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Impacts of Universal Health Coverage: A Micro-founded Macroeconomic Perspective

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Abstract

This paper studies the impact of tax-financed universal health coverage schemes on macroeconomic aspects of labor supply, asset holding, inequality, and welfare, while taking into account features common to developing economies, such as informal employment and tax avoidance, by constructing a dynamic stochastic general equilibrium model with heterogeneous agents. Agents have different education levels, employment statuses, and idiosyncratic shocks. Given three tax financing options, calibration results suggest that the financing options matter for outcomes both at the aggregate and disaggregate levels. Universal health coverage, financed by labor income tax revenue, could reduce inequality due to its large redistributive role. Social welfare cannot be improved when labor decisions are endogenous and distortions are higher than the redistributive gains for all tax financing options. In the absence of labor supply choice, mild welfare gains are found.

JEL Classification: E24, E26, E62, J11, H23, H51

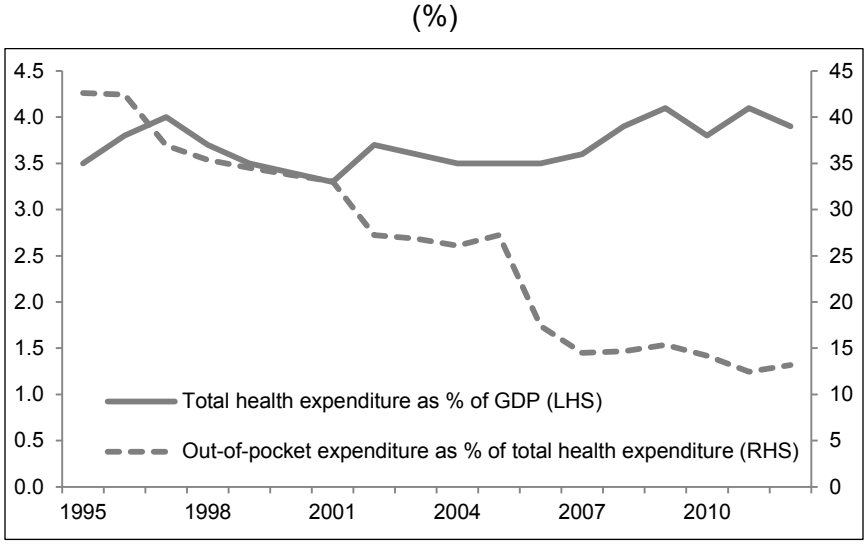
Contents

1. INTRODUCTION

In most developing countries, the goal of universal health coverage (UHC) is not easy to reach due to the fact that large, resource-poor populations have limited access to health services. [1] Given that resource-poor people cannot afford out-of-pocket health expenditures, or can only do so by sacrificing other priorities, a health financing system where people are required to pay for use directly is one of the major barriers to reaching UHC. Although cost sharing is necessary to prevent the overutilization of health services arising from the potential problem of moral hazard, universal coverage is more likely to be reached when the out-of-pocket ratio for direct payment is sufficiently low. Against this backdrop of the relationship between UHC and direct payment, a way to reach UHC is to lower out-of-pocket expenditure to such a degree that people are not likely to suffer financial hardship.[2] A cross-country estimation based on 59 countries by Xu et al. (2010) suggests that when the out-of-pocket ratio is lower than 15%–20% of total health expenditure, the chance of incurring financial catastrophe could be negligible.

For policymakers who are faced with the agenda of UHC, issues such as how to raise related revenue and effectively reduce the out-of-pocket ratio are the main concerns. Insurance and tax revenue are in practice two major approaches for health system financing, which differ by funds being pooled directly in the former and indirectly in the latter. However, due to the large presence of economic informality in developing countries (Schneider 2002), financing through compulsory wage-based health insurance contributions can only be enforced in the formal sector and is restricted in scale. Moreover, voluntary private health insurance has a limited participation rate and plays a marginal role in most developing countries (Drechsler and Jutting 2005).

Figure 1: Health Expenditure and Out-of-pocket Ratio in Thailand



GDP = gross domestic product, LHS = left-hand scale, RHS = right-hand scale.

Source: World Bank, World Development Indicators.

[1] According to the World Health Organization (2010), UHC is defined as the goal that all people have access to health services and do not suffer financial hardship in paying for them.

[2] The World Health Organization advocates that among all issues of UHC, it is most critical to develop a health financing system that can effectively remove the financial barriers to health service access.

Alternatively, UHC schemes financed by government revenue have attained universal coverage effectively in developing countries such as Brazil, Mexico, and Thailand. In the case of Thailand, a UHC scheme called the Universal Coverage Scheme (UCS), financed through general government revenue since 2002, was implemented successfully to provide more effective coverage. As a result of the scheme, by 2012, the average out-of-pocket health expenditure ratio in Thailand had declined to 13% (as shown in Figure 1) and almost 100% health protection coverage had been reached. Thailand's experience shows that reaching universal coverage financed by government revenue can be feasible.

Besides the two financing options above, a World Health Organization (2010) report discusses many other innovative methods, including foreign exchange transaction tax, bank account transaction tax, and various excise taxes. However, the applicability of some of these options has yet to be evaluated and more attention should be paid to existing tax-based financing schemes (Savedoff 2004). In addition, studies related to UHC financing have been few, and literature analyzing the impacts of UHC is even scarcer, especially regarding the effects from a macro perspective.[3]

This paper tries to fill the research gap by exploring the following questions. First, what is the impact on individuals in terms of their optimal decisions for labor supply and asset holdings? Second, what are the impacts on inequality and social welfare? Third, what are the different impacts at both the aggregate and disaggregate levels. To quantitatively answer these questions, the paper adopts a modern dynamic stochastic general equilibrium framework, which is being increasingly used for the study of social security and public finance.

In a model economy, there are heterogeneous agents who have different employment statuses over time, a government that collects revenue and spends on the provision of social security and other expenditures, and firms that employ labor and capital for producing goods in a competitive environment. While facing income and expenditure risks, individual agents of differing ages and levels of education make their decisions on labor and consumption. UHC is modelled by the lowering of the out-of-pocket ratio, since financing is one of the most important aspects. The calibrated exercise is based on the Thai economy using both micro household survey panel data and macro indicators. Micro household data from the Thai Socio-Economic Survey (SES) 2005–2007, including 6,000 households and more than 20,000 individuals, are used to estimate the value and shocks of health expenditure and transitions of employment, while the other key macro indicators are taken or estimated as targets of the benchmark model.

This study is closely related to studies on health insurance such as those by Jeske and Kitao (2009) and Hsu (2012), but differs by focusing on tax-based UHC and allowing workers to transition to different sectors, which causes efficiency and tax differences.[4] It is also related to studies of labor supply (and social security) such as Heckman (1993), Saez (2002), Imrohoroglu and Kitao (2009), and Kitao (2014). Extending from Hsu et al. (2014), this paper allows for endogenous labor decisions and a more comprehensive social security structure. The paper also targets income distributions both at the aggregate level and the disaggregate level, while recognizing the efficiency differences that arise due to differences between sectors and differing levels of education.

[3] A few studies look at the impact on labor markets from a partial equilibrium perspective, such as Aterido, Hallward-Driemeier, and Pages (2011) and Wagstaff and Manachotphong (2012).

[4] Other related literature includes Kotlikoff (1986), Huggett (1993), and Aiyagari (1994).

The paper is constructed in the following order. Section 2 introduces the model. Section 3 explains the details of calibration. Section 4 analyzes the benchmark economy and the findings based on various experiments. Finally, Section 5 gives the concluding remarks.

2. ECONOMIC ENVIRONMENT

Agents in the economy are endowed with two types of education and go through their lifecycle from young to old. When they are young, they are endowed with one unit of labor time at each period, but face unemployment risk. If they work, they are either employed in the formal sector or the informal one. All young, working agents face idiosyncratic efficiency risks that cannot be insured. In addition, both young and old agents face health expenditure risks that can only be partially insured. The government collects consumption tax, capital income tax, labor income tax, and social security contributions. Among them, the labor income tax and social security contributions are assumed to be collected only in the formal sector. The fiscal outlays of government include pension payments, public health expenditure, social assistance, and other government expenditure. This section describes features of the benchmark economy.

2.1 Demographics

The population consists of working young and retired old people. Young agents retire with probability π_o and old agents die with probability π_d in each period, and such probabilities are assumed not to vary by education level or sector. When an old agent dies in a period, a newborn young agent replaces the old at the beginning of the same period, so that the measure of the entire population remains the same.

2.2 Individuals

Each agent is endowed with one type of education that does not change over the individual's lifetime. Meanwhile, agents face the following individual shocks: employment status shocks (determining whether agents have a chance to work and, if so, in which sector), individual productivity idiosyncratic shocks, and health expenditure shocks.

2.2.1 Education

The shares of high education and low education in the population are λ and $1-\lambda$. We denote education type by e, of which the set is given by

$$e = \begin{cases} h, & \text{high education} \\ l, & \text{low education} \end{cases} \quad (1)$$

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

2.2.2 Employment Status Shock

Young agents face employment status shocks. They have a chance of either working or being unemployed. When they work, they have a chance of being either in the formal sector or the informal sector. The formal sector is defined as an economic sector in which labor income is taxed, social security contributions are collected accordingly, and related social security benefits are provided upon contribution. In contrast, the informal

sector is characterized by tax avoidance and non-participation in some social security programs. We denote employment status as j, of which the set is

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

Such status shocks evolve stochastically via N-state Markov chains, Π^e. Meanwhile, sectors are assumed to be associated with sector-specific efficiencies, ε_j, and agents' total individual labor efficiencies are affected accordingly when they transit from one sector to another.

2.2.3 Individual Productivity Shock

The individual labor efficiencies of working young agents are jointly affected by their endowed education-specific efficiencies, ϵ_e, sector-specific efficiencies related to the sector where they work, ε_j, and time-varying education-dependent idiosyncratic shocks, η_e, evolving stochastically via education-dependent Markov chains, Ψ^e, with each state value taken from given finite sets, Q^e. Therefore, the natural logarithm of total individual labor efficiency, z, is determined by

$$log(z) = log(\epsilon_e) + log(\varepsilon_j) + log(\eta_e) \quad (3)$$

As agents do not change their education type over their life cycle, ϵ_e is constant once they are endowed with one type of education. The variation of labor efficiency, therefore, comes from the transitions of employment status, ε_j, and idiosyncratic shocks, η_e.

2.2.4 Health Expenditure Shock

Regardless of the differences across education type and sector, all agents face the uncertainty of age-dependent health expenditures caused by health expenditure shocks, x^t, where

$$t = \begin{cases} y, & \text{young} \\ o, & \text{old.} \end{cases} \quad (4)$$

The health expenditure shocks, x^t, take the values from given finite sets, X^t, and evolve stochastically via Markov chains, Ω^t. The ratios of out-of-pocket health expenditure are denoted by ω^t.

2.3 Preference and Production

A utility preference function including both consumption and leisure is defined as

$$U = u(c, n) \quad (5)$$

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

Requiring both inputs of labor and capital, the production function is written as

$$Y = AF(K, L) \quad (6)$$

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 assumed to be homogenous across sectors and all markets behave competitively.

2.4 Government

2.4.1 Tax Revenue and Social Security Contribution

The government collects a consumption tax, $T_c(c)$, a capital income tax, $T_k(k)$, wage-based social security contributions, $T_{sc}(wzn)$, and a labor income tax, $T_l(y)$, where the taxable labor income, y, is the net labor income after the deduction of social security contribution, denoted by $y = wzn - T_{sc}(wzn)$. Regarding the tax revenues or social security contributions above, the corresponding rates are τ_c, τ_k, τ_l, and τ_{sc}.

In the context of the economy with an informal sector where the collection of tax is constrained by economic informality, the wage-based labor income tax, $T_l(y)$, and the social security contributions, $T_{sc}(wzn)$, are assumed to be only enforced in the formal sector.

2.4.2 Social Security Expenditure

The government provides old-age pension benefits, TR_{pb}, to entitled agents who contribute to a pension pool when they work in the formal sector. It also provides social protection, TR_c, where a minimum consumption level is guaranteed. In addition, for people who previously worked in the formal sector before encountering unemployment shocks, the government assists them with an unemployment benefit, TR_{ub}.

A contribution-based healthcare scheme is provided to workers in the formal sector. In order to reach universal health coverage, the government also runs a universal coverage scheme to lower out-of-pocket health expenditure for informal workers and non-workers (retired people) to a level comparable to the formal workers' scheme. Financed directly by the government budget, an increase of the public health expenditure $(1-\omega^y)x^y + (1-\omega^o)x^o$ lowers the private out-of-pocket ratios, facilitating easier access to health services for all people and helping to achieve universal health coverage.

2.4.3 Budget Balance

Assuming that the government balances the budget at each period, the government budget balance is denoted by

$$T_R = G, \tag{7}$$

where

$T_R = \int \{T_c(c) + T_k(k+b) + T_l(y) + T_{sc}(wzn)\} d\Phi(s) + D'$, and

$$G = \int \left\{TR_{pb} + TR_c + TR_{ub} + (1-\omega^y)x^y + (1-\omega^o)x^o\right\} d\Phi(s) + D(1+r) + G_{others}$$

should be satisfied at each and every period.

In Equation (7), the left side, T_R, is the fiscal revenue that the government collects from the entire economy, including the tax revenues and social security contributions mentioned earlier. In addition, D' is the debt issued in the current period and is part of government revenue. For the collection of capital income tax revenue, b is a lump sum transfer of accidental bequests collected from the decedent and redistributed to all survivors, which is written as follows:

$$b' = \int \pi_d k' \mathrm{d}\, \Phi(s) \tag{8}$$

As for capital, the bequest is taxed accordingly. $\Phi(s)$ is the distribution of the population over a state space s, where $s = (e, k, j, j_{-1}, z, x^t)$.

The total government fiscal outlays on the right-hand side, G, consist of the aforementioned social security payments, redemption of debt, and other government expenditure. D is the one-period debt issued in the previous period and is assumed to be fully redeemed with an interest payment at a rate of r. G_{others} is the sum of spending that includes all other government expenditure.

2.5 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, the agents' problems are written as follows:

$$V_t(s) = \begin{cases} \max\left\{E\{u(c,n) + \beta(1-\pi_o)E[V_y(s')|s] + \pi_o E[V_o(s')|s]\}\right\} & if\ t = y \\ \max\{E\{u(c,n) + \beta(1-\pi_d)E[V_o(s')|s]\}\} & if\ t = o \end{cases} \quad (9)$$

subject to

$$(1+\tau_c)c + k' = Wel + TR_{\underline{c}} \quad (10)$$

$$k' \geq 0 \quad (11)$$

where

$$Wel \equiv \begin{cases} wzn + (1 + r(1-\tau_k))k - T_{sc}(wzn) - T_l(y) - \omega^y x^y, & if\ t = y\ and\quad j = f \\ wzn + (1 + r(1-\tau_k))k - \omega^y x^y, & if\ t = y\ and\quad j = nf \\ \left(1 + r(1-\tau_k)\right)k - \omega^y x^y + \begin{cases} TR_{um} & if\ j_{-1} = f \\ 0, & otherwise \end{cases}, & if\ t = y\ and\ j = um \\ ps + \left(1 + r(1-\tau_k)\right)k - \omega^o x^o, & if\ t = o, \end{cases} \quad (12)$$

and

$$TR_c \equiv \max\{(1+\tau_c)\underline{c} - Wel, 0\} \quad (13)$$

$$TR_{um} \equiv \tau_{um} \int wzn\, d\Phi(s_e) \quad (14)$$

$$ps \equiv \tau_{ps}(\Xi) \int wzn\, d\Phi(s_e) \quad (15)$$

In the value function, Equation (9), the future value is discounted by a discount factor, β, and is a weighted average of the conditional expectations of young and old agents for the problem of young agents, where the retirement probability, π_o, serves as the weight. Regarding the problem for old agents, the future value is discounted by the discount factor after adjustment of the survival probability. Equation (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 (12), working young agents in the formal sector have labor income and accrued capital income, pay all kinds of taxes, and make social security contributions, as shown in the first row, where ω^y and x^y are the out-of-pocket expenditure ratio and the total health expenditure for young agents. The second row indicates the avoidance of labor tax and social security contributions in the informal sector, and unemployed young agents who do not have labor income and may receive unemployment benefits, depending on their previous employment status, are specified in

the third row. Finally, the fourth row defines the wealth of old agents, where ps is their pension benefit and $\omega^o x^o$ is their out-of-pocket health expenditure.

Equation (13) gives the definition of $TR_{\underline{c}}$. As shown in Equations (14) and (15), the unemployment benefit, TR_{um}, and the pension payment, ps, are percentages of the average labor income of each education group. Furthermore, as shown in Equation (15), the replacement rate, $\tau_{ps}(\Xi)$, is a function of the contribution time, Ξ.

2.6 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 either high or low education, in the formal or informal sector respectively, a set of prices $\{w, r\}$ determined by the aggregate capital per capita, K, and the 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 the population over the state space $\Phi(s)$ which is characterized by

(i) shares of the population differing by education, which are λ and $1-\lambda$;

(ii) a retirement probability, π_o, and a death probability, π_d;

(iii) an individual efficiency, z, caused by education efficiencies, ε_e, sectoral efficiencies, ε_j, and idiosyncratic productivity shocks, η_e, with values from Q^e evolved with transition probability matrices Ψ^e; and

(iv) health expenditure shocks, x^t, with values from X^t evolved with transition probability matrices Ω^t,

such that

(i) agents with high and low education, from the formal and informal sectors, and the unemployed, at young and old ages, solve their respective individual constrained maximization problems;

(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 (7);

(v) both the 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 the population with high and low education in terms of asset holdings and labor supply.

3. CALIBRATION

Function forms, blocks of parameters, and key features of the model are presented in this section. The function forms include the household utility, firm production, worker efficiency, and pension benefit replacement rate. Utilizing panel data from the Thai SES 2005–2007 and various other sources, this section introduces the details of referred and estimated parameters used in the model, while pointing out other parameters for calibration targets that are adopted in the benchmark economy.

3.1 Preference and Production

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

$$u(c,n) = \frac{[c^{\phi}(1-n)^{1-\phi}]^{(1-\mu)}}{1-\mu} \quad (16)$$

where ϕ determines the choice between consumption and leisure. μ determines the inter-temporal elasticity of substitution of the consumption-leisure bundle and is related to the risk aversion. Such risk aversion, γ, as derived by Healthcote et al. (2008), is given by

$$\gamma = 1 - \phi + \phi\mu \quad (17)$$

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

$$Y = AK^{\alpha}L^{1-\alpha}. \quad (18)$$

The two factor prices derived from the firm optimization problem are as follows:

$$w = (1-\alpha)AK^{\alpha}L^{-\alpha} \quad (19)$$

$$r = \alpha AK^{\alpha-1}L^{(1-\alpha)} - \delta \quad (20)$$

where the capital depreciates at a rate of δ in each period and its income share is indicated by α.

The model period is annual and the discount factor, β, in the agents' problem Equation (9) is adjusted to match the capital output ratio of 3.4. The utility parameter, ϕ, targets the social average working hours of 1/3, and μ is set to target a medium value of risk aversion of 2. In the production function, the total factor productivity, A, is normalized to be unitary. The capital income share, α, follows the estimated value of 0.3144 in Ahuja et al. (2004) and the annual capital depreciation rate, δ, is estimated from the data at 5.2%.

3.2 Demographics and Education

The retirement probability, π_o, is set at a value indicating that young agents are expected to work for 45 years, and the death probability, π_d, is chosen so that the dependency ratio of old over young people is 13%. Tertiary education (including vocation school) and above is defined as "high education" while the secondary school and below are defined as "low education", accounting for 25% and 75% of workforce, respectively, estimated from the data. Such shares are denoted by λ and $1-\lambda$ in the model.

The shares of the working population in the informal sector and the formal sector are jointly determined by the transition matrices and the shares of the population with different levels of education. We assume there is a transitory bias as a result of the short period of the panel, of which the parameter is used to target the labor force share, given that 62% of them work in the informal sector. Further, we calibrate the permanent efficiency gap parameters, ϵ_e, as result of the education difference in Equation (3) by targeting the Gini coefficient of 0.394 (the Gini coefficient of Thailand in 2010 according to World Bank estimates). As the efficiencies ϵ_e (ϵ_h and ϵ_l) are in relative terms, the former is normalized and the latter is calibrated accordingly.

3.3 Employment and Sector Transition

Agents are subject to employment shocks that cause working agents to be in the formal sector, the informal sector, or unemployed. Markov-chain transition probability matrices are constructed from the SES data with three employment statuses and corresponding transition probabilities, shown in Table 1.

The transitory sector efficiencies ε_j (ε_f and ε_{nf} ; the value is zero when unemployed) are used to target the sector's shares of output, where the output of the informal sector accounts for 44%.[5] In the same fashion as ϵ_e, we only calibrate ε_{nf} while normalizing ε_f.

Table 1: Transition Probabilities of Employment Status

High Education			
	Formal	Informal	Unemployed
Formal	0.7058	0.2652	0.0290
Informal	0.7356	0.2364	0.0280
Unemployed	0.6940	0.2715	0.0345
Low Education			
	Formal	Informal	Unemployed
Formal	0.3678	0.6065	0.0257
Informal	0.2119	0.7589	0.0292
Unemployed	0.3294	0.6706	0.0000

Source: Thailand SES; authors' calculations, transitory bias adjusted.

3.4 Individual Productivity, Sector, and Education Efficiency

For Equation (3), of which the calibration targets ϵ_e and ε_j have been described in Sections 3.2 and 3.3, the remaining idiosyncratic shock, η_e, is assumed to follow an AR(1) process written as

$$\ln\eta_e = \rho_e \ln\eta_e{}' + \zeta_e \tag{21}$$

where $\zeta_e \sim N(0, \sigma_e^2)$.

The persistence parameters of AR (1) ρ_e are assumed to be the same across education and the estimates of Hubbard et al. (1995) of 0.95 for both high and low education groups are used.[6] Therefore, we calibrate two values of the standard error σ_e (σ_h and σ_l respectively) by targeting Gini coefficients of wage income in each education group. Estimated from the same data, the Gini coefficients of wage income for groups with high and low levels of education are 0.434 and 0.381 respectively.

As labor supply is endogenous in the model, the corresponding wage income inequality is jointly determined by endogenous labor hours, the product of total individual efficiency, $\varepsilon_e \varepsilon_j \eta_e$, the social wage rate, and labor hours. The AR(1) process of Equation (21) is then approximated by a five-state Markov chain using the method of Tauchen (1986).

[5] As estimated in NESDB and NSO (2004).

[6] As both ρ_e and ζ_e can be used to target the within-group Gini coefficient, the alternative setting of calibrating ρ_e while standardizing ζ_e does not affect the results. The estimation of persistence would only be possible for panel data with a longer time horizon..

3.5 Health Expenditure Shocks

To parameterize health expenditure shocks for young and old agents, Hsu et al. (2014) calibrated directly from the SES panel data following the method of Jeske and Kitao (2009). Each process is simplified with only two states, including "low" and "high" for the lower 95% and top 5% of the health expenditure distribution. The health expenditure for young agents X^y and old agents X^o is stated relative to the average social wage, and evolves via the transition probabilities Ω^y and Ω^o, respectively. We follow the same method and refer to the values estimated by Hsu et al. (2014).

3.6 Social Security System

The Thai social security system includes old-age pension, social insurance, unemployment, and health coverage schemes. This subsection elaborates on such social security tiers.

Unemployment benefit. Unemployed young agents are entitled to unemployment benefits if they worked in the formal sector in the period before becoming unemployed. In practice, an unemployed person receives 50% of his or her average salary over the past 5 years for 6 months.[7] Given the annual frequency of the model, the unemployment benefit ratio, τ_{um}, is set at 25% of the average labor income during the first period of unemployment and the agent does not receive further benefits if the unemployment status carries on after the first period.

Social insurance. The government provides social insurance for minimum consumption, which agents in the economy can receive if their own net wealth is below a predetermined level. The amount of consumption subsidy, the difference between minimum consumption and net wealth, is estimated from the data at 8.45% in terms of the social average wage in the model.

Old-age pension. In addition, the workers who have contributed to the social security pool while working in the formal sector are also entitled to old-age pension benefits once they are retired. The pension benefit is a percentage, τ_{ps}, of the education-dependent average labor income of the last 5 years.[8] The formula of the replacement rate in Thailand, τ_{ps}, is as follows (Pfau and Atisophon 2009):

$$\tau_{ps}(\Xi) = \frac{1.5\Xi - 2.5}{100} \tag{22}$$

where Ξ represents the number of years of contributions to the pension system.

Agents are assumed to contribute to the pay-as-you-go old-age pension system when they are in the formal sector. As the shock of employment is transitory, all agents work in the formal sector for some time, either longer or shorter. Suggested by the stationary values of the transition matrix for employment of Table 1, a worker with high education has a higher probability to work in the formal sector. As a result, given that the expected working years of young agents are the same, the value of Ξ is higher for agents with high education compared with low education.

[7] To avoid the exponential computational cost to track the five-period history, instead of calculating the 5-year average labor income explicitly, we approximate it by the education-dependent cross-sectional average value.

[8] The value is approximated by the cross-section average due to the same reason as the calculation of the unemployment benefit.

Health care schemes. Before the implementation of the UCS, social security participation was limited to workers in the formal sector based on a contribution-benefit principle. With the implementation of the UCS financed by general tax revenue, workers in the informal sector and all retirees, who were not entitled otherwise, could be covered with a lower out-of-pocket ratio. The aggregate flat out-of-pocket ratio is used for the approximation of actual ratios. The ratios of out-of-pocket health expenditure for the young generation and the old generation, ω^t, as a percentage of total expenditure on health, are set at a uniform rate of 14% after the implementation of UCS. Prior to the UCS, the ratio for the formal workers was the same as afterward, while the ratio was set at 37% for the previously less insured group. Total health expenditure is 4% of GDP.

Social security contributions and others. The contribution rate, τ_{sc}, is 10%, the sum of contributions from employers and employees in the economy. The model tries to capture those pillar schemes while simplifying the existing social security system in the Thai economy. The simplifications include the following categories. First, some features of benefits calculations have been deliberately left out, such as the minimum and cap of benefit. Second, other tiers of social security, such as maternity and work injury, are also not included in the model since they play a relatively minor role. Finally, other secondary pension schemes are also not part of the model.

3.7 Government Fiscal Revenue and Expenditure

Government revenue consists of consumption tax, capital income tax, labor income tax, and social security contributions. Following Diaz-Gimenez and Diaz-Saavedra (2009), we calibrate three tax rates, including τ_c, τ_l, and τ_k, by targeting the shares of the corresponding tax revenues, in the percentages of GDP. In addition, social security contributions paid by workers in the formal sector are collected by the government as revenue, of which the rate is denoted by τ_{sc}.

Government fiscal outlays include all kinds of social security expenditure, interest payment, and government consumption. The government issues bonds, which are assumed to be held only for one period, replacing the existing debt while keeping the debt-to-GDP ratio, D/Y, constant. Given such a simplification, only interest payments occur. In the benchmark economy, government consumption, G, is endogenously determined to balance the government budget. Social security expenditures such as old-age pension, unemployed benefit, social assistance, and public health expenditure are determined by the policy choices of τ_{um},$\tau_{ps(\Xi)}$, ω^t, $\tau_{\underline{c}}$ and other endogenous variables jointly.

The details of both the estimated parameters and calibration targets are included in Appendix A for further reference. We conclude this section by summarizing the parameters of the values to be calibrated in the following section. Such parameters consist of the discount factor, β, the utility parameters, ϕ and μ, the demographic parameters, π_o and π_d, the education and sector specific efficiency parameters, ϵ_e and ϵ_j, the standard deviations of idiosyncratic shocks, σ_e, and the tax rates, τ_c, τ_l and τ_k. In addition, $\tau_{ps(\Xi)}$ is determined by Ξ, which depends on the Markov-chain stationary distribution of the employment transition matrices.

4. ANALYSIS

In this section, the constructed benchmark economy is described particularly with comparison of actual benchmark values and targeted values. The analyses focus on the steady-state equilibrium. Firstly, a benchmark economy with UCS is calibrated with key targets being matched to the data of the Thai economy, assuming government consumption to balance the government budget. All the non-ratio values are in real terms, instead of nominal ones. The target values have been chosen based on the average values after 2007, which is the period after full implementation of UCS.

To investigate the effects of UCS, this paper conducts simulations of removing UCS, in which the out-of-pocket ratio of workers in the informal sector and all old people is raised back to the pre-UCS level. The results under different tax financing options are compared with the benchmark economy, including the impacts on various dimensions such as labor supply, asset holdings, social welfare, and inequality. The computation procedure is enclosed in Appendix C.

4.1 Benchmark Economy

Table 2 shows the key features of such a benchmark economy, with closely matching calibration targets representing various key features of the Thai economy. For instance, the capital output ratio and health expenditure output ratio are 3.4042 and 3.99%, respectively, given the targets of 3.4 and 4.0%. The Gini coefficients of the benchmark economy are only slightly higher than the calibration targets, at 0.4371, 0.3832, and 0.3965 compared with 0.4340, 0.3810, and 0.394 for the within group and economy-wide Gini coefficients. The details of such calibration targets are enclosed in Appendix A.

Table 2: Key Economic Features of the Benchmark Economy

Name	Calibration Target	Benchmark Value
Capital output ratio	3.4000	3.4042
Total health expenditure output ratio	4.00%	3.99%
Risk aversion of utility function	2.0000	2.0000
Aggregate labor hours per worker	1/3	0.3344
Working years	45	45
Old-age dependency ratio	13%	13%
Informal sector size (% of work force)	62%	62%
Informal sector output (% of total output)	44.00%	44.90%
Gini coefficient for labor income (high education)	0.4340	0.4371
Gini coefficient for labor income (low education)	0.3810	0.3832
Gini coefficient for income (social average)	0.3940	0.3965
Labor income tax (% of GDP)	2.20%	2.18%
Capital tax (% of GDP)	5.40%	5.47%
Consumption tax (% of GDP)	10.80%	10.79%

GDP = gross domestic product.

Source: Ministry of Finance, Thailand; NESDB, Thailand; World Bank; United Nations; authors' calculations.

Parameters of the benchmark economy are included in Table 3 as an overview. In addition to the parameters described in the earlier section, the calibrated values of the remaining parameters are set as follows. β is 0.9040 as a result of calibrating the capital output ratio of 3.4000. μ and ϕ are given by 3.5510 and 0.3920 for labor hours and risk aversion. π_o and π_d are set at 0.2220 and 0.1790, for which young agents work for 45 years on average and the old-age dependency ratio is determined at 13%. Given the values of 0.7273 and 0.7000, the education and sector-specific efficiencies, ϵ_l and ϵ_{nf}, could help to target the economy-wide Gini coefficient of 0.3940 and the output share of the informal sector of 44.00%, respectively. Finally the tax rates, τ_c, τ_l, and τ_k, which are 16%, 6.4%, and 35%, are also calibrated to match the tax revenue shares of 2.2%, 5.4%, and 10.8%, accordingly.

Table 3: Parameters of the Benchmark Economy

Parameter	Value	Description
Households		
β	0.9040	Discount factor
μ	3.5510	Utility parameter
ϕ	0.3920	Consumption-leisure parameter
π_o	0.2220	Retirement probability
π_d	0.1709	Death probability
ω^t	0.1400	Out-of-pocket ratio
λ	0.2500	Share of high education group
ϵ_h	1.0000	Education-specific efficiency (high education), normalized
ϵ_l	0.7273	Education-specific efficiency (low education)
ρ_e	0.9500	AR(1) persistence (Hubbard et al. 1995)
σ_h	0.2230	AR(1) standard deviation (high education)
σ_l	0.1790	AR(1) standard deviation (low education)
Firms		
α	0.3144	Capital income share (Ahuja et al. 2004)
δ	0.0520	Depreciation rate
A	1.0000	Total factor productivity
ε_f	1.0000	Sector-specific efficiency (formal sector), normalized
ε_{nf}	0.7000	Sector-specific efficiency (informal sector)
Government		
τ_c	0.1600	Consumption tax rate
τ_l	0.0640	Labor income tax rate
τ_k	0.3500	Corporate income tax rate
τ_{sc}	0.1000	Social security contribution rate
τ_{um}	0.2500	Unemployment benefit
$\tau_{\underline{c}}$	0.0845	Minimum consumption transfer of social average wage
τ_{ps}	Eq. (22)	Pension benefit replacement rate
D/Y	0.4300	Public debt ratio

Source: Authors.

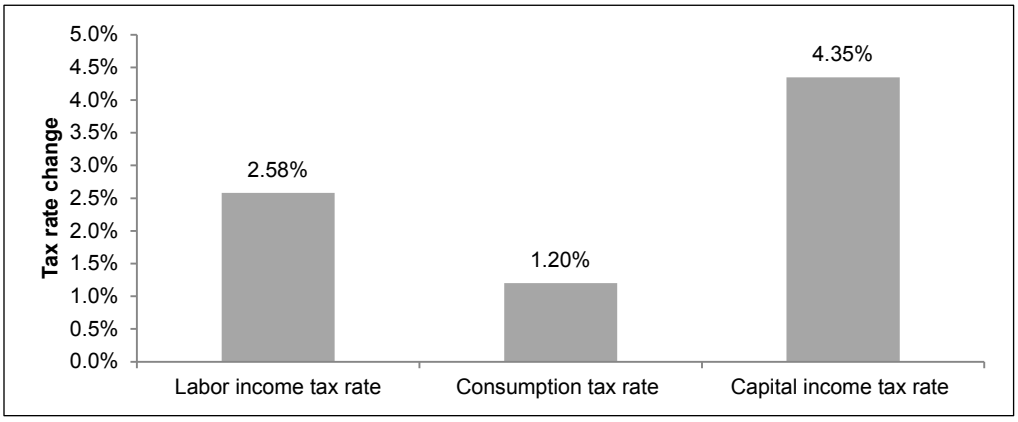
The benchmark model is closed by choosing government consumption to be endogenously determined. With government consumption at 14.01% of GDP, the government balances the budget accounting for 22.22% of GDP. The endogenous interest rate is 4.03% and the wage rate is 1.2027, serving as the factor prices for capital and labor. More details of the benchmark economy can be found in Column (1) of Appendix B, Table B1.

4.2 Tax-based Financing Options

In a real-world economy, general revenue instead of certain ear-marked financial resources is often used to finance the increment of public health expenditure arising from a UHC scheme. However, from a policy-making perspective, it might be more relevant to examine the effects given a specific financing option. In the model economy described above where the government revenue comes from various sources such as labor income tax, consumption tax, and capital income tax, we examine each of them separately.

The benchmark economy in the earlier subsection implements a tax-financed UHC scheme through which the informal and old-age agents can access healthcare with a lower out-of-pocket ratio, financed by government revenue. In this subsection, through counterfactual experiments of removing the coverage scheme, three corresponding economies derived from the benchmark are constructed in order to examine different financing scenarios.[9]

Figure 2: Financing Cost of Universal Health Coverage



Source: Authors.

When the labor income tax is assumed to finance the expenditure in a UHC economy, counterfactually, the labor income tax rate falls from 6.4% to 3.82% if no such coverage scheme is implemented.[10] If the consumption tax is assumed to finance the scheme, the financial cost is more equally shared across different social groups. Thanks to a larger tax base, the change of the consumption tax rate is less, from 16% to 14.8%, with the removal of the scheme. Finally, removal of the health coverage scheme makes the

[9] Social security contribution is equivalent to labor income tax for its tax effect, and the debt–GDP ratio is assumed to be constant, which prevents the government from raising revenue through issuing additional debt. Accordingly, we do not give further analysis for these two options.

[10] As the effect of general equilibrium influences the levels of health expenditure and government consumption in the very short run, we fix both expenditures at the values instead of ratios at the alternative economies to prevent such short-run adjustment.

capital income tax rate fall from 35% to 30.65% if the capital income tax is assumed for the purpose of financing (the details of these economies are shown in Appendix B, Table B1, columns (2)–(4)).

In other words, given the incumbent tax structure, increasing the labor income tax rate for formal workers by 2.58% (the tax rate difference with and without the universal coverage scheme), or consumption tax by 1.2%, or capital income by 4.35% is required to finance the health coverage scheme in order for the government to balance its budget, as shown in Figure 2.

4.3 Labor Supply and Asset Holding

To meet the financing needs of the UHC scheme, three taxes can be chosen to balance the government budget, as mentioned above. However, their effects can differ at both the macro and individual levels through different transmission channels. We solve the model numerically and track the decision rules and distributions, which enables us to examine an individual agent's behavior in terms of consumption, labor, and asset holdings at each state space. For simplicity of expression, this section describes the patterns of labor supply and asset holdings after grouping individuals according to their education type and sector status. On top of that, the macro-aggregated values are also examined.

Labor supply. In the absence of a universal coverage scheme, a large portion of the population, including informal workers and elderly people, need to self-finance higher out-of-pocket health expenditures. Therefore, precautionary saving against larger expenditure shocks comes into play, which they take into account in their consumer–leisure decisions.

In the benchmark economy where such a coverage scheme is provided, in contrast, we find a UHC economy could discourage labor supply at the aggregate level when it is financed by labor income tax and consumption tax, but encourages labor supply when it is financed by capital income tax. As shown in Table 4, the negative impact of labor income tax financing is similar to, but slightly less than, consumption tax (–0.51% compared with –0.60%), taking into account the shares of the working population in the formal and informal sectors for different education groups. Capital income tax, however, has a positive impact by increasing the labor supply, with a relatively small 0.12% increase in aggregation.

At the disaggregate level, the results are consistent with the literature that labor income tax has the highest distortion for the labor supply. We find that in the formal sector, where the labor income tax is enforced, labor supply is discouraged more compared with the less-distortive consumption tax. Agents with low education are especially less willing to work, at a reduction of 2.81% compared with 0.42% when the consumption tax is used to finance the scheme.

It is worth noting that for the case of labor income tax financing, agents in the informal sector, in contrast, increase their supply of labor. Especially for agents with high education, their labor supply increases by 3.48%. Given that employment shocks are transitory, the forward-looking rational agents could take advantage of not being taxed when they work in the informal sector, foreseeing that they have to bear an increased labor income tax rate in the formal sector. We do not observe such a pattern when consumption tax or capital income tax is used.

Table 4: Labor Supply Changes of Tax-financed Universal Health Coverage

	Labor Income Tax	Consumption Tax	Capital Income Tax
All	-0.51%	-0.60%	0.12%
High education	-0.45%	-0.51%	0.15%
Formal	-1.55%	-0.48%	0.14%
Informal	3.48%	-0.73%	0.11%
Low education	-0.51%	-0.60%	0.15%
Formal	-2.81%	-0.42%	0.15%
Informal	0.58%	-0.68%	0.16%

Source: Authors.

From the findings above, we observe diverse impacts on the labor supply both at the aggregate and disaggregate levels from these tax options. At the micro level for working agents, their labor supplies are negatively related to asset holdings and positively related to productivity, and respond differently to various taxes and factor prices.

Table 5: Asset Holding Changes by Tax-financing Option

	Labor Income Tax	Consumption Tax	Capital Income Tax
All	-4.50%	-3.65%	-3.11%
High education	-2.19%	-0.06%	0.15%
Formal	-2.39%	0.01%	0.23%
Informal	-1.11%	0.24%	0.46%
Unemployed[a]	-1.93%	0.34%	0.51%
Unemployed[b]	-0.59%	0.69%	0.81%
Old age	-4.28%	-2.27%	-2.29%
Low education	-5.60%	-5.38%	-4.67%
Formal	-6.42%	-5.12%	-4.44%
Informal	-5.09%	-5.24%	-4.52%
Unemployed[a]	-6.70%	-5.37%	-4.71%
Unemployed[b]	-5.45%	-5.85%	-5.13%
Old age	-7.44%	-7.55%	-6.87%

[1] Unemployed from the formal sector.

[2] Unemployed from the informal sector.

Source: Authors.

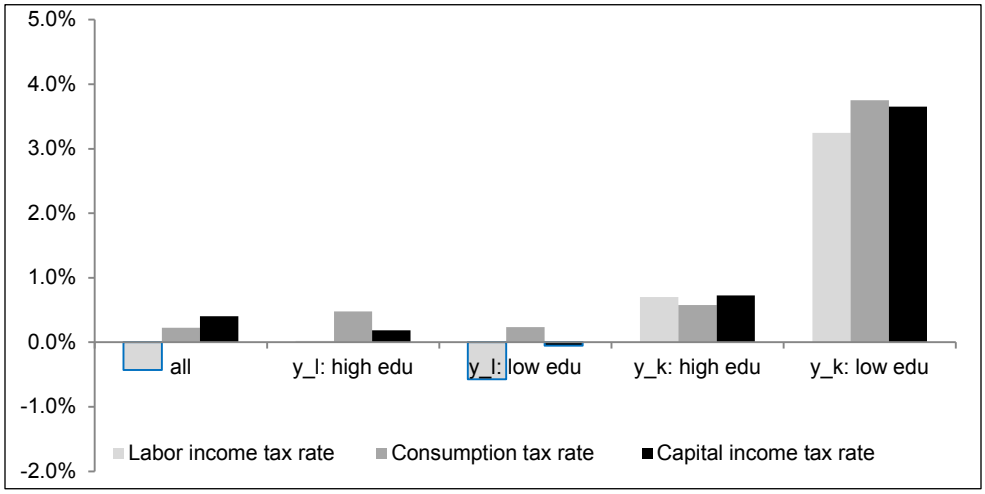
Asset holdings. The changes of asset holdings turn out to be more profound than the changes of labor supply with a couple of distinctive patterns being observed in the following. First, at the aggregate level, all financing options lead to lower asset holdings since the provision of universal coverage dampens the need for precautionary saving in the social average. Second, the old generation decreases assets under all financing options and the size of the reduction is greater than for the young generation. Third, the financing option of labor income tax causes the young agents with both high and low education to hold fewer assets, while only young agents with low education reduce assets when the other two financing options apply.

Output. Social security schemes such as a UHC scheme financed by a certain type of tax revenue could affect output through a few transmission channels. First, in a partial equilibrium, setting holding tax constant, better social security is likely to discourage both labor supply and saving. Second, better insurance against expenditure shocks helps agents smooth their consumption more efficiently. Third, when sources of financing are taken into account, rising tax rates could affect individuals' decisions as well. Finally, on top of these channels, the changes of wage rate and interest rate due to general equilibrium effects influence behavior as well. As a consequence of all the factors above, diverse impacts of labor supply and asset holding responding to different tax options, as shown in Table 4 and 5, lead to changes of production, which is a function of labor and capital. Financing UHC with all three tax options results in a negative impact on output largely due to a declining aggregate capital. In comparison, among these three, capital tax could be preferred to the other two taxes, given an increase of labor supply and a lesser reduction of capital.

4.4 Income Distribution

In terms of impacts on income distribution, the three tax options to finance UHC also bear different implications. Regarding the impact on (total) income inequality measured by the Gini coefficient, the labor income tax could reduce the income Gini coefficient by 0.43%, as shown in the first column of Figure 3. In contrast, the consumption tax increases the Gini coefficient by 0.23% and capital income tax by 0.40%. Enforced in the formal sector where workers have higher incomes on average, the labor income tax has a larger redistributive effect to reduce inequality economy-wide, compared with the other options.

Figure 3: Income Gini Coefficient Changes by Tax-financing Option



y_l = labor income; y_k = capital income.

Source: Authors.

As there are two kinds of income—capital income for all agents who hold assets and labor income for agents who work—we examine both the Gini coefficients of capital income and labor income for the respective groups. The second to fourth columns of Figure 3 plot the changes in the Gini coefficients for labor income and capital income (for details, see Appendix B, Table B1).

Regarding the within-group changes of inequality, for all three tax options, the increasing tax rate leads to a higher Gini coefficient of the high education group's labor income and both groups' capital incomes. There is a negative impact on the labor income Gini for the financing cases of labor income tax and capital income tax, applying only to the low-education group with decreases of 0.57% and 0.05%, respectively. The most pronounced increases of the within-group Gini are in the capital income Gini of the low-education group, ranging from 3.24% to 3.75% depending on the tax option. Such within-group variation of the Gini coefficient is the consequence of individuals' decisions, as mentioned in Section 4.3, where each individual agent within the group re-makes optimal decisions of work time and savings under the new circumstances of health expenditure coverage and tax burden.

In this subsection, we examine the tax-financed UHC's impacts on the income distributions evaluated by the Gini coefficients, including income economy-wide and group-based component incomes. Our experiments suggest that the labor income tax could reduce inequality while the capital income tax could increase it. At the disaggregate component income level, capital income inequality increases for all three cases.

4.5 Welfare Comparison of Financing Options

In this section, we further examine the impact on welfare measured by consumption-equivalent variation (CEV) with the measure ζ obtained by

$$\zeta = \frac{\int V^{alt}(s)d\Phi(s)^{\frac{1}{\phi(1-\mu)}}}{\int V^{bm}(s)d\Phi(s)} - 1 \quad (24)$$

where $V^{alt}(s)$ and V^{bm} are the value functions of agents in an alternative economy and the benchmark economy. $\int V^{i}(s)d\Phi(s)$ describes the average expected lifetime values of all agents in the economy, i, where alt is the alternative economy and bm is the benchmark economy.[11]

We would like to examine first of all whether UHC could bring better welfare or not, given different financing options; and secondly, determine which tax financing is better among UHC economies. To answer the first question, we compare the non-UHC economies based on the assumptions of different financing options with the benchmark economy. The results suggest that an economy without UHC could have high welfare with gains from 1.17% to 1.43% depending on the financing options for the UHC economy. In other words, UHC economies are worse-off in term of welfare change (see Appendix B, Table B3 for more details).

The effects on welfare could be attributed to both the level change and the distribution change of lifetime utility, which are determined by consumption and leisure. In a UHC economy, agents might mostly benefit from a higher level of leisure but might also have to accept a lower level of output (and consumption) on average. A negative impact on welfare could result when the total gain of the beneficiary is less than the total loss of the disadvantageous group, taking such individual level effects and social distribution effects into account.

[11] See Lucas (1987), Heathcote et al. (2013), and Hsu and Yang (2013) for details related to the derivation of Equation (24).

To answer the second question, we construct two more economies financed by consumption tax and capital income tax, respectively.[12] At the economy-wide level, both the consumption tax and the capital income tax are preferred to labor income tax with positive values of CEV at 0.14% and 0.15%, respectively. As shown in Table 6, such CEV gains are contributed by the more productive high-education group with substantial 1.09% and 1.19% changes, outweighing the losses of the low-education group of 0.18% and 0.20% with a larger population size, for the cases of the consumption tax financing and the capital income tax financing, respectively. The high-education young generation also prefers the capital income tax to the labor income tax, while the low-education young generation prefers the opposite.

Table 6: Welfare Consumption-equivalent Variation Compared with Labor Income Tax Financing

Group	Financed by Consumption Tax	Financed by Capital Income Tax
CEV: All	0.14%	0.15%
CEV: High education	1.09%	1.19%
Young generation	1.12%	1.19%
Old generation	0.36%	1.39%
CEV: Low education	-0.18%	-0.20%
Young generation	-0.21%	-0.26%
Old generation	0.28%	0.70%

CEV = consumption-equivalent variation.

Source: Authors.

The old generation gains from the alternative economies with either a higher consumption tax or a higher capital income tax, compared with the economy with a higher labor income tax. Although old people have to be taxed more in the two alternative economies compared with the benchmark economy, where the higher labor income tax rate does not apply to them, they still have the welfare gain in the higher tax economies. Such gains are largely due to the fact that they rely on asset income and pension benefits for living, which depend on factor prices and output. The total effects of such factor prices and output are more favorable to the old people in the alternative economies.

The findings above suggest that there are differing welfare implications for people with different productivities and ages. While the young people with high productivity prefer the capital income tax to the labor income tax, the young people with low productivity favor the opposite. Old people are similar to the highly productive young people. So, given the population structure, highly productive young people and old people can gain more in total than the total loss of the low-productivity young people, and the capital income tax, closely followed by the consumption tax, is better than the labor income tax in terms of the CEV welfare change.

Comparing Table 6 with the results of Hsu et al. (2014), where labor supply is exogenous, welfare changes at the group level show a similar sign mostly while differing in size when labor is endogenously determined. In cases of consumption tax financing or capital income tax financing, the high-education group is much better-off compared with

[12] An economy without UHC is constructed as shown in Appendix B, Table B1, Column (2), assuming labor income is used for financing in the benchmark. Based on this, an economy with UHC financed by consumption tax is constructed as shown in Column (5) and an economy with UHC financed by capital income tax is shown in Column (6), Table B1.

the case of labor income financing, while the low-education group is less worse off. Even with a much smaller share of the population, the total gain of the high-education group outweighs the loss of the low-education group and results in a net gain for the whole economy.

5. DISCUSSION

The adjustments of the labor supply from young working agents have acted as an important channel to buffer against shocks and policy changes, including changes to health coverage and the corresponding tax rate changes. If the labor supply is exogenous, the impacts on income distribution and social welfare can be different without such additional channels for individual optimization.

The impact on income distribution can be dampened without labor supply adjustment. According to our analysis, different UHC financing schemes affect the capital income distribution and total income distribution. However, while the signs remain the same, the impacts are smaller in magnitude than for the case of endogenous labor. Meanwhile, the labor distortions of tax can be reduced substantially without labor adjustment. The welfare impact on young agents with high education decreases, while the welfare impact on old agents with high education increases. The welfare impact turns out to be positive for young and old agents with low education and in aggregation the social CEV suggests a net welfare gain in the range of 0.21%–0.27%. Therefore, under these circumstances, the characteristics of the labor market, such as the labor adjustment of different working groups, could be the key determinants for the outcome of social welfare (see more details in Appendix D).

We also examined the sensitivities of education-specific and sector-specific efficiency parameters. When either efficiency difference is smaller, the Gini coefficient of total income equality also becomes smaller. If there is no difference in sector efficiency, the UHC economy financed by labor income tax cannot reduce inequality. Given the lower redistribution when efficiency is equalized across education or across sectors, the welfare loss to finance a UHC economy could be larger since the gain from redistribution to offset the loss of distortion when labor is endogenous is less.

6. CONCLUSION

In this paper, 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 is not negligible. Meanwhile, thanks to the bottom-up approach linking individual behavior to the macro landscape, we allow individuals to make decisions given factor prices, while their collective behavior also determines factor prices. In addition, linkages between social security expenditure and financing sources are also modelled explicitly.

In such an economy where heterogeneous agents differ by ability, luck, individual work effort, and expenditure shocks, and face different levels of tax obligation and social security protection, we examined the impacts of UHC at both the aggregate and disaggregate levels, on various economic fronts such as labor, capital, output, income distribution, and social welfare. We find that the behavior of agents differs in terms of labor supply, asset holdings, and consumption, caused by permanent and transitory productivity shocks.

Regarding the impacts on income distribution and welfare, among three tax financing options for UHC, labor income tax financed UHC could mitigate income inequality due to its large redistributive effect. However, all tax-financed UHC schemes failed to improve social welfare when labor is assumed to be endogenous and the distortion of labor supply decision could be relatively high. In the absence of such choice of labor supply, mild welfare gains could be witnessed for such tax-financed UHC schemes.

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APPENDIX A: CALIBRATION PROCESS

A1. Employment Transition

We use the SES data to construct the transitions for the employment and health expenditure shocks. The variable "a_11" is used to distinguish the work force from among all the samples and the variable"f5_1" is used to identify workers from the formal and informal sectors. Among the groups, the "employer" and "private company employee" groups are the ones where it is difficult to tell whether workers are from the formal or informal sector. The employer samples are not included since the model is a competitive model with no additional capital rent left over for employers. Second, when a worker is private company employed, the additional information about type of wage "f9_1" is used to serve as a criterion to differentiate workers from one sector to the other. The workforce in the formal sector consists of people working in government, state enterprises, and private companies with regular monthly payment; the workforce of informal sector consists of people who are self-employed without employees, working without paying for a household business, and working in private companies without regular monthly payment. Such a strategy of differentiating sectors can also be found in Wagstaff and Manachotphong (2012). We assume there is a transition bias estimated from the data and calibrate a bias parameter, ξ_1, for its stationary share of the formal and informal sectors in terms of population, for which we target 38% of workers in the formal sector and 62% working in the informal sector.

A2. Health Expenditure Transition

The reported health expenditure was 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 on out-of-pocket payments is used, "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 status of health expenditure with its stationary share. We only calculate health expenditure status based on the year 2005, instead of a 3-year average, since the survey shows that most do not have any health insurance scheme and the relative difference between the young and old generation is distinct in 2005. Then we use a recovery adjustment function and calculate the stationary value of health cost by integrating over the young and old generations. In addition, we use this parameter to adjust the total health expenditure to match the more recent target of 4% of the 2008–2012 average. The transitory bias adjustment is similar to employment status. Tables A1 and A2 replicate Tables 6 and 7 of Hsu et al. (2014) for reference.

Table A1: Status of Health Expenditure

Status	Range	Expenditure (baht)	% of Average Income
		Young generation (X^y)	
Low	0%–95%	137.48	1.72%
High	95%–100%	3871.81	48.44%
		Old generation (X^o)	
Low	0%–95%	260.57	3.26%
High	95%–100%	7821.95	97.86%

Source: Authors.

Table A2: Transition Probabilities of X

	Young (Ω^y)			Old (Ω^o)	
	Low	High		Low	High
Low	0.950	0.050	Low	0.954	0.046
High	2.942	0.580	High	0.875	0.125

Source: Authors.

A3. Out-of-Pocket and Total Health Expenditure

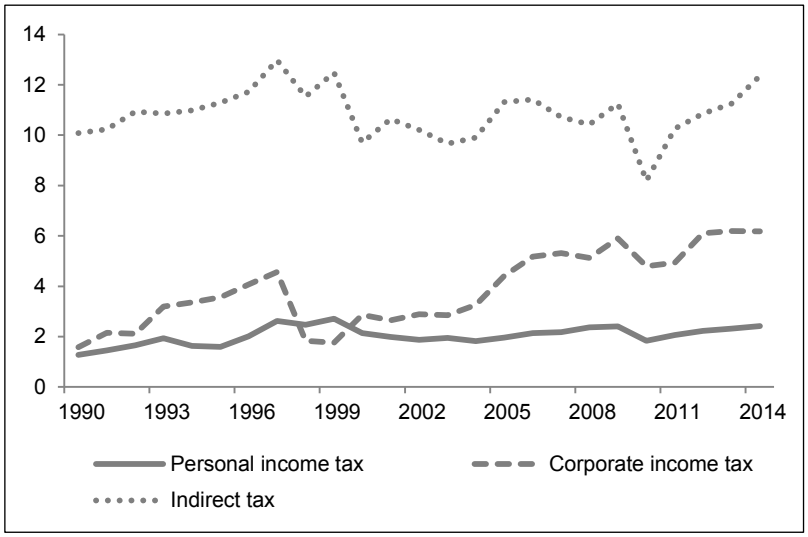
The reform of the health care system to promote the universal health coverage started from 2002. The established National Health Security Office effectively implemented the reform in the following years, accompanied by lower private contributions and elevated national health expenditure. As shown in Figure 1, the out-of-pocket ratio has been declining and has been below 15% since 2007. On the other hand, the total health expenditure has been rising and stabilized after 2007 between 3.9%–4.1% of GDP. Given such a structural change of the health care system, we use the more recent data with the average of 2008–2012 as our targets in the model economy, in which the total health expenditure is 4% of GDP and the out-of-pocket ratio was 14% of total health expenditure.

A4. The Components of Tax Revenue

Personal income tax largely consists of labor income (employment) tax, dividend income, and interest income from savings, bonds, etc. However, due to the lack of further disaggregate data and the fact that labor income tax accounts for the majority of personal income tax, we assume personal income tax revenue is equal to labor income tax revenue. Corporate income is assumed to be the same as capital income in the model as this is the only source in the model related to capital. Indirect taxes in various forms, given the nature that they are ultimately borne to consumers, are therefore summed up to be represented as consumption tax in the model. The averages of 2005–2014 of tax revenue as a percentage of GDP, 2.2%, 5.4%, and 10.8%, are the target ratios of the benchmark economy in the model for labor income, capital income, and consumption tax revenue, respectively.

Figure A1: Share of Tax Revenues in Thailand

(% of GDP)

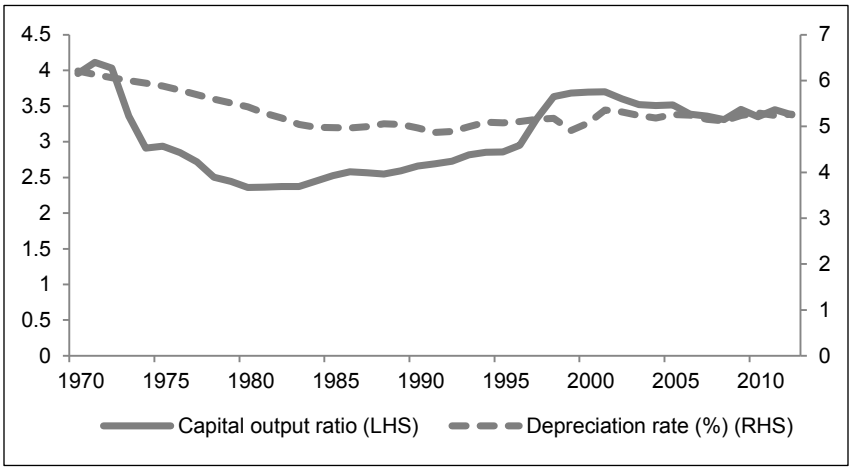


Source: Ministry of Finance, Thailand.

A5. Capital Output Ratio and Depreciation Rate

We define the capital stock at period *t*, the average of capital stock at the beginning of the period and the end of period (the beginning of next period) by $\overline{K}_t = \frac{K_t^b + K_{t+1}^b}{2}$. The capital output ratio is the capital stock divided by the nominal GDP (approximation of output) obtained by $\frac{K}{Y} = \frac{\overline{K}_t}{Y_t}$. The depreciation rate is the ratio of the deprecation value within period *t* over the capital stock at the beginning of period *t*. Given the following data, the capital output ratio and depreciation rate can be calculated. The law of motion for capital follows $K_{t+1}^b = K_t^b(1-\delta) + I_t$. We target the average values of the most recent 5 years, which gives a *K/Y* ratio of 3.4 and a depreciation rate δ of 5.2%.

Figure A2: Capital Output Ratio and Deprecation Rate



LHS = left-hand scale, RHS = right-hand scale.

Source: National Economic and Social Development Board; World Bank World Development Indicators.

Table A3: Variables for Calculating Capital Output Ratio and Deprecation Rate

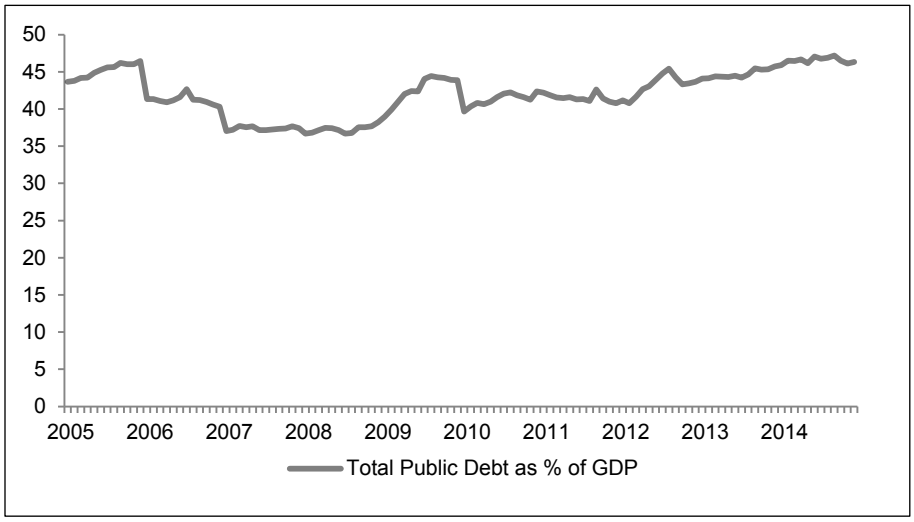
Variables	Definition	Source
$K_t^b(1-\delta)$	Net capital stock, the value of fixed assets after deducting depreciation	National Economic and Social Development Board
$K_t^b\delta$	Capital stock depreciation	National Economic and Social Development Board
Y_t	GDP nominal	World Bank World Development Indicators

GDP = gross domestic product.

A6. Public Debt to GDP Ratio

The public debt to GDP ratio has been relatively stable across the period. We use the average ratio of 2009–2014 as our target in the model, which is 43%.

Figure A3: Public Debt to GDP Ratio

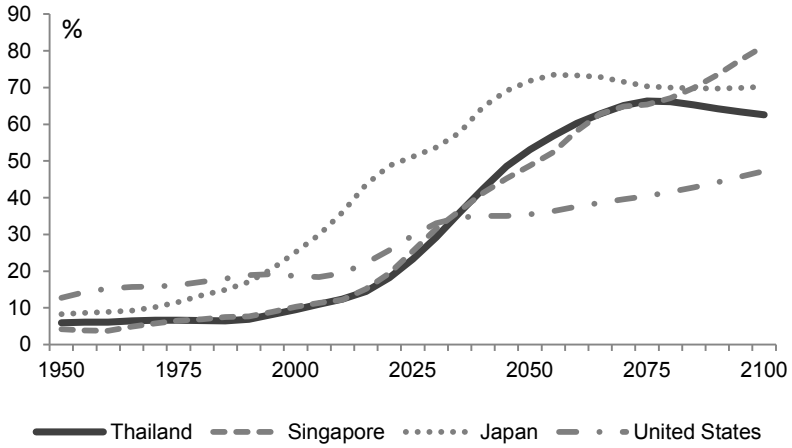


Source: Ministry of Finance, Thailand

A7. Population Structure in Thailand

According to data from the United Nations, Thailand has started to experience a fast aging trend since 2010. The old-age dependency ratio of old people (aged 65+) over young people (aged 15–64) will increase sharply in the following decades, from 12.4% in 2010 to 23.3% in 2025 and further reaching to 53.1% in 2050. We use the average of 2009–2014 (the annual figure is estimated through the interpolation of the 5-year figures) and target 13% in the model.

Figure A4: Old-age Dependency Ratio



Source: United Nations, Department of Economic and Social Affairs, population estimates and projections.

APPENDIX B: VARIOUS MODEL ECONOMIES

Table B1: Economic Features of Various Economies

Model	(1)	(2)	(3)	(4)	(5)	(6)
Labor income tax rate (formal)	6.40%	3.82%	6.40%	6.40%	3.82%	3.82%
Consumption tax rate	16.00%	16.00%	14.80%	14.80%	17.18%	16.00%
Capital income tax rate	35.00%	35.00%	35.00%	30.65%	35.00%	39.94%
Aggregate capital per capita	1.2581	1.3187	1.3073	1.3006	1.2708	1.2772
Aggregate labor per capita	0.2107	0.212	0.2118	0.2103	0.211	0.2126
Aggregate labor hour per capita	0.3344	0.3361	0.3364	0.334	0.3342	0.3369
Interest rate (r)	4.03%	3.78%	3.82%	3.81%	3.98%	3.99%
Wage rate (w)	1.2027	1.2181	1.2153	1.2159	1.2059	1.205
Output per capita	0.3696	0.3768	0.3754	0.3731	0.3711	0.3737
Capital output ratio (K/Y)	3.4042	3.5000	3.4825	3.4863	3.424	3.4182
Total health expenditure (X/Y)	3.99%	3.92%	3.93%	3.96%	3.98%	3.95%
Fiscal revenue (% of output)	22.22%	21.19%	21.22%	21.34%	22.17%	22.06%
- Labor tax	2.18%	1.32%	2.17%	2.18%	1.32%	1.32%
- Capital tax	5.47%	5.26%	5.30%	4.58%	5.43%	6.13%
- Consumption tax	10.79%	10.79%	9.98%	10.80%	11.59%	10.79%
- Social security contribution	3.78%	3.82%	3.77%	3.78%	3.83%	3.82%
Fiscal outlay (% output)	22.22%	21.18%	21.22%	21.34%	22.17%	22.06%
- Old-age pension	3.00%	3.03%	3.00%	3.00%	3.04%	3.04%
- Unemployment benefit	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
- Social assist. for cons. floor	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
- Public health expenditure	3.43%	2.74%	2.75%	2.77%	3.42%	3.40%
- Government consumption	14.01%	13.74%	13.78%	13.88%	13.95%	13.86%
- Interest payment	1.73%	1.62%	1.64%	1.64%	1.71%	1.71%
Gini: Labor income (high education)	0.4371	0.437	0.435	0.4363	0.4390	0.4377
Gini: Labor income (low education)	0.3832	0.3854	0.3823	0.3834	0.3862	0.3849
Gini: Capital income (high education)	0.4835	0.4801	0.4807	0.48	0.4828	0.4835
Gini: Capital income (low education)	0.3945	0.3817	0.3797	0.3801	0.3960	0.3958
Gini: Total income (social average)	0.3965	0.3982	0.3956	0.3949	0.3990	0.4000

Cons. = consumption.

Notes: (1) is the benchmark UHC economy; (2)–(4) are non-UHC economies assuming the benchmark financed by labor income, consumption, and capital income tax, respectively; (5)–(6) are UHC economies financed by consumption and capital income tax, constructed from (2) based on the assumption that UHC in (1) is financed by labor income tax.

Aggregate labor per capita is the effective term which is the product of labor hours and individual efficiency, compared with labor hours.

Source: Authors.

Table B2: Impact on Income Gini Coefficient

Group\Option	Labor Income Tax	Consumption Tax	Capital Income Tax
all	-0.43%	0.23%	0.40%
high education	0.02%	0.48%	0.18%
low education	-0.57%	0.23%	-0.05%
high education	0.70%	0.58%	0.72%
low education	3.24%	3.75%	3.65%

Source: Authors' calculations.

Table B3: CEV Welfare Changes without UHC

Group	(2)	(3)	(4)	(5)	(6)
CEV: All	1.43%	1.33%	1.17%	0.14%	0.15%
- CEV: High education	2.26%	1.18%	0.93%	1.09%	1.19%
- Young generation	2.38%	1.28%	1.05%	1.12%	1.19%
- CEV: Formal	2.30%	1.27%	1.05%	1.03%	1.10%
- CEV: Informal	2.61%	1.27%	1.04%	1.35%	1.42%
- CEV: Ump from formal	2.48%	1.26%	0.01%	1.23%	1.33%
- CEV: Ump from informal	2.46%	1.58%	1.31%	0.91%	1.04%
- Old generation	-1.22%	-1.62%	-2.65%	0.36%	1.39%
- CEV: Low education	1.16%	1.38%	1.26%	-0.18%	-0.20%
- Young generation	1.18%	1.43%	1.33%	-0.21%	-0.26%
- CEV: Formal	0.98%	1.42%	1.33%	-0.40%	-0.46%
- CEV: Informal	1.25%	1.43%	1.33%	-0.15%	-0.18%
- CEV: Ump from formal	1.63%	1.52%	1.40%	0.15%	0.13%
- CEV: Ump from informal	1.18%	1.53%	1.39%	-0.32%	-0.31%
- Old generation	0.74%	0.54%	0.05%	0.28%	0.70%

CEV = consumption-equivalent variation, ump = unemployed.

Notes: All compared with the benchmark UHC economy; (2)–(4) are non-UHC economies, assuming the benchmark financed by labor income, consumption, and capital income tax, respectively; (5)–(6) are UHC economies financed by consumption and capital income tax, compared with UHC economy financed by labor income tax.

Source: Authors.

APPENDIX C: COMPUTATION PROCEDURE

The method of dynamic programming is used to provide a numerical solution for the model. 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 the guessed values and actual numbers converge. In our paper, the individual problems are solved by the Endogenous Grid Method (EGM) proposed by Carroll (2006) and the simulations are conducted through the non-stochastic simulations as of Young (2010). The basic procedure is as follows:

(a) have initial guesses of the aggregate capital, labor and the endogenous tax option to clear government budget;

(b) solve the problems of agents in all the state space, which includes education, asset, individual productivity, employment, one-period history of 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 labor, and then calculate the endogenous tax rate or government expenditure to clear the government budget;

(d) go back to step (a) and update the guessed values if the convergence criteria are not satisfied, and repeat (b)–(d) until the convergence criteria are satisfied.

APPENDIX D: SENSITIVITY TESTS

D1. Economies with Exogenous Labor

A standard utility function with the endogenous choice of consumption and exogenous labor is assumed to be

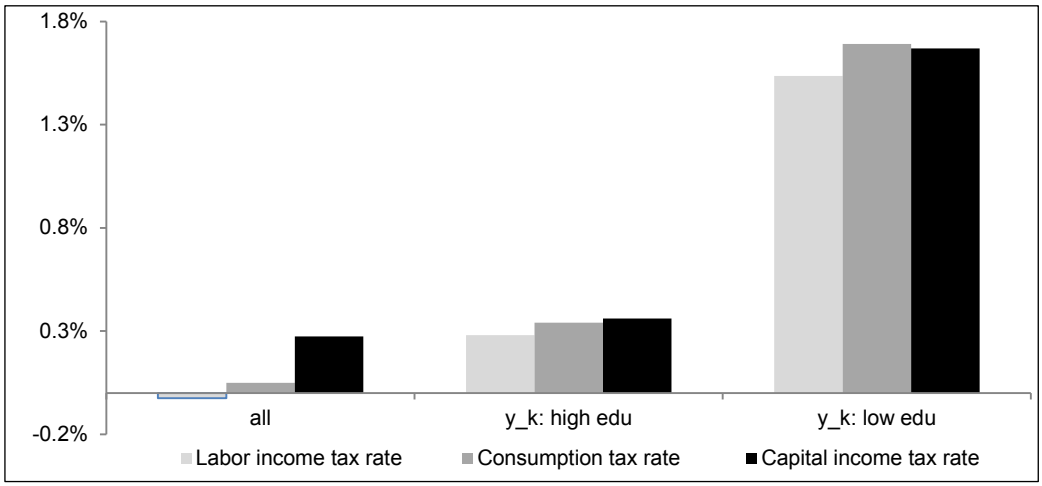
$$u(c) = \frac{c^{1-\mu}}{1-\mu}.$$

We recalibrate the new benchmark economy to match the targets in Table 2 and construct the same experiments as the case of endogenous labor. The results are shown as follows.

In terms of impacts on income distribution for three tax options to finance UHC, the results differ for the case of exogenous labor supply in the following, compared with the case of endogenous labor supply. Due to the exogenous labor, there is no impact on labor income distribution. It continues to have positive impacts on capital income distribution of both education groups for these three tax options, however, with smaller magnitudes.

At the aggregate level, labor income tax financing could reduce the income Gini coefficient by 0.02%, while consumption tax increases it by 0.05%, and capital income tax by 0.27%. Such reduction of inequality by labor income tax financing can attribute to the gaps between groups, instead of within groups, where inequality increases.

Figure D1: Impact on Income Gini Coefficient (Exogenous Labor)



y_k = capital income.

Source: Authors.

The exogeneity of labor supply has a higher impact on welfare. The distortions of tax are reduced substantially without labor adjustment. So financing UHC through tax neither negatively affects young agents with high education as much as endogenous case, nor positively affects young agents with low education as much. The aggregated values turn out to have welfare gains by implementing tax-financed UHC schemes. Table D1 gives evidence for the welfare changes from the counterfactual experiments of removing UHC.

Table D1: Welfare Changes of Removing Tax-financed UHC (Exogenous Labor)

Group	(7)	(8)	(9)
CEV: All	-0.26%	-0.27%	-0.21%
- CEV: High education	0.78%	0.00%	0.10%
- Young generation	0.95%	0.24%	0.24%
- CEV: Formal	0.95%	0.24%	0.24%
- CEV: Informal	0.93%	0.23%	0.23%
- CEV: Ump from formal	0.98%	0.26%	0.26%
- CEV: Ump from informal	1.06%	0.41%	0.40%
- Old generation	-3.13%	-2.75%	-3.21%
- CEV: Low education	-0.61%	-0.41%	-0.32%
- Young generation	-0.51%	-0.33%	-0.24%
- CEV: Formal	-0.43%	-0.29%	-0.19%
- CEV: Informal	-0.55%	-0.36%	-0.26%
- CEV: Ump from formal	-0.27%	-0.21%	-0.09%
- CEV: Ump from informal	-0.28%	-0.08%	0.01%
- Old generation	-1.86%	-1.32%	-1.30%

CEV = consumption-equivalent variation, UHC = universal health coverage, ump = unemployed.

Note: (7)–(9) are non-UHC economies, assuming the benchmark financed by labor income, consumption, and capital income tax, respectively

Source: Authors.

D2. Efficiency Parameters

To construct such experiments, first of all, the education efficiency is assumed to be the same across education levels while holding sector efficiency unchanged. Then, the sector efficiency is assumed to be the same across sectors while holding education efficiency unchanged. In each case, the counterfactual financing exercises for the three finance options are further conducted and compared against their respective benchmarks for inequality and welfare.

By intuition, equalizing efficiency by either education or sector should reduce the income inequality. Our experiments suggest the Gini coefficient of total income equality falls from 0.3965 to 0.3820 and 0.3764, respectively. As shown from the comparisons of each financing option against their benchmarks, when there is no sector efficiency difference in the third row of Table D2, the UHC economy financed by labor income tax loses its redistributive role to reduce inequality. Instead, the inequality increases.

Table D2: Changes of Income Gini Coefficient

	Labor Income Tax Rate	Consumption Tax Rate	Capital Income Tax Rate
ε_{nf}=0.7,ϵ_l=0.7273	-0.43%	0.23%	0.40%
ε_{nf}=0.7, ϵ_l=1	-0.65%	0.08%	0.31%
ε_{nf}=1, ϵ_l=0.7273	0.85%	0.16%	0.32%

Source: Authors.

Regarding CEV welfare changes, given the lower redistribution when efficiency is equalized across education level or sector, the welfare loss should be bigger due to lower gains from redistribution to offset the loss of distortion. Therefore, a non-UHC economy with a lower tax is strictly better off and more so when there is less efficiency difference. Especially when the sector efficiency disappears, the size of the welfare loss by financing UHC through labor income is large, as shown in Table D3.

Table D3: CEV Welfare Changes without UHC (Equalizing Efficiency)

Group	Labor Income Tax	Consumption Tax	Capital Income Tax
ε_{nf}=0.7,ϵ_l=0.7273	1.43%	1.33%	1.17%
ε_{nf}=0.7, ϵ_l=1	1.64%	1.47%	1.31%
ε_{nf}=1, ϵ_l=0.7273	2.85%	1.54%	1.44%

CEV = consumption-equivalent variation, UHC = universal health coverage.

Source: Authors.