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Aging, Inadequacy and Fiscal Constraint: The Case of Thailand

by

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Aging, Inadequacy, and Fiscal Constraint: The Case of Thailand *

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Abstract

We use an overlapping generations model to study the challenge in developing countries with a large informal sector and aging populations. We use Thailand as a case study and incorporate its labor market structure and its public pension system into the calibrated model. Unlike developed countries, workers in developing countries commonly transit from the formal sector to the informal sector, which can be in the early stage of their working life. This labor market feature crucially limits the coverage of the contributory social security system. We find that 66% of Thai elderly (aged 60 years old or over) are ineligible for social security annuity benefits because of an insufficient number of years paying into the social security fund. In addition, we use our model to evaluate two schemes to raise the existing universal basic pension income to the poverty line; namely, uniform benefits and pension-tested benefits. We find that pension-testing effectively improves the targeting efficiency, and non-trivially lower the cost of the basic pension income program.

Keywords: Overlapping generations model, Fiscal sustainability, Pension, Social Security, Thailand

JEL Codes: J1, H55, I3

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1 Introduction

Compared to rich industrialized nations, several middle-income developing countries experienced a much faster rate of population aging. For instance, Malaysia, Indonesia, and Thailand saw their elderly shares double in just 20 years, whereas it took the United States and the United Kingdom 69 and 45 years, respectively, for the share of the population aged 65 or over to double from 7% to 14% (World Bank, 2015). Despite experiencing a rapidly aging population, these middle-income countries had a late implementation of compulsory public pension programs. Thus, unlike rich developed counterparts, the public pension system in these middle-income countries faces more challenges and must address dual problems; namely, its fiscal sustainability and its large coverage gap.

The reforms to achieve the fiscal sustainability of the public pension system in rich developed countries have been extensively studied in the existing literature. However, what we learned from these studies cannot be applied to developing countries where the labor market is strikingly different with typically sizeable informal sectors (see e.g. La Porta and Shleifer (2008), Duflo and Banerjee (2011)) and there is a large pension coverage gap (Palacios and Knox-Vydmanov, 2014). In addition, the mandatory retirement age and age discrimination commonly seen in their formal sector make a typical reform of raising the full pensionable age a less compelling option to sustain the SS program and close the pension coverage gap

Our study is among the few to develop an overlapping generations model to assess public pension schemes for developing countries featuring an aging population and a large informal sector where workers are not subject to income tax filing and compulsory social security contributions.[1] An important model component is the dynamics between formal and informal sectors; one starting their working life in the formal sector can exit to the informal sector

[1]This is due to a lack of enforcement and asymmetric information. For example, in Thailand, a single person with an annual income less than 120,000THB is exempt from tax filing. Since the earnings of many self-employed or small businesses cannot be verifiable by the government, a large fraction of workers can avoid reporting their earnings.

later on. While early literature views the formal and informal sectors as dual disconnected labor markets (Rauch (1991)), recent studies document that workers switch between the two sectors throughout their lives (Meghir et al. (2015) and Bosch et al. (2007)). Since individuals' pension benefits depend on the number of years they contribute to the social security program, the transition between sectors is an important feature for accurately evaluating pension reforms in developing countries.

Our full life-cycle model is developed for the Thai economy. Compared to other middle-income countries, the population aging in Thailand is at the forefront while its social security system, which is a combination of a compulsory social security (SS) program for formal workers and a universal basic pension income or old-age-allowance (OAA), was introduced only around 20 years ago. Unlike the SS program, every elderly is entitled to the OAA after reaching a certain age. Both schemes, however, have been criticized as outdated due to the lack of indexation to wage growth and inflation. Consequently, their benefit values have diminished over time (see, e.g., ILO (2022), World Bank (2021)). In addition, even with indexation, many parties believe that the universal pension benefit is inadequate. In the past few years, there were at least eight bills proposing to increase its benefit amount.[2,3]

We construct an overlapping generations model of the Thai economy which matches several features in the data related to labor supply, consumption, and accumulated wealth across educational groups and over life-cycle, and use it to study (i) the fiscal sustainability of the SS and OAA programs after indexing benefits to wage growth and (ii) the reforms to increase the OAA from currently 600-1000 THB per month to 3,000 THB (approximately the poverty line). The OAA program is currently funded by the general government revenue, and we assume that the government increases consumption tax (or VAT) to finance its reform.

Our study delivers three sets of key results. We first document that the fraction of formal workers is quickly declining with age. From the SS administrative data, the exit from the

[2]See https://lis.parliament.go.th/ for details of each bill.

[3]There is also an effort to introduce voluntary retirement saving programs for Thai informal workers and participants receive a government subsidy. Even though the program was introduced around the same time as the SS program for formal workers, its participation rate is very low.

formal sector to the informal sector is noticeably higher among the younger age groups. Since the SS benefits depend on the duration in the formal sector, our documentation implies that reforming the SS program alone will be insufficient to provide a pension income for many formal workers who exit early to the informal sector.

Second, we find that indexing the existing SS and OAA programs are costly. It requires a substantial hike in SS contribution after the SS fund is depleted in 2045. In the long run aging economy, both employers' and employees' contributions must be increased from currently 3% to over 20% to balance the SS budget. In addition, indexing the OAA to wage growth will quickly raise the public debt to the debt ceiling (60% of GDP) in 2035, and the consumption tax must be increased by 1.4% (from currently 7% to 8.4%) to finance its long-run cost (2% of GDP).

Third, once introducing a uniform increase of the OAA benefits to the poverty line (3,000 THB), the program cost rises further to 8.3% of GDP. Consequently, the consumption tax needs to increase substantially to 15.9% in the long run. However, the implicit redistribution embedded in the raised benefits brings a large ex-ante welfare gain (1.57% of consumption equivalence). The high cost of the uniform benefit scheme is driven by its inefficient targeting. We show that "pension testing" is an effective screening tool to target the elderly in need. Following an ILO proposal, the pension testing will decrease the OAA benefit by one THB for every three THB of SS annuity income. By introducing the pension testing, the long-run consumption tax needed to finance the OAA reform is lower at 13.6%, while the fraction of elderly (older than 70 years old) whose after-tax consumption below the poverty line drop to 3.9%, compared to 4.2% under the uniform OAA benefits. The ex-ante welfare gains further increase to 1.63% of consumption equivalence. The rise in welfare gain is due to the consumption tax reduction, thus lowering the intra-temporal distortion between consumption and leisure, and the redistribution from the college-educated group who likely has a long career in the formal sector and is less likely to pass the pension testing to the lower-educated groups who likely exit the formal sector soon after entering the labor markets.

Broadly, our paper belongs to literature using a quantitative framework to study the social security system. These studies offer several insights into the social security system in developed countries. Börsch-Supan (2000), French (2005), Keane and Wasi (2016) studied the effect of social security programs on labor supply, and Zhao (2014) examined the effect of social security program on aggregate healthcare spending. Gustman and Steinmeier (2004), Pashchenko and Porapakkarm (2022), and Coile et al. (2002) studied Social Security claiming behaviors. Related to ours are Auerbach and Kotlikoff (1987), Imrohoroğlu and Kitao (2012), Kitao (2014), Nishiyama (2015), Huggett and Ventura (1999), Conesa and Krueger (1999), Attanasio et al. (2007), and Kudrna et al. (2019) who, among others, studied the fiscal sustainabilities of the social security programs and reform options.

Closer to ours is a subset of the literature evaluating pension reforms in middle-income developing countries with aging populations. Jung and Tran (2012), Song et al. (2015), and Kudrna et al. (2022) studied the case of Brazil, China, and Indonesia, respectively. Our paper focuses on the pension system in Thailand. In addition, departing from these studies where formal and informal sectors are viewed as parallel labor markets, using the administrative data of the Thai SS program, we document the age- and education-dependent exit from the formal sector to the informal sector and incorporate it into our study. We show that in this environment "pension testing" is an effective screening tool to redistribute from high-educated people who likely work longer in the formal sector to low-educated ones who likely exit the formal sector early.

The article is organized as follows. The next section provides a background of Thai economy and its public pension programs. Section 3 and 4 present our life cycle model and its calibration, respectively. Section 5 discusses our findings from indexing the SS and OAA program and raising the OAA benefits to the poverty line. The last section provides the conclusion.

2 Background of Thai economy

2.1 Economic structure

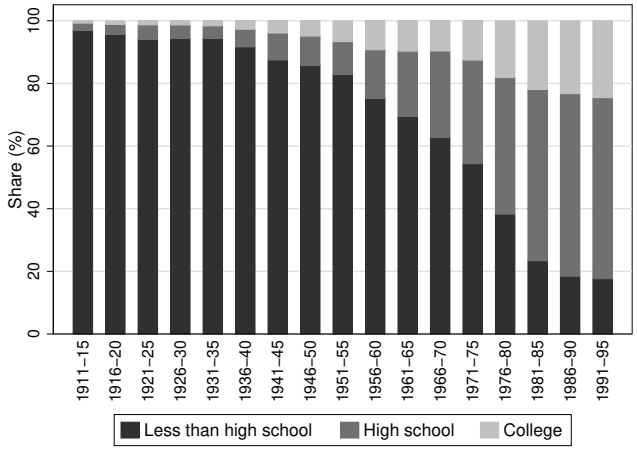
Over the past two decades, the Thai economy grew modestly with the average annual growth rate of GDP per capita at 3.6%. The country is, however, aging rapidly. Between 1980 and 2019, fertility rates declined from 3.4 to 1.5 birth per woman and life expectancy increased from 64 to 77 years. Consequently, the share of the population aged 65 years or older is predicted to double from 13 to 26 percent in the next 20 years.[4] Thanks to its series of educational reforms in 1978, 1999, and 2009, the composition of the later cohorts has shifted from mainly lower than high school toward high school or higher education. As seen in panel (a) for Figure 1, the share of people without high school degrees for cohorts and born before 1960 was more than 75%. For those born in 1990 or later, the share for the high school and college-educated group rose and became stable at around 60% and 20%, respectively.

Concurrently with the education reform, the agriculture sector has largely shrunk from approximately two-thirds to one-third of the labor force. The decline is offset by the rise in shares of the manufacturing, trade, and service sectors with a mix of both formal and informal businesses. Labor Force Survey (LFS) has information on workers' types of jobs, whether workers contribute to the SS program, and their occupations. In panel (b) of Figure 1, we classify individuals into agricultural, informal, and formal sectors and report the composition by age in the year 2016-2019. It shows that the share of formal workers quickly declines after the age 40 years old. This rapid decline likely reflects a common practice of age discrimination in Thailand, where formal businesses, e.g. large corporations, often require job applicants to be younger than 30 or 35 years (Lekfuangfu et al., 2016).

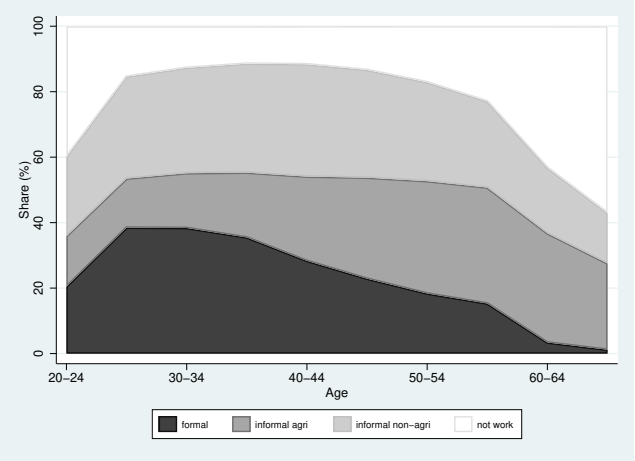
For the rest of the paper, we will define formal workers as those who currently work in registered firms and must participate in the compulsory SS program. In Sector 4, we use the Social Security Administrative data to further document and estimate the education- and

[4] See data.worldbank.org

age-dependent exit rate from the formal sector.



(a) By education and cohort



(b) By sectors and age

Figure 1: Population composition (LFS: 2016-2019).

2.2 Social Security and old-age allowance programs

Thailand has three main public pension schemes: the government workers' pension scheme; the contributory Social Security (SS) scheme for formal workers; and the non-contributory old-age allowance (OAA) scheme.[5] We focus on the last two schemes, which cover approximately 90% of the population.

[5]see Ratanabanchuen (2019) for details of government workers' pension scheme.

The Social Security scheme, also known as Article 33, was set up in 1990 as a broad scheme combining together several welfare programs and public insurance programs for formal workers. The initial scheme included unemployment insurance, disability insurance, maternity benefits, etc. (See Table A.1 in Appendix A for details.) The old-age public pension program of Article 33, or the so-called Social Security program in our study, was added to the scheme in 1998 and became mandatory for workers in all registered firms in 2002.[6] Since its incipient, the number of registered workers increased from 6 million in 2002 (17 % of the workforce) to more than 11 million (29 % of the workforce) in 2020.

The old-age public pension fund (or called SS fund in this study) receives contributions from three parties; specifically, 3% of earnings from both employees and employers and 1% from the government.[7] The maximum Social Security taxable earning has remained fixed at 15,000 THB from the start. To be eligible for the Social Security annuity benefits, SS participants must pay contributions for at least 180 months (15 years). SS members who contributed between 12 and 179 months will receive a lump sum benefit which is the sum of their own and their employer's contributions. For those who contributed less than 12 months, their lump sum benefit is equal to the total of their own contributions. The earliest eligibility age to collect their SS benefit is 55 years old. Unlike the Social Security program in developed countries, there is no benefit adjustment from delaying claims.

All Thai citizens aged 60 years or older, excluding retired civil servants, are eligible for the OAA benefits which were launched in 2009. The program is tax-financed. The initial benefit amounts were 500 THB per month for all age groups but were changed in 2011 to 600-1000 THB, depending on the age of recipients.

There are also three voluntary public pension saving accounts, specifically targeting informal workers, namely (i) SS Article 39 for those who formerly participated in the Article 33

[6]The Social Security Act initially required employers in non-agricultural sectors with 20 or more employees to register. After its expansion in 1993, employers with ten or more employees must join, and it subsequently expanded to employers with at least one employee in 2002.

[7]In reality, these contributions are also spent on the child allowance benefit. However, this is a small part of the fund. Therefore, we assume that the contributions go into the old-age public pension fund.

scheme; (ii) SS Article 40 for those who cannot join the SS article 39; and (iii) the National Savings Fund (NSF) which was established in 2015. To give incentives to participate in these programs, the government offers a matched contribution. However, the matched rate is relatively small and the overall participation rates in these voluntary programs remain low (see Wasi et al., 2021). Thus, we abstract from these small voluntary pension programs in this paper.

3 Model

Our model period is corresponding to 5 years. We use the year 2000 as our base year, which is prior to the introduction of SS and OAA programs. Afterward, the economy is in transition due to the following forces. First, the population structure is aging and reaches its new stable structure in the year 2200. Second, the SS and OAA programs are introduced in the year 2005, requiring policy variables adjustments to balance budgets.

This section describes our overlapping generations model with two private sectors, namely formal and informal sectors. To study the effects of the aging population on the SS and OAA programs, we focus on individuals working in the private sector who are the main beneficiaries of the two programs. Their economic model is explained in Section 3.1. In Section 3.2, we discuss the Thai government budgets which also take into account several other spending and revenues not explicitly modeled in Section 3.1.

For convenience, we normalize variables in our model by real GDP per capita. Thus, one unit in our model is corresponding to real GDP per capita in that period.

3.1 Households in private sectors

An individual enters the private labor market at the age 25 years old, and can live up to 99 years old with the age-dependent survival probability ξ_j^b. The survival probability is also specific to the birthyear cohort (b). Denote age as j where $j = 1$ is corresponding to age 25-29

years old and the maximum age $J = 15$ which is equivalent to 95-99 years old. Individuals are ex-ante different in their education level, namely, less than high school, high school, and college: $e \in \{L, H, C\}$.

An individual is endowed with one unit of time which can be allocated for working (l) and leisure, and derive utility from consumption (c) and leisure:

$$u_e(c, 1-l) = \frac{\left(c^{1-\nu_e} \cdot (1-l)^{\nu_e}\right)^{1-\rho}}{1-\rho}, \tag{1}$$

where ρ and ν_e are the coefficient of relative risk aversion and leisure weights. The future utility is discounted by β_e. We set ρ to 2.0, which is in the range used in the quantitative macroeconomic literature. To capture different economic outcomes across education groups, we allow ν_e and β_e to be education-specific and calibrate their values by matching simulated working hours and accumulated assets in our model to the corresponding statistics in the Thai data.

Individuals can save in risk-free assets ($a \geq 0$) and receive a fixed interest rate of r. We set r to 4% (per year). We assume that individuals enter the labor market with zero assets. Since we abstract from an intergenerational link, we assume that assets of deceased individuals are equally distributed among living individuals with the same education level.[8]

3.1.1 Formal and informal sectors

During their working age, individuals are exogenously assigned to work in either the formal or informal sectors. Denote $o_j \in \{0, 1\}$, where $o_j = 1$ if an individual gets an offer from the formal sector and $o_j = 0$ if otherwise. Informal workers can flexibly adjust their working hours. In contrast, the working hours in the formal sector are inflexible and formal workers can only work full time: $l \in \left\{0, \bar{l}\right\}$. We set $\bar{l} = 0.4$, which is a fraction of 112 total available weekly hours or equivalent to working 45 hours per week.[9]

[8] For an alternative assumption where there exists an actuarially-fair one-period annuity market, see Storesletten et al. (2004)

[9] We assume 16 available hours per day.

To replicate the declining fraction of formal workers with age as documented in Figure 1, we assume that individuals with a formal job offer can lose their offer in the next period with an education- and age-dependent probability $1 - \pi_j^o(e)$. Given that the reverse transition rate from being informal workers to formal workers in the data is rather small, we assume that individuals can only continue working in the informal sector till their retirement age after exiting from the formal sector. Thus, being in the informal sector is an absorbing state.

Following the mandatory retirement practice in Thailand, we fix the mandatory retirement ages in the formal sector at 55 and 60 years old for high school and college groups, respectively. In contrast, those moving to the informal sector prior to their mandatory retirement ages can continue working till age 70 years old.

Note that once reaching their mandatory retirement age, people in the formal sector cannot move to the informal sector. This is consistent with the SS administrative data where there is a large increase in retirement at ages 55 and 60 years old. The assumed large friction to move from the formal sector to the informal sector among older workers can be attributed to the difference in required human capital and skills between sectors. The assumption also replicates the selection into retirement observed in the data. Specifically, those who plan to retire early would choose to stay in the formal sector till their mandatory retirement while those who plan to continue working longer would be better off moving to the informal sector earlier to accumulate new skills.

Everyone working in the formal sector compulsorily participates in the SS program and receives SS benefits once they reach their eligible age (J_{ss}). Depending on the number of years they work and participate in the program, the benefits can be paid either in a lump sum or annuities till death. The benefit amount is calculated from the SS benefit formula described in Section 3.1.3.

The earliest eligible age to collect the SS benefits is 55 years old. Since there is no benefit increase from delaying claims, we assume that people who stay in the formal sector collect their benefits at their mandatory retirement ages while SS participants who move to the

informal sector take their benefits at age 55 years old.

From age 60 years old onward, everyone receives OAA benefits (OAA_j) of which amount varies by age. We summarize the retirement age (J_R) and age to collect the SS benefit (J_{ss}) and OAA benefits (J_{OAA}) for each group in Table 1.

	Retirement	SS benefit[a]	OAA benefit
All education in informal sector	70 ($J_R = 10$)	55 ($J_{ss} = 7$)	60 ($J_{OAA} = 8$)
High school in formal sector	55 ($J_R = 7$)	55 ($J_{ss} = 7$)	60 ($J_{OAA} = 8$)
College in formal sector	60 ($J_R = 8$)	60 ($J_{ss} = 8$)	60 ($J_{OAA} = 8$)

[a] For people ever paying the SS contribution.

Table 1: Retirement age and eligible age for SS benefit and OAA benefits

3.1.2 Labor productivity shock

In each period t, working-age individuals aged j receive a labor productivity shock, $z_{jt}(e, o_j)$, which depends on age, education, and current working sector. Once they are retired, we set their productivity to zero.

We parameterize the labor productivity shock as:

$$z_{jt}(e, o_j) = \begin{cases} w_t \cdot \lambda_j(e, o_j) \cdot exp\Big(\eta_j(e, o_j)\Big), & \text{if } j < J_R \\ 0 & \text{if } j \geq J_R \end{cases} \tag{2}$$

where w_t is the average productivity in period t. Denote the growth rate of w_t as μ_w. We set μ_w to 3.2% (per year) which is the average growth rate of Thai GDP per capita in 2010-2019. $\lambda_j(e, o_j)$ is the age-dependent deterministic productivity, capturing return to experience which differs for each education and sector.

The persistent productivity shock $\eta_j(e, o_j)$ follows a first-ordered discrete Markov process. Given the next period sector $o_{j'}$, we denote its conditional transition probability as $\pi_j^{\eta}(\eta_{j'}|\eta_j, o_j, o_{j'}, e)$. Combining this transition probability with the probability to continue being in the formal sector $\pi_j^{o}(e)$, we can compute the transition probability from state $\{\eta_j, o_j\}$ to the next period state $\{\eta_{j'}, o_{j'}\}$.

3.1.3 Social security and Old-age allowance programs

Our SS system is modeled after the SS program in Article 33. Everyone working in the formal sector must participate and contribute to the system at the rate τ_{ss} of 3% of his or her SS taxable earnings.[10]

$$y_{ss} = \begin{cases} min\left(\widetilde{y}_{max},\ l \cdot z_{jt}\left(e, o_j\right)\right) & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ 0 & \text{if otherwise,} \end{cases} \tag{3}$$

$\widetilde{y}_{max}$ is the maximum earnings subject to SS payroll taxes, which is 15,000 THB. The SS contribution or payroll tax is

$$Tax_{ss} = \tau_{ss} \cdot y_{ss} \tag{4}$$

Once reaching eligible age (J_{ss}), individuals participating in the SS program are eligible for pension benefits. Those contributing less than 15 years (3 model periods) will receive their benefit as a lump sum of which amount is equal to their accumulated contribution from both employers' and employees' parts. For those contributing at least 15 years, they receive annuity pension benefits. The annuity amount depends on the number of contributing years (n_{ss}) and the average earnings during the last five contributing years (i_{ss}).

To formalize the SS benefit formula, let's denote the accumulated contribution up to age j from both employers' and employees' parts, called earning points, as ep_j. For working-age individuals ($j < J_R$), the dynamic of accumulated contributions to the next age j' is defined as [11]

$$ep_{j'} = \begin{cases} ep_j + 2 \cdot Tax_{ss} & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ ep_j & \text{if otherwise.} \end{cases} \tag{5}$$

Since the payroll tax in Eq (4) only counts the contributions of employees, we multiply by

[10] We abstract from the payroll taxes for unemployment and other benefits in Table A.1.

[11] In practice, we need to keep track of ep_j only among SS participants whose contributing years is no more than 15 years ($n_{ss_j} \leq 3$) since ep_j does not affect the annuity benefit.

two to obtain the total contribution. The dynamic of contribution years and average earnings over the last 5 contribution years are:

$$n_{ss_{j'}} = \begin{cases} n_{ss_j} + 1 & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ n_{ss_j} & \text{if otherwise} \end{cases} \tag{6}$$

$$i_{ss_{j'}} = \begin{cases} y_{ss_j} & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ i_{ss_j} & \text{if otherwise} \end{cases} \tag{7}$$

Once reaching eligible ages (J_{SS}), SS participants receive their SS benefit, which is calculated as follows:

$$pen_j(ep_j, n_{ss_j}, i_{ss_j}) = \begin{cases} \Big(20\% + 1.5\% \times \big(5n_{ss_j} - 15\big)\Big) i_{ss_j} & \text{if } j \geq J_{ss} \text{ and } n_{ss_j} \geq 3 \\ ep_j & \text{if } j = J_{ss} \text{ and } n_{ss_j} < 3 \\ 0 & \text{if } j < J_{ss} \text{ or } n_{ss_j} = 0 \end{cases} \tag{8}$$

For SS participants who contribute at least 15 years ($n_{ss_j} \geq 3$), their annuity benefit is a fraction (or replacement rate) of their earnings during the last 5 contributing years. The fraction is set to 20% plus 1.5% for each additional year of their contribution after 15 years. Thus, the replacement rate of SS annuity benefits is increasing in the number of contributing years. Those who contribute less than 15 years get a lump sum benefit ep_j at age J_{ss}. SS participants can only claim benefits at the eligible ages J_{ss}

In contrast to the SS program where beneficiaries must work in the formal sector and pay their contributions, everyone is entitled to receive OAA benefits once reaching age 60 years old.[12] The benefit schedule is increasing in age as shown in Table 2.

[12] As of 2015, around 72% of eligible people takes the OAA benefit. We abstract from modeling a (one-time) fixed cost to participate in the program. It is likely that the application and benefit transfer processes will be easier in the future, and participation will increase.

age		monthly OAA
younger than 60	$j < J_{OAA} = 8$	-
60-69	$j = \{8, 9\}$	600 THB
70-79	$j = \{10, 11\}$	700 THB
80-89	$j = \{12, 13\}$	800 THB
90 or older	$j = \{14, 15\}$	1,000 THB

Table 2: OAA benefit schedule

3.1.4 Taxation

Only formal workers pay income taxes.[13] The income tax base (y_{base}) includes both earnings net of the SS contribution and interest income. We parameterize the progressive tax function as follows:

$$Tax_y = \begin{cases} 5 \cdot exp\Big(\lambda_1 + \lambda_2 \cdot ln(y_{base}/5)\Big) & \text{if } o_j = 1 \text{ and } l = \bar{l}, \\ 0 & \text{if otherwise,} \end{cases} \tag{9}$$

where the income tax base is defined as

$$y_{base} = r \cdot a + l \cdot z_{jt}\,(e, o_j) - Tax_{ss}. \tag{10}$$

The parameters λ_1 and λ_2 are estimated from the *annual* tax filing in 2015-2017 from the Revenue Department. Thus, in Eq(9) we convert the 5-year income tax base into annual income before applying the tax function. In addition, everyone pays consumption taxes (Value-Added Tax). The existing tax rate (τ_c) is 7%.

3.1.5 Household's optimization problems

We can now formalize the households' problems during their working age and retirement using the above setup. The time subscript t is omitted to simplify the notation.[14]

[13] The Thai tax codes stipulate that everyone who has annual interest income above 20,000THB must pay tax on interest income. Based on the Deposit Protection Agency data (2017), the median deposit is 3,142 THB. Therefore, it is likely that most informal workers and retirees do not pay tax on interest income.

[14] In the steady state in the baseline year (2000) and after the economy reaches a stable aging population (2200), the time subscript t is redundant since all variables are time-invariant. However, these variables change over time during the transition between the two steady states.

Working-age individuals $(j < J_R)$

Individuals can work up to their retirement age (J_R) depending on their education and the current working sector as described in Table 1. In each period, the set of state variables of an individual aged j in both formal and informal sectors is $x_j = \{a_j, z_j, ep_j, n_{ss_j}, i_{ss_j}, o_j, e\}$. Denote the value function of an individual in the formal and informal sector as $V_j^F(x_j)$ and $V_j^I(x_j)$, respectively. The recursive problem of an individual in the formal sector is[15]

$$V_j^F(x_j) = \max_{a_{j'}, c_j, l_j} \; u_e(c_j, 1-l_j) + \beta_e \xi_j^b \Big(\pi_j^o \, \mathbb{E}_j \, V_{j'}^F(x_{j'}) + (1-\pi_j^o) \, \mathbb{E}_j \, V_{j'}^I(x_{j'}) \Big) \tag{11}$$

and the problem of one in the informal sector is

$$V_j^I(x_j) = \max_{a_{j'}, c_j, l_j} \; u_e(c_j, 1-l_j) + \beta_e \xi_j^b \, \mathbb{E}_j \, V_{j'}^I(x_{j'}) \tag{12}$$

Each individual faces the budget constraint:

$$\begin{aligned} (1+\mu_w) \, a_{j'} = \; & (1+r) a_j + l_j z_j(e, o_j) + Beq(e) - (1+\tau_c) c_j - Tax_{ss_j} - Tax_{y_j} \\ & + \; pen_j(ep_j, n_{ss_j}, i_{ss_j}) + OAA_j, \end{aligned} \tag{13}$$

and the dynamic of $\{ep_j, n_{ss_j}, i_{ss_j}\}$ as shown in Eq (5)-(7).

The utility function $u(c_j, 1-l_j)$ is specified in Eq (1) and the conditional expectations on the RHS of Eq (11) and (12) are over the labor productivity shock described in Eq (2). The term $1+\mu_w$ in the budget constraint is derived from normalizing the budget equation by the real GDP per capita. $Beq(e)$ is the equally redistributed asset of deceased individuals with the same education.

The SS contribution $\left(Tax_{ss_j}\right)$ and income tax $\left(Tax_{y_j}\right)$ are defined in Eq (4) and (9), respectively, and only formal workers pay them. Once reaching their eligible ages (J_{ss}), individuals who previously pay their SS contributions will receive their benefit pen_j of which amount is calculated from Eq (8).

[15] The problem of individuals one period before their retirement age $(j = J_R - 1)$ is slightly different since they will be fully retired in the next period. Thus, the expected value function on the RHS of Eq (11) and (12) is replaced with the value function of retirees.

The OAA_j is the universal income support for all elderly who are at least 60 years old ($j \geq J_{OAA}$). OAA_j is computed from the monthly benefit schedule in Table 2. In the base year (2000) prior to the introduction of the SS and OAA systems, Tax_{ss}, pen_j, and OAA_j are set to zero.

Retirees ($j \geq J_R$)

After retirement, individuals can no longer work and receive their income from OAA benefit and SS benefit (if any). Their state variables are $x_j^R = \{a_j, ep, n_{ss}, i_{ss}, e\}$. Note that $\{ep, n_{ss}, i_{ss}\}$ are no longer changed but fixed to the values at age J_R. Their recursive problem is

$$V_j^R(x_j^R) = \max_{c_j, a_{j'}} \quad u_e\left(c_j, 0\right) + \beta_e \xi_j^b V_{j'}^R(x_{j'}^R) \tag{14}$$

subject to the budget constraint: [16]

$$\left(1+\mu_w\right) a_{j'} = (1+r)a_j + pen_j(ep, n_{ss}, i_{ss}) + OAA_j + Beq\left(e\right) - (1+\tau_c)c_j. \tag{15}$$

3.2 Government budgets

The government runs two separate budgets: the SS program and the general government budget. Since we model only individuals in the private sector, to fully capture the total fiscal budget of the Thai government, we need to add its other revenue sources and spending. We discuss each budget in detail below.

3.2.1 SS budget

The SS program is assumed to be launched in 2005, which is corresponding to the first period during the transition. There are two sources of revenue for the SS fund (SSF). First, both workers and their employers in the private formal sector contribute equally to the fund.

[16] Although some Thai elderly rely on their adult children's financial support, the longer life expectancy and lower fertility rate have weakened this informal insurance mechanism over time. (Lekfuangfu et al., 2020).

Second, the government gives subsidies which are set to $\tau_g = 1\%$ of SS taxable earnings from formal workers.

Let $\mathbf{x}_t$ be the state variables of households in period t and $\Gamma_t(\mathbf{x})$ is its corresponding measure, of which total measure is normalized to one $\left(\int \Gamma_t(\mathbf{x}) = 1\right)$.

The SSF balance in period t can be written as:

$$(1+n)(1+\mu_w)\, SSF_{t'} = (1+r_{SSF})SSF_t + (2\tau_{ss}+\tau_g) \int_{j<J_R} y_{ss}\ \Gamma_t(\mathbf{x}) - \int_{j\geq J_{ss}} pen\ \ \Gamma_t(\mathbf{x}) \tag{16}$$

r_{SSF} is the fixed rate of return on SSF. We set r_{SSF} at 2.24% per year which is the average historical return between 2016-2020 (3.61%) subtracted by the average inflation (1.36%).[17]

The last term is its spending on SS benefits. The term $1+\mu_w$ and $1+n$ are derived from normalizing the SS budget by GDP. This allows us to conveniently express the aggregate variables as a fraction of GDP. We set the initial SSF_1 in the year 2005 to zero.[18]

3.2.2 General fiscal budget

Our general fiscal budget replicates the actual structure of government expenditures and revenues during 2000-2020.

Government expenditures

We divide the expenditures into four categories, namely, (i) the debt repayment; (ii) the OAA expenses for individuals in the private sector; (iii) the subsidies related to the SS earnings, and (iv) the general public spending. The subsidy rate to the SS fund (τ_g) is 1%.[19] The general public spending (G_t) includes salaries and pensions of civil servants, the

[17] The return on SS fund (r_{SSF}) is lower than the return on households' saving (r) which reflects the strict regulations of the SS fund to invest only in low-risk asset classes.

[18] The SS program was gradually introduced prior to 2005. Thus, the balance of SS fund was 273 billion THB in 2005. Since we abstract from this initial amount, our projected depletion of SS fund should be slightly earlier than the case when taking this initial balance into account.

[19] Similar to the household's payroll taxes, we abstract from government subsidy on unemployment and other benefits.

government's consumption and investment, and other public expenses. We assume that the general public spending is a fixed proportion of GDP and the fraction is set to 15.9%, which balances the general fiscal budget in the base year (2000).

Government revenues

In our model, we divide the revenue into four groups, namely, (i) the income tax from the formal workers; (ii) consumption tax from individuals in the private sector; (iii) income tax and consumption taxes from the non-private sector, denoted as NP_t; and (iv) other sources of revenue, denoted as REV_t. The first two groups are explicitly captured by the private sector in Section 3.1.

For each individual in the non-private sector, we assume that one's income tax is equal to the average income tax of formal private workers and one's consumption tax is equal to the average consumption tax of those who start their career in the formal sector, i.e., those who receive SS benefits. This assumption reflects the fact that the excluded group — namely, civil servants, state enterprise workers, and employers — are likely in the upper-income groups. To compute the income and consumption taxes from non-private sector (NP_t), we multiply the average income and consumption taxes by the size of the non-private sector relative to the private sector (θ_{NP}), which is set to the ratio of individuals in the non-private sector and the private sector in the LFS data: $\theta_{NP} = 9.76\%$. Finally, we fixed the revenue from other sources at 9% of GDP, which is the average value during 2000-2020.

The difference between the revenue and expenditures is financed by new public debt $D_{t'}$. Eq (17) is the general fiscal budget normalized by GDP per capita.[20]

$$\begin{aligned}(1+n)\,(1+\mu_w)\,D_{t'} = & \int_{o=1\ \cap\ l=\bar{l}} Tax_y\ \Gamma_t\,(\mathbf{x}) \quad + \int \tau_c \cdot c\ \Gamma_t\,(\mathbf{x}) \quad + \quad REV_t \ + \ NP_t \\ & - \ (1+r_B)D_t \ - \int OAA \ \ \Gamma_t \ \ (\mathbf{x}) \ - \int_{o=1\ \cap\ l=\bar{l}} \tau_g \cdot y_{ss}\ \Gamma_t\,(\mathbf{x}) - \ G_t,\end{aligned} \tag{17}$$

[20]The treasury reserve is omitted as it remains relatively constant over the years.

The income and consumption taxes from the non-private sector is defined as

$$NP_t = \theta_{NP} \int_{o=1 \cap j<J_R} (Tax_y)\ \Gamma_t(\mathbf{x}) + \quad \theta_{NP} \int_{o_{(j=1)}=1} \tau_c \cdot c\ \Gamma_t(\mathbf{x}). \tag{18}$$

r_B is the interest rate for government debts. We set r_B to 0.9% (per year) which is the average return of 10-year government bonds during 2015-2020 (2.26%) subtracted by the 10-year average inflation (1.36%).

4 Parameters and initial distributions

4.1 Population structure

The base year's population structure is assumed to be stationary and constructed from the United Nations (UN) estimates of survival probability $\left(\xi_j^b\right)$ and the shares of the population by age group in the year 2000 (Figure 2).

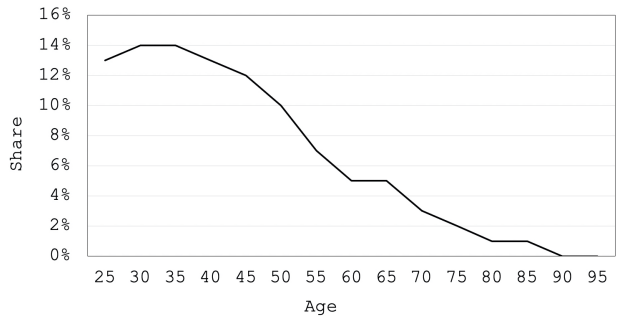


Figure 2: Thai population structure in the base year (2000)

Once the economy experiences the aging population from 2005 onward, we introduce cohort-specific survival probabilities and entry rates of new cohorts at age 25.[21] Since the UN's projection is only available till the year 2100, we linearly extrapolate the increasing survival rates trend until 2150, after which it no longer changes.

[21] We use the median version of survival rates from UN_PPP2019_Output_AbridgedLifeTable_BothSexes and the rate of new entrants from WPP2019_pop_F07_1_population_by_age_both_sexes. The change in our population excludes migrant workers older than 25 years old since only few foreign workers take up the SS and OAA benefits.

The left panel of Figure 3 presents the survival probabilities of the cohorts living in the base year (2000) and the new entering cohorts during the selected transitional years (2050, 2100, and 2150 onward). Over time, the dependency ratio (population older than 65 divided by population aged 25-65 years) increases from 14% in the base year (2000) to 69% in 2200 (the right panel of Figure 3).

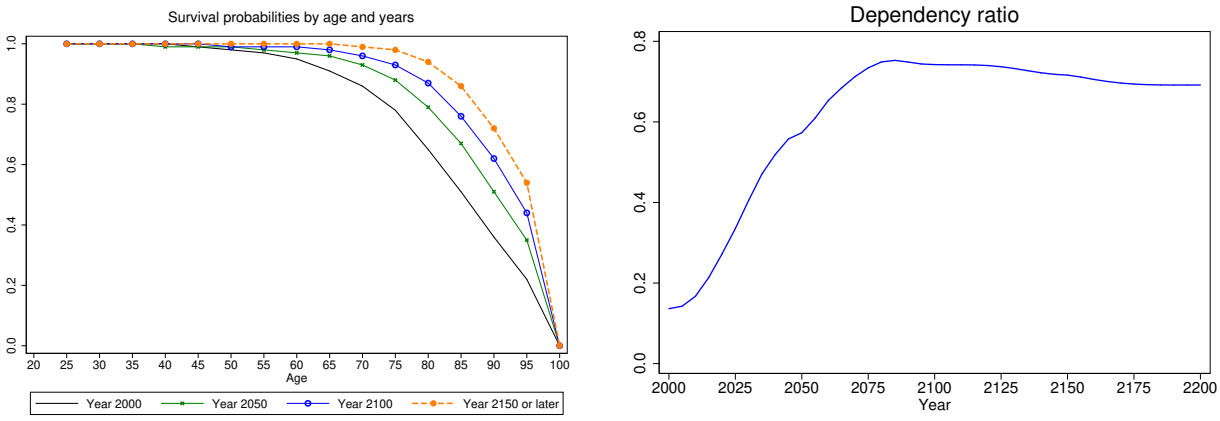


Figure 3: Survival probabilities by birth cohort (left), and old-age dependency ratio (right)

4.2 Formal and informal sectors

4.2.1 Initial distributions (25 years old)

We obtain the educational share of people aged 25-29 years old from the LFS. The first column of Table 3 reports the education in the base year. We assume that the educational shares of entering cohorts aged 25 years old are constant once the transition starts (the second column).

The share of formal workers by education in the LFS, however, remains relatively stable throughout all waves. The last column reports the initial fraction of people working in the formal sector by education in our model. Since only a small fraction of workers with less than high school degree works in the formal sector, we assume all of them are informal workers.

	% of population (base year 2000)	% of population (2005-2200)	% in formal sector (2000-2200)
Less than high school	34 %	18 %	0 %
High school	47 %	58 %	83 %
College	19 %	24 %	100 %

Table 3: Education share and shares of formal workers by education among people aged 25 years old

4.2.2 Transition from the formal to informal sectors : $\pi_j^o(e)$

A key feature of our model is that there is a transition from the formal to informal sectors. We utilize both the Social Security Administrative data and the LFS data to estimate the age- and education-specific probabilities to leave the formal sector. The Social Security Administrative data has a large advantage since it contains all SS participants' earnings history till they left their employers in the formal sector. However, it does not have educational information. To impose individuals' education, we turn to the sample of formal workers in the LFS (2016-2019) and estimate an ordered logit model of their education using a set of covariates observed in both the LFS and the Social Security Administrative data. The covariates in the ordered logit model include wage at the age 25 years old, gender, firm size, residence area (urban/rural), and their interactions. Individuals' education in the Social Security Administrative data is, then, assigned to the most likely education level predicted by our estimated ordered logit model. Finally, for each education and 5-year age group, we estimate $\pi_j^o(e)$ from the corresponding fraction of people who left the program in the Social Security Administrative data.

The left panel of Figure 4 presents the actual number of SS members by age group and birth year. For each birth year cohort, the number of members quickly declined as they are approximately older than 30-35 years old. The right panel of Figure 4 shows the estimated exit probability by education conditional on being in the formal sector last period $\left(\pi_j^o\right)$. The high school group is more likely to leave the formal sector than the college group. In addition, the exit rate is noticeably high among young workers (around 40% and 25% for high school and college groups, respectively) and continuously declines with age.

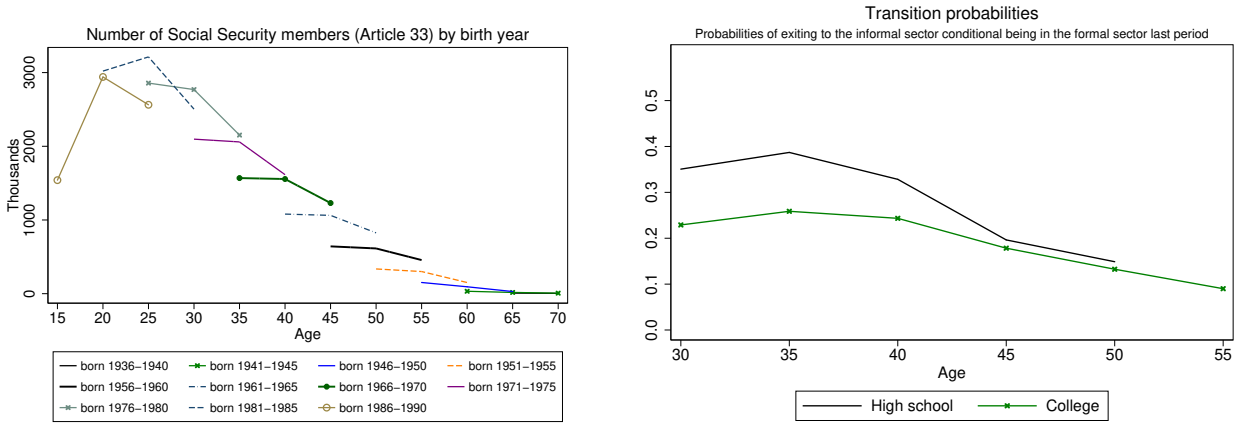


Figure 4: The number of people actively paying SS contributions by age and birth cohort (left), and the transition probabilities from formal to informal sector π_j^o (right)

4.2.3 Composition of workers during the transition

Figure 5 shows the changes in education and sector composition of the working-age population. The shares of workers with less than high school, high school, and college degrees converge to 23%, 53%, and 24% around the year 2070, respectively, which is roughly in line with the shares in developed economies. As education improves, the shares of young formal workers increase. But the overall share of formal workers (black line and orange line) only slightly increases because the increasing share of young formal workers is offset by the rising share of older workers who exit into the informal sector.

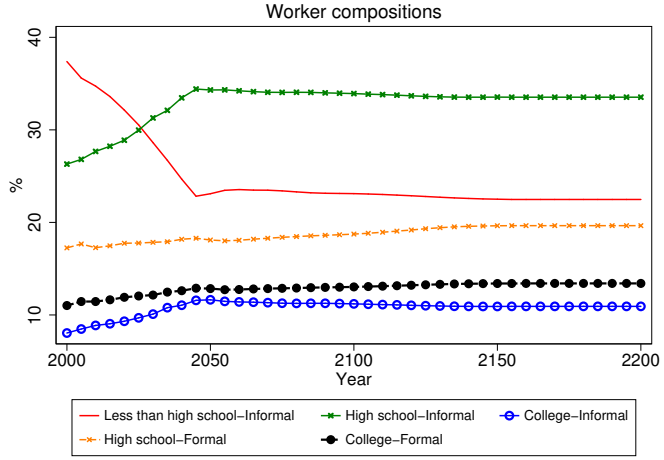


Figure 5: Composition of workers during the transition periods

4.2.4 Labor productivity

As discussed in Section 3.1.2, our hourly wage shock is characterized by the age-deterministic profile λ_j and the first-ordered Markov process η_j, both of which are specific to education and sector. The profiles λ_j for age 25-60 are estimated as a quadratic of age from the LFS (2016-2019) and are assumed to linearly decline to zero at the age of 80.[22] The earning profiles are, then, scaled to match the average income of workers by sector and education in the LFS.

For each education level, we estimate η_j directly from the LFS. In our model, an individual draws his hourly wage shock η_j every five years and its 5-year transition can be partitioned into three blocks, depending on the current and next period sectors.

$$\begin{array}{c} \\ o_j = 0 \\ o_j = 1 \end{array} \begin{array}{c} \begin{array}{cc} \underline{o_{j'} = 0} & \underline{o_{j'} = 1} \end{array} \\ \begin{bmatrix} \eta_{j'}|\eta_j, o_j = 0, o_{j'} = 0 & - \\ \eta_{j'}|\eta_j, o_j = 1, o_{j'} = 0 & \eta_{j'}|\eta_j, o_j = 1, o_{j'} = 1 \end{bmatrix} \end{array}$$

For individuals continuing working in the same sector ($o_j = o_{j'}$), we parameterize their hourly wage shock as an AR(1) process:

$$\eta_{j'} = \rho_\eta^o \eta_j + \epsilon_{j'}^o; \qquad \epsilon_j^o \sim N\left(0, \sigma_{\epsilon^o}^2\right). \tag{19}$$

The implied cross-sectional variance of η_j for each age can be written recursively as

$$\sigma_{\eta_{j'}^o}^2 = \left(\rho_\eta^o\right)^2 \sigma_{\eta_j^o}^2 + \sigma_{\epsilon^o}^2. \tag{20}$$

We obtain the empirical counterpart of η_j by regressing the log-wage equation separately for individuals working in the formal and informal sectors:

$$log\left(wage_j\right) = f\left(age\right) + D_{year_j} + \eta_j.$$

$wage_j$ and D_{year_j} are individual's hourly wage and year-dummy variable. $f\left(age\right)$ is polynomial degree two of age. By assuming that $\sigma_{\eta_1^o}^2 = \sigma_{\epsilon^o}^2$, we can estimate ρ_η^o and $\sigma_{\epsilon^o}^2$ by minimizing the sum square difference between the cross-sectional variance in Eq(20) and

[22] See Figure B.1 in Appendix B.

the corresponding empirical variance from the LFS.[23] Table 4 reports our estimates for each education and sector.[24] We discretize the estimated AR(1) process into a 3-state Markov process using the Rouwenhorst method. We report the transition matrix and the grid values of our hourly wage shock process in Appendix B.1.

	σ_ϵ^2	ρ
Less than high school	0.039	0.5119
High school in informal sector	0.044	0.5965
High school in formal sector	0.043	0.7088
College in informal sector	0.116	0.7111
College in formal sector	0.102	0.6401

Table 4: Estimated AR(1) process of hourly wage shock η_j

Since the LFS is cross-sectional, we cannot estimate the hourly shock process of formal workers who exit into the informal sector $(o_j = 1, o_{j'} = 0)$. We assume that its discrete Markov process has the same transitional probabilities as workers who consecutively work in the informal sector $(o_j = 0, o_{j'} = 0)$.

4.3 Preference parameters

We use leisure weight to match the average working hours of informal workers by education in the LFS.[25] Discount factors are calibrated to match the net worth of people aged 25-54 by education in the Household Socio-Economic Survey (SES). Table 5 reports the estimated ν_e and β_e by education. As shown in the second column, people from a lower education group put less weight on their leisure. This is driven by the fact that people with low education on average have a lower wage but work longer hours than their higher-educated counterparts. The third column shows that compared to the lower educated groups, the college-educated are more patient and, consequently, have a noticeably more accumulated net worth.

[23] $\sigma_{\epsilon^o}^2$ and ρ^o are identified by the intercept and the concavity of the cross-sectional variance profile, respectively.

[24] Figure B.2 in Appendix B compares the variances implied by our model and the estimated variance from the LFS.

[25] Each individual has 5,840 available hours per year (16 hours per day, 365 days per year). In addition, we assume that all formal workers only work full-time.

	leisure weight (ν_e)	Discount factors (β_e)
Less than high school	0.608	0.936
High school	0.608	0.941
College	0.8	1.028

Table 5: Leisure weight and discount factor by education

Table 6 compares selected moments from our model and the data.[26] The shaded cells are our targeted moments. The average weekly hours worked by education in the model and the data are well matched, and the lowest educated group works longer hours than the high school and college graduates.[27] For high school and college groups, our average weekly working hours are slightly lower than the average hours worked in the LFS because the number of hours per week for all formal workers in our model is fixed. The net worth in our model and the data are well matched for the working age group and are reasonably close for the 55-69 years old group.

To externally validate our calibrated model, the non-shaded cells in Table 6 compare several non-targeted moments between our model and the data. Overall, our model can reasonably replicate the variation in average labor income, consumption, and net worth across education and age groups.

5 Results

In this section, we introduce the aging population, the SS program, and the OAA programs into our calibrated model. All changes are unexpected to the households living in the base year. Section 5.1 discusses the indexation of the SS and OAA programs and their fiscal sustainability in the long run. Section 5.2 studies different schemes to increase the basic pension income (OAA).

[26] Table B.1 in Appendix B summarizes our model parameters.

[27] The labor supply typically increases with education in developed countries. In the LFS, the lowest educated group mostly works in the informal sector, while the larger share of high school and college groups works in the formal sector. The informal jobs include security, maids, sales, street vendors, and taxi drivers which usually require long work hours.

	25-54 years old				55-69 years old	
	Weekly hours	Monthly labor income	Monthly consumption	Net worth	Monthly consumption	Net worth
Data						
All	45	7,793	5,487	320,734	5,898	873,507
Less than high school	48	5,021	3,724	172,462	3,574	372,920
High school	46	7,167	5,385	283,554	5,954	798,699
College	46	14,139	8,819	668,457	9,818	1,926,420
Data source	LFS	LFS	SES	SES	SES	SES
Model						
All	46	8,208	6,081	321,283	4,704	637,544
Less than high school	48	5,036	4,046	173,704	2,919	342,782
High school	45	7,709	5,910	284,633	4,333	544,793
College	43	14,958	10,055	667,637	8,717	1,376,316

Table 6: Working hours, consumption, and net worth in the base year (2000): model vs data. All nominal values are based on the year 2000 price. The weekly hours and labor income data are from the LFS while the consumption and net worth data are from the SES, which are converted into the individual-level using the OECD adult-equivalence scale. The shaded cells are the targeted moment and the non-shaded cells are non-targeted moments.

5.1 Indexing the SS and OAA programs

Due to the lack of indexation of the SS and OAA programs to economic growth, the economic value of the SS and OAA programs diminishes over time and eventually becomes a negligible fraction of average wage and consumption. To maintain the economic value of the programs, we index both SS and OAA programs to the average wage growth. Specifically, the maximum SS taxable earning ($\widetilde{y}_{max}$) and the OAA benefits (OAA_j) are scaled up by the average wage growth (μ_w).

To finance both programs in the aging economy we use the following arrangement. For the SS program, when the SS fund is depleted, we increase both employers' and employees' contributions to balance the SS budget in Eq.(16). In addition, the increasing government spending from the OAA program is firstly financed by government debts (D_t). Once the government debt hits the legislative debt ceiling at 60%, we increase the consumption tax (τ_c) to balance the general government budget in Eq.(17). In our context, the consumption tax is the only feasible tax instrument. Unlike developed countries, the personal income tax base in developing countries with a large informal sector is rather small, and capital gains are

commonly under-reported, making it infeasible to raise a large revenue from income-based taxation. In addition, raising earnings tax is often viewed as discouraging formality.

Projected costs of indexation: Figure 6 shows the cost projection of the OAA program which is indexed to the wage or GDP growth. Due to the aging population, its spending quickly increases from 2005 when it was introduced. The government debt hits its ceiling in 2035 and the consumption tax has to increase. In the long-run aging steady state (2200), the total spending of the OAA program is almost 2% of GDP which requires an increase in consumption tax from currently 7% to 8.4%.

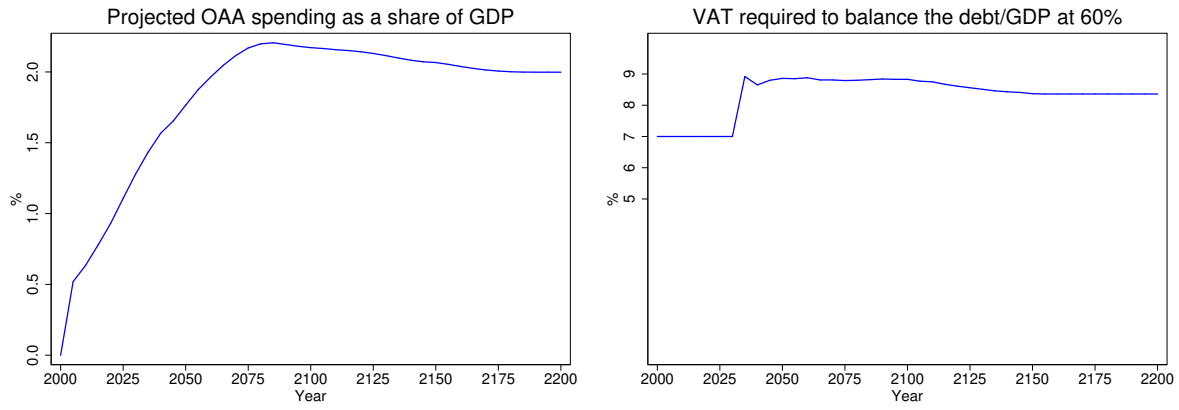


Figure 6: Projected cost of OAA program (left) and required consumption tax to balance the government budget (right)

The left panel of Figure 7 reports the projected balance of the SS fund when benefits are indexed to wage growth.[28] The fund will be in deficit in 2045, which is less than four decades after its incipient. The rapid depletion of the SS fund is partly due to the aging population as commonly discussed in the case of developed countries. A less discussed reason for the case of Thailand is its SS benefit formula. Specifically, following the earning profile, individuals' SS contribution increases over age. But their annuity benefits are computed from the last five years of contributions, which is likely higher than the average contributions. Thus, as

[28]In Appendix C we compare our projected SS fund with the historical SS fund balance till 2015.

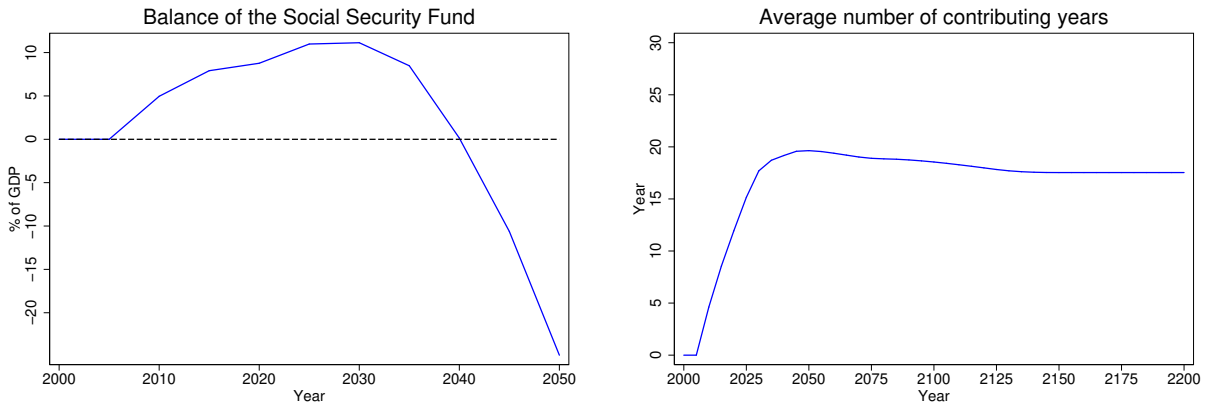


Figure 7: Projected balance of social security fund (left) and average number of contributing years among people aged 60 years old who ever pay SS contributions (right)

more people start collecting annuity benefits, the SS fund grows slower.[29] As shown in the right panel of Figure 7, the average contributing years among people aged 60 years old who ever pay SS contributions quickly increases after 2005, thus hastening the depletion of the SS fund. To keep paying the promised benefits in the long run steady state (2200), the contribution rate must considerably increase from 3% to 22.5% (or 45% in total from both employer and employee parts).[30,31]

Long-run adequacy of the SS program: Two salient features of the Thai labor market are the mandatory retirement age among formal workers and their exit into the informal sector, which can happen in the early stage of their working life. Accounting for the formal-informal transition for people allows our model to generate a rich heterogeneity in contribution histories, from which SS benefits are calculated. Table 7 presents the long-run

[29]Since SS annuity benefits are paid to participants who pay contributions longer than 15 years, all SS beneficiaries receive only lump sum benefits prior to 2020.

[30]ILO (2016) projected that after indexing benefits to the wage growth the increase in the total contribution rate to cover the cost of the social security scheme (including all benefits in Table A.1 in Appendix A) would be 32% in 2113. Note that ILO used a higher wage growth; thus, requiring a lower contribution rate.

[31]The large increase in contribution rates is politically infeasible. In addition, the participation in the formal sector, assumed to be exogenous here, will be negatively affected by the large payroll tax increase. (See Narita (2020) who use a calibrated search and matching model to study the effect of labor income taxes on endogenous participation in the formal sector in Brazil.) Alternatively, if the contribution rate is fixed, our model predicts that the SS benefits must be drastically cut to 30% of the current real value. Thus, a more plausible scenario is a combination of raising contribution rates and cutting benefits.

distribution of contributing years among the retirees aged older than or equal to 70 years old in 2200. The elderly in the lowest educated group is always in the informal sector, hence neither contributing to nor receiving benefits from the SS program. More importantly, even though the majority of higher educated groups enter the labor market as formal workers, 66% (44%) of the high school (college) group pays contributions less than 15 years over their working life and receives benefits as a lump sum payment. Consequently, 66% of the elderly population receives no annuity SS benefit even after the program is indexed and financially sustainable.

	All	By education		
		Less than high school	high school	college
$0 \leq n_{ss} < 15$	66%	100%	66%	44%
$n_{ss} \geq 15$	34%	–	34%	56%

Table 7: Distribution of the elderly (>60) by number of years contributing to the SS fund (n_{ss}) in 2200

The above result illustrates that once taking into account the structure of the Thai labor market, a reform of the SS program cannot provide sufficient insurance against longevity risk and old-age poverty. In contrast, the basic pension income (OAA) is an entitled program, thus covering all elderly. However, a reform to increase its benefits is costly. In the next section, we discuss different schemes to raise the basic pension income.

5.2 Increasing basic pension income (OAA)

In this section we consider two schemes to raise the OAA benefits for everyone aged 60 years old or above to 3000 THB per month (approximately the poverty line); namely, (i) uniform OAA benefits and (ii) pension-tested OAA benefits. Unlike the uniform scheme where every elderly receives the same benefit amount, the OAA benefit is reduced by one THB for every three THB of SS annuity income under the pension-testing scheme. While some developed countries, such as Australia, adopt a mean-tested pension benefit, pension-testing is readily implementable in developing countries where income and assets are likely under-reported

and unverifiable.

Raising the OAA benefits has been currently in debate and proposed to the Thai parliament. Thus, we assume that the OAA benefits increase starts in 2025, which is a few years from now and is unexpected. Similar to Section 5.1, both SS and OAA programs are indexed to wage growth, and in the following discussions we benchmark their long-run outcomes with the outcomes in the baseline economy with indexation.

Costs of increasing OAA benefits: Figure 8 illustrates the cost of raising the OAA benefits to the poverty line. In the long run steady state (2200), the total spending under the uniform benefits and the pension-tested benefits is equal to 8.3% and 6.5% of GDP, respectively, compared to 2% in the baseline case with indexation. The public debt hits the debt ceiling (60% of GDP) once the OAA benefits increase, requiring a large increase in consumption tax to balance the government budget. The required long-run consumption tax is raised to 15.9% and 13.6% for the uniform and pension-tested benefit cases, respectively. The corresponding tax rate is 8.4% in the baseline case with indexation.

Our results show that while raising the OAA benefits to the poverty line is very expensive, the pension-testing option can help offset the program cost (as a percentage of GDP) and the required increase in consumption tax as large as two percentage points.

Long-run responses of households: The bottom two panels of Table 8 report the households' responses to the increase in OAA benefits in the long-run steady state (2200) whereas the top panel is our benchmark case. Overall, compared to the baseline economy with indexation, people work less (second column) and save less (last two columns) when the OAA benefits increase. The decrease in saving is more pronounced among the high school and lower educated groups for all age groups. Since the OAA benefits are paid out as long as one is alive, it is equivalent to an annuity. As shown in Table 7, a large fraction of high school and lower educated groups pay SS contributions for less than 15 years and receive no

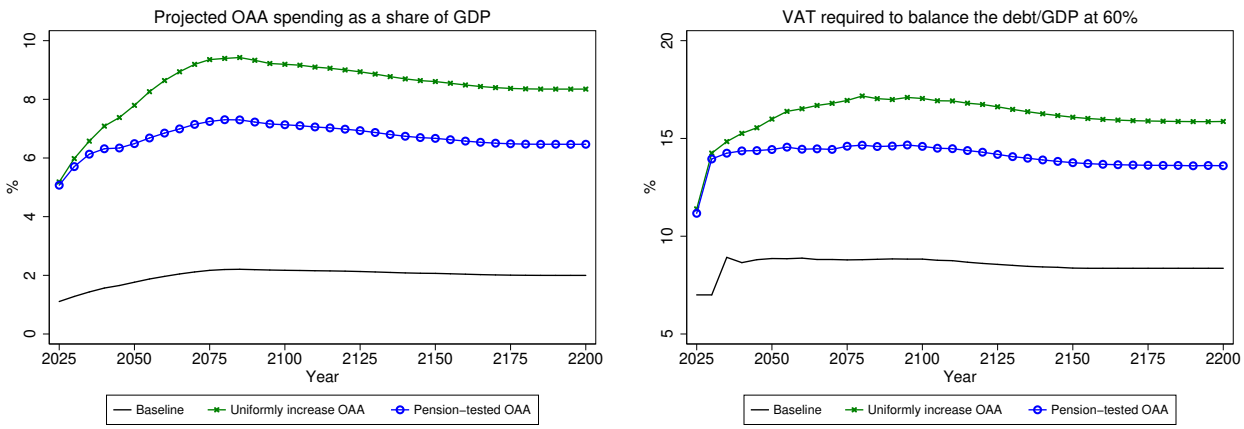


Figure 8: Total OAA spending (left) and required consumption tax to balance the government budget when raising the OAA benefits to 3000THB (right)

SS annuity benefits. The increase in OAA benefits reduces their exposure to longevity risk, consequently lowering their self-insurance through saving.

The decreased exposure to longevity risk after retirement partly accounts for the lower labor supply among the working-age population. In our model, the large increase in consumption tax also affects labor supply through the intratemporal distortion. Specifically, when pre-tax consumption becomes more expensive, people substitute their consumption with leisure, consequently working less.[32]

In the following, we use two measures to compare the two OAA schemes: poverty rate among the elderly and ex-ante welfare gains/losses. Since the OAA reform directly targets at the elderly, the former is a measurable statistic of interest for policymakers. However, the latter is a more comprehensive measure of the reform outcomes.

Poverty rate reduction Table 9 compares the poverty rate among retirees older than 70 years old in the long run steady state in 2200. We define an elderly living in poverty if her *after-tax* consumption is below the poverty line. The poverty line in 2200 is constructed

[32]Note that the labor supply of formal workers cannot adjust along the intensive margin. Their labor supply is less distorted than that of informal workers. As shown in the second column of Table 8, since the majority of the college group is in the formal sector, their weekly hours, on average, do not change after the increased OAA benefits.

	25-54 years old		55-69 years old
	Weekly hours	Net worth	Net worth
Baseline + Indexation			
All	47	384,201	913,254
Less than high school	50	248,790	504,714
High school	47	258,711	659,249
College	44	776,626	1,804,145
Indexation + uniform OAA			
All	46	314,973	730,143
Less than high school	48	169,724	298,108
High school	46	189,621	476,429
College	44	714,141	1,637,226
Indexation + pension-tested OAA			
All	46	330,493	770,846
Less than high school	48	169,724	298,108
High school	46	204,625	515,894
College	44	742,021	1,710,077

Table 8: Households' responses to different OAA schemes in long-run steady state (2200)

by inflating the poverty line in the base year with the average wage growth.

Overall, the increase in OAA benefits reduces the poverty rate among the elderly from 4.8% in the baseline to 4.2% and 3.9% under uniform and pension-tested OAA schemes, respectively. The largest reduction is among the lowest educated group. Notice that even though the benefit amount in both schemes is the same, the poverty rate is lower when using pension-testing. This is due to the fact that consumption tax under the pension-tested scheme is lower and the elderly can enjoy a higher after-tax consumption.

	Baseline + indexation	Indexation + uniform OAA	Indexation + pension-tested OAA
All	4.8%	4.2%	3.9%
Less than high school	16.7%	14.7%	12.9%
High school	3.2%	2.9%	2.8%
College	0.0%	0.0%	0.0%

Table 9: Poverty rate among the elderly (≥ 70) in year 2200

Welfare evaluation We use consumption equivalence to measure the ex-ante welfare gains/losses from increasing OAA benefits. Specifically, we compute the percentage of con-

sumption (Δ) a new entrant at age 25 years old in the baseline case with indexation is willing to give up in order to be as well off as if she enters into an economy with the raised OAA benefits. Formally, it is calculated from the following:[33]

$$\Delta = \left(\frac{V_{RS}(e)}{V_0(e)} \right)^{\frac{1}{\nu_e \cdot (1-\frac{1}{\gamma})}} - 1 \tag{22}$$

$V_0(e)$ and $V_{RS}(e)$ are the value function of a new entrant with an education e in the baseline with indexation and an economy with increased OAA benefit, respectively.

Table 10 presents the long-run welfare gains/losses from the two OAA reforms among people entering the economy after the year 2200. Our welfare measure captures the key trade-off of the reforms. On the one hand, the increase in consumption lowers welfare by distorting individuals' consumption and labor supply decisions.[34] On the other hand, since the rich consume more, the increased consumption tax implicitly redistributes resources from the rich to the poor. This implicit redistribution increases welfare. The first row of Table 10 shows that the latter effect is larger. The uniform OAA reform generates a large welfare gain of 1.57% in terms of consumption equivalence. In addition, when introducing the pension-testing scheme, the welfare gain goes up further to 1.63% because of its progressive benefit schedule and the lower consumption tax.

The last three rows of Table 10 report the welfare gains/losses of new entrants at age 25 years old by education. Under the uniform OAA reform, the lowest educated group benefits most from the implicit redistribution while the college-educated group bears the welfare

[33] Specifically, we derive the consumption equivalence (Δ) from:

$$\begin{aligned} V_{RS}(e) &= \mathbb{E}\left(\sum_{j=1}^{J} \beta_e^{j-1} \prod_{k=1}^{j} \xi^k \frac{\left(\left((1+\Delta) c_j \right)^{\nu_e} {l_j}^{1-\nu_e} \right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} \right) \\ &= (1+\Delta)^{\nu_e \cdot (1-\frac{1}{\gamma})} \cdot V_0(e) \end{aligned} \tag{21}$$

where c_j, l_j are optimal consumption and leisure in the baseline economy.

[34] The consumption tax increases the price of consumption relative to the price of leisure, which is equal to wage. Thus, individuals will consume less and take more leisure. However, an increase in consumption tax does not change the relative price of consumption goods between periods. So, the intertemporal decision (consumption and saving) is much less distorted.

losses: 5.5% and -1.2% in terms of consumption equivalence, respectively. When introducing the pension-testing, the lowest educated group enjoys a higher welfare gain (7.5%) from the lower consumption tax while the college-educated counterpart incurs a higher welfare loss (-2.1%) since they are now less likely to receive OAA benefits.

Figure 9 shows the ex-ante welfare gains/losses for each entering cohort during the transition periods. For all education groups, the welfare gains (losses) among the latter cohorts are higher (less) than the earlier cohorts. Since the OAA benefits are paid out as annuities and the latter cohorts tend to live longer, they value the raised OAA amount more than the earlier cohorts.

	Uniform OAA	Pension-tested OAA
Average	1.57 %	1.63 %
Less than high school	5.5 %	7.5 %
High school	1.5 %	1.4 %
College	-1.2 %	-2.1 %

Table 10: Long-run ex-ante welfare gains/losses from raising the OAA benefits to the poverty line in 2200

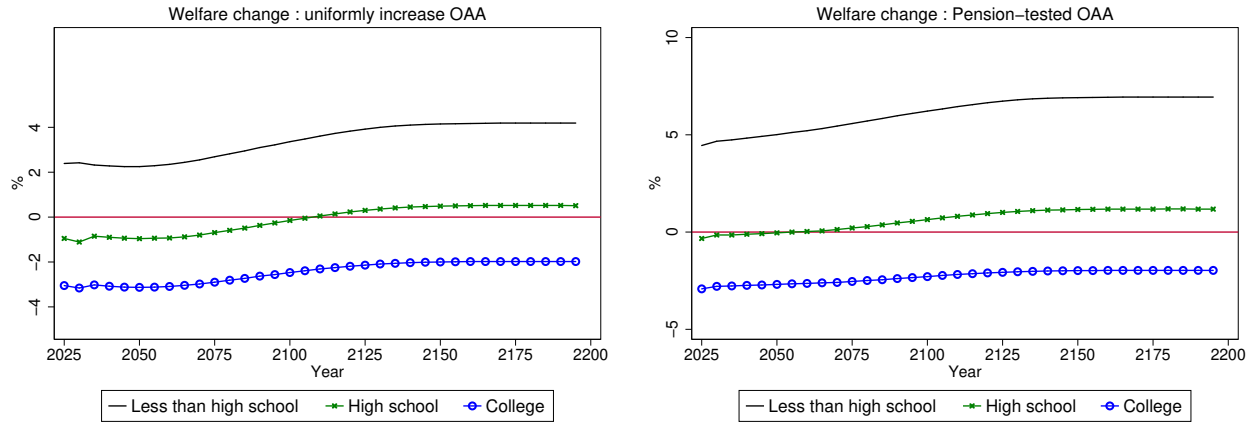


Figure 9: Ex-ante welfare gains/losses by education and birth cohort: uniform OAA benefits (left) and pension-tested OAA benefits (right)

6 Conclusion

In this paper, we discuss the challenge to provide income support for the elderly in middle-income developing countries with a large informal sector and aging population. Using Thailand as a case study, we develop an overlapping generations model featuring its formal-informal labor market structure and its two public pension programs, namely the contributory social security program and the universal basic pension income (so-called, old-age allowance or OAA). The model is calibrated to match several statistics from Thai data.

We show that if the social security program is indexed to wage growth, its balance is projected to quickly run into deficit in 2045, which is less than four decades after its launch and driven by the rapidly aging population, the late introduction of the social security program, and the annuity benefit formula which is not financially viable. To make the program financially sustainable in the long run, the contribution rate must substantially increase from the current 3% to 22.5% (or 45% in total from both employers' and employees' parts).

More importantly, we documented that the exit rate of formal workers to the informal sector is *age-dependent*, with a high exit rate among young workers. Since only people contributing longer than 15 years are eligible for SS annuity benefits, more than half (66%) of the elderly population (60 years old or above) are ineligible for SS annuity income and exposed to longevity risk even after the program is financially sustainable. Our finding shows that not only the size of the informal sector, but the dynamics between formal and informal sectors are also important in studies of social security reforms in developing countries with an informal sector.

While uniformly increasing the OAA benefits for all elderly aged 60 years old or above can better insure everyone against the longevity risk, it is costly. We illustrate that pension-tested benefits can lower the cost of uniformly increasing OAA benefits to the poverty line (3,000 THB) from 15.9% of GDP to 13.6%, and reduce the poverty rate among the elderly (70 years old or above) from 4.2% to 3.9%. In addition, since college graduates are more likely

to work and stay in the formal sector while the lower-educated group more likely works in or exits early into the informal sector, the pension-tested OAA scheme redistributes resources from people with high lifetime earnings to those with low lifetime earnings; thus, increasing the ex-ante welfare.

Overall, our results show that pension-testing effectively improves the targeting efficiency of the basic pension income program and non-trivially lowers its cost. More importantly, it is readily implementable in countries where other income sources are prone to under-reporting.

The public pension system in developing countries is an integrated system of contributory and non-contributory programs which, together, provide income support for the elderly with different working histories in formal and informal sectors. Thus, a promising research avenue to explore is a more comprehensive reform that includes all pension programs. This integrated reform can further improve efficiency and, thus, lower the overall cost of the public pension system. Specifically, in the case of Thailand, the replacement rate of SS annuity benefits is increasing in the number of contributing years. Since the number of contributing years is positively correlated with labor income, the existing redistribution within the SS program is regressive; individuals who stay long in the formal sector enjoy both high lifetime earnings and high replacement rates. This is in contrast to developed countries where the replacement rate is declining with lifetime earnings. A reform that makes the SS benefits progressive combined with an increase in pension-tested OAA benefits studied here will likely lower the cost of OAA program further.

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Appendix

A Additional background of Thai social security scheme

In Thailand, there are several welfare and public program for formal workers which are lumped together under the social security scheme and receives funding from the contributions of employees, employers, and the government. Table A.1 reports how the contributions are allocated. We explicitly incorporate only the contribution for the 2-benefit type (old-age pension and child allowance) in our studies.

	Employee	Employer	Government
Unemployment benefit	0.50%	0.50%	0.25%
4-benefit type (health, maternity, disability, death)	1.50%	1.50%	1.50%
2-benefit type (old-age pension, child allowance)	3%	3%	1%
Total	5%	5%	2.75%

Table A.1: Social Security Contribution Rates

B Supplementary for the model calibration

B.1 Labor productivity

Figure B.1 below plots the age-dependent wage profile $\lambda_j^o(e)$ for each education and sector which is estimated from the LFS while Figure B.2 compares the variance of wage shock $\left(\eta_j^o\right)$ from our estimated wage shock process and the corresponding residual from the wage regression as explained in Section 4.2.4.

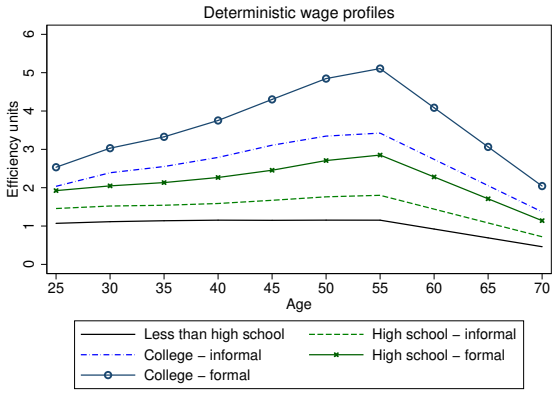
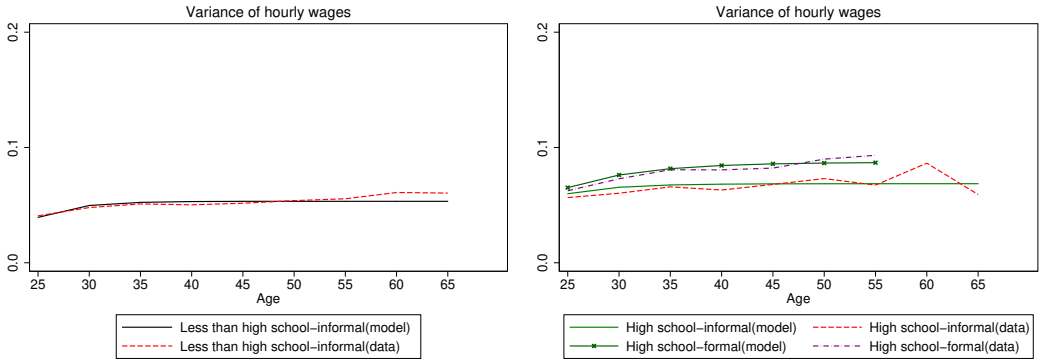
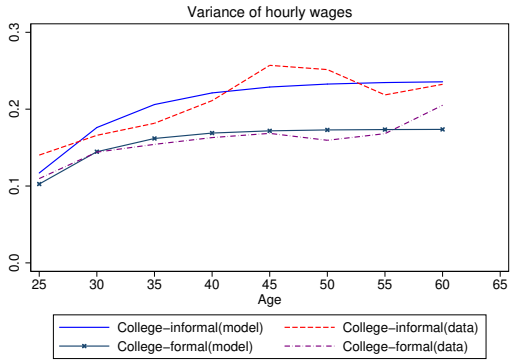


Figure B.1: Deterministic wage profile (λ_j)



(a) Less than high school group

(b) High school group



(c) College group

Figure B.2: Variance profiles of hourly wage shock: model vs data (LFS)

In the following, we report the discretized 3-state Markov process of the wage shock process $\pi_j^{\eta}(\eta_{j'}|\eta_j, o_j, o_{j'})$ as described in Section 4.2.4.

Less than high school

$$\exp(\eta) \in \{0.721, 1.000, 1.386\}$$

$$\Pi_j = \begin{pmatrix} 0.571 & 0.369 & 0.060 \\ 0.184 & 0.631 & 0.184 \\ 0.060 & 0.369 & 0.571 \end{pmatrix}$$

High school in the informal sector

$$\exp(\eta) \in \{0.690, 1.000, 1.448\}$$

$$\Pi_j = \begin{pmatrix} 0.637 & 0.322 & 0.041 \\ 0.161 & 0.678 & 0.161 \\ 0.041 & 0.322 & 0.637 \end{pmatrix}$$

High school in the formal sector

$$\exp(\eta) \in \{0.502, 1.000, 1.990\}$$

$$\Pi_j = \begin{pmatrix} 0.732 & 0.247 & 0.021 \\ 0.124 & 0.753 & 0.124 \\ 0.021 & 0.247 & 0.732 \end{pmatrix}$$

College in the informal sector

$$\exp(\eta) \in \{0.659, 1.000, 1.518\}$$

$$\Pi_j = \begin{pmatrix} 0.730 & 0.249 & 0.021 \\ 0.124 & 0.751 & 0.124 \\ 0.021 & 0.249 & 0.730 \end{pmatrix}$$

College in the formal sector

$$\exp(\eta) \in \{0.555, 1.000, 1.803\}$$

$$\Pi_j = \begin{pmatrix} 0.672 & 0.295 & 0.032 \\ 0.148 & 0.705 & 0.148 \\ 0.032 & 0.295 & 0.672 \end{pmatrix}$$

B.2 Summary of model parameters

Parameters		Values	Sources/comments
Demographics			
Survival probabilities	ξ	See 4.1	United Nations
Retirement age	J_R	See Table 1	
SS eligible age	J_{SS}	See Table 1	
Maximum age	J	99	
Aggregate wage growth	μ_w	3.16 % p.a.	Growth rate of real GDP per capita (2010-2019)
Preferences			
Discount factor (annual)	β_e	See 4.3	Target average net worth age 25-54
Taste parameter of consumption	ν_e	See 4.3	Target average working hours
Deterministic age earning profile	$\lambda_j(o,e)$	See 4.2.4	
Wage shock process	η_j^o	See 4.2.4	Labor Force Survey (LFS)
Government			
Progressive income tax	λ_1, λ_2	$-17.3, 2.1$	Revenue department
Old-age allowance (THB per month)	OAA	See Table 2	Actual rate
Government spending (% GDP)	G	15.90%	Balance the government budget in 2000
Consumption tax	τ_c	7%	Actual rate
Government contribution to SSF	τ_g	1%(1)	Actual rate
Other sources of revenue	REV_t	9% of GDP	Average value during 2000-2020
Social security			
Transition probabilities (exit formal)	π_j^o	See 4.2.2	SSO
Social security benefit	$pen(.)$	See 3.1.3	Actual SSO formula
Price variables			
Return on savings (annual)	r	4%	
Return on SS fund (annual)	r_{SSF}	2.24%	Average real returns on SSF investment(2)
Return on government debt (annual)	r_B	0.9%	Average real 10-year government bond yield(3)
SS contribution rate	τ_{ss}	3%	Actual rate
Maximum taxable earnings (per month)	$\tilde{y}_{max}$	15,000	Actual rate
Poverty line		1627 THB	NESDC value of 2000-2004

(1) of SS taxable earnings
(2) The real return on SSF is the average historical return between 2016-2020 which equals 3.61% per year, subtracted by the 10-year average rate of inflation 1.36%
(3) Average real 10-year government bond yield 2015-2020 is 2.26%

Table B.1: Parameters summary

C Social security fund: model and data (2000-2015)

To evaluate our model performance in terms of its financing projection of the SS program, Table C.1 compares our projected SS fund balance (after converted into nominal values) with the available historical data. Note that the model assumes the SS fund started with zero balance in 2005. As described in Section 2.2, the social security scheme started collecting contributions in 1998 before expanding its coverage to all registered firms in 2002. If we were to assume an actual 2005 balance of 273,730 million THB, the model's SS fund balance in 2015 would be 1.18 trillion THB, which is close to the actual SS fund balance (1.28 trillion THB).

Year	Actual	Model
2000	57,530	–
2005	273,730	0
2010	653,139	483,744
2015	1,280,147	904,811

Table C.1: Social security fund balance (millions THB, nominal value)