Reaching Universal Health Coverage through Tax-based Financing Schemes: Challenges of Informal Economy and Population Ageing

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Abstract

Universal health coverage (UHC) has been increasingly discussed by policymakers and the general public, and many different schemes exist to reach the goal of universal coverage. For instance, health insurance scheme has been a common approach in such developed countries as Japan. By focusing on the impacts of UHC in developing countries with a large informal economy, this research discusses a UHC scheme financed directly through government tax revenue to cover the uncovered population. Compared with voluntary schemes like insurance, such a scheme helps to reach universal coverage effectively in developing countries.

The impacts of UHC financed though tax revenue can be multi-fold at both the macro and micro levels. In this study, the macro perspectives are of primary interest, although the linkages between individual behaviors and aggregate effects are also being discussed. To answer the research questions of welfare and financing options, the modern macroeconomics approach of Dynamic Stochastic General Equilibrium (DSGE) model with heterogeneous agents is applied and the calibration is based on the case of one developing country. Furthermore, as developing countries are no exception to the trend of population ageing, demographic change is examined within the context of universal health coverage. Other factors such as the health cost inflation and the changing size of the informal economy are also examined.

This dissertation starts with the background in Chapter One, which gives a quick overview of universal health coverage, the coverage schemes in Thailand, and the challenges of implementing the universal coverage scheme. After the overview, the motivation, methodology and data are briefly described. Finally, the outline of the dissertation follows and the future research agenda is explored.

After the introduction, Chapters Two to Four provide the main content of the dissertation. The settings of the model of these three chapters are similar as follows. The model has two sectors (formal and informal), two types of education (high, which is high school and above, and low, which is below high school), a standard production function with both capital and labor consisting of formal and informal labor input, and government balancing the budget by collecting revenue and spending on a multi-tier social security system. Such a social security system includes a universal coverage scheme for health service access, an old-age pension program, and a social safety net. The UHC scheme is implemented to cover the uninsured citizens who do not contribute to the social security pool, who are workers in the informal sectors, and who are the old retirees in the model. However, each chapter also differs in the following aspects. Chapter Two focuses on the financing of UHC, assuming inelastic labor and taking a progressive labor income tax into consideration besides proportional taxes. Chapter Three examines financing the path of ageing for three kinds of proportional taxes, given the cases of both an inelastic and an elastic labor supply. Chapter Four studies the effect of the labor supply on the UHC scheme and health cost inflation.

The findings of the dissertation are as follows. First, given that the labor supply is inelastic, there is a consistent welfare gain of running the universal coverage scheme regardless of which tax financing option is chosen, although the choice does matter for the size of welfare gain. Among all the options, the one with the highest redistributive effects–progressive labor income tax–brings the largest welfare gain. Secondly, in terms of financing ageing, three kinds of proportional tax options are examined. A large tax hike would be required for the population age structure in 2050 (i.e. for the case of labor income tax, an additional 11% increase in the tax rate would be required to balance the budget). It was also found that a formalization of the informal sector can substantially alleviate the tax burden. Regarding welfare comparison among alternative tax options, the labor

income tax is preferred as it brings the largest redistributive effect due to the existence of a large informal labor sector. Without the informal sector, a capital tax would be better than labor or consumption taxes. When labor is endogenous, the distortive effect of labor income tax on the labor supply outweighs the redistributive effect, where a capital tax is a better choice than a labor income tax and a consumption tax. Third, the labor supply pattern in response to UHC is examined for both intensive and extensive margins (labor hours and participation rates). The labor supply responses were shown to have a different direction depending on the type of tax. When health cost inflation needs to be financed, a capital income tax performs better by increasing the labor supply and output.

Finally, Chapter Five summarizes the findings of the dissertation and discusses the policy implications. The success of implementing the UHC scheme financed by government revenue in Thailand relies on many factors, including the low level of national total health expenditure, the accumulation of health service capacity for decades, and the institutional arrangements. Meanwhile, both the short-term feasibility and long-term sustainability of the UHC should be considered, especially within the context of ageing. Finally, in order to design and implement a UHC scheme which fits the different nature of each country, that the welfare gain or loss depends on a spectrum of policy choices and endogenous factors such as financing options, labor market and overall economic characteristics should also be well understood.

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And finally, I thank the colleagues of the Policy Analysis Program, with whom I shared the joys and pains for studying through various courses, passing qualification examinations together, and helping each other to be more professional in our research.

To my beloved parents, my dearest wife and son

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Chapter 1

Introduction

1.1 Background

In developing countries, a very big share of the resource-poor population has limited access to health service and universal health coverage (UHC) is not reached. According to WHO (2010), "among all the issues which need to be addressed to reach UHC, developing a health financing system which can remove the financial barriers for health services access is most critical"[1]. In a health financing system where people are required to pay for use directly, UHC is difficult to obtain as resource-poor people simply cannot afford to pay for the out-of-pocket health expenditure or have to tradeoff for other priorities such as food. Against this background, a health financing system which reduces the reliance on direct payments should encourage the use of health services to reach a universal coverage.

Although maintaining the out-of-pocket payment at a certain level for cost sharing is necessary to prevent the potential moral hazard problem for over-utilizing health service, universal coverage is more likely to be reached when out-of-pocket ratio for direct payment is sufficiently low. Therefore, one way to reach universal coverage is to lower out-of-pocket expenditure to a degree at which people are not likely to suffer financial hardship. In this connection, we model that to achieve UHC, is to lower out-of-pocket ratio. Empirically, a cross-country estimation based on 59 countries (Xu et al., 2010) shows that when the out-of-pocket ratio is lower than 15%-20% of the total health expenditure, the chance of incurring financial catastrophe is negligible.

Among all the health financing schemes to reduce direct payments, various health insurance schemes are a common approach used by many countries, especially developed countries. However, as the insurance schemes are mostly based on the principle of volunteer participation and the premiums can be substantial, they play a minor role in developing countries because most resource-poor people cannot afford the insurance pre-

[1]UHC is defined by WTO as the goal that "all people have access to health services and do not suffer financial hardship paying for them"

miums. Alternatively, to reach universal coverage effectively, the UHC schemes financed by government revenues have been practised as a shortcut in such developing countries as Brail, Mexico and Thailand.

In the case of Thailand, the Universal Coverage Scheme (UCS) has been implemented successfully, with financing through the general government revenues since 2002, to cover 25% of the previously uninsured population. It replaced the two schemes from the 1990s—the Medical Welfare Scheme (MWS) which targeted the elderly, the children and the poor, and the Voluntary Health Card Scheme (VHCS) which targeted the farmers and the informal sector. The former was purely tax-financed, while the latter was based on both tax revenues and private contributions. Besides the UCS, which in total covered 74.6% of the Thai population, the pure wage-based Social Security Scheme (SSS) covered the formal private sector and the tax-financed Civil Servant health Benefit Scheme (CSMBS) provided free health care at public facilities for government employees and their direct relatives. These three schemes covered up to 97% of the total population (figures as of 2007).

Such kind of coverage extension can not go alone without the accumulation of health service capacity for the past decades. Expanded rapidly since the 1960s, the public health sector has been playing a dominant role in providing the health service in Thailand and the main provider—the Ministry of Public Health owns about two-thirds of all hospitals and beds nationwide. Manpower has also witnessed a steady growth (Sakunphanit, 2006), although such challenges as the demographic changes and the inequitable distribution of health resources remain (Pagaiya et al., 2008). Meanwhile, a new National Health Security Office (NHSO) was established to act as a purchaser of health service for the UCS; such an institutional arrangement of purchaser-provider split helps to control costs effectively. Therefore, despite the real public health expenditure per capita having increased substantially, the total health expenditure (as percentage of GDP) has been relatively

stable between 3-4% (Figure 1.1). The UCS, together with the establishment of NHSO, highlights continuous efforts to give all Thai citizens access to health care services over the past decade, which has driven down the out-of-pocket ratio lower than 15% nowadays. As shown in Figure 1.2, the out-of-pocket ratio decreases as the public health expenditure absorbs the health cost.

Thailand's experience suggests the feasibility of reaching universal coverage through tax financing[2]. The issue of how to raise funds and manage them efficiently to reduce out-of-pocket ratios, and long-term sustainability are some of key the concerns for policy makers who are faced with the agenda of universal coverage. In practice, insurance and tax revenues are two major methods for health system financing. In the former, funds are pooled directly, and in the latter funds are pooled indirectly. However, due to a large presence of economic informality, which is common to developing countries (Schneider, 2002), financing through a compulsory wage-based health insurance contributions can only be enforced in the formal sector and it thus restricted in scale. Moreover, voluntary private health insurance has a more limited participation rate and plays a marginal role in most developing countries (Drechsler and Jütting, 2005). Although many innovative financing options has been discussed in WHO (2010), which include foreign exchange transaction tax, bank account transaction tax and various excise taxes, given the potential cost of international coordination and the effects on financial market and real economy, the applicability of some of these options has yet to be studied. Therefore, with the limited options remaining for policymakers of developing countries, various tax-based financing schemes deserve more detailed study (Savedoff et al., 2004) [3].

[2] To a large extent, the success of implementing the UCS in Thailand depended on its relatively low total health expenditure as of output, compared with other countries.

[3]Comparing tax with debt, tax revenues are likely to be more sustainable than debt. However, in consideration of the political process, issuance of debt is much simpler than increasing tax rates. Therefore, debt ratio is likely to increase when the level of social security is improved through a UHC scheme and other social security programs financed by government general revenue before resorting to tax instruments. In this research, the more sustainable financing source–tax is of interest

However, many challenges must be addressed in order to sustain UHC. Among those challenges, the fast trend of population ageing, the large size of the informal sector, and the potential increase of total health expenditure due to higher service utilization and potential health cost inflation are the key aspects examined in this research. All these factors are either directly related to the cost of UHC or to the government's ability of generating tax revenue to finance it.

Fast Population Ageing First, with no exception to the global trend of population ageing, Thailand is one of the countries facing a fast population ageing in Southeast Asia. The projections of old-age dependency ratios of Thailand, Singapore, Malaysia, the United States and Japan are shown in Figure 1.5 (the United Nations's population forecast). Thailand faces a quickly ageing population and, within the ASEAN region, Thailand ranks second to Singapore. The old-age dependency ratio in Thailand will be 45% in 2050, up from 13% in 2005.

The impacts of population ageing on the health financing system is twofold. First, as old people require more health care than young people, the ageing population will significantly increase the average health cost and the overall HUC burden. Second, population ageing implies a shrinkage of the labor share that results in a smaller tax base for the government to tax. Therefore, massive social welfare programs such as UCS shall be examined within such a context of long-term population ageing.

Large Informal Economy Further, the existence of an informal economy constrains government choices to effectively raise tax revenue and design social security protection for their citizens. According to the Thai National Statistics Office (NSO), informal employment refers to "employed persons who are not protected and have no social security from work". With this definition, more than 60% of labor force is working in the informal sector in Thailand, a share which has been relatively stable over the past decade (Figure 1.3) and represents 40%-45% of GDP as estimated by the Thai NSO.

As shown in Figure 1.4, the representation of education in the formal and informal sectors displays a very clear pattern in which people with higher levels of education are more likely to work in the formal sector than people with less education. As people with higher levels of education are more productive on average, the formal sector, which has a higher share of higher education workers, is therefore more productive, which leads to a higher share of output even though the working population in the formal sector is less than in the informal sector.

Increase of Health Expenditure Last but not least, a somewhat controversial issue is the extent to which the provision of UHC increases the total health expenditure due to both the moral hazard problem and higher demand for health services. In Thailand, the institutional arrangement of purchaser-provider split and the payment method of capitation have been used to control cost effectively, which leads to the total health expenditure as percentage of GDP having been relative stable (Figure 1.1). However, as the time series are too short, any statistically significant conclusion cannot be drawn. Furthermore, it is possible that some other developing countries may not be able to establish such an institutional arrangement to help contain the cost when they decide to implement a tax-financed UHC policy. If we look at the cases of developed countries, although they are either dominated by public or private health service providers, health expenditure cost normally inflates faster than the average consumption price. Therefore, developing countries may display a similar trend to it in the longer term.

1.2 Motivation, Methodology and Data

As mentioned above, the promotion of UHC through government revenue has been the policy for the past decade by a few developing countries and their experiences have been widely shared among other countries with a UHC agenda. However, the studies on such

policies has been very limited in terms of impacts, and especially on the effects from a macro perspective. One of the reasons for such a research gap is that UHC financed through government revenue is a relatively new phenomenon. Secondly, as it is implemented in developing countries, it has been largely overlooked by the researchers from developed countries, except a few limited studies that look at the impact on labor markets from the perspective of partial equlibrium (Aterido et al. 2011, Wagstaff and Manachotphong 2012).

To address such a research gap, I am interested in exploring several key questions related to UHC. For instance, what kind of social welfare change such tax-financed UHC may bring, who are likely to lose and who to win, which tax financing option should be used to finance the coverage scheme and what is a burden in both the short and long terms, are the questions which I am interested to explore.

To quantitatively analyze the sustainability of Thailand's UHC and to assess its financing options and macro responses, this research adopts a modern dynamic general equilibrium framework with a large number of heterogenous agents, who face employment/sector and health expenditure shocks at each period, production with both formal and informal workers, and a government which collects taxes/social security contributions and provides a multi-tier social security system. Given that, this framework is able to recognize the characteristics of developing countries by modelling the informal economy, calibrating their unique tax structure in contrast to the developed counterparts, and allowing the demographic transition and health cost inflation in one framework. Consequently, it aims to build a theoretical model more applicable to the setting of developing countries by answering the research questions above through a case study of Thailand.

Data based on both a micro household survey and macro indicators are used. The micro household data of Thai household survey 2005-2007, which includes 6000 households and more than 20,000 individuals, are used to estimate the value and shocks of health

expenditure and transitions of employment/sector, while the other key macro indicators are taken as targets which the benchmark model economy tries to match, in order to capture the important features of the Thai economy.

1.3 Organization, Findings and Future Research

The dissertation is organized in the following way. Chapter Two follows this introduction. It builds a theoretical framework for an economy with dual sectors where agents with different levels of education face both income and expenditure shocks. The government runs a multi-tier social security system and implements a universal coverage scheme to protect the uninsured citizens who do not contribute to the social security pool. In this chapter, the welfare impacts of various options on the aged economy are studied. Chapter Three focuses on financing options to finance the population ageing, which causes fewer young people to work and more old people to pay higher health expenditures. Meanwhile, the cases assuming elastic labor are also being examined in comparison to the inelastic one. Chapter Four explores the labor supply impact of the coverage scheme and the potential health cost inflation, and the changes of labor supply are further decomposed into level and distribution components. Compared with the previous two chapters, it differs also in that both education and sector efficiencies are calibrated directly to match the moments from the data. Finally, Chapter Five discusses the policy implication and concludes the dissertation.

The findings of the dissertation are as follows. First, given that the labor supply is inelastic, there is a consistent welfare gain of running the universal coverage scheme regardless of which tax financing option is chosen, though the choice does matter for the size of welfare gain. Among all the options, the one with the highest redistributive effects–progressive labor income tax, brings the largest welfare gain. Secondly, in terms

of financing ageing, three kinds of proportional tax options are examined. I found that a large tax hike would be required for the 2050 population age structure. I also found that a formalization of the informal sector can substantially alleviate the tax burden. With welfare comparison among alternative tax options, the labor income tax is preferred due to the existence of a large informal labor sector. Without the informal sector, a capital tax would be better than labor and consumption taxes. Thirdly, the labor supply pattern in response to UHC is examined. I found that the labor supply responses can face in different directions depending on the type of tax. When health cost inflation needs to be financed, a capital income tax performs better by increasing labor supply and output.

The current research focuses on the various impacts of a universal health coverage scheme in the setting of developing countries where the informal sector plays the important roles of absorbing the labor force and producing final goods. In addition, as the characteristics of labor markets are important for individual decision making, this research models the flow of work force between employment and unemployment as well as, formal and informal employment dynamics using a Markov Chain stochastic shock estimated from panel data. Through this extension from the standard heterogenous-agents DSGE, the model can be applied to developing countries on a broad range of such research topics as taxation, insurance and welfare programs, to name just a few.

However, the model is limited as it excludes such cases as those in which an individual faces the working opportunities for both sectors, or in which the individual increases the chances to work for the formal sector through investing human capital in themselves or their descendents. In order to capture these features, the current model can be extended along these directions. I would like to add them into my research agenda in the near future, so that the results of welfare comparison and labor responses can be re-examined.

In addition, the impact of population ageing on the size of informality can also be studied in the extended framework. The current research can be also strengthened from

the stochastic two-generation model to a full-fledged life cycle model with more features of age-profile, given that the required data for parameterization are available.

Figures

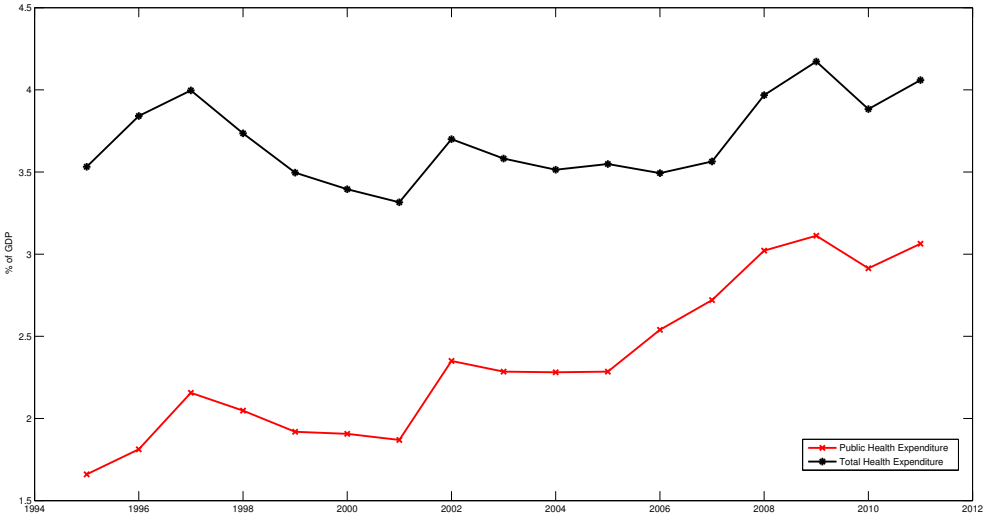


Figure 1.1: Public and Total Health Expenditure as of GDP

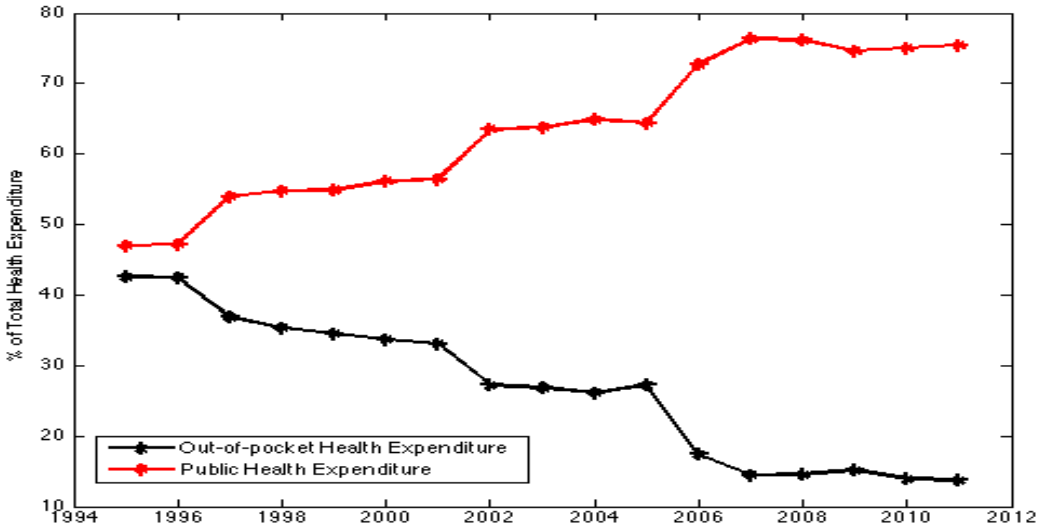


Figure 1.2: Out-of-Pocket Expenditure as of Total Health Expenditure

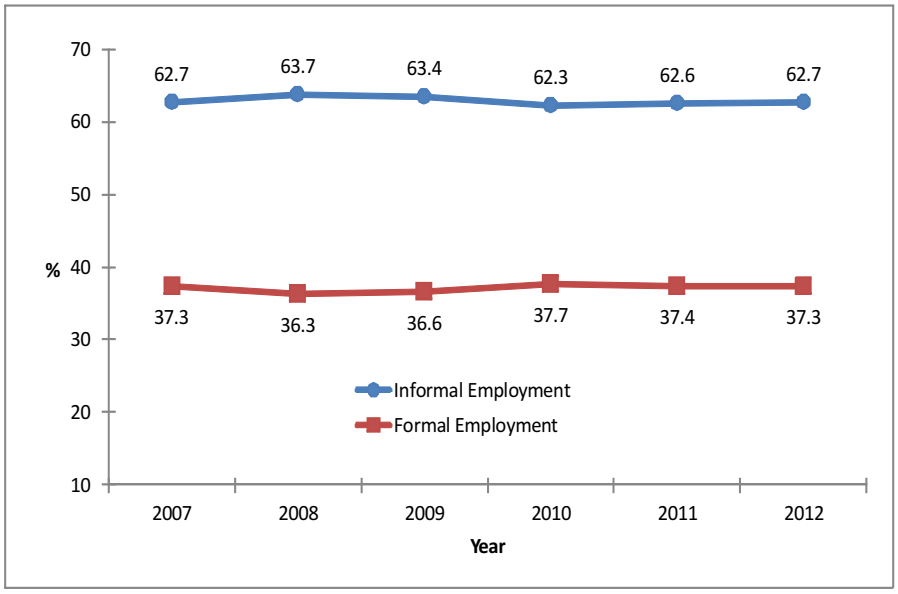


Figure 1.3: Relative Stable Informal Sector Size (Pop.)

Source: Thai NSO

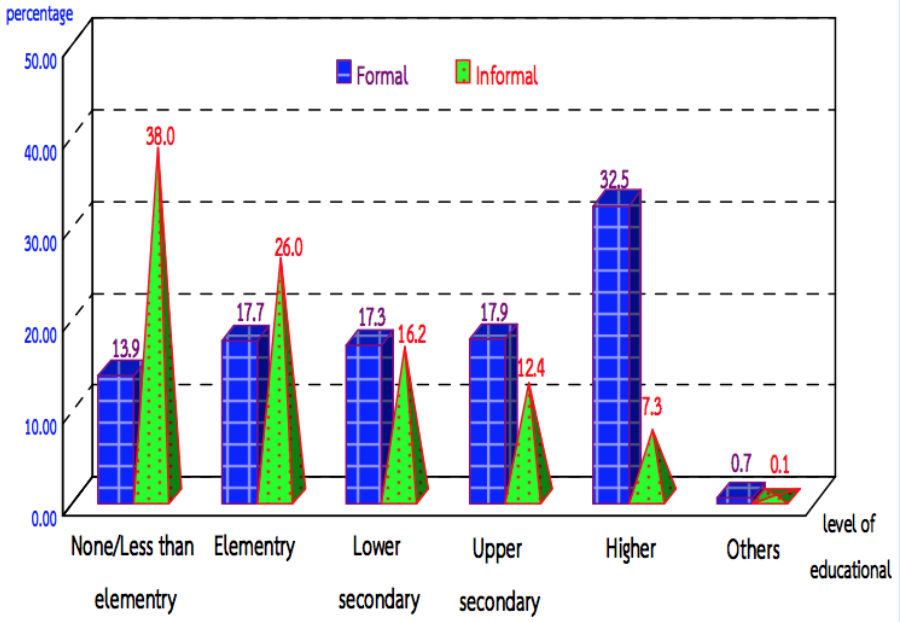


Figure 1.4: Sector Allocation of Education

Source: Thai NSO

http://web.nso.go.th/en/survey/lfs/imp/imp09.htm

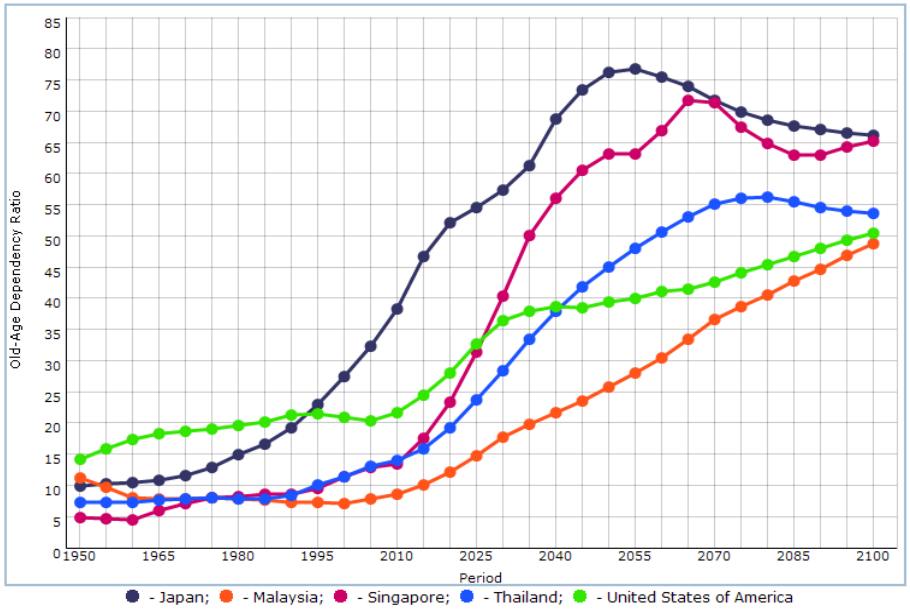


Figure 1.5: Projection of Old-age Dependency Ratios

Source: UN

Chapter 2

Universal Health Coverage and Welfare

2.1 Introduction

Given that many aspects of financing for universal coverage are of interest to both researchers and policymakers, this chapter focuses on the welfare justification and long-term burden of financing universal coverage through tax revenue for the Thai economy, which has a very large informal sector in terms of population and is facing a rapid ageing of its population. The implications of various financing options are also discussed.

Due to the long-term impact of population ageing at the macro level where factor prices may change substantially, the framework of general equilibrium instead of micro approaches is applied in this chapter. To quantitatively study universal health coverage regarding the issues above, this paper builds a heterogenous-agents dynamic and stochastic general equilibrium model which includes the following features:(a) the coexistence of formal and informal sectors, young and old generations, with two types of education; (b) comprehensive social security programs in the formal sector, consisting of a history-dependent unemployment benefit, defined-benefit old-age pension and social health insurance through wage-based social security contribution; (c) the provision of universal health coverage, which extends the health service accessible to workers in the informal sector and non-working old in both sectors through a reduced out-of-pocket payment ratio, from workers in the formal sector; (d) social security contributions and progressive labor income tax are collected in the formal sector only. In the model, agents face uncertainties of individual productivities, health expenditures, and retirement and death; in addition, they make their own individual decisions about consumption and saving. If agents are in the formal sector, where they pay social security contributions, they are entitled to the unemployment benefit when they are unemployed from the formal sector and pension benefits when they are old. If agents only work in the informal sector, they do not pay any social security contribution and therefore are not entitled to either benefit above.

This chapter models as stochastic processes both the dynamics of individual productivity and employment in the formal sector, the informal sector, or being unemployed. There are also alternative modelling approaches to economic informality. For instance, Rauch (1991) explores the relation between the size of companies and informality. Evidence suggests that informal workers tend to be less educated and earn less than formal workers, which has been interpreted to mean that low-skill workers face entry-barriers into the formal sector. De Paula and Scheinkman (2007) investigate the determinants of informality and find the firm size is correlated with formality. Amaral and Quintin (2006) suggest that informal managers choose to substitute low-skill labor for physical capital due to less access to outside financing. Using a CGE model with three forms of dualism–scale, wage and evasion, Fortin et al. (1997) analyze the relationship between the tax system and the informal sector. Meanwhile, an expanding literature models the economic informality in a framework of search-matching, which argues either the characteristics of workers or the factors of firms as the major determinants of economic informality. More recently in a search or(and) matching framework, Bosch and Esteban-Pretel (2012) and Esteban-Pretel and Kitao (2013) has looked at the impact of labor policy to the size of informal sector.

This study contributes to the existing literature on the issues of national health care, saving and insurance by extending the stylized model to a dual-sector model with both formal and informal sectors, and focusing on the role of universal health coverage through tax-based financing. This related literature is pioneered by Kotlikoff (1986) who analyzes the effects of health expenditure shocks on precautionary savings, followed by Huggett (1993) and Aiyagari (1994). The framework of the paper is connected with the recent related studies such as Jeske and Kitao (2009) who has endogenous health insurance choice, and Hsu (2012) who explains the reasons behind differences in savings rates by US households covered with health insurance , compared with those without coverage. Recent

research such as Attanasio et al. (2010) also evaluate alternative financing schemes for the public health insurance program in the United States. As most of the related literature focuses on the US and other developed countries, this paper also differs by calibrating the model based on a developing country, Thailand, where the universal coverage scheme is financed through tax revenues. In addition, the existing studies about universal health coverage are only empirical, as to my knowledge, compared with my study which combines both theoretical extension and empirical exercises. For instance, Aterido et al. (2011) and Wagstaff and Manachotphong (2012) studied the potentially distortive effect of universal health coverage on labor market choices for the cases of Mexico and Thailand, respectively.

Meanwhile, it is also another attempt to model the progressive labor income tax directly into a heterogenous-agents stochastic model. A high order polynomial function, instead of the three-parameter function, is used in the paper, which was proposed by Gouveia and Strauss (1994) to parameterize the effective tax rate, followed by the literature such as Conesa and Krueger (2006) and Conesa et al. (2009).

This chapter is constructed as follows. In Section 2.2, a dual-sector model with two types of education is set up. The estimation and calibration is described in 2.3. The analysis of welfare and the simulation scenarios follow in Section 2.4 and finally Section 2.5 concludes.

2.2 Model

The model economy is characterized by agents with either a high or low level of education who work in the formal or the informal sector, or are unemployed, given the transitions of employment status and individual productivity, in an environment where comprehensive social security and taxation systems exist. This section describes the settings of the benchmark economy where a universal coverage scheme is financed by tax revenues.

2.2.1 Economic Informality and Education Background

The paper follows the literature in defining informality as tax and regulation avoidance (De Paula and Scheinkman, 2007; Fortin et al., 1997; Rauch, 1991). In the model economy, the formal sector is an economic sector in which labor income is taxed accordingly and the comprehensive social security programs are provided based on social security contributions. In contrast, the informal sector is characterized by labor tax avoidance and no participation in the social security program. The education type e includes two levels of education, high and low, the shares of which are denoted as λ and $1-\lambda$ in terms of their population, respectively. Such an economic formality dichotomy follows a traditional argument that firms and workers in the informal sector avoid taxation or any formal regulation from the government.

2.2.2 Demographics

The population in both sectors consists of working young and retired old people. Young agents retire with probability π_o and old agents die with a probability π_d for every period, and such probabilities are assumed not to vary across education and sector. When old agents die during a given period, newborn young agents replace them at the beginning of the same period, so that the measure of whole population remains the same. Therefore, the ratio of population between old agents and young agents in the economy, which are π_o /(π_o+ π_d) and π_d/(π_o+ π_d) accordingly, does not also vary across education or sector.

2.2.3 Preference

A standard utility function in which consumption is assumed to characterize agents' utility in the economy is written as

$$u = \frac{c^{1-\sigma}}{1-\sigma} \tag{2.1}$$

where σ denotes the inter-temporal elasticity of substitution for consumption.

2.2.4 Production Technology and Asset Market

A continuum of firms in a competitive market of goods is assumed to have a general Cobb-Douglas production function, which is expressed as

$$Y = AK^{\alpha}L^{1-\alpha} \tag{2.2}$$

where A is the total factor productivity, K is the aggregate capital per capita in the economy and L is the effective labor per capita employed by the firms. The capital income share is indicated by α and the depreciation rate of capital is δ in each period. Firms in both sectors possess the same type of production function as Equation (2) although their workers differ in the dynamics of individual efficiencies. The capital is homogenous across sectors and all the markets behave competitively. Without losing generality, a representative firm is assumed to exist to employ labor and capital for production. Regarding the prices for labor and capital, the wage (w) and the net-of-depreciation capital return (r) are derived from the representative firm's problem for profit maximization and are

expressed as follows:

$$w = (1 - \alpha)AK^{\alpha}L^{-\alpha} \tag{2.3}$$

$$r = \alpha AK^{\alpha-1}L^{(1-\alpha)} - \delta \tag{2.4}$$

where δ is the depreciation rate.

In an incomplete market, only a single risk-free one-period asset is available. Borrowing is bounded at a certain level b and individuals may hold assets as savings to smooth their consumption over their lifespan if necessary. Moreover, precautionary savings also partially insure individuals against idiosyncratic shocks. When old agents die, newborn young agents who replace them are assumed to receive their assets if any. However, as old agents have no bequest motivation in their utility, such bequests are purely accidental.

2.2.5 Individual Shocks

The economy is populated with agents who have either high or low levels of education and are given a fixed labor endowment. Agents with an education type e face the following individual shocks: employment shocks, individual productivity shocks, and health expenditure shocks.

Individual Productivity and Employment Shocks

Young agents face the employment shocks and have chance to either work or be unemployed. When they work, they have chance to be either in the formal sector or the informal sector. All the probabilities of either being employed or not or being in the formal or informal sector when employed are governed by stochastic shocks. The employment

shocks, denoted as j, includes the following set

$$j = \begin{cases} f, & \text{formal} \\ nf, & \text{informal} \\ um, & \text{unemployed.} \end{cases} \tag{2.5}$$

Besides the uncertainty of employment status, young agents also face individual productivity shocks, which cause the agents to have different productivities across time. Joint labor shocks are constructed to include both employment and individual productivity shocks, denoted as z. The values that these joint idiosyncratic labor shocks for agents take from a given finite set Z^e. The evolution of joint labor shocks follows a first-order Markov process with the transition probability matrix Ψ^e.

Age-dependent health expenditure shock

Regardless of the difference across education types and sectors, all agents face the uncertainty of health expenditures caused by health expenditure shocks x^t , where

$$t = \begin{cases} y, & \text{young} \\ o, & \text{old.} \end{cases} \tag{2.6}$$

The values which health expenditure shocks x^t take are from a given finite set X^t. The evolution of health expenditure shocks follows a first-order Markov process with the transition probability matrix Ω^t, and the out-of-pocket health expenditure is ω^t.

2.2.6 Government

There are three kinds of taxes from which the government collects its revenue: consumption tax $T_c(c)$, capital (income) tax $T_k(k)$ and labor (income) tax $T_l(y)$, where y is taxable income–labor income minus the amount of social security contributions.

In addition, a wage-based social security contribution $T_{sc}(wz)$ is also collected. The corresponding rates τ_c, τ_k, $\tau_m(y)$ and τ_{sc}, where $\tau_m(y)$ is the schedule of marginal tax rates and varies depending on different income brackets of income. Social security contributions are collected to provide old-age pension, unemployment, and sickness benefits. $T_l(y)$ is a tax scheme defined as

$$T_l(y) = \begin{cases} 0, & y \leqslant y_1 \\ \rho_1(y - y_1), & y_1 \leqslant y \leqslant y_2 \\ \rho_1(y_2 - y_1) + \rho_2(y - y_2), & y_2 \leqslant y \leqslant y_3 \\ \vdots & \\ \rho_1(y_2 - y_1) + \rho_2(y_3 - y_2) + \cdots + \rho_n(y - y_n), & y > y_n. \end{cases} \tag{2.7}$$

and

$$\tau_m(y) = \begin{cases} 0, & y \leqslant y_1 \\ \rho_1, & y_1 \leqslant y \leqslant y_2 \\ \rho_2, & y_2 \leqslant y \leqslant y_3 \\ \vdots & \\ \rho_n, & y > y_n. \end{cases} \tag{2.8}$$

where ρ is a set of rates $\{0\ \rho_1\ \rho_2 \cdots\ \rho_n\}$ and $\dot{y}$ is a set of income brackets $\{y_1\ y_2 \cdots\ y_n\}$.

Working agents in the formal sector pay all kinds of tax and social security contribution when they work, are assisted by unemployment benefit when they are temporarily unemployed. They are entitled to an old-age pension when they retire and are covered by health insurance when they are sick. Due to the difficulty collecting personal income tax in the informal sector, working agents in this sector avoid paying this tax and do not make any social security contribution. Without any contribution, agents are not entitled to an old-age pension, unemployment, and also no health care benefit if there is no universal coverage.

The social security contribution function $T_{sc}(wz)$ is a percentage of labor income with a cap $\bar{T}_{sc}$, which is written as

$$T_{sc}(wz) = \begin{cases} \tau_{sc} wz, & wz \leqslant \bar{T}_{sc} \\ \tau_{sc} \bar{T}_{sc}, & wz > \bar{T}_{sc}. \end{cases} \tag{2.9}$$

The contributions are tax-deductible and the related old-age pension benefits are tax-exempt when the retirees receive them.

For the benchmark economy where the UCS has been implemented, the government finances it by tax revenues to help working agents in the informal sector and retired agents from both sectors to have access to health care. The government also provides social insurance for consumption where a minimum consumption level $\underline{c}$ is guaranteed. Assuming that government balances the budget for each period, the equation is

$$G_R = G_T, \tag{2.10}$$

where

$$G_R \equiv \int \{T_c(c) + T_k(k) + T_l(y) + T_{sc}(wz)\} d\Phi(s), \text{ and}$$
$$G_T \equiv \int \{TR_{\underline{c}} + TR_{um} + TR_{ps} + (1-\omega^y)x^y + (1-\omega^o)x^o\} d\Phi(s) + G.$$

should be satisfied in each and every period. In Equation (2.10) for the government's budget balance, the left side G_R is the fiscal revenue which government collects from the entire economy, and the total government fiscal outlays G_T on the right side include transfers for social consumption insurance $TR_{\underline{c}}$, unemployment benefits TR_{um}, old-aged pension TR_{ps}, the health expenditure for both young and old generations covered by government (thus ω^y and ω^o are out of pocket expenditures by agents), and government expenditure G—an overall spending including all other government expenditures. $\Phi(s)$ is the distribution of population over the state space s with $s = (k, j, j_{-1}, z, x^t)$. Specifically, $s = (k, j, z, x^y)$ when agents are young and working, $s = (k, j_{-1}, x^y)$ when unemployed, and $s = (k, x^o)$ when agents are old.

2.2.7 Individual problems

Young Agents' problem with Education e

The information in the economy is assumed to be available to all agents. Given a state for a young agent of education e and the expectation through transition probabilities for individual productivities and health expenditures, a young agent's problem is written as follows:

$$V_y(s) = max\{E\{u(c) + \beta\{(1-\pi_o)E[V_y(s')|s] + \pi_o E[V_o(s')|s]\}\}\}, \tag{2.11}$$

subject to

$$(1+\tau_c)c + k' = Wel + TR_{\underline{c}} \tag{2.12}$$

$$Wel \equiv wz + [1 + (1-\tau_k)r]k - T_{sc}(wz) - T_l(y) - \omega^y x^y \tag{2.13}$$

$$TR_{\underline{c}} \equiv \begin{cases} (1+\tau_c)\underline{c} - Wel, & if \;\; Wel < (1+\tau_c)\underline{c} \\ 0, & otherwise \end{cases} \tag{2.14}$$

$$k' \geq b \tag{2.15}$$

when $j = f$—young agents are employed in the formal sector. In Value Function Equation (2.11), the future value is discounted by a discount factor β and is a weighted average of the conditional expectation of young and old agents, where retirement probability π_o serves as a weight. Equation (2.12) is the budget constraint and the total resource for allocation. The resource comes from the net wealth Wel and the transfer for the social consumption insurance $TR_{\underline{c}}$. Young agents are required to pay all kinds of tax and social security contribution. Equation (2.13), (4.13) gives the definitions of Wel and $TR_{\underline{c}}$ and Equation (2.15) states the borrowing constraint. $\omega^y x^y$ is the out-of-pocket expenditure for young agents where ω^y is the out of pocket ratio and x^y is the total health expenditure.

The problem is subject to Equation (2.12), (2.14) and (2.15) when $j = nf$—young agents are employed in the informal sector, where

$$Wel \equiv wz + (1 + (1-\tau_k)r)k - \omega^y x^y. \tag{2.16}$$

Compared with Equation (2.13) where labor income taxes and a social security contribution are collected, Equation (2.16) shows the avoidance of such labor taxes and social security contributions.

Lastly, the problem is subject to

$$(1+\tau_c)c + k' = Wel + TR_{\underline{c}} + TR_{um} \tag{2.17}$$

and Equation (2.14) and (2.15), when $j = um$—young agents are unemployed, where

$$Wel \equiv (1 + (1-\tau_k)r)k - \omega^y x^y, \text{ and} \tag{2.18}$$

$$TR_{um} \equiv \begin{cases} \tau_{um} \int min\{wz, \bar{T}_{sc}\}\Phi(s_e), & if \;\; j_{t-1} = f \\ 0, & otherwise \end{cases} \tag{2.19}$$

τ_{um} is the unemployment benefit rate and $\int min\{wz, \bar{T}_{sc}\}\Phi(s_e)$ is the capped average labor income in the formal sector for the calculation of unemployment benefits. For the unemployed agents, there is no labor income and they may rely on additional income if they were employed in the formal sector before the unemployment, as shown in Equation (2.18) and (2.19). Therefore, for agents with a given education level, they are exposed to the uncertainties of employment status, individual productivity and health expenditure at each period when they are young.

Old Agents' problem with Education *e*

Agents with education e retire when they become old and stop supplying labor. They receive an old-aged pension that is different according to their education type e and face the uncertainty of health expenditures with an out-of-pocket ratio ω^o. An old agent's problem is written as follows:

$$V_o(s) = max\{E\{u(c) + \beta(1-\pi_d)E[V_o(s')|s]\}\}, \tag{2.20}$$

subject to

$$(1+\tau_c)c + k' = Wel + TR_{\underline{c}} \tag{2.21}$$

where

$$Wel \equiv ps + (1 + (1-\tau_k)r)k - \omega^o x^o \tag{2.22}$$

$$ps \equiv \tau_{ps} \int min\{wz, \bar{T}_{sc}\}\Phi(s_e) \tag{2.23}$$

and Equation (2.14) and (2.15). In Value Function (2.20), π_d is the death probability. Equation (2.21) is a standard resource constraint with the wealth specified in Equation (2.22) for old agents. Pension payment ps is a percentage τ_{ps} of the average labor income in the formal sector, as shown in Equation (2.23). $\omega^o x^o$ is the out-of-pocket expenditure for old agents.

2.2.8 Competitive Equilibrium

A stationary recursive competitive equilibrium consists of a set of quantity $\{c, k', Wel\}$ for each young individual and each old individual with high or low levels of education, in a certain employment status or being unemployed, respectively. It further includes a set of prices $\{w, r\}$ which are decided by the aggregate capital per capita K and labor per capita L, government policies $\{\tau_c, \tau_k, \rho, \dot{y}, \tau_{sc}, \bar{T}_{sc}, \tau_{um}, \tau_{ps}, \omega^y, \omega^o, \underline{c}\}$ and a definition of pension benefits, and a stationary distribution of population over the state space $\Phi(s)$ which is characterized by

- ◇ (i). the ratio of population by education λ;

- ◇ (ii). the retirement probability π_o and death probability π_d, idiosyncratic labor productivity shocks z with the values from Z^e evolved with a transition probability matrix Ψ^i; and
- ◇ (iii). health expenditure shocks x^t from X^t evolved with transition probability matrix Ω^t,

such that

- ◇ (i). agents with high and low education, from the formal, informal sectors and the unemployed, young and old age, solve their individual constrained maximization problems, respectively;
- ◇ (ii). firms solve its profit maximization problem;
- ◇ (iii). resource feasibility condition $Y = C + I + G + X$ is satisfied, where $I = K' - (1-\delta)K$, $X = \int x d\Phi(s)$
- ◇ (iv). government policies satisfy government budget constraint Equation (2.10);
- ◇ (v). both labor and capital markets clear when $L = \int z d\Phi(s)$ and $K = \int k d\Phi(s)$, which integrate λ and $1-\lambda$ shares of population with high and low education, respectively, in terms of an asset holding.

2.3 Data, Estimation and Calibration

Among all the developing countries with a substantial presence of informal economy, Thailand is one of the earliest countries that have reached universal health coverage through its tax-financed UCS. To capture the basic features of the Thai economy, we use the Thai Socio Economic Survey (SES) panel data from the Thai National Statistics Office and the Thai macro economy indicators from various sources.

2.3.1 Preference and Production

The model frequency is one year for each period. The discount factor is adjusted to match the capital output ratio in Thailand. According to the National Economic and Social Development Board of Thailand, the capital output ratio in Year 2005 was 3.51 (which was also the approximate average of 2000-2010). The utility parameter σ with a value of 2 is set to target an average value of risk aversion, as suggested in the empirical estimates that range from 1 to 3. In the production function, the total factor productivity A is normalized to unity. The capital income share α is 0.3144 estimated in Ahuja et al. (2004) and the annual capital depreciation rate δ is set at 4.2% as of Tanboon (2008).

2.3.2 Demographics, Education and Sector Size

In Thailand, the official legal working ages are from 15 to 59 years and the working population accounted for 67% of the total population in 2006. By using the SES household samples, the actual expected working and retired ages can also be estimated by using the following method. The probabilities of participating labor force under each age are calculated by choosing the age range from 15 to 29, and then assigning these probabilities as the weights for each age to calculate the expected actual working age. Similarly, the retired age is also calculated by choosing an age range from 50 to 64. According the data in Year 2005, the expected working age is from 17.88 to 61.89. Athough slightly different from the legal working age, it yields approximately the same number of working years as the legal working age range. Therefore, the number of working years is set at 45 years for the young generation. More details are provided Appendix A.2.

The UN estimates show that the Thai old-age dependency ratio was around 13% in 2005. Accordingly, the retirement probability π_o is set to be 1/45 because young agents are expected to work for 45 years and the death probability π_d is set so that the population

shares between young and old match the dependency ratio. Tertiary (including vocation school) and above is defined as "high education", and secondary school and below is defined as "low education". The shares of population with high and low education are set at 25% and 75%, respectively.

Concerning the shares of working population and output in the informal and formal sectors, we calibrate the transition matrix of labor shocks to target the population share where 62% of the labor force is working in the informal sector, and the output share is endogenously determined.

2.3.3 Labor Productivity and Employment Shocks

A shock process through a transition matrix is used to capture the fluctuations of individual productivity and the changes of employment status. The variable "g1"-an average wage per month from Thai SES panel data is used to measure the wage income, which does not include other additional income such as overtime pay, bonuses, or average workplace welfare per month.

To distinguish the work force among all the samples, and identify workers from the formal and informal sectors, some variables from the SES survey are used. The variables "a_1" and "$f5\_1$" regarding to the work status and employer are used. Among those groups, "employer" and "private company employee" are the groups difficult to tell whether they are from the formal or informal sector. The samples of employers are not included since the model assumes full competition of firm with no additional capital rent remaining for employers. Second, when a worker is employed by a private company, the additional information about wage type "$f9\_1$" is used to serve as a criterion to differentiate workers of one sector from the other. Therefore, the workforce in the formal sector consists of people working in government, state enterprises, and private companies with

regular monthly payments; the workforce in the informal sector consists of people who are self-employed without employees, working without paying for household business and working in private companies without regular monthly payments. Such a strategy for the sectoral identification can also be found Wagstaff and Manachotphong (2012).

The people with high levels of education and those in the formal sector have a higher wage income than their counterparts. For instance, Figure 2.1 and Figure 2.2 shows the distribution of the groups by education and by economic sector in 2005, respectively. However, the distribution of high education is less centered that in the formal sector. Table 2.1 shows the sample size and corresponding means for social average and each group for the $2005 - 2007$ period.

In order to build the markov transition matrices to model the dynamics of wage uncertainty, the traditional approach is to estimate an AR(1) process and then discretize it through the method of Tauchen (1986). However, such estimation requires a panel data with a long time horizon that is not available for the case of Thailand (and most of other developing countries too). Therefore, we follow Jeske and Kitao (2009) and Hsu (2012) to construct such a matrix directly from the data, which is then adjusted to target aggregate formal-informal share for its transition bias due to the short horizon. As three-year data are available, the period is separated into two two-year panels.

Given the limited size of the samples, the wage income distribution is only discretized into three statuses as shown in Table 2.2 from the lowest and highest, which are the bottom 40%, from 40% to 75% and the top 25%, accordingly. Unemployment is added as an additional status and its corresponding wage income is zero. The average values in the last column in the Table 2.2 are used for the benchmark economy. The transition matrices for individual productivities and sector shocks are built in a joint manner, based on the weighted-average of the $2005 - 2006$ and $2006 - 2007$ matrices. However, high and low levels of education are separated into two matrices as there is no transition

between education statues. For the transition matrix of high education, the shocks are more persistent to concentrate into the formal sector, while the shocks are less persistent across sector for the matrix of low education. In addition, checking from the stationary values of this transition matrix, the share of the formal sector is larger than the informal sector for the case of high education, which is the opposite of the case for low education. In other words, this implies that the agents with high education are more likely to stay in the formal sector than those with low education. A joint transition matrix for individual productivity and employment is shown in Table 2.3. The bias adjustment process of the transition matrix is included in Appendix A.3.1.

2.3.4 Health Expenditure Shocks

The reported health expenditure consisted of out-of-pocket expenditure. Given the limitations of such ex-post data, the following steps are taken to approximate the unobserved information. First, a variable with the information of out-of-pocket payments is used , which is "h22"—expenditure on healthcare, to examine the distribution and transitional dynamics. Second, due to the likely mismatch of micro survey data and macro indicators, a recovery function is set to match the total health expenditures from the benchmark economy to the national total health expenditure per capita. Third, a transitory bias is assumed in order to match the distribution of the status of health expenditures with their stationary share.

Each process is simplified with only two states, including "low" and "high" for the lower 95% and top 5% of health expenditure distribution. Table 2.4 states the health expenditures after adjustment for young X^y and old agents X^o relative to the average social wage. The corresponding transition matrices Ω^y and Ω^o are shown in table 2.5. Further details on data handling and adjustment are included in Appendix A.3.2.

2.3.5 Social Security System

The Thai social security system is comprehensive, including an old-age pension, unemployment, and health care benefits. However, those social security programs only cover the workers in the formal sector, which is mainly based on the contribution-benefit principle before the launch of the UCS. With the implementation of the UCS, the workers in the informal sector and all retired people can enjoy access to health services with an increasing share of the financial burden shared covered under by general tax revenues.

Unemployed benefits

Workers in the formal sector are entitled to unemployment benefits. In practice, the unemployed receive 50% of the average salary of the past five years for a duration of six months. As the model frequency is annual, τ_{um} for an unemployed agent of education type e from the formal sector is set to receive 25% of the average contribution of each education type for the first period and cannot receive further benefits if the unemployment status continues into the next period.

Social insurance

The government guarantees social insurance for a minimum consumption for all agents regardless of age and sector. The variable "g18"—the money or assistance in goods from government is used and treated as an assistance to guarantee a minimum consumption. The minimum consumption in terms of social average wage is set at 8.45%.

Old-age pension

In addition, the workers in the formal sectors are also entitled to old-age pension benefits after they retire. The pension benefits are a percentage τ_{ps} of the expected lifetime average contribution. As shown in Pfau and Atisophon (2009), the formula of the

replacement rate in Thailand τ_{ps} is as follows:

$$\tau_{ps} = \frac{1.5\Xi - 2.5}{100} \tag{2.24}$$

where Ξ represents the number of years of contribution to the pension system. Although the expected working years of young agents with different levels of education are the same, Ξ is decided by their total time in the formal sector. After the calculation over the stationary values implied by the transition matrix of labor shocks, the young agents with high education are expected to work in the formal sector approximately 32.13 years and the young agents with low education 11.45 years. The corresponding replacement rates are 45.7% and 14.67%, respectively. The cap labor income for social security contribution $\bar{T}_{sc}$, which was Baht 15,000 in 2005, is therefore set at 1.76 (of the social average income).

Health care scheme

A lower out-of-pocket ratio is provided to all agents, who are not entitled otherwise, in the economy after the implementation of the UCS. Therefore, besides the formal workers who have health insurance benefit through the social security , all the rest agents are entitled to public health care under government financial support, by giving either free care or partial support given different types of illness. The aggregate flat out-of-pocket ratio is used for the approximation. And the ratio of health expenditure out of their pocket of the young and old generations, in percentage of total expenditure on health, which are ω^y and ω^o by notation, are set non-discriminatorily at 27.23%—an estimated aggregate out-of-pocket ratio by the World Bank for Year 2005 and the rest are borne by government. More details of social security system are enclosed in Appendix A.4.

2.3.6 Government Fiscal Revenues and Outlays

In Thailand, the tax revenues come from the direct income tax and indirect tax. The direct income taxes consists of a personal income tax, a corporate income tax and a petroleum income tax. We treat the sum of corporate income and petroleum as capital income, personal income tax as labor income tax, and indirect tax (excluding export-import related taxes) as consumption tax as it is ultimately born by consumers. According to the 2005 Thai Fiscal budget with the definition above, the corresponding tax revenues for the consumption tax, the capital tax, and the income tax are 9.38%, 4.44%, and 1.95% of GDP, respectively. We calibrate the corresponding tax rates in the model to target these revenue ratios. The details of tax tax revenue and the income tax scheme are included in Appendix A.5.1.

In Thailand, the personal income tax scheme $\tau_m(y)$ and $\dot{y}$ introduced in Section 2.2.6 are shown in the top line of Figure 2.3. The corresponding de jure effective tax rates τ_l is calculated and approximated by a high-order polynomial function, which is written as

$$\tau_l = \sum_{p=0}^{n} \gamma_p y^p \tag{2.25}$$

where p is the polynomial index from 0 to the order of n, and y is the labor income after the deduction of social security contribution, denoted as $y = wz - T_{sc}(wz)$. Following the method of Gouveia and Strauss (1994), we choose a degree of order n to be six as it sufficiently captures the shape of the effective income tax rates in Thailand. Given the polynomial function above, a calibration parameter ϵ_l is used to scale y to target the income tax revenue ratio, where the de facto effective tax rate can also be calculated from the model.

In the benchmark economy for the current economy, the government expenditure G is determined endogenously to balance the government budget. The other fiscal outlays,

which include the old-age pensions, unemployment benefits, social assistance, and public health expenditures, are determined by the policy choices of τ_{un},τ_{ps}, ω^y, ω^o, $\underline{c}$ and the model variables jointly.

2.3.7 Financial Market

The borrowing constraint b is set at 0 and agents are prevented from any borrowing. Therefore, precautionary saving acts as a buffer to various shocks.

2.3.8 Computation Procedures

The steady-state equilibrium is solved by the steps of Aiyagari (1994), which is to guess the aggregate values, solve the individual problems and then simulate the economy to update the aggregate values until convergency. In the paper, the individual problems are solved by the Endogenous Grid Method (EGM) proposed by Carroll (2006) and simulations done by non-stochastic simulation as of Young (2010), which reduces the simulation error compared with stochastic simulation. The basic procedure is as follows:

- ◇ (1) guess initial values of the aggregate capital and the endogenous variable. (The labor supply can be calculated directly through the stationary values of transition matrices Z^e, their corresponding values Ψ_e and the share of the population in terms of education λ. Alternatively, it can be set up as a value to guess.);
- ◇ (2) solve the problems of agents with different levels of education separately for their decision rules in all states, which are individual productivity, employment and sector, age, and health expenditure.
- ◇ (3) simulate an economy with the decision rules and the transition matrices above. Aggregate the distributions of individual asset holdings for both education types to

find the aggregate capital, and calculate the endogenous policy variable to clear the government budget; and

- ◇ (4) go back to step (a) if the convergence criteria for capital and endogenous variable are not satisfied, update the guesses by weighted averaging the previous guess and the values found from the step (3).

2.4 Analysis

The analysis in this section is focused on a steady-state equilibrium analysis. Firstly, a benchmark economy with universal coverage is calibrated with key targets being matched to the 2005 Thai economy, by choosing the government expenditures to balance the government budget. Secondly, a benchmark economy without universal coverage is constructed. A standard welfare analysis for the comparison of these two economies is conducted by measuring the Consumption Equivalent Variation (CEV). The CEV is calculated to measure welfare change, which is the percentage change in consumption in each period required to make an individual in the benchmark economy as well off in terms of expected life-time utility in the alternative economy.

$$\int V^{bm}((1+\xi)c(s))d\Phi^{bm}(s) = \int V^{alt}(c(s))d\Phi^{alt}(s) \tag{2.26}$$

whereV^{bm} and V^{alt} denote the value functions of benchmark and alternative economies, respectively. ξ indicates the relative welfare gain or loss of an alternative economy again the benchmark economy.

2.4.1 Benchmark Economy

The benchmark economy represents some main characteristics of the Thai economy in the middle 2000s, which include the major social security programs. As shown in Table 2.6, the model is calibrated to match the capital-output ratio, the health expenditure output ratio, the informal sector size in terms of workforce population, the risk aversion value that falls into the mean of the range of estimates and the tax revenue ratios of GDP. All the parameters of the benchmark economy are listed in Table 2.7.

Column (1) of Table 2.8 gives the details of this economy, which describes the main macro variables and the components of government fiscal revenues and outlays, in terms of percentage to output. Imposed in the formal sector in the economy, the effective labor income tax rate τ_l on the basis of weighted average for the formal sector is 2.53%, which consists of 6.11% and 1.33% for people of high and low levels of education, respectively. For the details of tax rates according to labor productivity, please refer to the lower curve of Figure 2.5.

In the current economy, pension payment is relatively modest and more spending goes to the public health expenditures due to the UCS. As the government expenditures are used to balance the budget, the value is fixed at 11.91% as of output. All the details are shown in the first column of Table 2.8.

2.4.2 Population Ageing with Universal Health Coverage

As shown in Figure 1.5, Thailand is one of the countries in the region which faces the fastest trend of ageing, with the old-age dependency ratio in Thailand will increase to 45% from 13% in Year 2005. Meanwhile, the benchmark in Subsection 2.4.1 is when the UCS has been adopted but still in the transition to further reduce Thai out-of-pocket

ratio, we assume that a long-term out-of-pocket ratio target by government is set at 15% — a value estimated by Xu et al. (2010) which sufficiently prevents the financial hardship due to illness.

Aged Economy

To examine the long-term impact of population ageing with the targeted out-of-pocket ratio, we construct a projected aged economy for 2050 by setting the consumption tax rate to be endogenous[1]. Furthermore, it is assumed that all other exogenous factors in the model such as technology progress, health cost inflation and various policy choices remain constant. Therefore, health expenditures and government expenditures are fixed at a constant ratio to output in this long-term projection, which means they adjust to the price changes of factor price in value. Column (2) of Table 2.8 describes this aged economy. The labor supply decreases by about 22% due to the ageing, and the capital stock increases by 2.4%. Correspondingly, the wage rate increases by about 9% while the interest rate decreases by 32%. The government has to spend more on the public health expenditures to run the UCS, with public health expenditures increasing by 50% from 3.50% of output to 5.25%. The following causes contribute to such a hike in public health expenditures. First, the increase of social wage drives up the health cost. Second, a larger share of the old-aged population, whose health costs are higher than those of young people, has to been taken care of. Third, lowering the out-of-pocket ratio brings an additional burden.

Meanwhile, the payment for old-age pension benefits increase from 2.74% to 9.45% of output, if the replacement ratio remains the same as what is defined in Year 2005 (as of

[1]The burden is shared across sector and age when financed by the consumption tax. Through the separate experiments, financing the long-term ageing by using the labor income tax with a small population of tax-payers cannot be achieved without changing the existing tax scheme. In the next chapter, financing ageing with alternative financing options is studied by replacing the progressive tax with a proportional one.

Subsection 2.3.5). Old people are less able to manage the expenditure shocks than the young people as they are lack of diversity of incomes. Therefore, they are more likely to to fall into the social safety net for assistance and government expenditures thus increase from 0.01% to 0.02%. In sum, the fiscal outlay expands from 17.44% to 26.08%. To balance the government budget, the consumption tax rate has to increase from 13.38% to 28.59% for the purpose of financing. As shown in Table 2.9, the decomposition of the long-term effect is listed as a percentage of the total government fiscal expansion. The remaining details of the economy are shown in Column (2) of Table 2.8.

Transition Dynamics

We have constructed an aged steady-state economy above. In the following, we consider the transition path to gain a better understanding of the dynamics during the transitional period. We assume that the starting point for the economy is 2005, and that the policy to finance ageing by using the consumption tax is unexpectedly announced. To calculate welfare along the transition path, we require one additional state variable, t, the time period (year). The state space s becomes $s = (k, j, j_{-1}, z, x^t, t)$ and the method of calculation is similar to Nishiyama and Smetters (2007).

As shown in Figure 2.4, after the policy is unexpectedly announced, rational agents adjust their endogenous consumption-saving behavior and induces a jump in aggregate capital. The aggregate capital reaches its peak before the old-age dependency ratio reaches its peak in 2050 because the interest rate is determined by both capital and labor. When the effect of labor dominates, the interest rate reaches the lowest point at the same time as the demographic change. The public health expenditure to cover the UCS and consumption tax rate increases steadily over the time and converges in the long run.

2.4.3 Welfare Analysis with Alternative Financing Options

For the purpose of identifying the welfare change caused by the low out-of-pocket ratios due to the UCS in the long term, a counterfactual economy is constructed by increasing the out-of-pocket ratios in 2050. The welfare changes are calculated between this scenario and the aged economy in Subsusection 2.4.2, in terms of the CEV defined at the beginning of this Section. Tax financing options are examined for their different effects on the welfare change, which are financed through the consumption tax, the progressive labor tax, the capital tax and the proportional labor tax.

To understand the welfare changes in the disaggregated groups, the distinguishing of the following three effects is essential: first, a positive coverage effect that the young agents are subsidised by universal coverage when they are in the informal sector and when they become old; second, a negative tax burden effect that the agents have to bear to finance the universal coverage (for the case of labor tax financing, the agents work in the formal sector bear this burden); finally, a pending general equilibrium effect coming from the price changes of factors which affect their labor and capital incomes. Therefore, whether an agent has a welfare gain or loss depends on the net effect of all these effects.

Consumption Tax Financing

The scenario in which out-of-pocket ratios are increased is constructed from the aged economy in Subsubsection 2.4.2 as shown in Column (2) of Table 2.8[2]. To examine the welfare implication of financing through the consumption tax, it is endogenously determined.

[2] The out-of-pocket prior to the UCS are set at 37% for the non-social security contributors and at 27.23% for the contributors. The former number is the average value of the out-of-pocket ratios of Thailand from 1995-2001 and the later is the ratio in Year 2005. This value is chosen for the comparison of welfare and the sign (i.e. positive or negative) is our main interest. For a country which wants to reach universal coverage by its lowering out-of-pocket ratio, the welfare change is determined by the current ratio and the target ratio

In this scenario, instead of fixing the ratio, the government expenditure and total health expenditure are fixed in the economies under alternative financing options, as the same level as the long-term benchmark economy in Subsection 2.4.2, instead of fixing the ratio. In such a way, the sudden changes of government expenditure and total health expenditure in level in the short run, due to the general equilibrium effects, can be prevented.

Column (3) of Table 2.8 introduces this economy. The consumption tax rate falls from 28.59% to 27%. Accordingly, the public health expenditure also declines from 4.46% to only 3.37%. In this economy, as young agents in the informal sector and old agents in both sectors have to self-insure for health expenditure shocks with larger sizes, the precautionary saving increases. Consequently, the capital stock increases from 4.4422 to 4.615, which drives the interest rate down and pushes the wage rate up. In absence of the UCS, agents are more likely to fall into the social safety net due to the health expenditure shocks. The government has to increase its budget for this purpose accordingly.

Compared with the long-term benchmark economy, the economy without the UCS has a welfare loss in term of the CEV, when the initial financing through the consumption tax is assumed. Column (1) of Table 2.10 lists the welfare changes in the aggregate and disaggregated levels. An economy without the UCS experiences an overall loss of 0.35%, where that young agents gain and old agents lose.

Progressive Labor Tax Financing

Alternatively, a progressive labor tax can also be used to finance the universal health coverage. Therefore, based on the counterfactual economy above where the UCS is removed, it is installed back by financing through progressive labor tax. As shown in Column (4) of Table 2.8, the average effective labor tax in the formal sector increases from 2.90% to 4.70%. (The middle line in Figure 2.5 shows the specific tax rates according to individ-

ual productivity.) Compared with the economy in Column (2) of Table 2.8 where the consumption tax is used, this economy has a lower output and capital accumulation. In terms of the CEV welfare change, a gain of an additional 0.71% in terms of the CEV is observed, compared with financing by the consumption tax. This additional gain comes from the redistributive effects of the progressive labor tax, under which young agents with high education lose and young agents with low education gain. Both old generations prefer to use the progressive labor tax instead of the consumption tax since they do not bear the burden (see Column (2) of Table 2.10).

Capital Tax Financing

Column (5) of Table 2.8 lists the economy where a capital tax is used to finance the universal coverage. The capital tax increases from 26.37% to 34.01%, and there is also a gain of 0.20% in terms of the CEV. Although young agents in the formal sector have both higher capital income and consumption compared with young agents in the informal sector, the average consumption ratio between them is 2.7744 while the asset holding is only 1.3889. Given the increase of consumption and capital tax and related tax burden, young agents with high education prefer a capital tax to a consumption tax, while young agents with low education prefer the opposite. (See Column (3) of Table 2.10).

Proportional Labor Tax Financing

Column (6) of Table 2.8 details the economy where a proportional labor tax is used to finance the universal coverage. The average effective labor tax increases from 2.90% to 7.91% (see the upper line in Figure 2.5 for the specific tax according to individual productivity). Such a tax increase is higher than for the case of using progressive labor since the calculation of the average tax also depends on the distribution of taxpayers.

Moreover, there is also a gain of 0.54% in terms of the CEV and slightly less than the gain from the progressive labor tax (see Column (4) of Table 2.10).

2.4.4 Discussion

As shown in the previous analysis , there is a consistent welfare gain from the UCS, regardless of the choice of financing options. Such a welfare gain come from both sources of risk sharing and resource redistribution, when the gain outweighs the loss from the distortive effects of taxes. Therefore, the size of the gain therefore depends on the policy choice of tax options. For the case of Thailand, financing by a labor income tax achieves the highest gain among all the options. However, such a ranking is specific to the characteristics of given economy. For instance, the literature which does not take the economic informality and tax progressivity into account may suggest a different ranking. In addition, as labor supply is exogenous and labor tax is not distortive to labor supply in the current setting, the welfare gain can be smaller or even negative if labor supply is endogenous.

The feasibility of financing universal health coverage by tax revenues depends heavily upon the cost of health expenditures. For the case of Thailand, the current total health expenditures as a percentage of GDP is one of the lowest countries in the world. It makes it possible to adopt the UCS without placing an overwhelming burden on the government budget. For most countries with higher total health expenditures, both the immediate financial burden to implement the UCS and long-term sustainability due to population ageing are of concern. The degree of absorbing health expenditures into government budgets to implement a broader health coverage and the long-term financing sustainability facing the government are two sides of one story which policy makers need to balance.

2.5 Conclusions

The provision of universal health coverage is "the most powerful tool that the public sector can offer" and it has become a key agenda in many developing countries nowadays (WHO, 2010). In this connection, its long-term financing issues in the context of the global trend of population ageing deserve more research attention. Incorporating the economic informality, which is a common feature in most of developing countries, and specifying multiple social security programs and a taxation system where the nonlinearity of effective labor income tax rates are parameterized, this paper addresses the universal health coverage from the burden of universal coverage in the context of population ageing and studies the welfare implications of various financing options.

In order to quantitatively provide the answers, a model with its parameters estimated using Thai panel data and calibrated to the key targets of the real economy has been built. We first examined the impact of population ageing with various social security programs in the long term, projected to Year 2050 and found that the government has to expand its budget by around 50%, compared with the 2005 budget. Thus, a large tax hike is required to balance the budget. The results also showed that the provision of universal health coverage, which de-facto subsidizes the people in the informal sector, the unemployed and the retired, has a substantial welfare impact in the long run for the society as a whole. Furthermore, the degree of gain depends on which tax is used to finance the program. Among all tax options, the labor tax offers a higher than either the consumption tax or the capital income tax, and a progressive labor tax is higher than a proportional tax.

Tables

Table 2.1: Mean of Wage Income

Group	Sample Size			Mean (Baht)		
	2005	2006	2007	2005	2006	2007
Social average	5975	4252	4192	7993	8436	9141
-High Edu	2344	1698	2398	13173	13528	14401
-Low Edu	3631	2455	1748	4650	4913	5242
-Formal	2912	2201	2310	12531	12724	13169
-Informal	3062	2050	1880	3677	3928	4235

Low: Bottom 40%; Fair: 40%-75%; High:Top 25%;
Monthly.

Table 2.2: Wage Income Status

		Value (Baht)			Relative to Social Wage			
Edu	Status	2005	2006	2007	2005	2006	2007	Average
	Low	4482	4736	5194	0.5607	0.5614	0.5682	0.5635
High (Z^h)	Fair	11777	11814	12362	1.4734	1.4004	1.3524	1.4087
	High	30494	30015	32896	3.8150	3.5581	3.5988	3.6573
	Low	1885	2166	2524	0.2358	0.2568	0.2761	0.2562
Low (Z^l)	Fair	4349	4648	5115	0.5441	0.5510	0.5596	0.5516
	High	9620	9709	10409	1.2035	1.1510	1.1388	1.1644

Low: Bottom 40%; Fair: 40%-75%; High:Top 25%.

Table 2.3: Transition Probabilities of Labor Shocks

High Education (Ψ^h)		Formal			Informal			Um
		Low	Fair	High	Low	Fair	High	Zero
	Low	0.1157	0.2892	0.2314	0.2735	0.0729	0.0091	0.0082
Formal	Fair	0.1347	0.3389	0.2491	0.2008	0.0206	0.0051	0.0508
	High	0.1142	0.3486	0.2885	0.2274	0.0076	0.0000	0.0136
	Low	0.2124	0.3793	0.1062	0.2679	0 .0000	0.0000	0.0343
Informal	Fair	0.3262	0.3262	0.2447	0.1029	0.0000	0.0000	0.0000
	High	0.3333	0.3333	0.3333	0.0000	0.0000	0.0000	0.0000
Um	Zero	0.1214	0.2427	0.3338	0.2679	0.0000	0.0000	0.0343
Low Education (Ψ^l)		Formal			Informal			Um
	Low	0.0422	0.0632	0.1265	0.3722	0.3190	0.0532	0.0238
Formal	Fair	0.0422	0.1097	0.2447	0.3619	0.1703	0.0426	0.0286
	High	0.0430	0.1183	0.2312	0.2509	0.2170	0.1153	0.0243
	Low	0.0579	0.0622	0.0729	0.4920	0.2271	0.0541	0.0339
Informal	Fair	0.0483	0.0644	0.1096	0.3820	0.2560	0.1178	0.0219
	High	0.0360	0.0990	0.1531	0.3066	0.2725	0.1022	0.0305
Um	Zero	0.0834	0.1668	0.0834	0.3156	0.3156	0.0351	0.0000

Um: Unemployed;
Original Source: Thailand SES;
Author' Calculation, transitory bias adjusted.

Table 2.4: Status of Health Expenditure

Young Generation (X^y)			
Status	Range	Average (Baht)	Ratio to Social Wage
Low	0-95%	135.89	1.70%
High	95%-100%	3867.18	48.38%
Old Generation (X^o)			
Low	0-95%	262.18	3.28%
High	95%-100%	7807.90	97.68%

Original Source: Thailand SES, Year 2005
Authors' Calculation, adjusted to match total health expenditure.

Table 2.5: Transition Probabilities of Health Expenditures

Young Generation (Ω^y)			Old Generation (Ω^o)	
	Low	High	Low	High
Low	0.950	0.050	0.954	0.046
High	0.942	0.058	0.875	0.125

Original Source: Thailand SES.
Authors' Calculation, transitory bias adjusted.

Table 2.6: Calibration Targets of the Benchmark Economy

K/Y	X/Y	Risk Aversion	Informal Size (Pop.)	T_l/Y	T_k/Y	T_c/Y
3.51	3.50%	2.00	62.00%	1.95%	4.40%	9.38%

Table 2.7: Summary of Parameters for the Benchmark Economy (Chapter 2)

Parameter	Values	Description
Households		
β	0.9521	Discount factor, target capital output ratio 3.51
σ	2.0000	Utility parameter, target risk aversion parameter 2
π_o	0.0227	Retirement probability
π_d	0.1740	Death probability, target old-age dependency ratio
ω^y,ω^o	0.2723	Out-of-pocket ratio
λ	0.2500	Share of high education group (Thai Labor Survey 2001-2005)
Firms		
α	0.3144	Capital income share (Ahuja et al., 2004)
δ	0.0420	Depreciation rate (Tanboon, 2008)
A	1.0000	Total factor productivity
Government		
–Revenue		
τ_c	0.1338	Consumption tax rate, target its tax revenue ratio
τ_k	0.2637	Capital income tax rate, target its tax revenue ratio
τ_{sc}	0.0500	Social security contribution rate
$\bar{T}_{sc}$	1.7600	Cap of contribution, of social average labor income
τ_l	–	Effective labor tax rate, a function with parameters as follows
ϵ_l	1.1239	Labor income scaler, target its tax revenue ratio
γ_0	-2.0211e-2	Intercept
γ_1	2.7423e-4	1st order
γ_2	-1.2857e-3	2nd order
γ_3	3.4991e-5	3rd order
γ_4	-5.1877e-7	4th order
γ_5	3.8813e-9	5th order
γ_6	-1.1461e-11	6th order
–Expenditure		
τ_{ps}^h	0.4569	Pension replacement rate for high education group
τ_{ps}^l	0.1467	Pension replacement rate for low education group
τ_{un}	0.2500	Unemployment benefit, of capped average wage by education
$\tau_{\underline{c}}$	0.0845	Transfer of minimum consumption, of social average wage

Table 2.9: Decomposition of Fiscal Effect of Population Ageing

	Health Coverage	Old-age Pension	Social Assistance
Case 1	22.22%	77.66%	0.12%
Case 2	15.96%	83.67%	0.37%

Case 1: the lower out-of-pocket ratio of 15%;
Case 2: the ratio is maintained at 27.3% of the 2005 level.

Table 2.8: Economies of Benchmark, with Aged Population and with Financing Alternatives

Model	(1)	(2)	(3)	(4)	(5)	(6)
labor income tax rate (formal)	2.53%	2.85%	2.90%	4.70%	2.84%	7.91%
- high ecuation	6.11%	6.68%	6.76%	9.65%	6.67%	9.19%
- low education	1.33%	1.57%	1.61%	3.05%	1.57%	4.10%
Capital Income Tax Rate	26.37%	26.37%	26.37%	26.37%	34.01%	26.37%
Consumption Tax Rate	13.38%	28.59%	27.00%	27.00%	27.00%	27.00%
Aggregate Cpital per Capita	4.3362	4.4422	4.615	4.3842	4.43	4.3859
Aggregate Labor Input per Capita	0.6942	0.5412	0.5412	0.5412	0.5412	0.5412
Interest rate (r)	4.75%	3.23%	3.04%	3.29%	3.24%	3.29%
Wage rate (w)	1.2199	1.3287	1.3448	1.3235	1.3276	1.3236
Output per capita (Y)	1.2351	1.0489	1.0615	1.0448	1.048	1.0449
Capital output ratio	3.5108	4.2353	4.3475	4.1963	4.2271	4.1976
Total health expenditure (% of output)	3.50%	5.25%	5.18%	5.27%	5.25%	5.27%
Fiscal revenues (% of output)	17.44%	26.08%	24.89%	26.16%	26.10%	26.16%
- labor tax	1.95%	2.15%	2.18%	3.21%	2.14%	3.21%
- capital tax	4.40%	3.60%	3.48%	3.64%	4.67%	3.64%
- consumption tax	9.38%	18.62%	17.52%	17.60%	17.58%	17.60%
- social security contribution	1.71%	1.71%	1.71%	1.71%	1.71%	1.71%
Fiscal outlays (% of output)	17.44%	26.08%	24.89%	26.16%	26.10%	26.16%
- old-age penson	2.74%	9.45%	9.46%	9.46%	9.46%	9.46%
- unemployment benefit	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%
- social assistance for cons floor	0.01%	0.02%	0.05%	0.02%	0.02%	0.02%
- public health expenditure	2.54%	4.46%	3.37%	4.48%	4.46%	4.48%
- government expenditure	11.91%	11.91%	11.77%	11.96%	11.92%	11.96%

(1)Benchmark (2005); (2)Financing through Consumption tax (2050);
(3) Remove the UCS assuming consumption tax financing (2050);
(4) Install the UCS from (3)with progressive labor income tax financing;
(5) Install the UCS from (3)with capital income tax financing;
(6) Install the UCS from (3)with proportional labor income tax financing;
*(3)-(6) are simulated by fixing G and X at level of (2), instead of their ratios.

Table 2.10: Welfare Comparisons of Various Economies

Group	(1)	(2)	(3)	(4)
CEV: all	-0.35%	0.71%	0.20%	0.54%
- CEV: high education	0.00%	-0.83%	0.58%	-0.48%
- Old Generation	-1.30%	0.34%	0.93%	0.55%
- Young Generation	0.65%	-1.41%	0.41%	-0.99%
- CEV: formal	0.65%	-1.41%	0.41%	-0.99%
- CEV: low productivity	0.65%	-1.38%	0.42%	-0.97%
- CEV: medium productivity	0.65%	-1.41%	0.41%	-0.99%
- CEV: high productivity	0.66%	-1.44%	0.39%	-1.00%
- CEV: informal	0.64%	-1.39%	0.44%	-0.98%
- CEV: low productivity	0.64%	-1.38%	0.44%	-0.98%
- CEV: medium productivity	0.64%	-1.39%	0.43%	-1.00%
- CEV: high productivity	0.66%	-1.39%	0.41%	-1.00%
- CEV: unemployed	0.74%	-1.42%	0.41%	-0.99%
- from formal sector	0.65%	-1.44%	0.40%	-1.02%
- from informal/unemployed	0.92%	-1.38%	0.43%	-0.94%
- CEV: low education	-0.47%	1.22%	0.07%	0.88%
- Old Generation	-1.20%	1.42%	0.45%	1.19%
- Young Generation	0.09%	1.07%	-0.21%	0.65%
- CEV: formal	0.08%	1.03%	-0.25%	0.60%
- CEV: low productivity	0.09%	1.07%	-0.20%	0.65%
- CEV: medium productivity	0.08%	1.03%	-0.24%	0.60%
- CEV: high productivity (	0.07%	1.02%	-0.28%	0.58%
- CEV: informal	0.09%	1.08%	-0.20%	0.67%
- CEV: low productivity	0.09%	1.08%	-0.18%	0.67%
- CEV: medium productivity	0.08%	1.07%	-0.22%	0.66%
- CEV: high productivity	0.07%	1.05%	-0.25%	0.64%
- CEV: unemployed	0.15%	1.07%	-0.20%	0.65%
- from formal sector	0.09%	1.00%	-0.27%	0.53%
- from informal/unemployed	0.16%	1.10%	-0.19%	0.69%

(1): Welfare change of removing the UCS in 2050;
(2): Welfare change of progressive labor income tax financing, compared with consumption tax financing;
(3): Welfare change of capital income tax financing, compared with consumption tax financing;
(4): Welfare change of proportional labor income tax financing, compared with consumption tax financing.

Figures

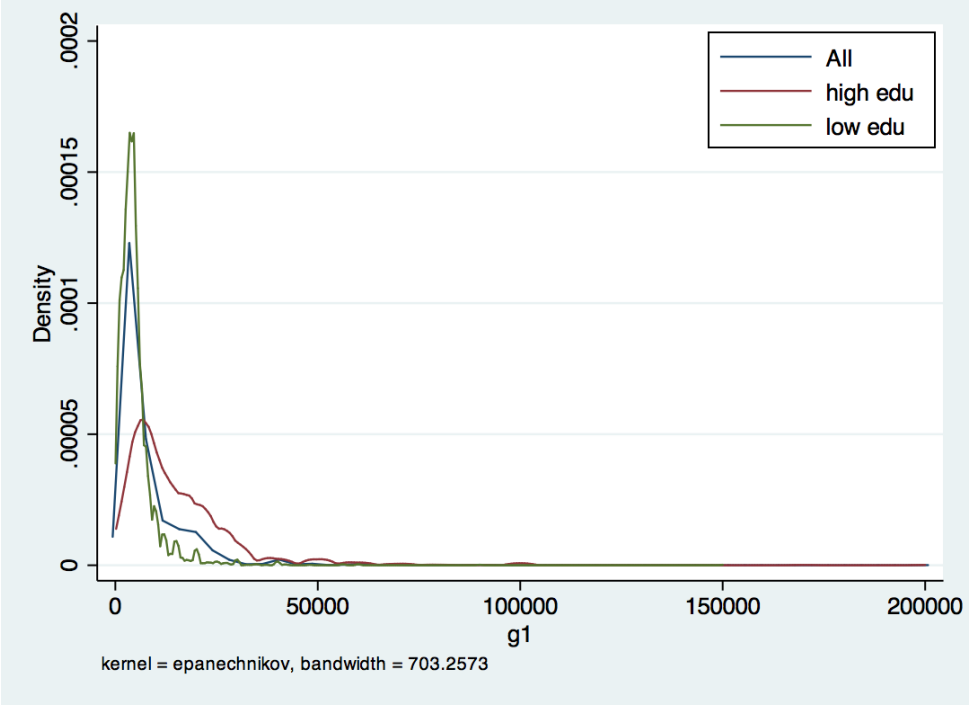


Figure 2.1: Distribution of Wage Income by Education

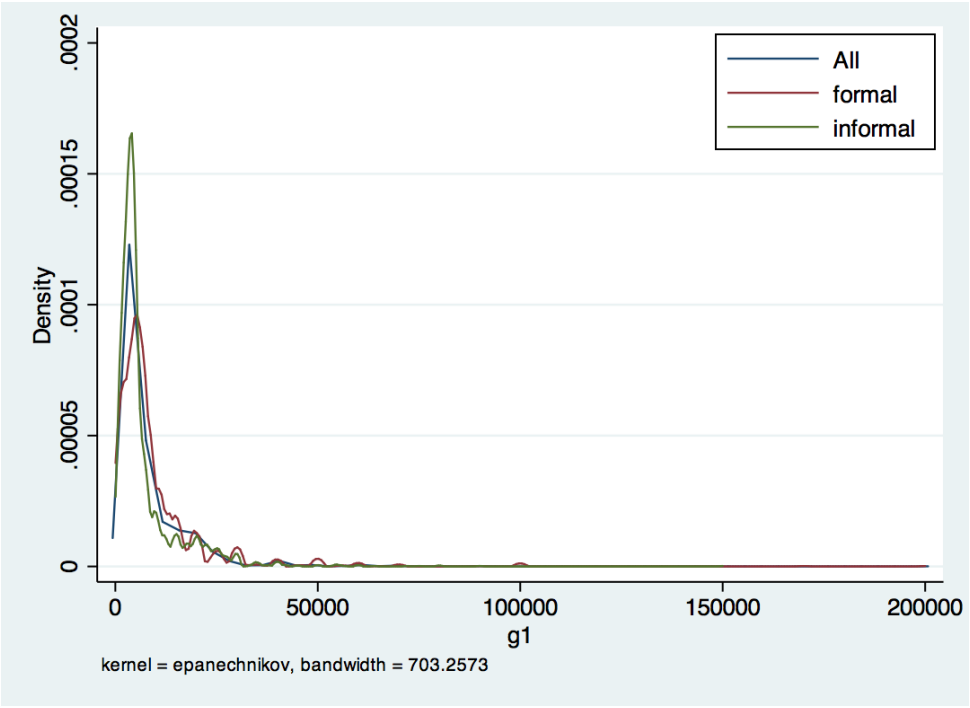


Figure 2.2: Distribution of Wage Income by Economic Formality

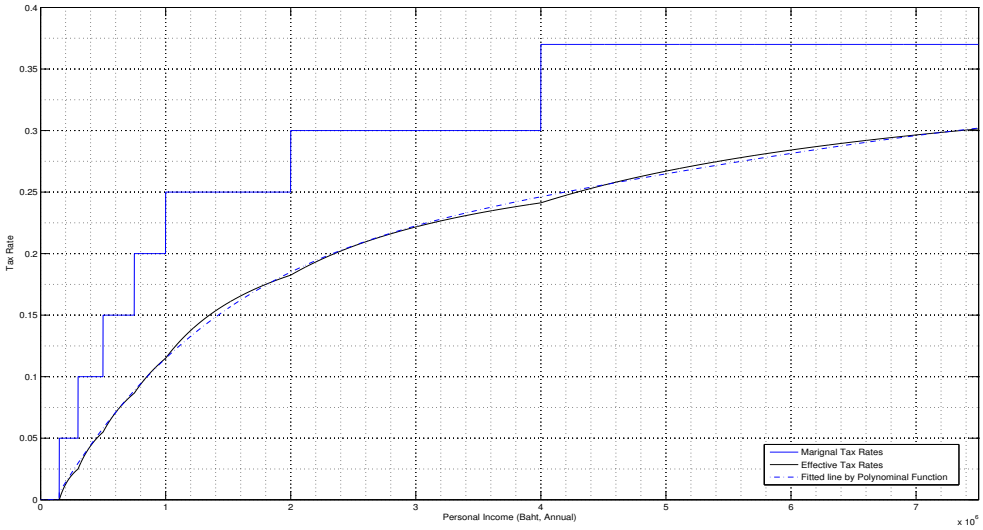
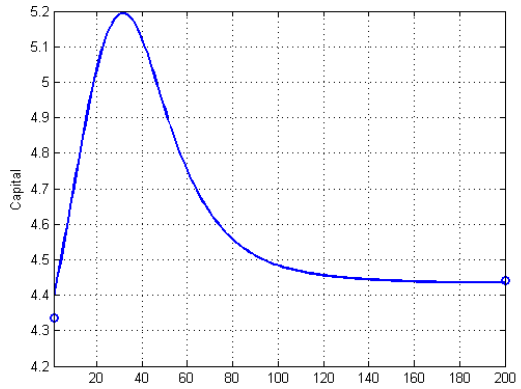
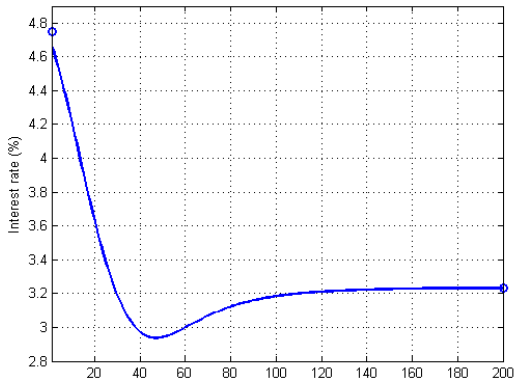


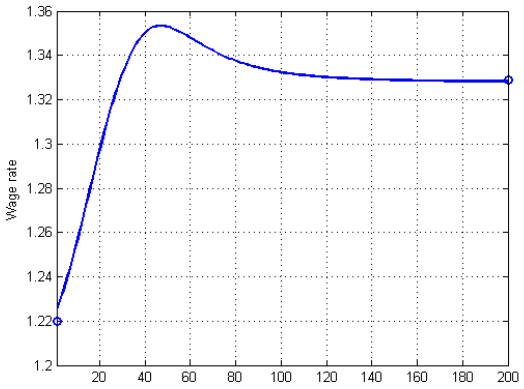
Figure 2.3: Progressive Labor Income Tax Rates



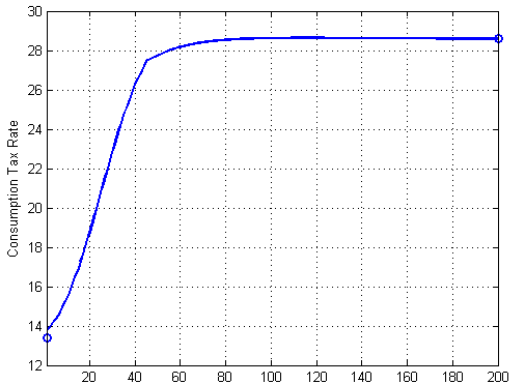
(a) Capital



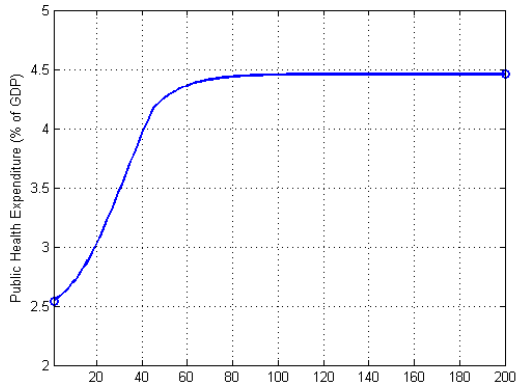
(b) Interest rate



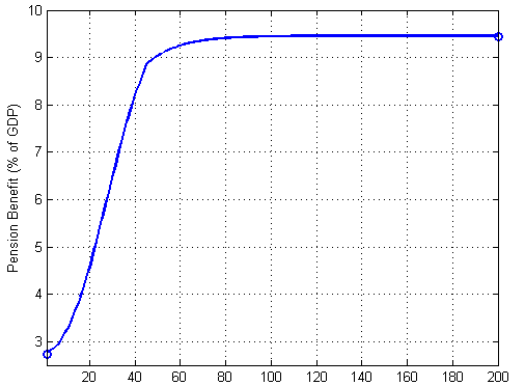
(c) Wage rate



(d) Consumption tax rate



(e) Public health expenditure



(f) Pension Benefit Expenditure

Figure 2.4: Transition Path

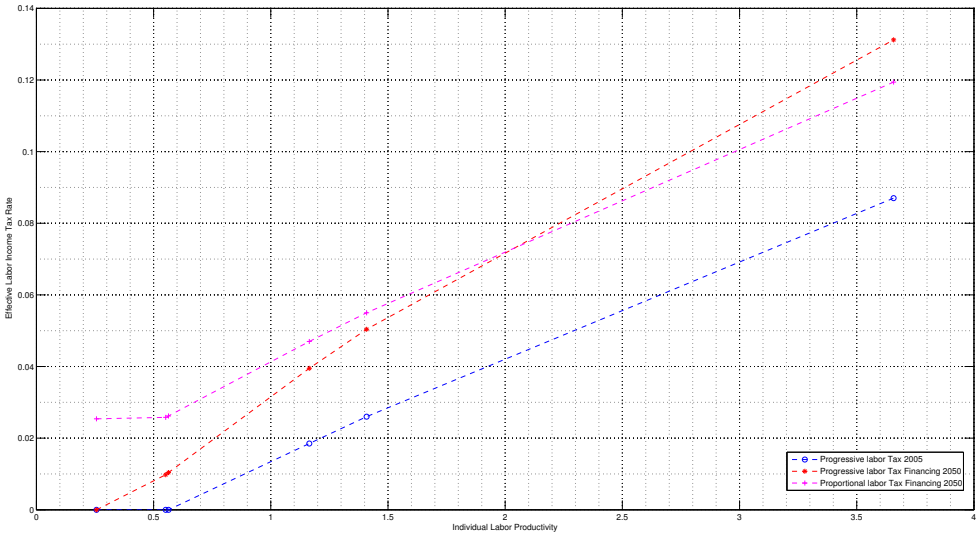


Figure 2.5: Effective Labor Tax Rates by Individual Productivity

Chapter 3

Financing Ageing

3.1 Introduction

The development of a health financing system is critical to reach the goal of Universal Health Coverage (UHC), which is currently being pursued by many developing countries. Among all options, effective expansion of the health coverage through tax revenue has been viewed as a shortcut to reach those previously uncovered. As mentioned in the previous chapter, however, there also exists a large informal sector and a trend of the rapid population ageing in the Thai economy which may affect the sustainability of the Universal Coverage Scheme (UCS). The estimates of the population working in the informal sector in Thailand are up to 60%, which has been relatively stable for the past years. For instance, the population of Thailand was approximately 67.5 million in 2010 with a labor force of 38.7 million, where 37.7% of the labor work was in the formal sector and 62.3% in the informal employment.

While the presence of the informal economy has constrained the pool of tax revenue, the population ageing drains the input of working labor and increases the burden of supporting the retired old in the long term. As shown in Figure 1.5, Thailand is faced with an increasingly severe ageing problem in the coming decades. It ranks among the top countries within the region, second only to Singapore. In this chapter, we focus on examining financing options for the ageing.

To quantitatively analyze the sustainability of Thailand's universal health insurance system and to assess potential reforms of its financing (taxation) scheme, the same modern dynamic general equilibrium framework with a large number of heterogeneous agents is adopted. This theoretical framework takes into account individuals' overtime responses to a policy/environment change and allows us to investigate the long-term consequence of the change. It also enables a comprehensive welfare analysis with consideration of the impacts on both the aggregate economy and individuals.

In the previous chapter, different tax options were examined regarding financing the scheme for universal health coverage, where the consumption tax is assumed to finance the path of ageing. To explore financing options for ageing, in the current chapter we replace the progressive tax with a standard proportional tax and examine alternative financing options such as labor and capital taxes. Meanwhile, the case of elastic labor is also presented.

The simulation results suggest that although the Thai UHC is inexpensive now, an additional 11% labor income tax would be needed to finance the UHC in 2050 when the population is more aged. If we consider medical price inflation to be the same as that in the US (0.6% per year on top of GDP growth), an additional 15% labor tax would be needed in 2050. In addition, the existence of the informal sector largely constrains the government's ability to collect labor income tax in an aging economy. If the economy can be fully formalized (i.e., with no informal workers), the additional labor tax needed for financing the UHC would be reduced to 8% in 2050 with the 0.6% annual health expenditure inflation.

Meanwhile, the existence of a large informal labor sector with high inequality has an important implication for fiscal policy. Labor income tax has a significant redistribution effect between informal (poor) and formal (rich) workers that is most preferred in terms of social welfare. In contrast, if there were no informal sector, a capital income tax would be most preferred.

This chapter is constructed as follows. In Section 3.2, the model is briefly described. The estimation and calibration are described in 3.3. The analysis of welfare and the simulation scenarios follow in Section 3.4 and finally Section 3.5 concludes.

3.2 Model

The model economy is characterized by agents with either high or low education who work in the formal sector, the informal sector, or are unemployed, given the transitions of employment status and individual productivity, in an environment where exist comprehensive social security and taxation systems exist.

To focus on comparing the effects of different taxes in financing the burden of ageing, we simplify the model in this chapter, compared with the model presented in Chapter 2. Specifically, we remove the feature of progressive labor income tax and replace it with a proportional one. Given the simplification, all three tax options become proportional. The remaining features are the same as the model economy in Chapter 2.

3.3 Data, Estimation and Calibration

The procedure of estimation and calibration follow the same steps as Chapter 2. In addition, the labor tax rates are directly calibrated to target its revenue share as of GDP.

3.4 Analysis

The analysis in this section is focused on the steady-state equilibrium analysis. Firstly, a benchmark economy with universal coverage is calibrated with key targets being matched to the Thai economy in 2005 by requiring government expenditures to balance the government budget. Secondly, a benchmark economy without universal coverage is constructed. We simulate the economy through various assumptions of tax financing options and also address the welfare comparison in this section.

3.4.1 Benchmark Economy

The benchmark economy includes several main features of the Thai economy in 2005. As shown in Table 3.1, the model is defined to match the capital-output ratio, the health expenditure output ratio, the informal sector size in terms of workforce population,the risk aversion value that falls on the mean of the range of estimates, and the tax revenue ratios of GDP of each corresponding tax match the real economy in 2005.

All the parameters of the benchmark economy are listed in Table 3.2. The calibrated tax rates are 13.05%, 26.10% and 4.64% for consumption, capital income, and labor income taxes, respectively.

3.4.2 Population Ageing

The old-age dependency ratio in Thailand will rise to 45% in Year 2050 from 13% in Year 2005. Meanwhile, the benchmark in Subsection 3.4.1 is when the UCS has been adopted but still in the process to further reduce Thai out-of-pocket ratio, we assume that a long-term out-of-pocket ratio target by government is set at 15% — a value estimated by Xu et al. (2010) to prevent potential financial hardships due to the illness. We simulate three aged economy in 2050 by using different taxes to finance the path of ageing; details are presented in Table 3.3.

Aged Economy with Various Tax Financing As shown in Column (2) of Table 3.3, we assume the government raises labor income tax, which increases 4.64% to 15.75% to balance the government budget. Total health expenditures increase as the economy is populated with more old people. The increased capital output ratio drives down interest rates and pushes up the wage rates.

When the consumption tax is used to finance ageing, as shown in Column (3) of Table 3.3, the consumption tax increases from 13.05% to 20.96%. Finally, Column (4) of Table 3.3 shows the economy where a capital income tax is used. The capital income taxes has to increase sharply from 26.10% to 75.41% in order to raise enough revenue.

Aged Economy with Health Cost Inflation In this simulation, since the health cost can potentially increase faster than the average consumption cost, we also project the aged economy allowing health cost inflation by a rate of 0.6%, which has been observed in the developed countries. As shown in Columns (5)-(7) of Table 3.4, to cover this health cost inflation, the labor income tax, consumption tax and capital income tax have to increase an additional 3.7%, 2.9% and 17.4% for consumption tax and capital income tax, respectively.

Formalization Further, we assume that in the aged economy with health cost inflation, all the informal economy can be formalized to pay the labor income tax and make social security contributions, while their individual productivities remain at the same level as before. Using the labor income tax to finance ageing, Column (8) of Table 3.4 shows that the hike of the labor income tax can be alleviated and reduced from 19.42% to 12.37%, instead.

3.4.3 A Welfare Comparison of Financing Options

We compare the three tax financing options above for welfare differences. A standard welfare analysis is conducted by measuring the Consumption Equivalent Variation (CEV), which is defined in Equation (2.26).

Welfare Difference The baseline is the economy financed by a labor income tax, with the existence of an informal sector as described earlier. Both economies financed by a consumption tax and a capital income tax are compared with the baseline economy, as

shown in Column (1) and (2) of Table 3.5, respectively. Both economies are subject to a welfare loss compared with the economy financed by a labor income tax for the society as a whole. Comparing two education types, the agents with the high level of education prefer the consumption tax while the agents with the low level of education prefer the labor tax. As the labor tax serves as a channel to redistribute the resources from the former to the latter, such preferences are logical.

A Counterfactual Test with Full Formalization As the redistribution from the productive agents to less-productive agents is done through a labor income tax, we examine such welfare comparison for three economies where all agents are subject to a labor income tax and social security contributions; this prevents the redistribution from the formal sector to the informal sector through a labor income tax and social security contributions. As shown in Table 3.6, the agents with low eduction are strictly worse-off with labor income tax, and prefer the capital income and consumption taxes to the labor tax. The agents with high education prefer the labor income tax. Such change is consistent with the redistribution effect as mentioned earlier, for in the current case there is no redistribution from the formal sector to the informal sector through the labor income tax since all have to pay such a tax.

3.4.4 A Case with Elastic Labor

As a labor income tax distorts the labor supply, therefore we would like to examine a case where the labor supply is endogenously determined and the utility function is assumed to be non-separable as follows,

$$u(c,n) = \frac{[c^{\phi}(1-n)^{1-\phi}]^{(1-\sigma)}}{1-\sigma} \tag{3.1}$$

where ϕ denotes the relative weight between consumption and leisure, and σ decides the inter-temporal elasticity of substitution of the bundle of consumption-leisure and relates to the risk aversion.

In this configuration, the additional parameter ϕ is calibrated to target average labor working hours 1/3, and the risk aversion γ is targeted to be 2, which is jointly determined by σ and ϕ by

$$\gamma = 1 - \phi + \phi\sigma. \tag{3.2}$$

Other calibration targets are the same as the economy with inelastic labor [1]. Table 3.8 lists the key features of the new benchmark economy with the parameters summerized in Table 3.9.

After we build the benchmark for 2005, we project the economy towards 2050 by using three different kind of taxes in the same as was done in the case of an inelastic labor supply. As shown from Table 3.10, the labor income tax has an impact on both types of agents through redistribution and a distortion effect.

Agents with high education are not only worse-off by the redistribution effect of the labor income tax as shown in Table 3.5 but they also suffer from by the distortive effect of the labor income tax on the labor supply. Agents with low education are better-off through the redistribution effect. However, because the distortion of the labor supply has a negative effect, the net gain is much smaller (Table 3.5). As a result for the social average, when labor is elastic, a capita tax is preferred for society as a whole although

[1]The data available from the data for labor dynamics are labor income instead of labor wage rate. Therefore, there is a consistent issue when it applies the parameters directly to the case with endogenous labor. However, as the purpose of this section is to do the sensitivity test of elastic labor, the results remain valid qualitatively in the presence of such an inconsistency

young agents with low education may still prefer a labor income tax since they gain more from redistribution than they lose from labor distortion.

3.5 Conclusions

Although the Thai UCS is affordable now, challenges exist that make the sustainability questionable due to the impact of ageing and other concerns. With all other aspects being equal, an additional 11% labor income tax would be needed to finance the ageing with the UCS in 2050 due to ageing. If excess medical price inflation is 0.6% per year, an additional 15% labor tax would be needed in 2050. If the economy is fully formalized, the government's ability to finance the ageing with the UCS can be significantly improved from our simulation experiments.

For countries with high informality, the labor income tax financing scheme has a redistribution effect that improves social welfare when the labor supply is not elastic. However, when labor is elastic, the welfare loss due to the distortion of the labor supply may outweigh the gain from redistribution.

Tables

Table 3.1: Benchmark Economy Features (Chapter 3, Inelastic Labor)

	K/Y	X/Y	Risk aversion	Informal Size (Pop.)	T_l/Y	T_k/Y	T_c/Y
Benchmark	3.5099	3.49%	2.00	62.00%	1.95%	4.40%	9.38%
Data	3.5100	3.50%	1.00-3.00	62.00%	1.95%	4.40%	9.38%

Table 3.2: Summary of Parameters for the Benchmark Economy (Chapter 3)

Parameter	Values	Description
Households		
β	0.9225	Discount factor, target capital output ratio 3.51
σ	2.0000	Utility parameter, target risk aversion parameter 2
π_o	0.0222	Retirement probability
π_d	0.1709	Death probability, target old-age dependency ratio
ω^y,ω^o	0.2723	Out-of-pocket ratio
λ	0.2500	Share of high education group (Thai Labor Survey 2001-2005)
Firms		
α	0.3144	Capital income share (Ahuja et al., 2004)
δ	0.0420	Depreciation rate (Tanboon, 2008)
A	1.0000	Total factor productivity
Government		
τ_c	0.1305	Consumption tax rate, target its tax revenue ratio
τ_k	0.2610	Capital income tax rate, target its tax revenue ratio
τ_l	0.0464	labor income tax rate
τ_{sc}	0.0400	Social security contribution rate
$\bar{T}_{sc}$	1.7600	Cap of contribution, of social average labor income
τ_{un}	0.2500	Unemployment benefit, of capped average wage by education
$\tau_{\underline{c}}$	0.0845	Transfer of minimum consumption, of social average wage

Table 3.3: Economies with Ageing

	Benchmark	Ageing, 2050		
	2005	τ_l	τ_c	τ_k
Model	(1)	(2)	(3)	(4)
Labor tax	4.64%	15.75%	4.64%	4.64%
Cons tax	13.05%	13.05%	20.96%	13.05%
Capital tax	26.10%	26.10%	26.10%	75.41%
Interest rate (r)	4.75%	2.53%	2.25%	2.13%
Wage rate (w)	1.2196	1.3899	1.4176	1.4293
K/Y ratio	3.5099	4.6718	4.8773	4.9652
X/Y ratio	3.49%	5.25%	5.25%	5.25%

Table 3.4: Economies with Ageing+Health Cost Inflation

		Ageing+ Medical Inflation, 2050			
	Benchmark 2005	τ_l	τ_c	τ_k	τ_l+ formalization
Model	(1)	(5)	(6)	(7)	(8)
Labor tax	4.64%	19.42%	4.64%	4.64%	12.37%
Cons tax	13.05%	13.05%	23.85%	13.05%	13.05%
Capital tax	26.10%	26.10%	26.10%	92.84%	26.10%
r	4.75%	2.61%	2.22%	2.08%	2.60%
w	1.2197	1.3831	1.4201	1.4355	1.3831
K/Y ratio	3.5099	4.6220	4.8954	5.0112	4.6222
X/Y ratio	3.49%	6.87%	6.87%	6.87%	6.87%

Table 3.5: Welfare Comparisons of Various Economies (Inelastic Labor)

Group	(1)	(2)
CEV: all	-0.81%	-0.55%
- CEV: high education	1.43%	0.43%
- Old generation	0.61%	-0.49%
- Young generation	3.08%	2.29%
- CEV: formal	3.10%	2.27%
- CEV: informal	3.01%	2.35%
- CEV: ump	3.06%	2.29%
- ump from formal sector	3.23%	2.37%
- ump from informal/ump	2.70%	2.15%
- CEV: low productivity (formal)	2.95%	2.21%
- CEV: medium productivity (formal)	3.10%	2.29%
- CEV: high productivity (formal)	3.21%	2.28%
- CEV: low productivity (informal)	3.00%	2.34%
- CEV: medium productivity (informal)	3.13%	2.43%
- CEV: high productivity (informal)	3.16%	2.35%
- CEV: low education	-1.56%	-0.87%
- Old generation	-0.76%	-0.37%
- Young generation	-2.54%	-1.50%
- CEV: formal	-2.28%	-1.36%
- CEV: informal	-2.63%	-1.55%
- CEV: ump	-2.56%	-1.46%
- umpfrom formal sector	-1.91%	-1.03%
- ump from informal/ump	-2.74%	-1.58%
- CEV: low productivity (formal)	-2.55%	-1.46%
- CEV: medium productivity (formal)	-2.25%	-1.30%
- CEV: high productivity (formal)	-2.18%	-1.35%
- CEV: low productivity (informal)	-2.65%	-1.50%
- CEV: medium productivity (informal)	-2.61%	-1.59%
- CEV: high productivity (informal)	-2.52%	-1.63%

(1): Financing ageing through consumption tax;
(2): Financing ageing through capital tax;
Both are compared with the economy financing through labor tax.

Table 3.6: Welfare Comparisons of Various Economies (Formalization+ Inelastic Labor)

Group	(1)	(2)
CEV: all	0.06%	0.28%
- CEV: high education	-0.66%	-1.44%
- Old generation	-0.98%	-1.86%
- Young generation	-0.01%	-0.58%
- CEV: low education	0.30%	0.86%
- Old generation	0.26%	0.58%
- Young generation	0.35%	1.21%

(1): Financing ageing through consumption tax;
(2): Financing ageing through capital income tax;
Both are compared with the economy financing through labor tax.

Table 3.7: Economies (Formalization+Inelastic Labor)

Model	(1)	(2)	(3)
labor income tax rate (formal)	10.07%	4.64%	4.64%
Capital income tax rate	26.10%	26.10%	63.37%
Consumption tax rate	13.05%	19.15%	13.05%
Aggregate capital per capita	5.1221	5.3642	5.4777
Aggregate labor input per capita	0.5412	0.5412	0.5412
Interest rate (r)	2.54%	2.33%	2.23%
Wage rate (w)	1.3896	1.4099	1.4192
Output per capita (Y)	1.097	1.113	1.1204
Capital output ratio	4.6692	4.8195	4.8891
Total health expenditure (% of output)	5.25%	5.25%	5.25%
Fiscal revenues (% of output)	19.53%	19.57%	19.57%
- labor tax	6.78%	3.13%	3.13%
- capital tax	3.11%	2.95%	6.92%
- consumption tax	8.46%	12.31%	8.34%
- social security contribution	1.18%	1.18%	1.18%
Fiscal outlays (% of output)	19.55%	19.57%	19.57%
- unemployment benefit	0.24%	0.24%	0.24%
- social assistance for cons floor	0.57%	0.59%	0.59%
- public health expenditure	4.46%	4.46%	4.46%
- government expenditure	14.28%	14.28%	14.28%

(1): Financing ageing through a labor income tax, 2050;
(2): Financing ageing through a consumption tax, 2050;
(3): Financing ageing through a capital income tax, 2050.

Table 3.8: Benchmark Economy Features (Chapter 3, Elastic Labor)

	K/Y	X/Y	γ	Informal Size	Avg. n	T_l/Y	T_k/Y	T_c/Y
Benchmark	3.5107	3.49%	2.00	62.00%	0.333	1.95%	4.40%	9.38%
Data	3.5100	3.50%	1.00-3.00	62.00%	1/3	1.95%	4.40%	9.38%

Table 3.9: Parameters for the Benchmark Economy (Elastic Labor)

Parameter	Values	Description
Households		
β	0.8327	Discount factor, target the capital output ratio 3.51
σ	3.0173	Utility parameter, target the risk aversion parameter γ=2
ϕ	0.4857	Consumption-leisure parameter, target the aggregate labor hours to be 1/3
Government		
τ_c	0.1332	Consumption tax rate, target its tax revenue ratio
τ_k	0.2602	Capital income tax rate, target its tax revenue ratio
τ_l	0.0413	labor income tax rate, target its tax revenue ratio

Table 3.10: Welfare Comparisons of Various Economies (Elastic Labor)

Group	(1)	(2)
CEV: all	0.54%	1.71%
- CEV: high education	2.83%	3.80%
- Old generation	2.25%	4.51%
- Young generation	3.85%	2.60%
- CEV: low education	-0.23%	1.01%
- Old generation	0.92%	4.32%
- Young generation	-1.34%	-2.05%

(1): Financing ageing through consumption tax;
(2): Financing ageing through capital tax;
Both are compared with the economy financing through a labor tax.

Table 3.11: Economies (Elastic Labor)

Model	(1)	(2)	(3)	(4)
labor income tax rate (formal)	4.13%	13.29%	4.13%	4.13%
Capital Income tax rate	26.02%	26.02%	26.02%	67.66%
Consumption tax rate	13.32%	13.32%	20.50%	13.32%
Aggregate capital per capita	2.1078	2.2076	2.3942	2.5877
Aggregate labor input per capita	0.3377	0.273	0.2745	0.285
Interest rate (r)	4.76%	3.30%	2.93%	2.73%
Wage rate (w)	1.2191	1.3225	1.3543	1.3716
Output per capita (Y)	0.6004	0.5266	0.5423	0.5702
Capital output ratio	3.5107	4.1919	4.415	4.5387
Total health expenditure (% of output)	3.49%	5.25%	5.25%	5.25%
line Fiscal revenues (% of output)	17.38%	20.08%	20.10%	20.24%
- labor tax	1.95%	6.19%	1.95%	1.94%
- capital tax	4.40%	3.63%	3.38%	8.38%
- consumption tax	9.38%	8.65%	13.14%	8.31%
- social security contribution	1.65%	1.61%	1.63%	1.61%
Fiscal outlays (% of output)	17.37%	20.07%	20.11%	20.24%
- unemployment benefit	0.34%	0.34%	0.34%	0.34%
- social assistance for cons floor	0.05%	0.83%	0.87%	1.00%
- public health expenditure	2.54%	4.46%	4.46%	4.46%
- government expenditure	14.44%	14.44%	14.44%	14.44%

(1): Benchmark, 2005;
(2): Financing ageing through a labor income tax, 2050;
(3): Financing ageing through a consumption tax, 2050;
(4): Financing ageing through a capital income tax, 2050.

Chapter 4

Labor Supply, Universal Health Coverage and Health Cost Inflation

4.1 Introduction

In Chapter Three, the cases with the assumptions of both inelastic and elastic labor are examined. As the results show, a labor income tax is preferred for its large redistribution effect when labor is not elastic. However, when labor is elastic, a capital tax is preferred since the distortive effect of a labor income tax can outweigh the redistribution gain. In order to understand the labor supply effect of universal health coverage in a deeper way, this chapter focuses on labor supply responses to such social security scheme.

We allow the labor to be elastic and extend the standard dynamic stochastic general equilibrium environment with two types of education, two sectors, and allowing a comprehensive social security system which includes old-age pension, unemployment and health care benefits. The utility function is chosen to be non-separable as it is consistent with the balance growth path. The economy is populated with agents differing by education and age who face idiosyncratic income risks due to both uncertainties of individual productivity and employment status. Meanwhile, borrowing is prohibited given the borrowing constraint. Accordingly, the total individual efficiency of agents is determined by the permanent productivity gap caused by education, the transitory gaps caused by sectoral efficiency and individual idiosyncratic shocks.

The economy includes both the formal and informal sectors. The labor income tax and social security contributions are collected in the former, yet absent in the latter. The government raises revenue in the economy through a set of tax instruments. Besides partially taxing labor income and social security contributions, the government also collects consumption and capital income taxes from the entire economy.

The calibrated exercise is based on the Thai economy with universal health coverage through a scheme called the Universal Coverage Scheme (UCS), using both micro household survey panel data and macro indicators. It is the same case as was addressed in

the previous chapters. However, the calibration strategy differs by calibrating the transitory individual shocks directly instead of estimating from data. In order to do that, the inequality of income distribution measured by the Gini coefficient in each education group is taken as a calibration target. We then conduct counterfactual policy experiments by removing the UCS under different tax instrument assumptions, which help us to establish the funding-benefit linkage and examine the impact on the labor supply. As the increase of health expenditures is of great concern regarding such a universal health coverage scheme, we study the effects of health cost inflation on the labor supply as well as on various other macro variables.

This study is related to the literature such as Kotlikoff (1986) who analyzes the effects of health expenditure shocks on precautionary savings, Huggett (1993) and Aiyagari (1994). More recent studies on health insurance such as Jeske and Kitao (2009) and Hsu (2012) are also closely connected. However, this study differs not only by focusing on universal health coverage which has not been studied in the previous literature, but also by including two sectors and employment status risk.

Furthermore, İmrohoroğlu and Kitao (2009) shows that given plausible values of the intertemporal elasticity of substitution (IES), the effects of social security reforms on the aggregate labor supply are not sensitive to the elasticity. However, the effect on the profile of hours over the life cycle is very sensitive to it. Our paper also discusses the labor supply effect of social security, we focus on labor supply effects in consideration of different financing options, and allow earning differences due to both ability and luck. Meanwhile, two margins of labor supply responses has been addressed (Heckman, 1993; Saez, 2002). First, individuals can respond along the intensive margin by varying their work hours. Second, they can respond by deciding whether to participate in the labor force or not. Kitao (2013) shows the response of both margins to social security reforms. In our paper,

labor supply in terms of both intensive and extensive margins is also modelled at the same time.

As it is difficult to solve it in an analytical way, the method of dynamic programming is used to provide a numerical solution. Our main findings include the following. First, the formal workers work longer hours on average than the informal workers given the same education, and the low-education workers toil longer than high-education workers given the same sector. Second, the removal of the UCS increases labor hours and the degree of change depends on the assumption of financing options. Finally, to finance the potential increase of health expenditure, the capital income tax performs better than labor income and consumption taxes as it encourages the labor supply.

The paper is constructed as follows. Section 4.2 introduces the model. Section 4.3 explains the details of calibration. In Section 4.4, various experiments follows the benchmark. Finally, Section 4.5 gives the concluding remarks.

4.2 Economic Environment

Agents in the economy are endowed with two types of education and go through their life cycle of young and old stages. When they are young, they are endowed with one unit of labor time at each period and face probabilities of being employed or unemployed. If they work, they are either employed in the formal sector or the informal one. Meanwhile, all the working young agents also face idiosyncratic efficiency risk that cannot be insured. In addition, both young and old agents face health expenditure risk that can be partially insured. The government collects the consumption tax, capital income tax, labor income tax and social security contributions. Among them, the labor income tax and social security contributions are only collected in the formal sector. The fiscal outlays of government include pension payments, public health expenditures, social assistance,

and other government expenditures. This section describes the features of the benchmark economy.

4.2.1 Demographics

The population consists of working young and retired old generations. Young agents retire with a probability ρ_o and old agents die with a probability ρ_d in each period, and such probabilities are assumed not to vary across education and sector. When old agents die in a period, newborn young agents replace them at the beginning of the same period, so that the measure of the entire population remains the same.

4.2.2 Individuals

Each agent is endowed with one type of education, which does change over the individual's lifetime. Meanwhile, agents with education e face the following individual shocks: employment status shock (deciding, whether to work and, if so, in which sector), individual productivity idiosyncratic shock, and health expenditure shock.

4.2.3 Education

The shares of high education and low education in terms of their population are λ and $1-\lambda$. Let's denote the education type as e, of which the set is denoted by

$$e = \begin{cases} h, & \text{high education} \\ l, & \text{low education} \end{cases} \tag{4.1}$$

It is assumed that the education difference imposes education-specific efficiency ϵ_e permanently on the agents as part of individual labor efficiency.

Employment Status Shock

Young agents face an employment status shock. They have chance to either have work offer or be unemployed. When they work, they have chance to be either in the formal sector or the informal sector. The formal sector is defined as an economic sector in which the labor income is taxed and social security contributions are collected accordingly, and the related social security benefits are provided upon contribution. In contrast, the informal sector is characterized by tax avoidance and no participation in the social security programs. Let's denote such employment status as j, of which the set is

$$j = \begin{cases} f, & \text{formal sector} \\ nf, & \text{informal sector} \\ um, & \text{unemployed.} \end{cases} \tag{4.2}$$

Such a status shock evolves stochastically via an N-state Markov chain Π^e. Meanwhile, sectors are assumed to be associated with sector-specific efficiency ϵ_j, and agents' individual labor efficiency is affected accordingly when they transit from one sector to another.

Individual Productivity Shock

The individual labor efficiency of working young agents is not only affected by their education and the sector where they work, but also by a time-varying idiosyncratic shock η_e, which also evolves stochastically via another Markov chain Ψ^e; the values of each state are taken from a given finite set Q^e. Therefore, the natural logarithm of total individual

labor efficiency, denoted as z, is determined by

$$log(z) = log(\epsilon_e) + log(\epsilon_j) + log(\eta_e) \tag{4.3}$$

Health expenditure shock

Regardless of the difference across education types and sectors, all agents face the uncertainty of health expenditures caused by health expenditure shocks x^t , where

$$t = \begin{cases} y, & \text{young} \\ o, & \text{old.} \end{cases} \tag{4.4}$$

The age-dependent health expenditure shocks x^t take the values from a given finite set X^t, and evolves stochastically via Markov chain Ω^t. The out-of-pocket health expenditure is denoted by ω^t.

4.2.4 Preference and Production

Utility preference includes both consumption and leisure as

$$U = u(c, n) \tag{4.5}$$

where c is the individual consumption and n the amount of individual labor supply in each period.

The production function, which requires both the inputs of labor and capital, is written as

$$Y = AF(K, N) \tag{4.6}$$

where A is the total factor productivity, K is the aggregate capital per capita in the economy, and L is the effective labor per capita employed by the firms. The capital is homogenous across sectors and all the markets behave competitively.

4.2.5 Government

Revenue

Government collects consumption tax $T_c(c)$, capital income tax $T_k(k)$, wage-based social security contributions $T_{sc}(wzn)$ and labor income tax $T_l(y)$. The corresponding tax or contribution rates are τ_c, τ_k, τ_l and τ_{sc}, respectively. Meanwhile, wage-based social security contributions $T_{sc}(wzn)$ and the labor income tax $T_l(y)$ are only enforced in the formal sector, where the taxable income for labor income tax y is the labor income after the deduction of the social security contribution, denoted as $y = wzn - T_{sc}(wzn)$.

Budget

The government provides an old-age pension benefit to the entitled agents, runs other social security programs such as a universal health coverage scheme to lower the out-of-pocket health expenditures, and guarantees social protection for consumption where a minimum consumption level $\underline{c}$ is guaranteed. Assuming that the government balances the budget in each period, is denoted by

$$G_R = G_T, \tag{4.7}$$

where

$$G_R \equiv \int \{T_c(c) + T_k(k+b) + T_l(y) + T_{sc}(wzn)\} d\Phi(s) + D', \text{ and}$$
$$G_T \equiv \int \{TR_{\underline{c}} + TR_{um} + TR_{ps} + (1-\omega^y)x^y + (1-\omega^o)x^o\} d\Phi(s) + D(1+r) + G.$$

should be satisfied in each and every period. D is the one-period debt issued in the previous period and redeemed at the current time, and D' is the debt issued in the current period.

In Equation (4.7) of the government budget, the left side G_R is the fiscal revenue which the government collects from the entire economy, and b is a lump sum transfer of accidental bequests to all survivors. It is assumed that accidental bequests are collected and redistributed to all survivors by a lump-sum transfer as follows:

$$b' = \int \pi_d k' \, d\Phi(s) \tag{4.8}$$

The total government fiscal outlays G_T on the right side consist of social security payments: transfers for social consumption insurance $TR_{\underline{c}}$, unemployment benefits TR_{un}, old-aged pension TR_{ps}, and health expenditures for both young and old generations covered by the government (so ω^y and ω^o are out-of-pocket expenditures by agents), $D(1+r)$ the interest payment for the pubic debt service plus debt redemption, and finally, government consumption G, an overall spending that includes all other government expenditures. $\Phi(s)$ is the distribution of population over the state space s with $s = (e, k, j, j_{-1}, z, x^t)$.

4.2.6 Agents' Problems

Given the state for an agent with education e and age t, and the expectation through transition probabilities for individual efficiency and health expenditure, agents' problems are written as follows:

$$V_t(s) = \begin{cases} max\{E\{u(c,n) + \beta\{(1-\pi_o)E[V_y(s')|s] + \pi_o E[V_o(s')|s]\}\}\} & if \;\; t = y \\ max\{E\{u(c,n) + \beta(1-\pi_d)E[V_o(s')|s]\}\}, & if \;\; t = o \end{cases} \tag{4.9}$$

subject to

$$(1+\tau_c)c + k' = Wel + TR_{\underline{c}} \tag{4.10}$$

$$k' \geq 0 \tag{4.11}$$

where

$$Wel \equiv \begin{cases} wzn + (1 + r(1-\tau_k))k - T_{sc}(wzn) - T_l(y) - \omega^y x^y, & if \;\; t = y \;\; \& \;\; j = f \\ wzn + (1 + r(1-\tau_k))k - \omega^y x^y, & if \;\; t = y \;\; \& \;\; j = nf \\ (1+r)k - \omega^y x^y + \begin{cases} TR_{um} & if \;\; j_{-1} = f \\ 0, & otherwise \end{cases} & if \;\; t = y \;\; \& \;\; j = um \\ ps + (1+r)k - \omega^o x^o, & if \;\; t = o, \end{cases} \tag{4.12}$$

and

$$TR_{\underline{c}} \equiv max\{(1+\tau_c)\underline{c} - Wel, 0\} \tag{4.13}$$

$$TR_{um} \equiv \tau_{um} \int wzn \, d\Phi(s_e) \tag{4.14}$$

$$ps \equiv \tau_{ps}(\Xi) \int wzn \, d\Phi(s_e) \tag{4.15}$$

In the Value Function Equation (4.9), the future value is discounted by a discount factor β and is a weighted average of the conditional expectation of young and old agents for the problem of young agents, where the retirement probability π_o serves as weight. In addition, the future value is discounted by the discount factor adjusted by survival probability for the problem of old agents. Equation (4.10) is the budget constraint and the total resource for allocation where the resource comes from the net wealth Wel and the transfer for the social consumption insurance $TR_{\underline{c}}$ conditionally.

Regarding Wel in Equation (4.12), working young agents in the formal sector have labor income and accrued capital income, pay all kinds of tax and make social security contributions, as shown in the first row, where ω^y and x^y are an out-of-pocket expenditure ratio and the total health expenditure for young agents. The second row indicates avoidance of the labor tax and the social security contributions in the informal sector, and unemployed young agents who do not have labor income but may receive unemployment benefit, depending on their previous employment status, are in the third row. Finally, the fourth row defines the wealth of old agents where ps is a pension benefit and $\omega^o x^o$ is the out of pocket health expenditure for them.

Equation (4.13) give the definition of $TR_{\underline{c}}$. As shown in Equation (4.14) and (4.15), the unemployment benefit TR_{um} and the pension payment ps are percentages of the average labor income, respect to each education group. Furthermore, as shown in Equation(4.15), $\tau_{ps}(\Xi)$ is the replacement rate, which is a function of the contribution time Ξ.

4.2.7 Competitive Equilibrium

A stationary recursive competitive equilibrium consists of a set of quantities $\{c, k', n, Wel\}$ for each young individual and each old individual with high or low education, in the formal or informal sectors, respectively, a set of prices $\{w, r\}$ which are decided by the aggregate capital per capita K and labor per capita L, government policies $\{\tau_c, \tau_k, \tau_l, \tau_{sc}, \tau_{um}, \tau_{ps}(\Xi), \omega^y, \omega^o, \underline{c}\}$, and a stationary distribution of population over the state space $\Phi(s)$ which is characterized by

- ◇ (i). a ratio of population by education λ;
- ◇ (ii). a retirement probability π_o and a death probability π_d;
- ◇ (iii). an individual efficiency z caused by an education efficiency difference ϵ_e, a sectoral efficiency difference ϵ_j and idiosyncratic productivity shocks η_e with the values from Q^e evolved with transition probability matrix Ψ^e; and
- ◇ (iv). health expenditure shocks x^t from X^t evolved with transition probability matrix Ω^t,

such that

- ◇ (i). agents with high and low education, from the formal sector, informal sector, and the unemployed, at young and old ages, solve their individual constrained maximization problems, respectively;
- ◇ (ii). firms solve the profit maximization problem;
- ◇ (iii). the resource feasibility condition $Y = C + I + G + X$ is satisfied, where $I = K' - (1 - \delta)K$ and $X = \int x d\Phi(s)$;
- ◇ (iv). government policies satisfy the government budget constraint Equation (4.7);

- ◇ (v). both labor and capital markets clear when $L = \int zn \, d\Phi(s)$ and $K = \int k \, d\Phi(s)$, which integrates λ and $1 - \lambda$ shares of population with high and low education, respectively, in terms of asset holdings and labor supply.

4.3 Calibration

The parametrization of the model is presented in this section. The exercise is based on the Thai economy, which has achieved universal health coverage through a scheme called the Universal Coverage Scheme (UCS). Meanwhile, it has a very large informal economy in terms of working population and output share. We target some main features of the Thai economy in the year 2005 which include the moments from the Thai Socio Economic Survey (SES) and other macro variables from various sources.

4.3.1 Preference and Production

A non-separable consumption-leisure utility function $u(c, n)$, which is compatible with a balanced-growth-path, is assumed in the economy. It is written as

$$u(c, n) = \frac{[c^{\phi}(1-n)^{1-\phi}]^{(1-\mu)}}{1-\mu} \tag{4.16}$$

where ϕ determines the choice between consumption and leisure. μ decides the inter-temporal elasticity of substitution of the bundle of consumption-leisure and relates to the risk aversion.

The expression of risk aversion γ and Frisch labor supply elasticity η as of Heathcote et al. (2008) is given by

$$\gamma = 1 - \phi + \phi\mu \tag{4.17}$$

$$\eta = \frac{1-n}{n}\frac{1-\phi(1-\mu)}{\mu} \tag{4.18}$$

respectively.

A continuum of firms in a competitive goods market is homogenous and assumed to follow a Cobb-Douglas production function for both sectors as

$$Y = AK^{\alpha}L^{1-\alpha}. \tag{4.19}$$

The two factor prices derived from firms's optimisation problem are as follows:

$$w = (1-\alpha)AK^{\alpha}L^{-\alpha} \tag{4.20}$$

$$r = \alpha AK^{\alpha-1}L^{(1-\alpha)} - \delta \tag{4.21}$$

where the capital income share is indicated by α and the capital depreciates at the ratio of δ each period;

The model period is annual and the discount factor is adjusted to match the capital output ratio. The utility parameter ϕ is set to target the social average working hours of 1/3, and μ is set to target the wage elasticity of labor supply suggested in Tanboon (2008). The risk aversion is determined given the value of μ and ϕ.

In the production function, the total factor productivity A is normalized. The capital income share α is estimated in Ahuja et al. (2004) and the annual capital depreciation rate δ is set as of Tanboon (2008).

4.3.2 Demographics and Education

The retirement probability π_o is set such that young agents are expected to work for 45 years, and the death probability π_d is set so that the population shares between young and old match the dependency ratio. Tertiary (including vocation school) and above is defined as "high education", and secondary school and below are defined as "low education".

Concerning the shares of working population in the informal and formal sectors, they are endogenously determined in the model by the transition matrix and the share of the population with different levels of education. We assume a transitory bias parameter due to the short panel and use it to target the population share.

4.3.3 Employment and Sector Transition

Agents are subject to the shocks of being employed or unemployment, and in either formal or informal sector while employed. A Markov-chain transition probability matrix is constructed from the Thai SES panel data, with three employment statuses of working in the formal sector, the informal sector, and unemployed. (Further details are provided in Appendix A.6.)

4.3.4 Individual Productivity, Sector and Education Efficiency

As the data in the Thai SES panel 2005-2005 only report the wage income and can not differentiate the wage rate and labor hours, we assume the idiosyncratic shock of working agents follows a AR(1) process, which is written as

$$\ln\eta_e = \rho_e \ln\eta'_e + \zeta_e \tag{4.22}$$

where $\zeta_e \sim N(0, \sigma_e)$.

The Gini coefficients of wage income inequality, estimated from the data for each education group, are targeted in order to calibrate the individual idiosyncratic shock process by choosing choose the parameters $\{\rho_e, \sigma_e\}$. As labor supply is endogenous in the model, the corresponding income inequality is jointly determined by endogenous labor and the product of total individual efficiency $\epsilon_e \epsilon_j \eta_e$, social wage rate and labor hours. The AR(1) process is then approximated by a five-state Markov chain using the method of Tauchen (1986).

The education efficiency parameter ϵ_e is calibrated to target the average labor income difference of two education levels. The sector efficiency parameter ϵ_j is calibrated to target the share of sectoral output share. We choose the efficiency parameters of high education and formal sector to be normalized as unitary, which leaves two parameters $\{\epsilon_l, \epsilon_{nf}\}$ to be calibrated accordingly. The persistence of AR (1) ρ_e is assumed to be the same across education level and uses the estimates of Hubbard et al. (1995) for both high and low education groups. Therefore, the final two parameters of ζ_e (ζ_h and ζ_l) are calibrated to target the gini coefficients after the other parameters are fixed.

4.3.5 Health Expenditure Shocks

The health expenditures for the young and old agents, as well as their corresponding transition probability matrix are directly calibrated from the panel data.

Each process are simplified with only two states, including "low" and "high" for the lower 95% and top 5% of health expenditure distribution. Table 2.4 states the health expenditure after adjustment for young agents X^y and old agents X^o relative to the average social wage. The corresponding transition matrices Ω^y and Ω^o and more details in data handling is included in Appendix A.6.

4.3.6 Social Security System

The social security system is comprehensive and includes old-age pension, social insurance, unemployment and health coverage schemes. Prior to the launch of the UCS, the social security participation was limited to the workers in the formal sector based on the contribution-benefit principle. With the implementation of the UCS financed by general tax revenue, the workers in the informal sector and all retired people can be covered with a lower out-of-pocket ratio.

Unemployed benefits

The workers in the formal sector are entitled to unemployment benefits. In practice, an unemployed person receives 50% of his or her average salary over the past five years for the duration of six months. As the model frequency is annual, τ_{um} for an unemployed agent of education type e from the formal sector is set to receive 25% of the education-dependent average labor income for the first period and cannot receive benefit further if the unemployment status continues in the next period[1].

Social insurance

The government provides social insurance for the minimum consumption which agents of the economy can get if their own net wealth is below the level. The subsidies of the difference between minimum consumption and net wealth are provided to qualified agents. The minimum consumption in terms of social average wage in the model is set at 8.45%.

Old-age pension

In addition, the workers who have contributed to the social security pool while working in the formal sectors are also entitled to old-age pension benefits when they are retired. The pension benefit is a percentage τ_{ps} of the education-dependent average labor income. The formula of the replacement rate in Thailand τ_{ps} is as follows (Pfau and Atisophon,

[1]Instead of calculating five-year average labor income explicitly, we approximate it by the cross-section average, to avoid the exponential computational cost to track the five-period history

2009):

$$\tau_{ps}(\Xi) = \frac{1.5\Xi - 2.5}{100} \tag{4.23}$$

where Ξ represents the number of years of contributions to the pension system. Although the expected working years of young agents with different levels of education are the same, Ξ is decided by their total time in the formal sector.

Health Care Schemes

A lower out-of-pocket ratio was provided to all agents in the economy after the implementation of the UCS, who were not entitled otherwise. The aggregate flat out-of-pocket ratio is used for the approximation for age-differentiated ratios. Moreover, the ratio of health expenditure out of the pocket of the young and old generations, in percentage of total expenditures on health, which are ω^y and ω^o by notation, are set the same at 15% after the implementation of UCS. Prior to the UCS, the ratio for the formal workers were the same as afterward, while the ratio was 37% for the previously uninsured group: the informal workers and the old people.

4.3.7 Government Fiscal Revenues and Expenditures

In addition to social security contribution, government revenues consist of consumption, capital and labor income taxes. Following Díaz-Giménez and Díaz-Saavedra (2009), we calibrate these three tax rates to target the shares of corresponding tax revenues, in the percentages of GDP.

In the benchmark economy, the government consumption G is endogenously determined to balance government budget. The other fiscal outlays, which include old-age pensions,

unemployed benefits, social assistance and public health expenditures, are determined by the policy choices of τ_{un},$\tau_{ps(\Xi)}$, ω^y, ω^o, $\underline{c}$ and the endogenous variables jointly.

4.4 Analyses

In this section, the analyses focus on the steady-state equilibrium. Firstly, a benchmark economy with the UCS is calibrated with key targets being matched to the Thai economy, by requiring the government consumption to balance the government budget; the labor supply in both intensive and external margins is described. Next, to investigate the labor effect of the UCS, a simulation of removing the UCS is conducted in which the out-of-pocket ratio of the workers in the informal sector is raised and all old people are returned to pre-UCS levels. The results are compared with the benchmark economy. Finally, the impact of health cost inflation is studied.

4.4.1 Benchmark Economy

The benchmark economy exhibits some major characteristics of the Thai economy in the middle 2000's; those include the primary social security programs. As shown in Table 4.1, the model is calibrated to match the capital-output ratio, the health expenditure output ratio, the informal sector size in terms of workforce population, the risk aversion value that falls on the mean of the range of estimates and the tax revenue of GDP in 2005. All the parameters of the benchmark economy are listed in Table 4.2.

Regarding intensive and extensive margins, we examine both the social aggregate level and disaggregate level by education and sector. As shown in Table 4.3 for average term for intensive margins of each group, in order to maximise their respective lifetime utility, the agents with low education work longer hours than the agents with high education since

education differences impose a permanent efficiency gap on workers. On the other hand, agents work longer hours when they are in the formal sector, compared with the hours in the informal sectors. As there is a sector efficiency in the formal and informal sectors, agents will try to work longer hours when they are in the formal sector, to benefit from the higher efficiency of the formal sector although they have to pay extra taxes. In terms of the extensive margins (participation) of Table 4.4, the pattern is very similar to the intensive margins: the formal workers work participate more than the informal workers, and the agents with low education participate more than the agents with high education. Compared with the participation rates in Kitao (2013) in which the productivity of young agents is age-dependent, the participation rate in the current stochastic ageing setting is higher for young agents due to lack of the feature of age-dependent individual productivity. Among all groups, the agents with low education who work in the formal sector have the highest level of participation.

Both the social averages of intensive and extensive margins depend on two factors, the labor supply decisions of individuals and their population distribution. Therefore, we examine both the labor supply and distribution upon asset holding in Figure 4.1 according to five states of individual idiosyncratic shock. In each row, the four groups by education and sector are shown according to their heterogenous asset holdings. The following observations can be made. First, labor supply is negatively related to asset holding and positively related to productivity. Second, when idiosyncratic individual productivity is higher, the distributions among the four groups diverge more significantly.

In order to examine the labor channel in a deeper way, we turn to the optimal condition of consumption-work for young agents, which is derived from a set of optimal conditions

as follows:

$$n = \begin{cases} 1 - \frac{(1-\phi)c(1-\tau_c)}{\phi wz(1-\tau_l)}, & if \frac{(1-\phi)c(1-\tau_c)}{\phi wz(1-\tau_l)} < 1 \\ 0, & if \frac{(1-\phi)c(1-\tau_c)}{\phi wz(1-\tau_l)} \geqslant 1 \end{cases} \tag{4.24}$$

where c is equal to $(\beta(1 + (1 - \tau_k)r))^{-1/\mu} E[c']$, the optimal condition for inter-temporal consumption.

Equation 4.24 is not a close-form expression as for the problem of young agents covers multiple periods. Nevertheless, it gives us insights about the labor supply response. As the value of z is determined in Equation 4.3, the average value in each subgroup are determined by the education and sector efficiencies. We can calculate the consumption per efficiency c/z to measure the threshold value for participation by using the equality of Equation 4.24. There are only two threshold values by sector caused by the difference of the labor income tax.

Meanwhile, we draw the distribution of (c/z) for all the working agents with low health expenditure shock. As shown in Figure 4.2, the two graphs in the first row display the distribution of agents in the formal sector for high and low education, while the cut-off vertical lines are the threshold value for non-participation. The second row shows the cases in the informal sector where the threshold value is higher than in the formal sector. As the participation rates are determined by both the distributions and the threshold values, we can observe the following. First, given the education level, there is a bigger share of non-participating population in the informal sector than in the formal sector. Second, given the sector, there is a bigger share of non-participating population for high education group than for low education group.

4.4.2 Labor effect of universal health coverage

Similar to other social security programs, the universal coverage scheme may reduce the incentive to work and impose a large efficiency cost. Therefore, we examine the labor supply effect of universal health coverage by removing the scheme, which is equivalently to increasing the out-of-pocket ratio of the informal workers and the old group to the level prior to the scheme, thus from 15% to 37% in the model. Table 4.5 shows the changes of intensive and extensive margins of the labor supply under different tax financing options.

When a labor tax is assumed, a tax burden is imposed on the formal sector to finance the scheme. When the scheme is removed and the tax reduced, both the labor supply hours and participation increase in the formal sector. In this sector, labor hours for agents with lower education increase more than those for agents with high education, while more agents with high education decide to participate in the labor market. It is the opposite situation for agents in the informal sector as both labor supply hours and participation decrease. At the societal level, the average labor supply increases more in terms of intensive margins than of external margins.

When a consumption tax or capital tax is used, the reduction of the tax burden is more equalitarian than with a labor tax, for the effects depending on their consumption and asset holdings. In the case in which the consumption tax is assumed, the impacts on labor supply are similar for different groups. At the aggregate level, labor hours and participation increase for almost all groups. In particular, for agents with low education and who work in the informal sector, the participation increases by 0.85%. When a capital income tax is assumed, the impacts displays a very different pattern. All groups reduce their labor hours. Concerning the extensive margins, agents with high education increase their participation while agents with low education reduce it. At the aggregate level, both intensive and extensive margins decline.

In short, the biggest positive change in labor hours is observed in terms of social average when a labor income tax is assumed for the UCS removal; the next largest positive change occurs with consumption taxes. However, it leads to a negative change when a capital income tax is assumed. The biggest change of participation is observed when a consumption tax is assumed.

To understand the change of the labor supply due to the universal coverage scheme in Table 4.5, taking the case of labor income tax as example, we graph the medium idiosyncratic state of the four groups separately and shows the changes in Figure 4.3. As we can see, the change of labor hour decision given current capital and the change of shapes of labor supply distribution co-determine the final change of labor supply, which is expressed as

$$\triangle \bar{n} = \int n \cdot ds \, d\Phi(s) - \int n^* \cdot ds^* \, d\Phi(s)$$

where n and ds are, respectively, the labor hour and density in each state of capital after the removal of the scheme; values with an asterisk $*$ are prior to the removal. We can rewrite this equation and decompose it into the level and distribution components as follows,

$$\triangle \bar{n} = \underbrace{\int (n - n^*) \cdot ds \, d\Phi(s)}_{\text{level effect}} + \underbrace{\int n^* \cdot (ds - ds^*) \, d\Phi(s)}_{\text{distribution effect}} \tag{4.25}$$

Using the definition in Equation 4.25, we further decompose the changes of aggregate labor hours accordingly, given different tax options (Table 4.6). Most the effects of level and distribution are in the opposite direction, which leads to the net effect being smaller than each effect separately. Therefore, both effects are critical for the change of labor hours for most of cases.

4.4.3 Labor and aggregate effects of health cost inflation

The extent to which the provision of universal health coverage increase the total health expenditures due to both the moral hazard problem and higher demand has been controversial issue. For the case of Thailand, the payment method of capitation has been used to control cost effectively. However, it has been generally observed that in most developed countries the health expenditure cost normally inflates faster than the average consumption price. In the longer term, developing countries might follow this trend. Therefore, the labor response towards health cost inflation is of interest. We examine it by assuming health cost inflation up to 50% where the cost inflation rate is denoted as q.

A shown in Figure 4.4, when different tax options to finance the increase of health expenditure are implemented, the changes of labor hours for each group vary by education and/or sector. At the aggregate level, the two graphs in the last row show the average labor hours and effective labor input. While the labor supply in both terms decreases in the case of a labor income tax, labor supply in both terms increase in the cases of consumption and capital income taxes, and the size of increase are relatively large.

Besides the changes of labor supply, Figure 4.5 also displays changes in the other macro variables along with the change of health expenditures. Capital and output per capita has a similar pattern as labor supply, and the capital labor ratio determines the two factor prices–interest and wage rates. Finally, the last graph shows how respective tax rate increases.

4.5 Conclusions

In this chapter, we studied a form of universal health coverage financed through government tax revenue, in the setting of developing countries where the informal economy has

a large presence and tax avoidance cannot be neglected. In an economy with different levels of tax obligations and social security protections, where the incomes of heterogeneous agents differ by ability, luck, and individual work efforts, we were able to study the labor supply responses in terms of both intensive and extensive margins to the impact of the UCS and health cost inflation. We found different labor supply patterns caused by permanent and transitory productivity shocks. In addition, we also found that a capital income tax, compared with labor income and consumption taxes, yielded two results. First, it has a positive impact on the labor supply when the UCS is installed (concluded from the counterfactual experiments of the UCS removal). Second, it also enhances the labor supply when the increase of health expenditures has to be financed and when labor supply is elastic.

Tables

Table 4.1: Targets of Benchmark Economy (Chapter 4)

	K/Y	X/Y	γ	Inf (%Pop)	Inf (Output%)	Avg. n
Benchmark	3.5188	3.50%	1.5403	62.00%	44.04%	0.3316
Data/target	3.51	3.50%	1-3	62.00%	44.00%	1/3
	Gn^h	Gn^l	$\bar{Linc}^h/\bar{LInc}^l$	T_l/Y	T_k/Y	T_c/Y
Benchmark	0.4522	0.3965	2.8069	1.95%	4.40%	9.38%
Data/target	0.4500	0.4000	2.8300	1.95%	4.37%	9.41%

Table 4.2: Summary of Parameters for the Benchmark Economy (Chapter 4)

Parameter	Values	Description
Households		
β	0.9254	Discount factor, target capital output ratio 3.51
μ	2.3339	Utility parameter, target wage elasticity 0.33
ϕ	0.4051	Consumption-leisure parameter, target aggregate labor hours
π_o	0.0222	Retirement probability
π_d	0.1709	Death probability, target old-age dependency ratio
ω^y,ω^o	0.1500	Out-of-pocket ratio
λ	0.2500	Share of high education group
ϵ_h	1.0000	Education-specific efficiency of high edu (normalised)
ϵ_l	0.4142	Education-specific efficiency of low edu
ρ_h, ρ_l	0.9500	AR(1) persistence for both edu
σ_h	0.2441	AR(1) standard deviation (high edu)
σ_l	0.1988	AR(1) standard deviation (low edu)
Firms		
α	0.3144	Capital income share
δ	0.0420	Depreciation rate
A	1.0000	Total factor productivity
ϵ_f	1.0000	Sector-specific efficiency, formal sector (normalised)
ϵ_{nf}	0.7810	Sector-specific efficiency, informal sector
Government		
–Revenue		
τ_c	0.0700	Consumption tax rate, target its revenue share
τ_l	0.0565	Labor income tax rate, target its revenue share
τ_k	0.2305	Corporate income tax rate, target its revenue share
τ_{sc}	0.1000	Social security contribution rate
–Expenditure		
τ_{un}	0.2500	Unemployment benefit
$\tau_{\underline{c}}$	0.0845	Transfer of minimum consumption, of social average wage
D	0.4500	Public debt, %GDP

Table 4.3: Intensive Margin of Labor Supply

	High edu	Low edu	Average
Formal	0.3411	0.3627	0.3573
Informal	0.3041	0.3207	0.3166
Average	0.3313	0.3317	0.3316

Table 4.4: Extensive Margin of Labor Supply

	High edu	Low edu	Average
Formal	96.31%	99.41%	98.63%
Informal	92.26%	96.34%	95.32%
Average	95.23%	97.15%	96.67%

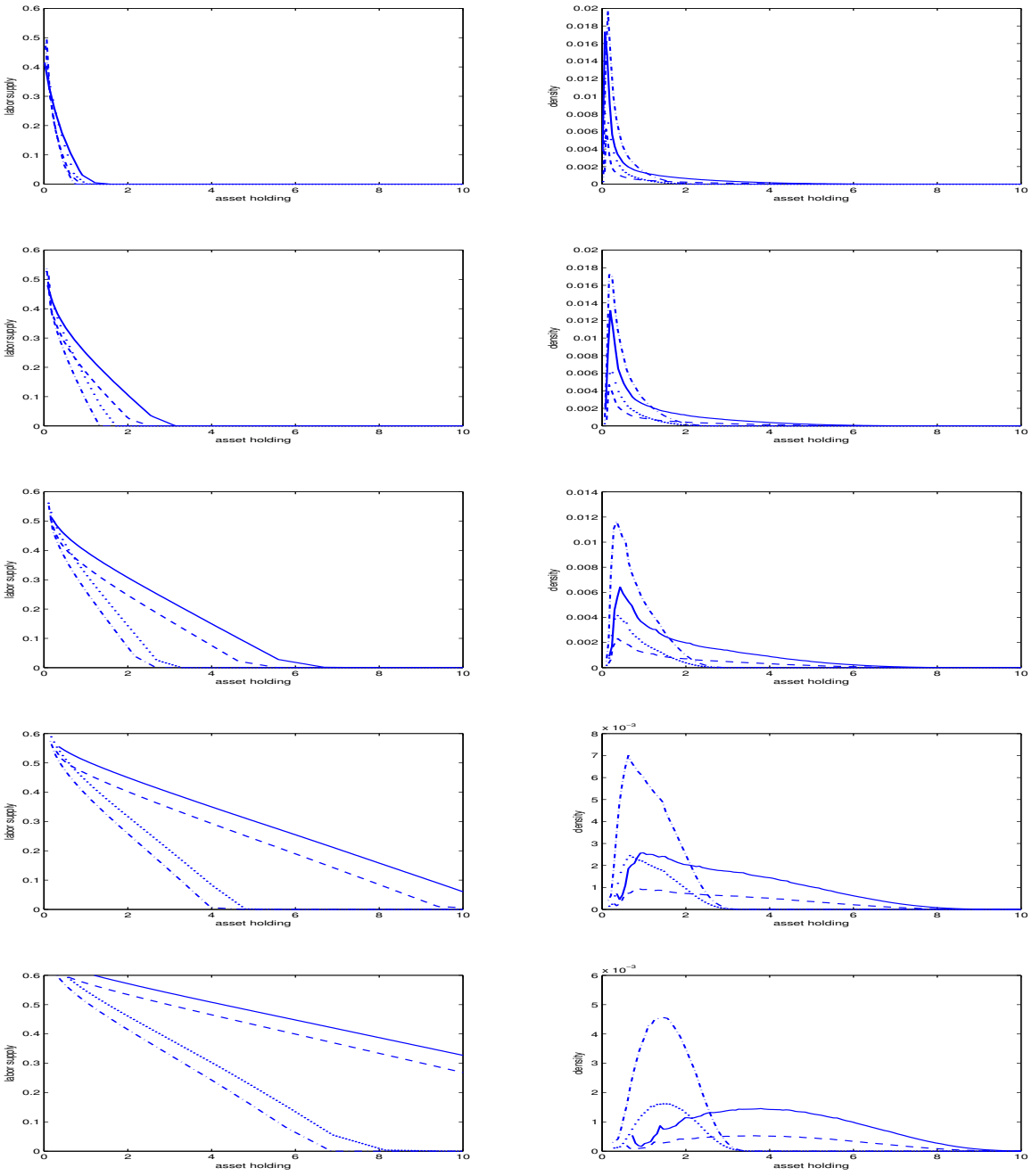
Table 4.5: Labor Hours Change to UCS Removal

Intensive Margins			
	High edu	Low edu	Average
(1) τ_l			
Formal	1.20%	2.59%	1.93%
Informal	-2.14%	-0.25%	-0.44%
Average	0.39%	0.57%	0.51%
L			0.50%
(2) τ_c			
Formal	0.32%	0.33%	0.31%
Informal	0.43%	0.50%	0.50%
Average	0.33%	0.45%	0.42%
L			0.31%
(3) τ_k			
Formal	-0.09%	-0.14%	-0.14%
Informal	-0.03%	-0.06%	-0.03%
Average	-0.09%	-0.09%	-0.09%
L			-0.13%
Extensive Margins			
(1) τ_l			
	High edu	Low edu	Average
Formal	0.55%	0.03%	0.29%
Informal	-0.07%	-0.17%	-0.17%
Average	0.40%	-0.12%	0.01%
(2) τ_c			
Formal	0.05%	-0.05%	0.00%
Informal	0.09%	0.85%	0.76%
Average	0.06%	0.61%	0.47%
(3) τ_k			
Formal	0.07%	-0.04%	0.02%
Informal	0.12%	-0.15%	-0.13%
Average	0.08%	-0.12%	-0.07%

Table 4.6: Decomposition of Labor Hour Changes

	High		Low	
	formal	informal	formal	informal
(1) τ_l				
Total	1.20%	-2.14%	2.59%	-0.25%
Level effect	1.62%	-1.55%	3.90%	1.17%
Distribution effect	-0.42%	-0.59%	-1.31%	-1.42%
(2) τ_c				
Total	0.32%	0.43%	0.33%	0.50%
Level effect	0.24%	0.36%	1.67%	2.17%
Distribution effect	0.08%	0.07%	-1.34%	-1.68%
(3) τ_k				
Total	-0.09%	-0.03%	-0.14%	-0.06%
Level effect	-0.23%	-0.18%	0.99%	1.36%
Distribution effect	0.14%	0.15%	-1.13%	-1.43%

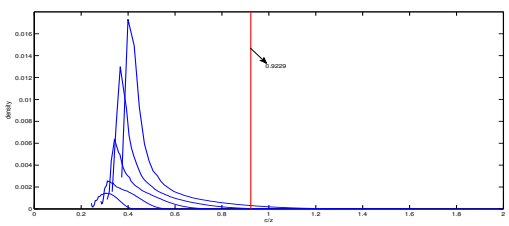
Figures



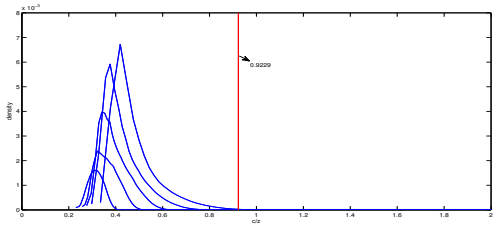
(i) labor supply (j) Density

Figure 4.1: Labor Hours and Distribution

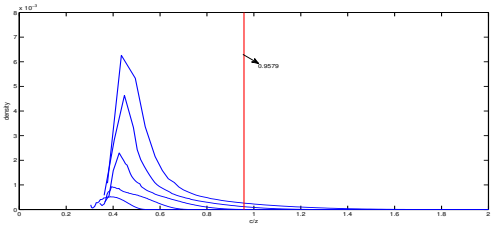
- formal,high edu; - -informal,high edu; . . formal, low edu; - . . informal, low edu;
from low to high idiosyncratic productivity states
states of low health expenditure



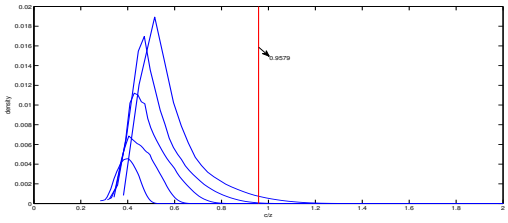
(a) formal, high edu



(b) formal, low edu



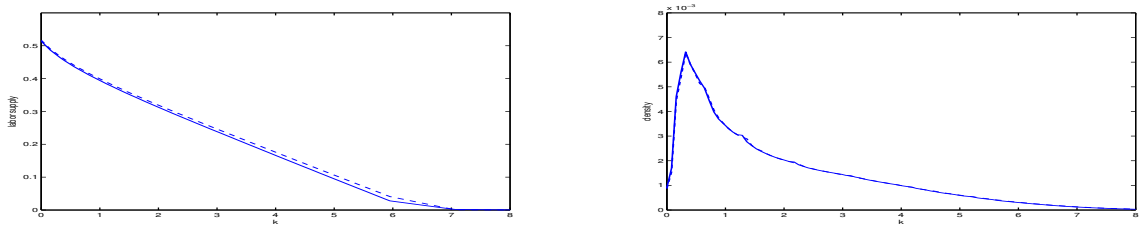
(c) informal, high edu



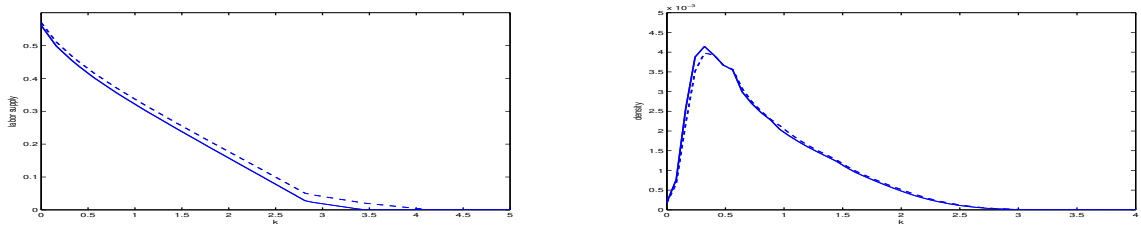
(d) informal, low edu

Figure 4.2: Distribution of c/z

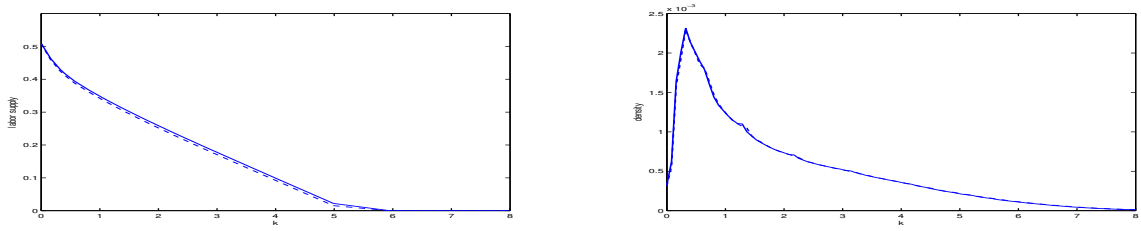
upper to lower lines in each figure represents lower to higher individual idiosyncratic productivity
conditioning on the state of low health expenditure



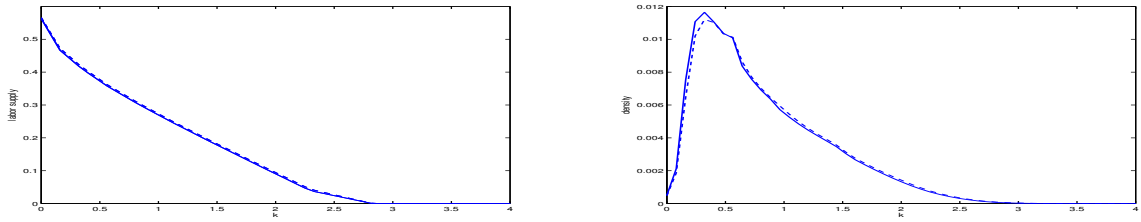
formal, high edu



formal, low edu



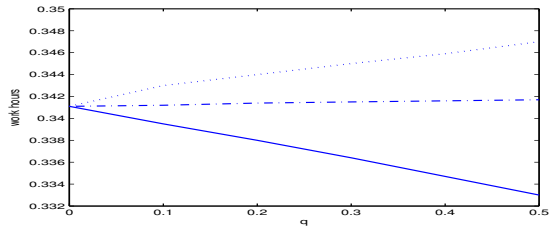
informal, high edu



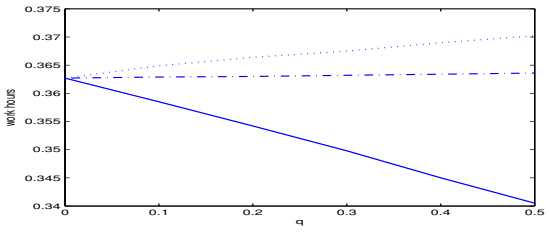
informal, low edu

Figure 4.3: Change of Level and Distribution of Labor Hours

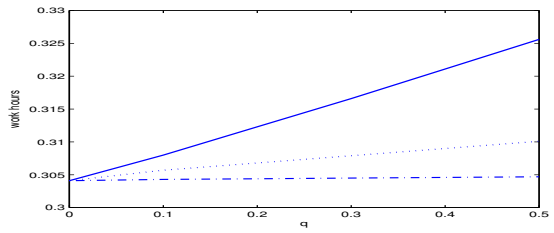
medium idiosyncratic and low health expenditure
— with the UCS; ...without the UCS



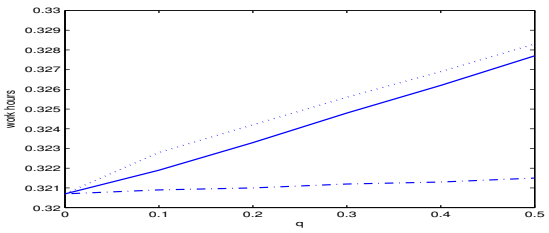
(a) formal, high edu



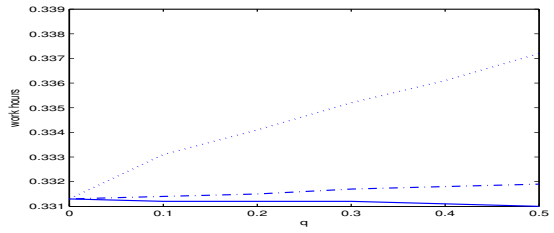
(b) formal, low edu



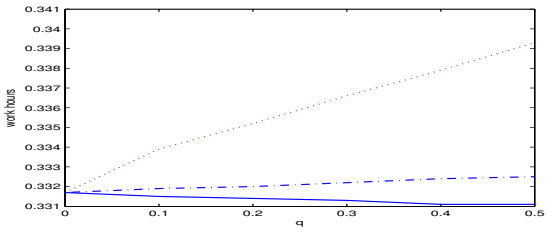
(c) informal, high edu



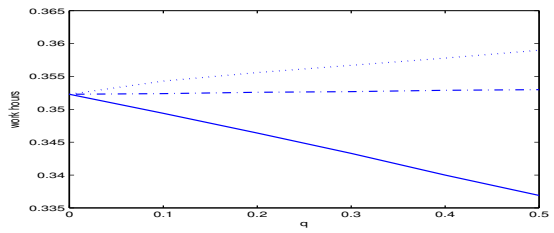
(d) informal, low edu



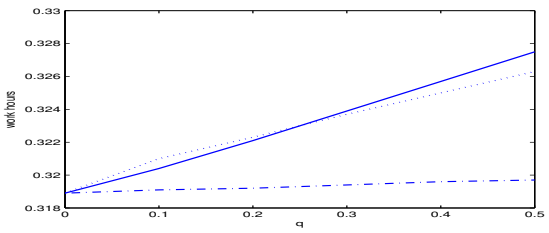
(e) high edu



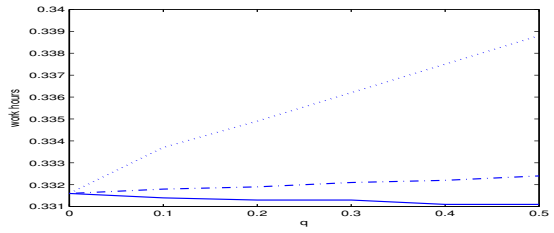
(f) low edu



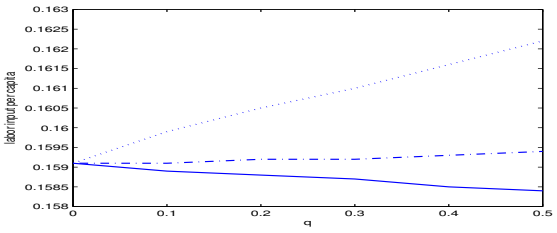
(g) formal



(h) informal



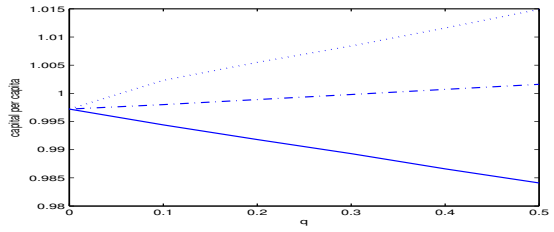
(i) labor hour per capita



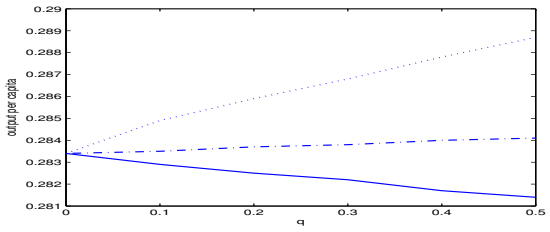
(j) labor input per capita

Figure 4.4: Effects Of Health Cost Inflation on Labor Supply

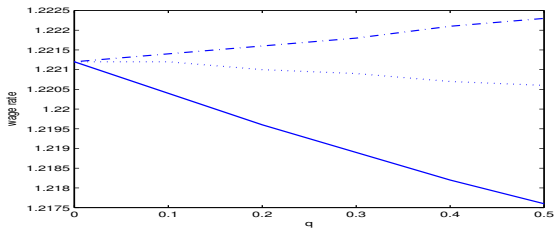
— labor income tax; −−consumption tax; ...capital income tax



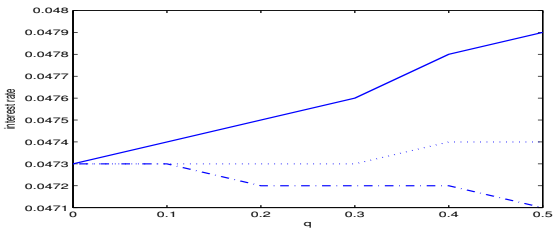
(a) capital per capita



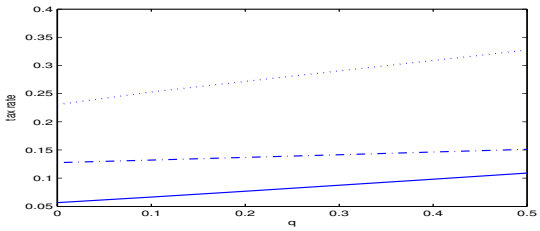
(b) output per capita



(c) wage rate



(d) interest rate



(e) tax rate

Figure 4.5: Effects Of Health Cost Inflation On Macrovariables
— labor income tax; −−consumption tax; ...capital income tax

Chapter 5

Policy Implications

Given the large presence of an informal economy, UHC schemes financed by government revenue can help to achieve the universal health coverage in an effective way, as shown from the experience of Thailand. The success of implementing the UHC scheme financed by government revenue in Thailand relies on many factors such as the low level of national total health expenditure and the accumulation of health service capacity for decades. In this study, issues addressed include the short-term feasibility of implementing a UHC scheme and long-term sustainability against a background of an ageing population, health cost inflation, and change of the size of the informal economy. Meanwhile, welfare changes and responses at the aggregate and disaggregate levels have been quantitatively examined, thus illuminating a spectrum of policy choices and different labor market assumptions. To understand the relations of the final outcomes and various factors such as financing options, the labor market, and overall economic characteristics, is helpful in order to design and implement a UHC scheme which fits the particular nature of the respective country.

In conclusion, the findings of this research comprise three primary aspects. First, given that the labor supply is inelastic, there is a consistent welfare gain of running the universal coverage scheme regardless of which tax financing option is chosen, although the choice does affect the size of welfare gain. Among the various options, a progressive labor income tax provides the highest redistributive effects–as well as the largest welfare gain. Secondly, in terms of financing ageing, three kinds of proportional tax options, were examined. A large tax hike was found to be necessary for the population age structure in 2050. In addition, a formalization of the informal sector will substantially alleviate the tax burden. With welfare comparison among alternative tax options, the labor income tax is most preferred as it brings the largest redistributive effect due to the existence of the large informal labor sector. Without the informal sector, a capital tax will be better than labor and consumption taxes. When labor is endogenous, the distortive effect of a

labor income tax on labor supply outweighs the redistributive effect, where a capital tax is a better choice than a labor income tax or a consumption tax. Third, the labor supply pattern in response to UHC was examined for both intensive and extensive margins (labor hours and participation rates). Results indicated that the labor supply responses can have a different direction depending on the type of tax. When health cost inflation needs to be financed, a capital income tax performs better than other two taxes by increasing labor supply and output.

5.1 Challenges and Opportunities

Any government that runs a tax-financed UHC scheme and other large-scale social security (or welfare programs) will be challenged to sustain its financing sources, largely due to the unprecedented and ongoing ageing of population. Developing countries such as Thailand, are no exception to this trend and will undergo very dramatic demographic changes. When the economy is populated with a larger number of old people who are retired from the labor market and a shrinking labor force of young people, generating tax revenue becomes increasingly difficult, which therefore affects all budget items, including UHC. In addition, the demographic transition itself will increase the spending on UHC if there is no change of benefits in terms of scope and depth.

The change of demographics may not only affect the sustainability of UHC as mentioned above, but also affect the size of the formal sector in a negative way. In Chapter Three, a counterfactual experiment of formalizing the entire informal sector showed that alleviating a tax hike was substantially possible. However, such a formalisation is less likely to happen in the economy with rapid ageing in which the formal sector would bear a larger burden. Therefore, the size of the informal sector might become even larger in the future, which would impose further constraints on the government's ability to raise tax revenue.

Although population ageing is relatively easier to predict in the long term, the consequence are harder to predict as there are other factors into play which may have a larger impact. For instance, the progress of overall technology and health technology, which is beyond the scope of this research, might offset the negative impact of an ageing population. Is technology likely to progress in an ageing society? While no definitive answer is possible at present, at least we can probe some positive elements leading in that direction. As shown in the projections of ageing, capital cost decreases when more old people holding saving for consumption. As we know, a lower cost of capital can potentially contribute to technology progress by inducing innovation. Meanwhile, when less labor is available, the rational business sector tends to develop and adopt better technologies to offset increasing real wages to maximise profits.

5.2 Policy Recommendation

Through this study, we found that there can be a social welfare gain socially by reaching universal health coverage through the tax revenue, given that labor supply responses in the labor market are inelastic. Among three tax options, a labor income tax is preferred due to its high redistribution effect when labor supply is inelastic and capital income tax is preferred when labor supply is elastic. For policymakers who regard the UHC as their key policy agenda, a prerequisite is to understand two areas, the characteristics of the labor market which somehow determine the welfare impact of such policy, in addition to other parameters of their economy. Unfortunately, the literature in this regard is scare. The only studies related are Aterido et al. (2011) and Wagstaff and Manachotphong (2012) about the effect of universal health coverage on labor market choices for the cases of Mexico and Thailand, respectively. To empirically enrich the understanding about their

labor market will be important for them to choose an effective strategy to implement UHC.

From a longer perspective, the cost of sustaining such schemes can be much higher than the initial implementation. Therefore, fiscal constraints, the capability to raise tax revenue, and political priorities are required to determine and maintain such a policy. The government, on the other hand, can play an important role in the process of ageing. First, disseminating information of government budget pressures to the general public can lead to a smoother political process when the government has to adjust their tax policy or social security benefits in order to make it sustainable. Second, increasing the awareness of the public on leading a healthy life is one of the best ways to reduce total health expenditures and allow people to work more years productively.

Appendix A

A.1 The details of Variables in use of Thai Socio Economic Survey

Variable a11–Work Status: 1 = Employed; 2 = Waiting for seasonal work; 3 = Unemployed; 4 = Looking for work; 5 = Retired; 6 = Long term illness or disability; 7 = Caring for other HH members; 8 = Going to school; 9 = Other (specify); blank = Not applicable.
Variable d5–Education: 1 = Below primary school; 2 = Primary school; 3 = Secondary school; 4 = Tertiary school; 5 = Vocational school; 6 = Bachelor's degree; 7 = Master's degree; 8 = Doctorate; 9 = Not reported; blank = Not applicable.
Variable–f5_1: 1 = Employer; 2 = Self employed without employees; 3 = Working without pay for a household business; 4 = Government employee; 5 = State enterprise employee; 6 = Private company employee; 7 = Cooperative group; 9 = Not reported ; blank = No answer/Not applicable.
Variable–f9_1: 1 = Per hour; 2 = Per day; 3 = Per week; 4 = Per month; 5 = Other (specify); 6 = Non-cash payment; 9 = Not reported; blank = No answer/Not applicable.

A.2 Demographics, Education of Thailand

As shown in Figure 1.5, the UN estimates of the Thai old-age dependency ratio was around 13% in 2005 and is projected to 45% in 2050. Furthermore, their definition of the old-age dependency ratio is the ratio of the population aged 65 years or over to the population aged 20-64. Although it has a different starting year for the young generation, it has the same working years as the model. We have borrowed the projected figure directly from
http://esa.un.org/wpp/JS-Charts/aging-old-dep-ratio_0.htm
Labor Force Survey by Education from Year 2001 to Year 2005 can be found from
http://web.nso.go.th/eng/stat/lfs_e/lfse.htm

A.3 Bias Adjustment

A.3.1 Bias Adjustment of the Transitions of Labor and Employment

A joint 7 by 7 transition matrix of z and j, which includes statuses in the formal sector, the informal sector and unemployment, is constructed. It states the probabilities of individuals who transit from the first year to the second year, observed from the Thai SES data for each education group

$$\Psi_{(z',j')|(z,j)} = \begin{cases} \Psi_{(z',j'=f)|(z,j=f)} & \Psi_{(z',j'=f)|(z,j=nf)} & \Psi_{(z',j'=f)|(z,j=um)} \\ \Psi_{(z',j'=nf)|(z,j=f)} & \Psi_{(z',j'=nf)|(z,j=nf)} & \Psi_{(z',j'=nf)|(z,j=um)} \\ \Psi_{(z',j'=um)|(z,j=f)} & \Psi_{(z',j'=um)|(z,j=nf)} & \Psi_{(z',j'=um)|(z,j=um)} \end{cases} \tag{A.1}$$

The share of the informal sector is under-estimated in the matrices constructed from the data for their stationary values. Therefore, we assume of a transitory bias from the construction of a short time horizon. To correct the bias, an adjustment function ϵ_1 is imposed to match the informal/formal ratio in terms of population and it is written as

$$\Psi_{(z',j')|(z,j)} = \begin{cases} (1-\epsilon_1)\Psi_{(z',j'=f)|(z,j=f)} & (1+\epsilon_1)\Psi_{(z',j'=f)|(z,j=nf)} & \Psi_{(z',j'=f)|(z,j=um)} \\ (1-\epsilon_1)\Psi_{(z',j'=nf)|(z,j=f)} & (1+\epsilon_1)\Psi_{(z',j'=nf)|(z,j=nf)} & \Psi_{(z',j'=nf)|(z,j=um)} \\ \Psi_{(z',j'=um)|(z,j=f)} & \Psi_{(z',j'=um)|(z,j=nf)} & \Psi_{(z',j'=um)|(z,j=um)}. \end{cases} \tag{A.2}$$

In addition, each row is normalized to one after adjustment. To target the weighted average matrices of 05-06 and 06-07 panel by 62% of workforce in the informal sector, the calibrated value of ϵ_1 is 0.1155.

A.3.2 Bias Adjustment of the Transitions of health Expenditure

We only calculate health expenditure status based on Year 2005 instead of a three-year average, since the survey shows most of participants do not have any health insurance scheme and the relative difference between the young and old generations was distinct in Year 2005. Then we use a recovery adjustment function $(1+\epsilon_2)$ which is multiple to each values of status by $(1+\epsilon_2)X^t$ and calculate the stationary value of health cost by integrating over the young and old generations. The calibrated value of ϵ_2 is 3.41 to match the total health expenditure per capita in Thailand, which was 3.5% by the World Bank estimate in Year 2005. The transitory bias adjustment is similar to the labor status but

in a simple way. The calibrated values for ϵ_3 and ϵ_4 are 0.4555 and 0.3334 in order to match the stationary share of 95% and 5%. The adjustment function is written as

$$\Omega^{y}_{(x')|(x)} = \begin{cases} (1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=l)} & \Omega^{y}_{(x'=h)|(x=l)} \\ (1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=h)} & \Omega^{y}_{(x'=h)|(x=h)} \end{cases} \tag{A.3}$$

where $\Omega^{y}_{(x'=h)|(x=l)}$ is 1- $(1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=l)}$ and $\Omega^{y}_{(x'=h)|(x=h)}$ is $1-(1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=h)}$, respectively, for the young generation. and

$$\Omega^{o}_{(x')|(x)} = \begin{cases} (1+\epsilon_4)\Omega^{o}_{(x'=l)|(x=l)} & \Omega^{o}_{(x'=h)|(x=l)} \\ (1+\epsilon_4)\Omega^{o}_{(x'=l)|(x=h)} & \Omega^{o}_{(x'=h)|(x=h)} \end{cases} \tag{A.4}$$

for the old generation.

Table A.1: Summary of Bias Adjustment Parameters

ϵ_1	ϵ_2	ϵ_3	ϵ_4
0.1155	3.4100	0.4555	0.3334

A.4 More Details of Thailand Social Security System

A.4.1 Pension System and Social Security Contribution

Thailand's pension system comprises the following:

- ◇ Old Age Pension, a pay-as-you-go financed state pension scheme for the private sector workforce. Participation is mandatory;
- ◇ Government Pension Fund, a defined contribution pension system exclusively for civil servants. Participation is mandatory;
- ◇ Occupational pensions may be provided on a voluntary basis by provident funds;
- ◇ Voluntary retirement savings can be made through personal savings plans, including the Retirement Mutual Funds, which target employees not covered by provident funds and/or those who wish to enhance their retirement savings.

http://www.pensionfundsonline.co.uk/country-profiles/thailand/79/

In our model, we simplify the pension system with just the most important tier, old age pension with varying payments towards retirees with high and low educations. For the implied values in / from the corresponding transitional matrices, the lifetime contribution with the cap are 1.3426 and 0.4526 in terms of individual productivity for high and low education, and the duration of working in the formal sector out of 45 working years are 32.1283 and 11.4452 years, respectively. Given the formula as of Pfau and Atisophon (2009), the values of replacement ratio are 45.69% and 14.67% accordingly.

The earning cap for pension contributions is Baht 15,000 in Thailand, which is equivalent to 1.76 times of social average salary of SES in 2005-2007.

http://www.ssa.gov/policy/docs/progdesc/ssptw/2010-2011/asia/thailand.

html http://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/individual-income-tax.pdf

More details about social security contributions and their benefits are available at http://www.sso.go.th/wpr/eng/benefit.html

A.4.2 Health Care System

In order to reach universal health coverage, Thailand started to implement the Universal Coverage Scheme (UCS) for health care in 2002, in addition to the existing Civil Servant health Benefit Scheme (CSMBS) and the Compulsory Social Security Scheme (SSS). For the case of Thailand, the role of private insurance companies is quite limited. The coverage under each scheme is shown in the following table.

Table A.2: Population Coverages of Health Care Schemes (2007)

Scheme	Target	Coverage
UCS	Citizen not covered under the CSMBS or SSS	74.60%
CSMBS	Government employees and their dependents	8.01%
SSS	Private or temporary public employees	12.90%
Private insurance	Individuals and private firms	2.16%

http://www.jointlearningnetwork.org/content/thailand&gt

There is a fairly good review of the history and development of Thai health care system by Sakunphanit (2006).

A.5 Taxation System in Thailand

A.5.1 The details of Tax Revenues in Thailand

The following lists the tax revenues from different category, as briefed in Thailand's Budget Brief, Fiscal Year 2005.

Tax Components in Thailand	Value (Million Baht)	as of GDP
Direct income	452420.00	6.35%
Petrulem	25000.00	0.35%
Personal income tax	138920.00	1.95%
Corporate income tax	288500.00	4.05%
Indrect	802382.90	11.26%
A. general sales tax	367400.00	5.16%
-Value added tax	336500.00	4.72%
-Specific business tax	23000.00	0.32%
-Stamp duties	7900.00	0.11%
B. Specific sales tax	330404.80	4.64%
-Petroleum and petroleum products	82390.00	1.16%
-Excise tax on import	30996.00	0.44%
-Consumption tax	199397.00	2.80%
-Mining royalties	470.20	0.01%
-Petroleum royalties	17143.20	0.24%
-Natural resources royalties	8.40	0.00%
C. Export - Import duties	103100.00	1.45%
D. Licensing fees	1478.10	0.02%
sum	1254802.90	17.61%

A.5.2 Thai Personal Income Tax Scheme and the modelling

Thailand imposes a personal income tax by using personal income tax schedules. The revenue from personal income tax was 41.28% of the value added tax in Year 2005.
The personal income tax scheme in Thailand as of 2005 is shown in the table below.

Table A.3: Marginal Rates and Income Brackets of Personal Income Tax

Tax Rates	From	To
0	0	150,000
5%	150,001	300,000
10%	300,001	500,000
15%	500001	750,000
20%	750,001	1,000,000
25%	1,000,001	2,000,000
30%	2,000,001	4,000,000
37%	4,000,001	up

To model this progressive income tax scheme, we do the following steps. First, we discretize the income from Baht 0 to $15,000,000$ with the grid distance of Baht $1,000$, an then we calculate the effective average tax rate at each grid point. Second, following Gouveia and Strauss (1994), we estimate effective average personal income tax rates with the polynomial function of degree 6, by the least square estimation.

Source: Thailand's Budget in Brief Fiscal Year 2005

http://www.bb.go.th/budget/inbrveE/inbrve48E/menu.htm

A.6 Modelling Transitory Shocks

To distinguish the work force among all the samples, and to identify workers from the formal and informal sectors, some variables from the survey are used. The variable "a_1" is used to for the former purpose. The variable"$f5\_1$" regarding to the employers is used to for the latter. Among those groups, distinguishing whether "employer" and "private company employee" fall in formal or informal sector is difficult. The samples of employers are not included since the model is a competitive model with no additional capital rent being left over for employers. Second, when a worker is employed by a private company, the additional information about type of wage "$f9\_1$" is used to serve as a criterion to differentiate workers of one sector from the other. Therefore, the workforce in the formal sector consists of people working in government, state enterprises and private companies with regular monthly payments; the workforce of the informal sector consists of people who are self-employed without employees, working without paying for a household business, or working in private companies without regular monthly payments. Such a strategy for the sectoral allocation can also be found Wagstaff and Manachotphong (2012).

We assume there is a transition bias estimated from the data and calibrate it for its stationary share of the formal and informal sectors in terms of population.

Table A.4: Transition Probabilities of Employment Status (High Education)

	f	nf	um
f	0.7058	0.2653	0.0290
nf	0.7356	0.2364	0.0280
um	0.6940	0.2716	0.0345

Original Source: Thailand SES.
Authors' Calculation, transitory bias adjusted.

Table A.5: Transition Probabilities of Employment Status (Low Education)

	f	nf	um
f	0.3678	0.6065	0.0257
nf	0.2119	0.7589	0.0292
um	0.3294	0.6706	0.0000

Original Source: Thailand SES.
Authors' Calculation, transitory bias adjusted.

The reported health expenditures were out-of-pocket expenditure. Given the limitation of such data ex-post, the following steps are taken to approximate the unobserved information. First, the variable with the information on out-of-pocket payment is used , namely, "h22"—expenditure on healthcare, to examine the distribution and transitional dynamics. Second, due to the likely mismatch of micro survey data and macro indicators, a recovery function is set to match the total health expenditures from the benchmark economy to the total national health expenditure per capita. Third, a transitory bias is assumed in order to match the distribution of status of health expenditure with its stationary share.

Following the same strategy in Appdenix A.3.2, we use a recovery adjustment function $(1+\epsilon_2)$ which is multiple to each values of status by $(1+\epsilon_2)X^t$ and calculate the stationary value of health cost by integrating over the young and old generations. The calibrated value of ϵ_2 is 3.41 to match the total health expenditure per capita in Thailand, which was 3.5% by the World Bank estimate in Year 2005. The transitory bias adjustment is similar to the labor status but in a simple way. The calibrated values for ϵ_3 and ϵ_4 are

0.4555 and 0.3334 in order to match the stationary share of 95% and 5%. The adjustment function is written as

$$\Omega^{y}_{(x')|(x)} = \begin{cases} (1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=l)} & \Omega^{y}_{(x'=h)|(x=l)} \\ (1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=h)} & \Omega^{y}_{(x'=h)|(x=h)} \end{cases} \tag{A.5}$$

where $\Omega^{y}_{(x'=h)|(x=l)}$ is 1- $(1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=l)}$ and $\Omega^{y}_{(x'=h)|(x=h)}$ is $1-(1+\epsilon_3)\Omega^{y}_{(x'=l)|(x=h)}$, respectively, for the young generation. and

$$\Omega^{o}_{(x')|(x)} = \begin{cases} (1+\epsilon_4)\Omega^{o}_{(x'=l)|(x=l)} & \Omega^{o}_{(x'=h)|(x=l)} \\ (1+\epsilon_4)\Omega^{o}_{(x'=l)|(x=h)} & \Omega^{o}_{(x'=h)|(x=h)} \end{cases} \tag{A.6}$$

for the old generation.

Table A.6: Summary of Bias Adjustment Parameters

ϵ_1	ϵ_2	ϵ_3	ϵ_4
0.1250	3.4100	0.4555	0.3334

The modelling of employment status shocks is similar to the health expenditure shocks. After calibrated from the data, a transitory bias parameter ϵ_1 is assumed to target the working population shares of sectors.

A.7 Computation Procedures

The steady-state equilibrium is solved by the steps of Aiyagari (1994), which are to guess the aggregate values, solve the individual problems and then simulate the economy to update the aggregate values until convergency. In is dissertation, the individual problems are solved by the Endogenous Grid Method (EGM) proposed by Carroll (2006) and the simulations are conducted by non-stochastic simulation as of Young (2010). The basic procedure is as follows:

- ◇ (a) make initial guesses of the aggregate capital, labor and the endogenous tax option to clear government budget;
- ◇ (b) solve the problems of agents with low and high educations separately for their decision rules in different states, which includes individual productivity, employment, age, and health expenditure shocks;
- ◇ (c) simulate an economy with the decision rules and the transition matrices above. Aggregate the distributions of individual asset holdings and labor supply for all types to find the aggregate capital, and calculate the endogenous variable to clear government budget;
- ◇ (d) go back to step (a) if the convergence criteria and the endogenous tax option are not satisfied, and update the initial guesses.

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