSES provides information on the out-of-pocket medical expenditures. We assume that there is a general proportional difference between the reported expenditures and the real total costs. Then, a multiplier is imposed on the re-
ported expenditures such that the average health expenditures are 3.5% of the GDP per capita, as estimated by the World Bank in 2005.

We only calculate the health expenditure status based on the year 2005 instead of a three-year average, as the survey shows that most of the samples do not have any health insurance scheme and the relative difference between the young and old generation is distinct in 2005. Then we use a recovery adjustment function \((1+\epsilon_2)\), which is multiplied to each value of the status by \((1+\epsilon_2)X_t\), and the stationary value of health cost is calculated by integrating over the young and old generations. The calibrated value of \(\epsilon_2\) is 3.41 to match the total health expenditure per capita in Thailand, which is 3.5% by the World Bank estimate in 2005. The transitory bias adjustment is similar to the labor status but in a simple way. The calibrated values for \(\epsilon_3\) and \(\epsilon_4\) are 0.4555 and 0.3334 in order to match the stationary share of 95% and 5%, respectively. The adjustment function is written as

\[
\pi(x')|(x) = \begin{cases} 
(1 + \epsilon_3)\pi(x'=l)|(x=l) & \pi(x'=h)|(x=l) \\
(1 + \epsilon_3)\pi(x'=l)|(x=h) & \pi(x'=h)|(x=h) 
\end{cases} \tag{23}
\]

where \(\pi(x'=h)|(x=l)\) is \(1- (1+\epsilon_3)\pi(x'=l)|(x=l)\) and \(\pi(x'=h)|(x=h)\) is \(1 - (1 + \epsilon_3)\pi(x'=l)|(x=h)\), respectively, for the young generation, and

\[
\pi(x')|(x) = \begin{cases} 
(1 + \epsilon_4)\pi(x'=l)|(x=l) & \pi(x'=h)|(x=l) \\
(1 + \epsilon_4)\pi(x'=l)|(x=h) & \pi(x'=h)|(x=h) 
\end{cases} \tag{24}
\]
A.8 Summary of Parameters

All the parameters of the benchmark economy are listed in Table 15.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Households</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.9225</td>
<td>Discount factor, targeting capital output ratio 3.51</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>2.0000</td>
<td>Utility parameter governing risk aversion</td>
</tr>
<tr>
<td>$\pi_o$</td>
<td>0.0222</td>
<td>Retirement probability, targeting average years of working</td>
</tr>
<tr>
<td>$\pi_d$</td>
<td>0.1709</td>
<td>Death probability, targeting old-age dependency ratio</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.2500</td>
<td>Share of high education group (Thai Labor Survey 2001–2005)</td>
</tr>
<tr>
<td><strong>Firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.3144</td>
<td>Capital income share (Ahuja et al., 2004)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.0420</td>
<td>Depreciation rate (Tanboon, 2008)</td>
</tr>
<tr>
<td>$A$</td>
<td>1.0000</td>
<td>Total factor productivity</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_c$</td>
<td>0.1305</td>
<td>Consumption tax rate, target its tax revenue ratio</td>
</tr>
<tr>
<td>$\tau_k$</td>
<td>0.2610</td>
<td>Capital income tax rate, target its tax revenue ratio</td>
</tr>
<tr>
<td>$\tau_l$</td>
<td>0.0464</td>
<td>Labor income tax rate</td>
</tr>
<tr>
<td>$\tau_{sc}$</td>
<td>0.0400</td>
<td>Social security tax rate</td>
</tr>
<tr>
<td>$\tilde{y}_{sc}$</td>
<td>1.7600</td>
<td>Cap income level for $\tau_{sc}$, ratio to average labor income</td>
</tr>
<tr>
<td>$\tau_{um}$</td>
<td>0.2500</td>
<td>Unemployment benefit–replacement rate</td>
</tr>
<tr>
<td>$\underline{c}$</td>
<td>0.0845</td>
<td>Minimum consumption, ratio to average labor income</td>
</tr>
<tr>
<td>$\omega^h$</td>
<td>0.2723</td>
<td>Out-of-pocket ratio, 2005</td>
</tr>
</tbody>
</table>