The provision of public universal health insurance: impacts on private insurance, asset holdings and welfare

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The Provision of Public Universal Health Insurance: Impacts on Private Insurance, Asset Holdings and Welfare

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Abstract

This paper aims to investigate impacts of public provision of universal health insurance (UHI) in an environment with household heterogeneity and financial market incompleteness. Various UHI polices with both distortionary (payroll-tax) and non-distortionary (lump-sum tax) financing methods are compared to address the trade-off between risk reduction and tax distortion as well as corresponding welfare implications. We undertake a dynamic equilibrium model with endogenous insurance choice and labor supply decisions to perform quantitative analyses. The results suggest that the UHI expenditure coverage rate would be too high in most OECD countries when the distortion effect is considered. We find a clear crowding out effect on asset holdings. Implications for private health insurance (PHI) purchases when UHI is introduced depend on the pricing and the design of coverage. We find the rich are sensitive to the price of PHI, and would prefer a supplemental plan when UHI is introduced.

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‡All errors are ours. Acknowledgement will be added.

1 Introduction

Most OECD countries offer universal health insurance (UHI). A number of middle income countries have also recently achieved universal health care (e.g. Korea, Taiwan, Singapore), and many others are moving in that direction (e.g. China, Mexico, Turkey,...). In fact, the World Health Organization (WHO) encourages countries to pursue universal coverage for improving and equalizing health care (the World Health Report 2008). UHI is desired for a variety of reasons that include UHI prevents adverse selection problem existing in private insurance market. Its pooling contract makes health insurance affordable for those with chronically poor health. Moreover, UHI reduces the need for precautionary savings, and might also save the administration cost of insurance due to less need for screening and monitoring.

However, the current literature provides very limited analyses on impacts of the UHI provision with an aggregate economy framework. This paper aims to shed light on this issue. In this paper, we focus on a specific form of UHI – a government-sponsored mandatory universal health insurance program, that is adopted in many OECD countries and middle income countries, which recently achieved universal coverage. This type of UHI is also widely considered by countries that are moving in the universal coverage direction.

Governments commonly play an important role of the UHI provision because of the adverse selection problem in private insurance markets. We observe that in those OECD countries with UHI available, government health care expenditures are usually much higher than private health care expenditures (see Figure 1). The provision of UHI prevents the adverse selection problem and is expected to improve the social fairness on health care. In addition to equalizing the health insurance coverage, the introduction of UHI will bring impacts on individuals and the economy in many aspects. First, the universal coverage generally reduces the level of uncertainty (i.e. improves risk sharing) and therefore precautionary savings. In addition, the mandatory public UHI would crowd out private health insurance (PHI) and asset holdings that will change household's portfolio choices, the wealth distribution and aggregate capital stock. Moreover, to finance the UHI, the government has to increase tax revenue. It is widely adopted to use a payroll tax (including earnings-dependent insurance premiums) for financing the UHI. Although it is viewed more 'fair' because high-earnings individuals pay more for the same insurance plan, it has a distortionary effect on labor/leisure decisions. There is obviously a trade-off between risk reduction and tax distortion. A non-distortionary financing method will be examined to disentangle the distortion caused by the payroll-tax financing.

We particularly focus on the effects through the increased tax burden/distortion, risk reduction, and the interaction with PHI and asset holdings. These effects will change individuals' decisions on savings, hours worked, and portfolio choice between insurance and assets, and therefore change aggregate labor supply, capital stock, wealth distribution and welfare. Because of the complexity of interactions and impacts, welfare changes in both individual level and aggregate level are not trivial to predict.

To better understand the impacts of the public UHI provision, we develop a dynamic stochastic equilibrium model with household heterogeneity, financial market incompleteness and endogenous demand of PHI. The source of household heterogeneity comes from different realizations of idiosyncratic uncertainties on income, medical expenditure, retirement, and death. Income shocks, which are generated by labor efficiency changes in the model, are not perfectly insurable. Medical expenditure shocks can be partially insured by purchasing a PHI plan from market when UHI is not available. However, not everyone would like to buy (or can afford) it. Because of the adverse selection problem, private insurance companies have an incentive to price-discriminate through health status screening, and therefore PHI offers less pooling and less risk-sharing.

In addition to PHI, households can accumulate assets to self insure against the income and medical shocks in a precautionary motive. When a mandatory tax-financed UHI program is introduced that partially covers the medical expenditure shocks for every household, the PHI, which now provides additional coverage to the rest part of the medical shocks, becomes complimentary to the UHI. The price of PHI therefore will decrease in response to the introduction of UHI and become more affordable. On the other hand, the medical risk has been reduced by the UHI coverage and so the demand of PHI will decrease as well as the necessity of precautionary savings. After the UHI is introduced, the change in PHI take-up ratio then depends on which force dominates. We also incorporate a social security (public pension) system and a means-tested social insurance system in the model to better characterize the factors that also affect saving decisions.

We perform a quantitative investigation on impacts of the UHI provision. A benchmark economy without UHI and economies with the UHI provision are compared. Clear crowding out effects are observed. We first find that the UHI provision significantly decreases the asset holdings because of a reduction of precautionary savings. Given the assumption that PHI becomes complementary with the same proportional markup, PHI take-up rate is also significantly decreased, particularly in wealth-rich households. Diverse trends of portfolio choices between high-wealth and low-wealth households are observed: High-wealth households tend to maintain assets rather than PHI compared with the low-wealth, while low-wealth households tend to rely on private and social insurances rather than keeping precautionary savings.

Although the payroll tax used for financing the UHI has a redistribution effect on wealth, we find that the provision of public UHI leads to a clear redistribution effect on welfare rather than on wealth. Redistribution effect on wealth is not clear – the wealth inequality might be worse when UHI is implemented because it crowds out more proportion of assets among the low-wealth than the high-wealth. Redistribution effect on welfare is clearly observed – The old gain more than the young, and the low-wealth gain more than the high-wealth.

Compared with the lump-sum tax (non-distortionary) financing, we also identify the distortion caused by the payroll tax financing of the UHI, which reduces labor supply and further crowds out PHI purchasing and asset holdings. The loss from the payroll tax distortion creates a welfare gap between the UHI provisions with a payroll tax financing method and with a lump-sum tax financing method.

An UHI policies with a higher expenditure coverage rate (i.e. a higher proportion of medical expenditure paid by the UHI) can provide a better risk sharing, but it needs a higher tax rate to finance the UHI expenditure. Hence there is a trade off between risk sharing and tax distortion. To study the welfare implication of the UHI provision, we also compare UHI policies with various expenditure coverage rates. The result shows an inverse U shape welfare pattern with increased coverage rates. We find that when the UHI expenditure coverage rate is greater than 50%, the additional distortion loss outweighs the additional welfare gain. It suggests that the rates in most OECD countries might be too high (the average is about 70%) when taking into account the tax distortion. We also perform sensitivity tests with different risk aversion levels, and find the robustness of our result.

We further incorporate Medicare, a public health insurance program for elderly individuals in the US, in the model to provide a more precise implication of a public UHI provision for the US since it is currently pursuing an universal coverage. Since the old, who need more medical care, have already been covered by Medicare, we find that the welfare improvement from a public UHI provision is smaller than it in the case without

Medicare – roughly 1% of lifetime consumption when the UHI is financed by a payroll tax (or equivalently an income-contingent premium). We also find that the UHI will mainly benefit the young (those below 65), and the old might be worse off. This welfare pattern, which is opposite to our finding in the case without Medicare, is because even though the old do not receive any additional benefit from the UHI, they are affected by the tax distortion caused by the financing of UHI.

The demand of PHI when UHI is introduced is also discussed. We find that when UHI provides primary coverage and PHI becomes complementary, which covers a proportion of out-of-pocket medical expenditures, wealth-rich individuals can easily use their assets to substitute the complementary PHI, and therefore are more sensitive to its price change. On the other hand, individuals with low wealth do not have this option and are less sensitive to the price change. We find that a supplemental PHI plan, which covers items not covered by UHI, would attract the rich more. We illustrate this by designing a catastrophic PHI that provides full coverage on the highest medical shock. We also find that if the proportion of markup of PHI is maintained at the same level after UHI is introduced and no new type of PHI is offered, insurance companies would lose customers. Particularly, richer individuals can more easily have options to substitute the PHI. Laschober et al. (2002) documented that rich individuals experienced a significant decline in total Medicare supplemental insurance coverage during 1996-99 when premiums of Medigap (individually purchased Medicare supplemental insurance) programs had double-digit increases, while the same decline was not observed among individuals with lower income. This finding is consistent with our model prediction.

This project is in line of the literature of investigations on the effects of public insurance provision in incomplete market environments.[1] In the existing macro-literature, it is widely agreed that medical expenditure shocks are important for understanding household's expenditure-saving decisions. However, the health insurance decision is usually absent from the model. A recent paper documented by Jeske and Kitao (2009), which uses a similar model to study welfare effects of the US tax policy on health insurance, is

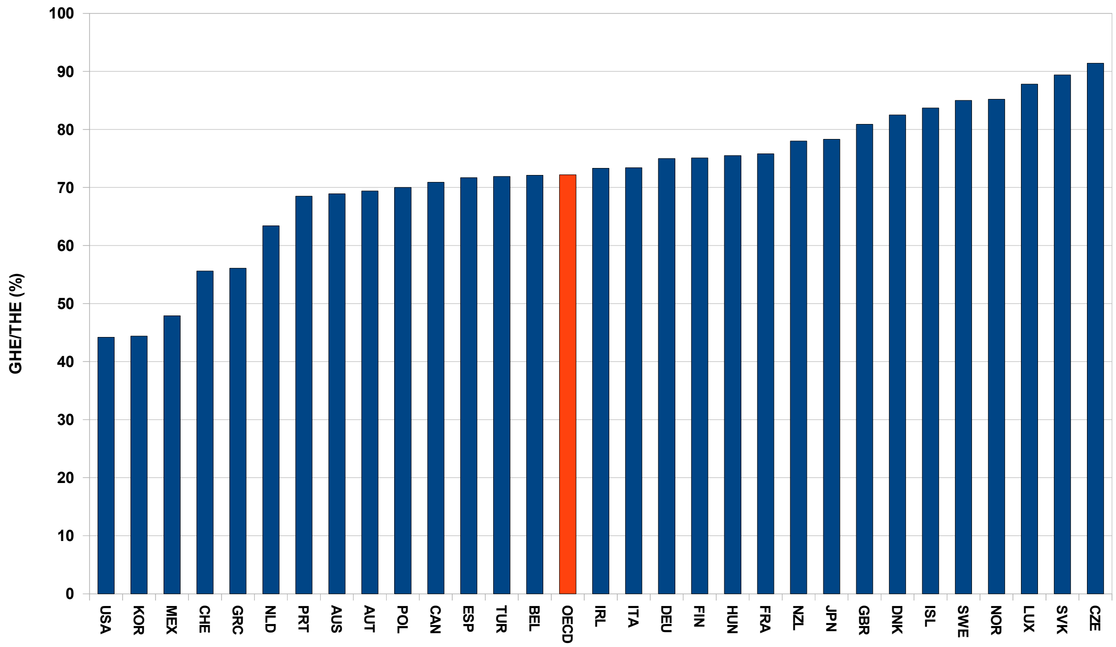
[1] Aiyagari and McGrattan (1998) study how government debt policy can change the net supply of assets for self-insurance. Imrohoroglu et al. (1995), Conesa and Krueger (1999), Storesletten et al. (1999), Huggett and Ventura (1999) and Huggett and Parra (2008) study the role of social security as a partial insurance and redistribution device. Domeij and Heathcote (2004) and Nishiyama and Smetters (2005) consider the distributional effects of mix of tax instruments. Hansen and Imrohoroglu (1992), Low et al. (2007) conducts quantitative explorations of unemployment insurance.

one that allows households to endogenously purchase health insurance. This paper also allows endogenous insurance purchasing, but we focus on the interaction between public mandatory UHI and decisions on purchasing PHI. In addition, the distortionary impact that the tax policy has on consumption-leisure decisions is not discussed because labor supply is assumed inelastic in Jeske and Kitao's analysis. We allow endogenous choice of labor supply, and find it is important when studying social welfare.[2] Another related paper is documented by Attanasio, Kitao and Violante (2010). They use a life-cycle model to study the financing of Medicare, a public UHI for elders in the US. They also allow endogenous labor decisions and take into account demographic changes. However, they do not discuss the endogenous demand of private health insurance since it is not their focus.

Although our results suggest that the expenditure coverage rate of UHI is better to set at a lower level (50%) than that in most OECD countries, it does not necessarily imply that a reduction of health insurance benefits in the OCED countries will lead to higher welfare. A reform of existing UHI is not the focus of this paper, and needs to take into account the cost during the transition. In addition, In this paper we provide a general study and investigate the trade-off between the effects of pooling one particular type of risks (medical expenditure risk) with universal health insurance and the distortionary effect of the marginal tax, by which the universal health insurance is financed. We abstract from some regulations on PHI in a specific country. When one applies the analysis framework to a specific country, it is necessary to take into account its regulations or some specific features on PHI carefully to provide a precise implication, e.g. subsidies from government/employers that enable more risk sharing with PHI.

The rest of paper is organized as follows. In the next section, we present some facts of health insurance system in OECD countries. Section 3 presents model economies. Section 4 discusses the choices of parameter values. Section 4 describes the calibration. Section 5 provides quantitative analyses and results with robustness tests. Section 6 concludes.

[2] Regarding the distortionary effects of marginal income taxes in the incomplete market models, Heathcote (2005) and Domeij and Heathcote (2004) also model household's endogenous choice of labor supply in the incomplete market environment in order to precisely measure the distortions created by proportional labor taxes when the effects of social policy are studied. We follow the endogenous labor setting in our analysis.



Source: Colombo and Nicole (2004)

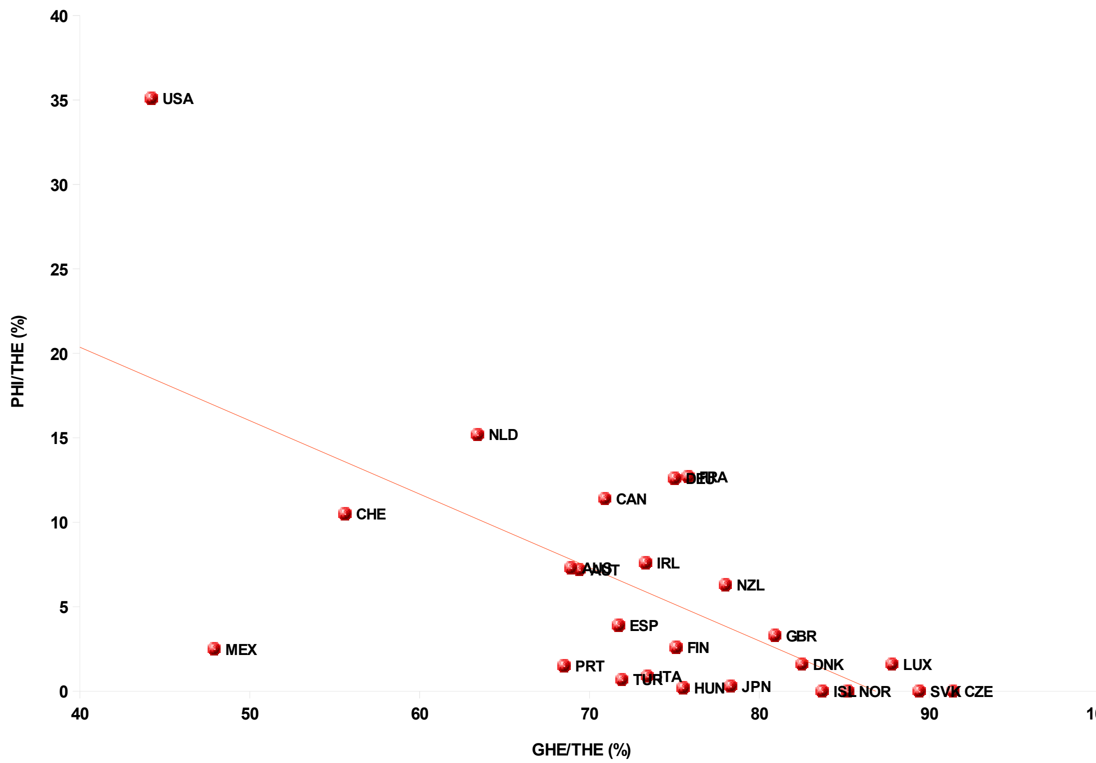
Figure 1: GHE as percentage of Total Health Expenditure

2 Some Facts from OECD

1) Size of Public Health System Varies across Countries

Colombo and Nicole (2004) investigated health insurance systems in OECD countries. They report the roles of public health insurance and private health insurance as well as the corresponding health care system in each country. They also provide data on public (government) health expenditure (GHE) and the expenditure that is covered by private health insurance.

Only four among the OECD countries, United States (USA), Netherland (NLD), Mexico (MEX) and Turkey (TUR), do not provide UHI, although forms and benefits of UHI vary across those countries providing it. Figure 1 shows the GHE as a percentage of to-



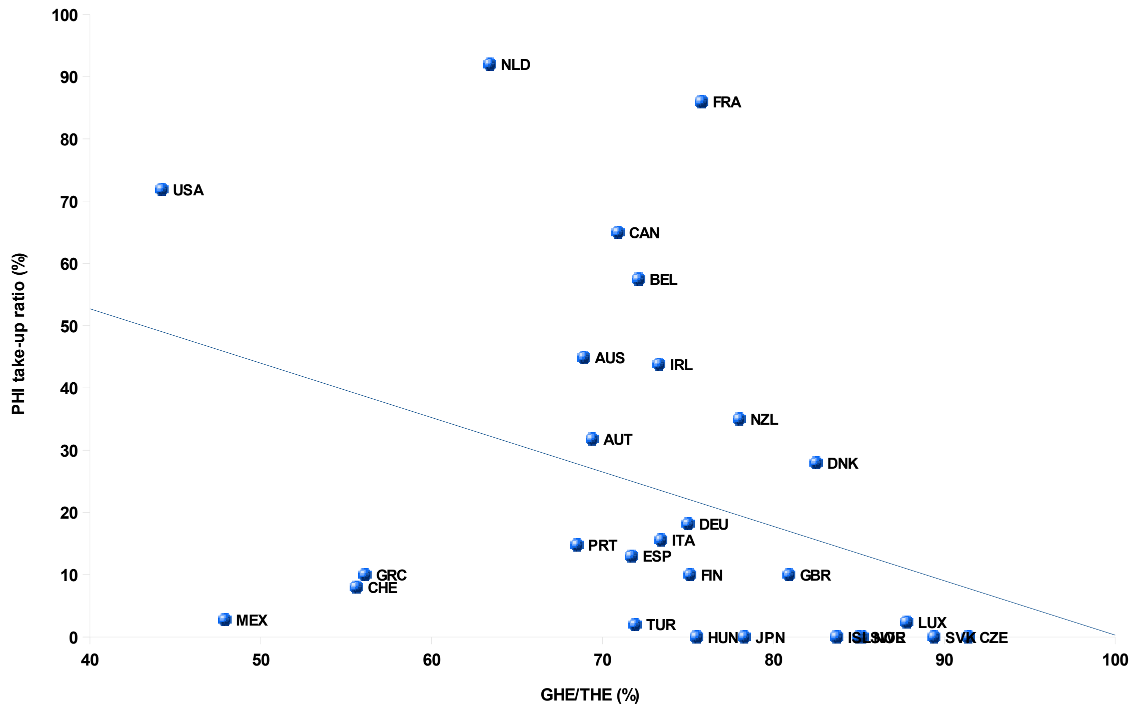
Source: Colombo and Nicole (2004)

Figure 2: GHE v.s. PHI Expenditure (as percentage of Total Health Expenditure)

tal health expenditure across OECD countries that can be used to approximate the size of public health insurance system of each country (or the coverage rate of public health insurance in those providing UHI). A large heterogeneity (roughly from 40% to 90%) is observed. The US, which does not provide UHI, has the smallest public health system among OECD countries.

2) Size of Public Health System v.s. PHI

Figure 2 shows the relationship between the private health insurance expenditures and public health expenditures as shares of total health expenditure across OECD countries. It also shows a huge heterogeneity of private health insurance expenditures. The PHI expenditure share varies from 35.1% (USA) to a negligible share. The GHE share is nega-



Source: Colombo and Nicole (2004)

Figure 3: GHE v.s. PHI take-up ratio (as percentage of Total Health Expenditure)

tively related to the PHI expenditure share. The correlation is -0.65.

In Figure 7, it displays the relationship between the percentage population covered by PHI (i.e. PHI take-up ratio) and GHE share across OECD countries. The PHI take-up ratio ranges from 71% (USA) to a negligible share and is negatively related with the GHE share (-0.36). The above facts observed from the OECD data suggest that the more does public health insurance covers, the less private health insurance cover the health expenditure and the less do people purchase private health insurance. It indicates a crowding-out effect of public health system on private health insurance.

3 The Model

We undertake a theoretical approach to understanding the interaction among UHI provision, PHI purchases, asset holdings, and the implications on welfare. A theoretical model economy is developed to characterize main factors that affect decisions of portfolio choice between assets and insurance.

In the model economy, there is no aggregate uncertainty, but households face an idiosyncratic labor productivity shocks and a medical expenditure shock. Financial markets in which households may trade full contingent claims against these risks are assumed unavailable. Instead, first, households can trade a non-state contingent asset at price of one unit of consumption good. Households purchase the asset at price one and then the asset returns $(1 + r)$ units of consumption next period regardless of any combination of next period shock realizations. This non-state contingent asset enables households to partially self-insure by accumulating precautionary asset holdings. Second, there exists a health insurance market where households can buy an insurance plan to hedge against the next period medical expenditure shock.

3.1 Demographics

The economy is populated by a continuum of finitely-lived households (measure one) and they maximize expected discounted lifetime utility from consumption and leisure. The population consists of two generations - the young and the old. Young agents supply labor and earn wage income and old agents are retired from market work and receive social security benefits. Young agents become retired with probability ρ_o every period and the old die and leave the economy with probability ρ_d every period. On average, the young work for $(1/\rho_o)$ years, and the old live for $(1/\delta_d)$ years before they die. In each period, the economy has new-born young households which replace the old households who die such that measure of total population stays constant. A similar setting, the stochastic aging and death, is also used in Jeske and Kitao (2009) to capture the features of retirement and death, which clearly have effects on agents' saving and insurance purchasing decisions, in an Aiyagari-Bewley type model. The demographic setting with the probabilities described above implies that every period there is $\frac{\rho_o}{\rho_o+\rho_d}$ fraction of old people and $\frac{\rho_d}{\rho_o+\rho_d}$ fraction of young people.

3.2 Labor and Medical Expenditure Shocks

Young household's effective labor supply depends on the hours worked and idiosyncratic labor productivity shock z, which is stochastic. In each period t, an idiosyncratic labor productivity shock takes one of $l < \infty$ values in a finite set $Z = \{z_1, z_2, ..., z_l\}$. Each household's productivity shock evolves independently according to a first-order Markov process with transition probability matrix π_z, which is $l \times l$ and an invariant distribution $\bar{\pi}_z$.

Both young and old households faces medical expenditure shocks x, which is also stochastic. In each period t, each household's medical expenditure shock takes one of $m < \infty$ values in a finite set $X_i = \{x_{1,i}, x_{2,i}, ..., x_{m,i}\}$ for $i \in \{old, young\}$. Each household's medical expenditure shock also evolves independently according to a first-order Markov process with transition probability matrix $\pi_{x,i}$, which is $m_i \times m_i$ for $i \in \{old, young\}$ and an invariant distribution $\bar{\pi}_{x,i}$ for $i \in \{old, young\}$.

3.3 Asset and Health Insurance Market Structures

3.3.1 Asset market

There is a non-state contingent claim which is an asset that households can purchase at one unit of consumption good and pays off $(1 + r) \geq 1$ units of consumption good next period. With trading this non-state contingent claim, households can partially insure themselves against any combination of idiosyncratic productivity shocks and medical expenditure shocks by accumulating precautionary asset holdings. One assumption that we made to present market incompleteness is that households are subject to a borrowing constraint. This borrowing limit on households' asset holdings specially affects the asset holding decision of low-wealth households since they cannot smooth their consumption over time when they are hit by falls in their disposable incomes.

3.3.2 Universal Health Insurance (UHI) Program

When the UHI is introduced, it mandatorily covers a constant fraction ω of household's medical expenditure x. Households pay $(1-\omega)\,x$ units of consumption good when the medical expenditure x is realized under the UHI coverage. This universal health insurance (UHI) program is financed by tax revenues. We use a higher ω to represent an economy with better UHI benefits in our numerical exercise.

3.3.3 Private Health Insurance (PHI) Market

In each period, households face an idiosyncratic medical expenditure shock x. Even with the UHI provided, households can still purchase a private health insurance contract that covers an additional fraction $\omega_p(x)$ of medical cost x. Hence with the health insurance contract, the net health expenditure becomes $\left(1-\omega-\omega_p(x)\right)x$, while it will cost the entire $(1-\omega)\,x$ without the private insurance. Households make a decision on whether to purchase a private insurance contract which will cover the fraction of next period's medical expenditures.

If a household decides to buy a private health insurance, a premium $q\,(x)$ has to be paid to an insurance company each period. The premium $q\,(x)$ is assumed to depend on a current state of medical expenditure x. This implies that we assume that there is price discrimination in the health insurance market.

Health insurance companies are risk-neutral and competitive. They can monitor each household's state of health expenditure without costs and each household's state of health expenditure is public information. They charge premium $q\,(x)$ such that the total amount covered by a contract is exactly financed by total amount of the premiums paid by the households. Insurance company can discriminate premiums for different contracts depending on the current state of individual's medical expenditure. We assume that there is no cross-subsidy across contracts. The premium for insurance contract that is offered to the household whose current medical expenditure state is x satisfy:

$$q\,(x) = (1+\psi)\,E\left[\omega_p(x')\cdot x'|x\right] = (1+\psi)\,\pi_{x,i}(x'|x)\omega_p(x')\cdot x', \tag{1}$$

where $\omega_p(x) \in [0,1]$ denotes a fraction of total medical expenditure (x) that is covered by the PHI program and ψ denotes a proportional mark-up for the insurance contract.

We set the effective coverage of PHI $\bar{\omega}_p(x)$ to be constant given the medical expenditure state x, which means that PHI covers $\bar{\omega}_p(x)$ of the remaining medical expenditure beyond the UHI coverage. Hence the PHI coverage of total medical expenditure $\omega_p(x)$ is linearly decreasing with the UHI coverage:

$$\omega_p(x) = \bar{\omega}_p(x)(1-\omega)$$

Given this assumption, the premium of PHI is also decreasing with UHI coverage from equation (1) since $\omega_p(x)$ decreases with UHI coverage.

3.4 Government

Government's revenue consists of revenues from different tax instruments, labor income tax τ_n, capital income tax τ_k, consumption tax τ_c, lump-sum tax TAX, social security tax τ_{ss} and newly issued government debt D'. The social security tax τ_{ss} is imposed on the young households' labor income. Bequests b are collected by the government as a revenue that reduces the TAX.[3]

Government runs three social programs: social security program, social insurance (safety net) program, and universal health insurance program. The social security program provides the old (retired) households with a benefit ss and it is financed by the social security tax imposed on labor income of the young households.

Government provides a social insurance that guarantees a minimum level of consumption $\underline{c}$ for every households by supplementing the income in case the household's disposable income plus assets (net after medical expenditure) falls below $\underline{c}$. We consider a simple transfer rule proposed by Hubbard et al. (1995). The transfer T will be made if the household's disposable income plus assets (net after medical expenditure) is smaller than a minimum level of consumption. The transfer amount will be exactly equal to the difference.

Government also provide a universal health insurance program which covers a constant ω fraction of total medical expenditure of all households. There is other government

[3]We do not model the annuity market for the old in this economy, and assume that all bequests are accidental and collected by the government that reduces the need of the lump-sum tax to balance the government budget (or even makes TAX as a transfer).

expenditure G, which is constant. Social insurance (safety net) program, universal health insurance program and other government expenditure are financed by the revenues from consumption tax and income tax.

Having described the revenues and expenditures of government, we now can be given the set of government budget constraints:

1. Social security benefit to the old is financed by the social security tax τ_{ss} imposed on labor incomes of the young.

$$\int (ss) d\Phi = \int \tau_{ss}(wzn) d\Phi \tag{2}$$

   where Φ is the distribution of households over the state space.

2. Social insurance, universal health insurance and other government expenditure are financed by the revenue from labor income tax (τ_n).

$$G + \int [T + \omega x] d\Phi + (1+r)D = \int [\tau_n(wzn) + \tau_k(ra) + \tau_c c + Tax + (1+r)b] d\Phi + D' \tag{3}$$

   where T is a transfer to the individual made for social insurance, x is individual medical expenditure, a is an individual asset holding, b is the bequest left by old agents when they die.

3.5 Production Technology

On the production side, we assume that there is a continuum of competitive firms operating a technology with constant returns to scale. Aggregate output Y is given by

$$Y = F(K, L) = AK^{\theta} L^{1-\theta},$$

where K and L are the aggregate capital and effective labor employed by the firm's sector and A is the total factor productivity which we assume to be constant. Capital depreciates at rate of δ every period. θ denotes the capital income share.

3.6 Household

3.6.1 Preference

We adopt a standard utility function $u(c,n)$, which is consistent with balance growth path and widely used in the growth literature, as below:

$$u\left(c,n\right)=\frac{\left[c^{\phi}(1-n)^{1-\phi}\right]^{1-\mu}}{1-\mu}, \tag{4}$$

where μ is the relative risk aversion coefficient.

labor Supply The utility function given by equation (4) implies that labor supply can be expressed as a function of consumption and effective wage rate:

$$n=1-\frac{(1-\phi)(1+\tau_c)c}{\phi(1-\tau_n-\tau_{ss})wz}. \tag{5}$$

3.6.2 Young household's problem

The state of an agent is summarized by a vector $s=(a,z,x,i_{HI})$, where a denotes asset holdings brought into the period, z the idiosyncratic shock to labor productivity, x the idiosyncratic health expenditure shock that has to be paid. The indicator function i_{HI} takes a value of 1 if the agent purchased private health insurance in previous period and 0 otherwise.

$$V\left(s\right)=\max_{c,n,a',i'_{HI}}\left\{u\left(c,n\right)+\beta\left(1-\rho_o\right)E\left[V\left(s'\right)\right]+\beta\rho_o E\left[W\left(s'\right)\right]\right\}$$

subject to

$$\begin{aligned}
&(1+\tau_c)c+a'+q\left(x\right)i'_{HI}=Wel_y+T\\
&Wel_y\equiv\left(1-\tau_{ss}-\tau_n\right)wzn+\left[1+\left(1-\tau_k\right)r\right]a-\left[1-\omega-i_{HI}\omega_p(x)\right]x-Tax\\
&T=\max\{0,\ (1+\tau_c)\underline{c}-Wel_y\}\\
&i'_{HI}\in\{0,1\};\ \ a'\geq 0;\ \ 1>n\geq 0;
\end{aligned}$$

where W is the value when the agent becomes old, and T is the transfer made by the means-tested social insurance system.

3.6.3 Old household

For the retired, they do not supply labor and receive social security payment ss as their main income source. Their labor productivity z is fixed at 0. Therefore they only face medical shocks without income shocks. They can also purchase a PHI plan to insure the medical shocks in addition to the UHI coverage.

An old agent's problem is:

$$W(s) = \max_{c,a',i'_{HI}} \left\{ u(c,0) + \beta (1-\rho_d) E\left[W(s')\right] \right\}$$

subject to

$$\begin{aligned}
&(1+\tau_c)c + a' + q(x)\, i'_{HI} = Wel_o + T;\\
&Wel_o \equiv ss + [1 + (1-\tau_k)\, r]\, a - \left[1 - \omega - i_{HI} \cdot \omega_p(x)\right] x - Tax;\\
&T = \max\{0,\ (1+\tau_c)\underline{c} - Wel_o\};\\
&i'_{HI} \in \{0,1\};\ \ a' \geq 0.
\end{aligned}$$

3.6.4 Recursive Competitive Equilibrium

A stationary recursive competitive equilibrium consists of household decision rules of asset holding a', labor supply n, PHI purchasing i'_{HI} and consumption c, a set of firm decision rules of capital rented K and effective labor employed L, a price system of w and r, a government policy of tax rates τ_n, τ_k, τ_c and TAX, a government debt D, a policy of UHI coverage ω, minimum consumption floor $\underline{c}$, and a distribution of households over the state variables $\Phi(s)$, such that:

a) given the price system, the decision rules of K and L solve the firm's problem;

b) given the price system, the insurance premium and the policy of tax rates, the decision rules of (a', n, c) solve household's problem;

c) government policies $(\tau_k, \tau_n, \tau_c, TAX, \underline{c})$ satisfy the government's budget constraints;

d) $\Phi(s)$ is stationary;

e) all markets clear: $L = \int (zn) d\Phi(s)$ and $K + D = \int (a+b) d\Phi(s)$;

f) resource feasibility condition is satisfied

$$Y = C + K' - (1-\delta)K + X;$$

where C is the aggregate consumption, and X is the aggregate medical expenditure.

4 Calibration

Although we do not focus on a specific country, we calibrate the benchmark model economy to the US. The main reason is that the benchmark is an economy without UHI, in which PHI is available, and the US satisfies this requirement. More importantly, among those few OECD countries without UHI, the US has good health expenditure and private insurance related survey data that largely help our calibration.

4.1 Utility and Production Functions

The model period is set to be one year. The risk aversion parameter μ is set at 2. The utility discount factor (β) is chosen so that capital-output ratio is equal to 3. The leisure utility parameter ϕ is chosen so that aggregate labor hours is equal to 0.33.

In the production function, the capital income share (θ) is set at 0.33, and the depreciation rate of capital (δ) is set at 0.08. The scaling production parameter A is calibrated to normalize the average wage income in the benchmark into unity.

4.2 Labor Productivity and Medical Expenditure Shocks

In the model, the labor efficiency shock (z_t) process is used to capture the income fluctuations. We employ a first order autoregressive AR(1) process to approximate the pattern of logarithm of labor efficiency shocks (or equivalently, income shocks).[4] The process is set as:

$$\log(z_{t+1}) = \rho_z \log(z_t) + \epsilon_{zt}, \tag{7}$$

where ρ_z is the serial correlation coefficient on labor productivity shock and ϵ_{zt} is white noise. We adopt the estimation provided by Hubbard et al. (1995). Because their estimation of income process, which is based on micro data, includes unemployment insurance

[4]See similar settings in Aiyagari (1994) and Hubbard et al. (1995) for example.

benefits, it better fits this model than other estimations based on aggregate data. They estimate the income-shock processes for three educational categories separately. Here the ρ_z is chosen to be 0.955 and the variance of ϵ_{zt} is set at 0.025, as in their middle-education group. We then apply the procedure described in Tauchen (1986) to approximate this AR(1) process using a three-state Markov chain, with a maximum and minimum equal to plus and minus 2 standard deviations of the unconditional distribution.

To characterize medical expenditure shocks, We directly use a Markov process instead of an AR(1) process because of the skewness of medical expenditure. We define four medical expenditure states as "low," " fair," "high," and "very high," which represent medical expenditure in the bottom 60%, from 60 to 95%, from 95 to 99% and in the top 1%, respectively. Jeske and Kitao (2009) use a similar setting and estimate the process of medical expenditure based on the Medical Expenditure Panel Survey (MEPS). Based on the report from Jeske and Kitao (2009), we are able to calculate the mean of medical expenditure of each group in the U.S. working-age and retired population in 2003. These expenditures were 0.9%, 10.8%, 50.0%, and 159.4% as of the average income in 2003 for the working-age population, and were 4.9%, 28.5%, 103.6%, and 226.5% for the retired population. Therefore, We set the four-state medical expenditure shocks, X_y and X_o for the young and the old respectively, as the above percentages of average labor income in the model (see table 1 and 2).

The MEPS provides two-year panels since 1996 that allows estimation on transitions of medical expenditure states. Monheit (2003) Monheit uses the data from the 1996/97 MEPS to study the persistence of medical expenditure. Jeske and Kitao (2009) also use the MEPS data to determine the transition probabilities of medical expenditure states. Our transition probabilities for the Markov chain of medical expenditures are calibrated based on the study of Jeske and Kitao (2009) The results are reported in Table 3 and Table 4.

4.3 Health Insurance

4.3.1 Private Health Insurance

Based on MEPS, the private health insurance provides various expenditure coverage rates depending on age and amount of medical expenditure. We use the report in Jeske and Kitao (2009) to set the effective coverage of PHI $\bar{\omega}_p(x)$ as $(.528\ .702\ .765\ .845)$ for the

Table 1: States of medical expenditure – the young (X_y)

State	Expenditure range	Average ($ in 2003)	Ratio to average income (2003)
Low	bottom 60%	310	0.9%
Fair	60 – 95%	3,597	10.8%
High	95 – 99%	16,629	50.0%
Very High	top 1%	53,013	159.4%

Original source: MEPS.
Calculation based on Jeske and Kitao (2009).

Table 2: States of medical expenditure – the old (X_o)

State	Expenditure range	Average ($ in 2003)	Ratio to average income (2003)
Low	bottom 60%	1,630	4.9%
Fair	60 – 95%	9,474	28.5%
High	95 – 99%	34,455	103.6%
Very High	top 1%	75,329	226.5%

Original source: MEPS.
Calculation based on Jeske and Kitao (2009).

young and $(.315\ .511\ .637\ .768)$ for the old with the four medical expenditure states.

The PHI serves as the primary insurance in the benchmark economy in which the UHI is not available. The markup ψ of PHI is chosen so that in the benchmark economy there are 70% of households purchase PHI, which is set to be consistent with the PHI market for the working-age population in the US. Although we do not match the PHI take-up ratio by income group, the simulation in the benchmark shows that the PHI take-up ration in the top 50% income group is 80% and the ratio in the bottom 50% income group is 60% that is consistent with the phenomenon observed in the US that PHI take-up ratio is increasing in income.

Table 3: Transition probabilities of X_y

	Low	Fair	High	Very High
Low	0.784	0.199	0.014	0.003
Fair	0.337	0.591	0.062	0.009
High	0.173	0.562	0.200	0.065
Very High	0.105	0.376	0.286	0.233

Original source: MEPS.
Calculation based on Jeske and Kitao (2009).

Table 4: Transition probabilities of X_o

	Low	Fair	High	Very High
Low	0.762	0.217	0.019	0.003
Fair	0.368	0.551	0.062	0.018
High	0.218	0.591	0.137	0.054
Very High	0.118	0.608	0.264	0.010

Original source: MEPS.
Calculation based on Jeske and Kitao (2009).

4.3.2 Universal Health Insurance

Various UHI policies are considered in our analysis to reflect the heterogenioty of . We use various expenditure coverage rates of UHI ω, from 30% to 90%, for our policy experiments. In these cases the PHI becomes supplementary and covers $\bar{\omega}_p(x)$ of the out-of-pocket expenditure $(1-\omega)x$ instead of total expenditure x.

4.4 Social Security, Safety Net and Government taxation

The social security payment is set as 45% of average labor income of the young adults. The minimum consumption floor provided by the safety net is set to 10% of average earning as in Attanasio et al. (2010). Consumption tax rate is set at 5%, capital income tax is 45% and labor income lax rate is 35% (including social security tax). Government debt to output ratio is 40%. The above parameters are selected to match the features in the US

Table 5: *Summary of Parameters*

Parameter	*Notation*	*Value*
Risk Aversion	μ	2.00
Depreciation Rate	δ	0.08
Capital Income Share	θ	0.33
Prob. of being retired	ρ_o	1/45
Prob. of Death	ρ_d	0.0889
Fraction of the Young	$\frac{\rho_d}{\rho_o+\rho_d}$	0.8
Social security benefit	ss	45% of average labor income
Min. consumption level	$\underline{c}$	10% of average labor income
Consumption tax rate	τ_c	0.05
Capital tax rate	τ_k	0.45
Labor tax rate	τ_n	0.35
Debt/GDP ratio		0.40

and also used in the literature.

5 Quantitative Analysis

The benchmark is an economy, in which UHI is not available. PHI serves as primary health insurance, and households make decisions on purchasing PHI, supplying labor and holding assets. Households who decide not to purchase PHI becomes uninsured.

We compare the benchmark economy and economies with economies, in which the environments are the same as the benchmark except that a public UHI program is implemented. We assume that when UHI is introduced, PHI becomes a complementary insurance that partially covers the rest of medical expenditure beyond the UHI coverage and that the markup of PHI does not change. Alternative PHI assumptions, when UHI is introduced, will also be discussed.

When the government provides UHI, it also needs to decide the expenditure coverage rate ω of the UHI and the financing method. If we use the fraction of public health expenditure in total health expenditure to approximate the ω, as we observe in Figure 1, it ranges between 40% to 90% among those OECD countries offering UHI. Most of those countries, which provide UHI, finance the UHI by payroll taxes and/or general government revenues. The payroll tax financing method has a redistribution effect because people with higher income pay more for the same expenditure coverage provided by the UHI. It is desired for social fairness although this tax also creates distortion. Our model with endogenous labor decision allows us to address the impacts of the distortion by comparing with a non-distortionary financing method. To determine an UHI policy, we face a trade-off between risk sharing and tax distortion.

In this section, we first investigate the case, in which UHI covers 50% ($\omega = 0.5$) of medical expenditures and it is financed by a payroll tax. We compare it with the benchmark economy to illustrate the impacts of UHI.

Then we further investigate different UHI policies with various ω (from 0.4 to 0.9) and cases under a lump-sum tax (a non-distortionary tax) financing method. Impacts of UHI on welfare, asset holding and PHI purchasing decisions with the two financing methods are discussed. Robustness tests are also performed.

Moreover, we discuss the application of this framework to the US, in which a public health insurance, Medicare, already exists but only covers old individuals. Implications for private insurance (alternative designs) when UHI is introduced are also discussed.

Table 6: Aggregate features – Benchmark v.s. UHI ($\omega = 0.5$)

	ω	L	K	PHI	r	K-Y ratio	Increased tax
Benchmark	0	0.33	5.16	0.70	3.01%	3.00	0.00%
UHI	0.5	0.32	4.49	0.29	4.23%	2.78	8.59%

Notes: L is average effective labor; K is average asset holdings; PHI is PHI take-up ratio;Increased tax is the increase in payroll tax compared with the benchmark.

5.1 Public UHI Provision – Deviation from the Benchmark

Aggregate features

Table 6 presents the aggregate features of the benchmark economy and the economy with UHI provision, which covers 50% of medical expenditure primarily and is financed by a payroll tax. We can observe clear crowding-out effects on asset holdings and PHI purchases. The PHI take-up ratio is only 0.29 in the economy with UHI, that is much lower than the 0.7 in the benchmark economy. The capital-output ratio is also lower than it in the benchmark economy (2.78 v.s. 3.00) because of the lower average asset holdings. Moreover, the UHI provision leads to a higher tax burden – additional 8.59% payroll tax is imposed on the working population. The substitution effect caused by the distortionary payroll tax decreases labor supply in the economy with UHI – the average effective labor hours become 0.32 compared with 0.33 in the benchmark.

PHI take-ups and asset holdings

We observe a significant crowding-out effect on PHI purchases across wealth and generations when UHI is implemented (see table 7). Given the assumption that PHI becomes complementary with the same proportional markup, we find a difference between wealth-rich and wealth-poor households. Those in the top-50% wealth group largely drop their PHI while more in the bottom-50% group maintain their PHI. In the benchmark when UHI is not available, there are almost 80% of the top-50% wealth group purchase PHI. However, in the economy when UHI is offered, only 14% of households in the top-50% group purchase the PHI. In contrast to the top-50%, in the bottom-50% wealth distribution there are still more than 40% of households purchasing the PHI when the UHI is offered.

Table 7: PHI take-up ratio – Benchmark v.s. UHI ($\omega = 0.5$)

wealth group	Benchmark	UHI	Deviation
	Old generation		
top 50%	77.41%	13.71%	-63.71%
bot'm 50%	63.47%	41.47%	-22.00%
	Young generation		
top 50%	79.45%	13.80%	-65.65%
bot'm 50%	60.40%	44.73%	-15.66%

Notes: Deviation is the difference between the UHI economy and the benchmark.

Table 8: Asset holdings – Benchmark v.s. UHI ($\omega = 0.5$)

wealth group	Benchmark	UHI	Deviation
	Old generation		
top 50%	9.195	8.008	-12.91%
bot'm 50%	1.397	1.180	-15.54%
	Young generation		
top 50%	9.014	7.858	-12.82%
bot'm 50%	1.235	1.042	-15.61%

Notes: Deviation is the percentage change from the benchmark.

A significant crowding out effect on asset holdings is also observed (table 8). Nevertheless, we find that the trend of asset holdings across wealth groups is opposite to the PHI purchasing – the bottom 50% group drops asset holdings (by 16%) more than the top 50% (by 13%). This result suggests that when UHI is implemented, the wealth-rich tend to allocate more assets than private insurance in their portfolio, but the wealth-poor tend to rely on private and social insurance programs rather than on precautionary savings.

Portfolio choices

To understand the difference between the high-wealth and the low-wealth households, we first need to understand the features of the two portfolio choices – assets and health insurance. Assets can insure both income and health expenditure shocks, but are not state contingent. To be well self-insured, households need to accumulate enough assets. PHI is state contingent, and so households can be well insured against health expenditure shocks by simply purchasing a PHI plan. However, unlike the assets, PHI can do nothing with income shocks.

There are two channels through which the introduction of universal health insurance affects the private health insurance take-ups. First, compared to the benchmark case, where the universal health insurance (UHI) is not available, private health insurance (PHI) is crowded out by UHI since the expenditure risk is reduced. This risk reduction lowers down PHI take-up ratio in aggregate, i.e. a crowding-out effect (risk-reduction channel). Second, PHI becomes more affordable with higher UHI coverage since the expected out-of-pocket medical expenditure is lower and so PHI premium is lower. More people on average purchase PHI rather that self-insuring by accumulating the non-state contingent asset because the price of PHI is cheaper, i.e. a crowding-in effect (substitution channel).

Table 7 and 8 compare the PHI take-ups and asset holdings between two wealth groups (top 50% wealth rich vs. bottom 50% wealth poor) and show that the two channels work differently across the wealth groups. When UHI provides primary coverage, the wealth-rich allocate more resources on self-insurance (savings) while the wealth-poor rely more on complementary PHI. That is, risk-reduction channel dominates in the wealth-rich group while substitution channel is stronger in the wealth-poor group. This is because, to the low-wealth households in any case it is difficult to accumulate enough assets for self-insurance. In addition, the out-of-pocket medical expenditure is still a burden to them as long as the UHI requires co-payments (ω is not one). Since the price of PHI is cheaper now, they are more willing to maintain PHI, compared with the wealth-rich, to insure against the medical expenditure shocks.

To the wealth-rich, with the UHI provision, the uncertain out-of-pocket medical expenditures become relatively small, and the benefit of purchasing a complementary PHI plan that covers a proportion of out-of-pocket expenditures becomes unattractive to them. They can more easily use their assets to replace the complementary PHI, but poor households do not have this option. Moreover, the rate of asset return r is higher with the UHI provision since the aggregate capital is crowed out. Given the normal assumptions of preferences, the high-wealth will response more to the higher asset return (by increasing

Table 9: Welfare Comparison: Rich v.s. Poor

wealth group	Benchmark	with UHI $\omega = 50\%$	Deviation (CEQ)
top 50%	-33.269	-33.323	-0.41%
bot'm 50%	-48.626	-47.078	8.49%

Note: Welfare is measured by life time value with equilibrium distribution; Deviation is calculated by using the certainty equivalent consumption (CEQ) measure; $CEQ = (V_{\text{UHI}}/V_{\text{benchmark}})^{1/[\phi(1-\mu)]}$.

Table 10: Welfare Comparison: Young v.s. Old

wealth group	Benchmark	with UHI $\omega = 50\%$	Deviation (CEQ)
Old	-47.79	-45.83	11.09%
Young	-39.24	-38.79	2.94%

Note: Welfare is measured by life time value with equilibrium distribution; Deviation is calculated by using the certainty equivalent consumption (CEQ) measure; $CEQ = (V_{\text{UHI}}/V_{\text{benchmark}})^{1/[\phi(1-\mu)]}$.

asset holdings) than the low-wealth. Therefore, we observe a less percentage reduction in asset holdings but a sharper decline in PHI take-ups among the households in the top-50% wealth group.

The result is based on our assumption of PHI design when UHI is introduced. We will discuss alternative PHI plans in section 5.5. This finding also indicates that the wealth-rich households might be sensitive to price changes in PHI. The effect of price changes on PHI take-ups will also be discussed in section 5.5.

Welfare

The UHI's redistribution effect on wealth is not clear, and the wealth distribution might be even more unequal since the gap of asset holdings between the high-wealth and the low-wealth is enlarged. However, we observe a clear redistributions effect on welfare between young and old generations and between high- and low-wealth groups. Table 9 and 10 summarizes the results.

The main factors of UHI provision that affect welfare are as follows:

1) Risk reduction: it increases individual's ability to insure the medical expenditure risk because the general expenditure coverage is increased by UHI when PHI has a limitation on the coverage.
2) General equilibrium effect: the reduction of precautionary savings will increase interest rate and lower down wage rate.
3) Tax effect: the increased burden on payroll tax or income tax used for financing the UHI program has a income effect and a distortion that discourages labor supply and asset holdings.

In general, the old generation gains more than the young generation from the UHI provision because their UHI coverage is subsidized. The young generation need to share old people's insurance cost with the payroll tax financing scheme. Moreover, we can also observe that the low-wealth people gains more than the high-wealth. One reason is that the benefit of risk reduction is larger for low-wealth people, who are unable to self insure against medical shocks, but smaller for high-wealth people, who are already self-insured. In addition, the high-wealth people (who are rich in the model because they consistently have higher labor productivity and so higher labor income) are forced to pay more for the same coverage offered by UHI.

5.2 Discussion – various UHI policies, and the trade-off between risk reduction and tax distortion

We also perform experiments with various UHI expenditure coverage ω that reflect the heterogeneity among the OECD countries as shown in figure 1. In addition, the same experiments are performed under a non-distortionary financing scheme, a lump-sum tax, to discuss the distortion effect of the financing of UHI.

With various settings of the UHI co-insurance rate ω (from 0.4 to 0.9) under the payroll-tax financing scheme, the results are consistent with our analysis above (see the blue lines in figure 4 to figure 9). We can see that a UHI program with a larger ω crowds out more PHI purchases and asset holdings (figure 4 and figure 7), and its higher payroll tax rate reduces more labor (figure 5).

Payroll tax financing v.s. lump-sum tax financing

If the UHI is financed by the non-distortionary lump-sum tax, the cost of UHI implemen-

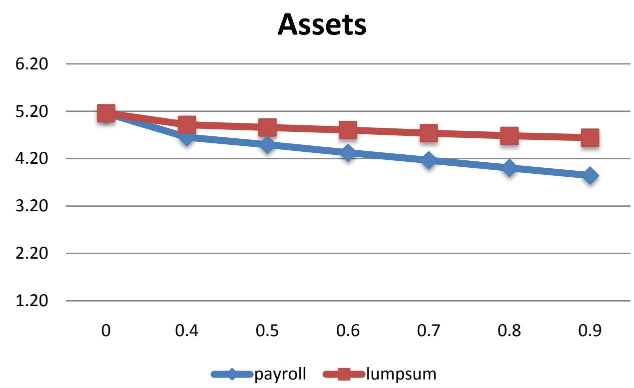


Figure 4: Average Asset Holdings – various UHI ω

tation is equally shared by all agents in the economy, regardless of wealth level and age. This method is rarely adopted to finance the UHI or other social insurance programs because it does not match the common concept of "social fairness." We however find that this non-distortionary financing method help us disentangle the distortion created by a distortionary payroll tax.

We re-do the simulations with ω from 0.4 to 0.9 under the lump-sum financing scheme. The results are represented by the red lines in figure 7 to figure 9. The figure 4 and figure 7 show that PHI and asset holdings are also crowded out (compared with the benchmark with $\omega = 0$) but they are less crowded out than under the payroll tax financing method. Labor hours are not decreased as when the UHI is financed by the distortionary payroll tax because the lump-sum tax does not distort the wage rate. Instead, it brings a negative income effect that increases the incentive to work more.

Asset holdings

Figure 4 presents the aggregate asset holdings in the benchmark economy and the economy with UHI provision. We can observe clear crowding-out effects on asset holdings in both financing methods. With lump-sum tax financing, we clearly see that providing UHI without distortion in the economy reduces the precautionary savings motive so that agents' asset holdings on average are lower. When the payroll tax financing method

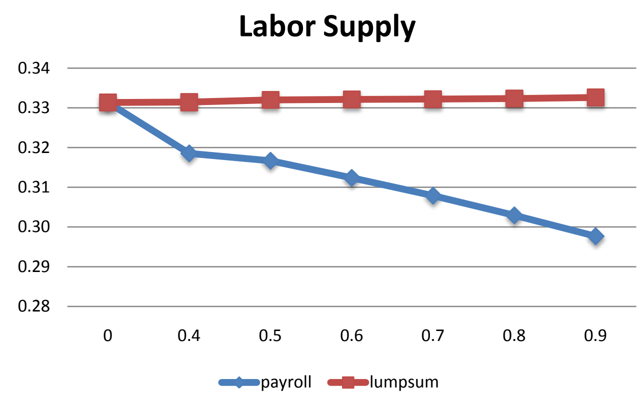


Figure 5: Average Labor Supply – various UHI ω

is used, the volatility of after-tax earnings that households face is reduced, and so the precautionary saving motive becomes further lower.

Labor Supply

Figure 5 shows effects of two different financing methods on agent's average labor supply and 6 presents equilibrium payroll tax rates. We clearly see non-distortionary property of the lumpsum tax but since lumpsum tax will change agent's asset holdings and consumptions, it will have minimal effect on labor supply through the income effect so that the labor supply does not stay constant at the benchmark level. On the other hands, when government uses the payroll tax to finance the UHI, the increase in the payroll tax rate will distort the labor supply decision and as the tax rate increases the labor supply monotonously decreases - the substitution effect dominates even though asset holdings decreases so that agents have incentive to work more.

PHI take-ups

In Figure 7, we observe a significant crowding out effect on PHI purchases in the economies when UHI is implemented. Although the premium of PHI becomes cheaper as UHI coverage ω increases, there is less space that PHI can cover. Figure 7 confirms

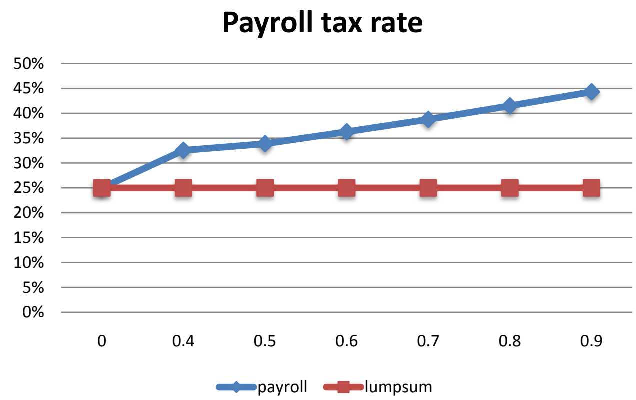


Figure 6: Payroll Tax Rate – various UHI ω

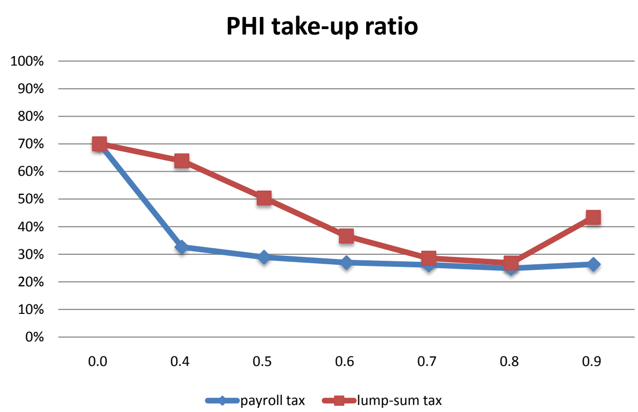


Figure 7: PHI take-up ratio – various UHI ω

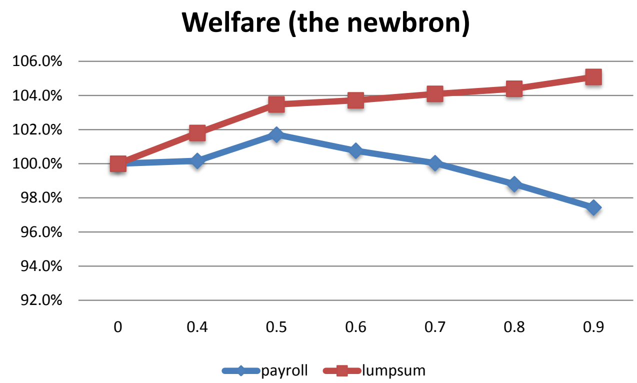


Figure 8: Welfare comparison (newborn babies) – various UHI ω

that the substitution effect (PHI being cheaper) is dominated by the crowding-out effect. Similar to asset holdings, we also find the payroll tax financing crowds out more PHI take-ups than the lump-sum tax financing scheme. Note that when $\omega = 0.9$ and the PHI becomes very cheap, the PHI take-up ratio increases a bit but is still lower than that in the benchmark.

Welfare Implication

To understand the impacts on welfare, we adopt two measures of social welfare: 1) ex-ante expected lifetime discounted utility of a newborn agent and 2) average cross-sectional expected lifetime utility. Again, we use the certainty equivalent consumption (CEQ) to calculate welfare deviation form the benchmark to economies with various UHI coverage across different financing schemes (lump-sum tax vs. payroll tax).[5] Figure 8 presents the result with the first welfare measure (newborn babies) and Figure 9 presents the result with the second welfare measure (average social value). Note that welfare with lump-sum tax financing is computed to disentangle the distortionary effect of payroll tax. Any gaps between social welfare with lump-sum tax and payroll tax reflect the aggregate welfare effect of the distortion.

If we use social average lifetime value to measure social welfare (Figure 9), the social

[5] $CEQ = (V_{\text{UHI}}/V_{\text{benchmark}})^{1/[\phi(1-\mu)]}$.

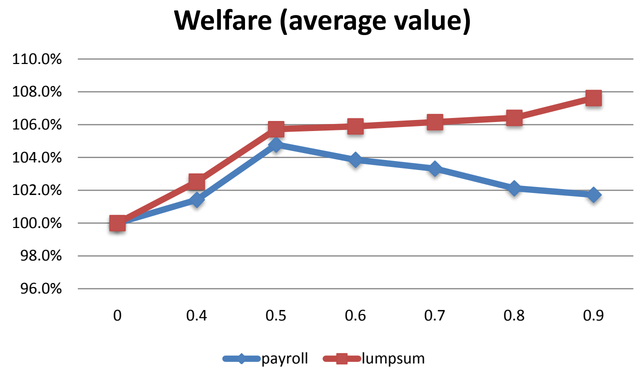


Figure 9: Welfare comparison (social average lifetime value) – various UHI ω

welfare is always higher with any positive UHI coverage than in the benchmark economy where UHI coverage is absent. Moreover, with lump-sum tax financing, the welfare is monotonously improving over the UHI coverage, while with a payroll tax financing scheme, the welfare is improving up to the coverage around 50% and then deteriorated afterward so that the social welfare as a function of the UHI coverage shows an inverse U shape. It implies that marginal social gain (benefit) is bigger than marginal social cost (distortion) up to the UHI expenditure coverage of 50%, but the marginal cost of tax distortion outweighs the marginal gain when the UHI coverage becomes higher.

We also use another measure of social welfare, expected value of newborn babies, to do the comparison. Figure 8 presents the result. The pattern is the same as with the measure of social average value, but we can see that the social welfare is even lower than the benchmark when the UHI coverage is higher than 70%.

As we found in Figure 8 and 9, allowing endogenous labor decisions plays an important role here. It is crucial to model the endogenous labor supply for carefully investigating the welfare implication of a policy when the policy requires additional distortionary tax to be introduced for government budget balance. In our analysis, the payroll tax financed UHI does not necessarily leads to higher welfare.

It is not hard to understand the general welfare effect. In the case that we analyzed, as being a primary health insurance, PHI has a limitation on covering full medical cost.

From the US data, we find the PHI coverage is about 70% on average. With the UHI serving as the primary insurance, people can use PHI as a supplementary/complementary insurance to further reduce the uncertainty that improves welfare. Moreover, as found in Hubbard and Judd (1986), Aiyagari (1995), Imrohoroglu (1998) and Conesa et al (2009), the crowding-out on asset holdings caused by the UHI provision and the tax distortion also contribute to the welfare in the environment with incomplete markets. In the benchmark economy, because of market incompleteness, precautionary savings lead to an over-accumulation of capital (and consequently over-supply of labor). The reduction in capital resulted from UHI provision adjusts the capital and makes the aggregate better off. However, we also observe that the tax distortion effect can outweigh the additional welfare gain under the payroll tax financing scheme while it does not under the lump-sum financing. In our numerical exercise, we find when the UHI expenditure coverage rate is greater than 50%, the additional distortion effect outweighs the additional welfare gain. The rate (50%) is actually much lower than the OECD average.

5.3 Sensitivity Tests

The level of risk aversion, which is governed by the parameter μ in the utility function, is an important determinant of household's saving/health insurance purchasing decisions and affects the welfare measurement of our policy experiments. In the benchmark analysis, we set μ at 2, which is used by many previous studies. To test the robustness of our results, we also perform the above experiments with different levels of risk aversion, particularly $\mu = 1.5$ (less risk averse) and $\mu = 3$ (more risk averse).[6]

Higher risk aversion

In figure 10 we show the analysis results when households are more risk averse (with $\mu = 3$). We can see that the comparison across various UHI policies (various ω) and financing methods is the same as with $\mu = 2$ except the welfare measured by social average value. The social welfare under some UHI policies (when ω is 0.4 and 0.5) is higher with a payroll tax financing scheme than with a non-distortionary lump-sum tax scheme.

[6]We also try some smaller values for μ, e.g. $\mu = 1$. However, when μ is close to 1, households become less risk averse and the PHI take-up ratio is always lower than 70% (our calibration target) even with a zero mark-up in the PHI premium in the benchmark economy. Therefore, we can not compare these cases with our benchmark analysis.

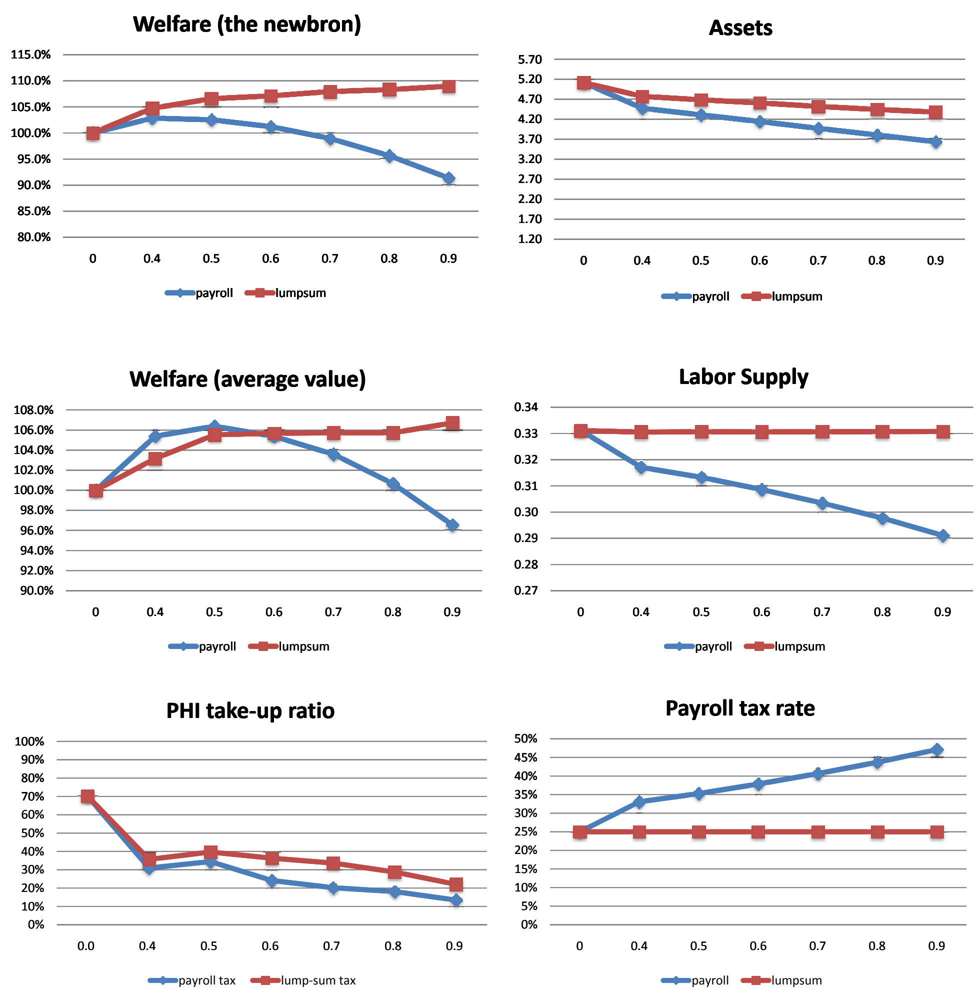


Figure 10: Sensitivity Test ($\mu = 3$) – various UHI ω

This finding also verifies the result from many previous studies on capital tax with incomplete markets, e.g. Hubbard and Judd (1986), Aiyagari (1995), Imrohoroglu (1998) and Conesa et al (2009). Because of market incompleteness, precautionary savings lead to an over-accumulation of capital (and consequently over-supply of labor). The reduction in capital resulted from UHI provision adjusts the capital and makes the aggregate better off.

With the payroll-tax financing, assets are further reduced The difference in labor supply between the payroll-tax financing and the lump-sum tax financing is the reason – the tax distortion reduces labor supply and so lowers down the labor income fluctuation and the marginal product of capital (i.e. asset return) that further discourage asset holding.

With a higher risk aversion, which implies a higher overaccumulation of capital in the benchmark economy, the gain from the capital adjustment is higher. Therefore, we observe the payroll-tax financing outperforms the non-distortionary lump-sum tax financing method in welfare. However, when ω is set higher, the loss form distortion on labor still dominates. Even though the payroll tax financing can gain more with some UHI policies, we still find an inverse U shape of welfare pattern across the policies with various ω. The peak of social welfare with the payroll tax financing is still at $\omega = 0.5$ (i.e. 50% co-insurance rate).

Lower risk aversion

Figure 11 displays the analysis results when households areless risk averse (with $\mu = 1.5$). We can clearly observe that the comparison across various UHI policies (various ω) and financing methods is the same as with $\mu = 2$. Since the overaccumulation of capital is even smaller with a smaller risk aversion, the loss from labor distortion governs the difference between the payroll tax financing and the lump-sum tax financing. In this case, we still find that the UHI policy with ω set at 0.5 leads to highest social welfare. All these analyses suggest that the optimal UHI coverage ratio with payroll tax financing would be much lower than the current OECD average (70%).

5.4 Implication for the US – the Existence of Medicare

The US is currently pursuing an universal health insurance coverage. The analysis framework can be also applied to the US, but in the previous analysis we do not take into account an US specific public health insurance program, Medicare, which provides

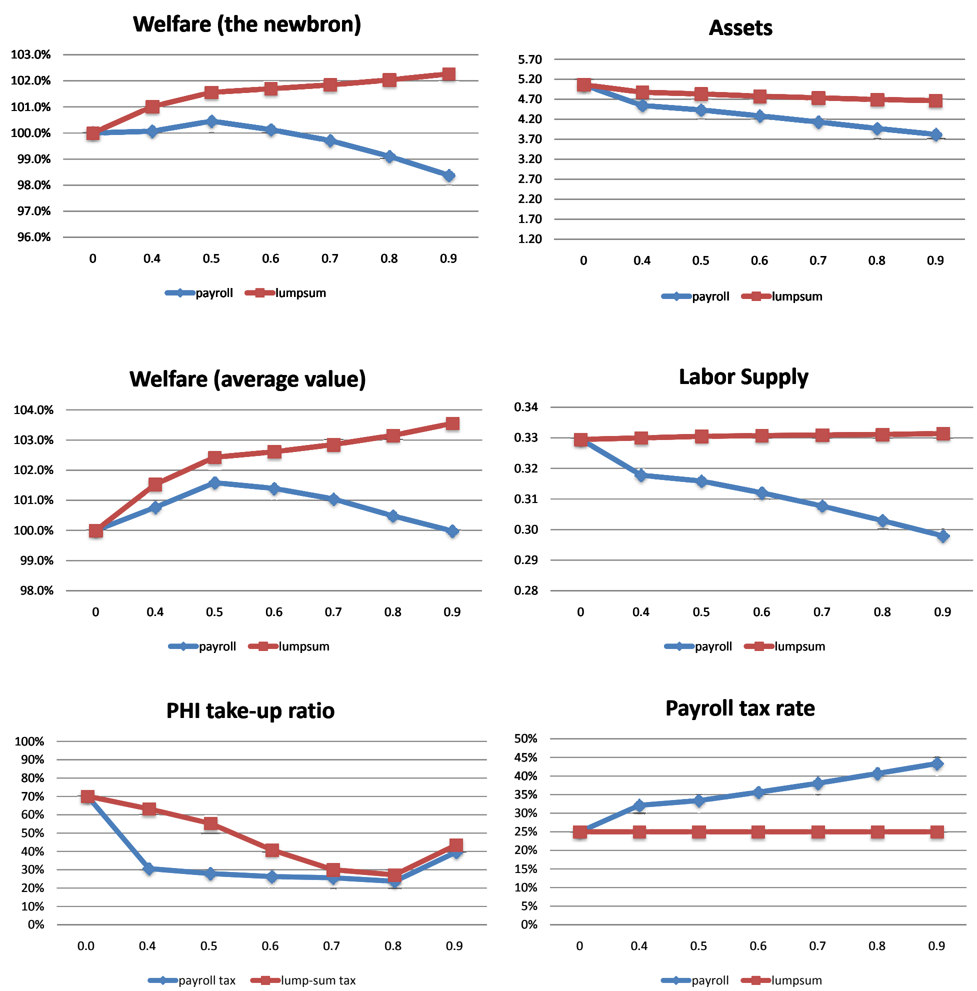


Figure 11: Sensitivity Test ($\mu = 1.5$) – various UHI ω

universal health insurance coverage to individuals with age 65 and above (the old agents in our model).

To provide a more precise implication for the US, we incorporate Medicare in the model. The model with an addition of Medicare and corresponding calibration for quantitative analysis are described in Appendix A. With the existence of Medicare, individuals will be automatically covered by Medicare without the need of purchasing PHI when they become old. Therefore, in the benchmark, young agents still need to make a decision on PHI purchasing, while all old agents have health insurance coverage from Medicare.

The current Medicare covers, on average, 50% of total medical expenditures for those qualified individuals (Attanasio, Kitao and Violante, 2010). In our experiments of public UHI implementation, we assume that if the UHI's expenditure coverage rate ω is smaller than or equal to 50%, the old will still enjoy their original Medicare benefits and there is no change in their insurance coverage; if ω is larger than 50%, the UHI will provide additional coverage to the old to fill up the gap between Medicare and the UHI.

As in the previous analysis, we investigate UHI implementation with various coverage rates ω. We still assume the public UHI is financed by payroll tax (or equivalently an income-contingent premium). An alternative lump-sum tax financing method will also be performed for comparison.

We find that the impacts of UHI implementation on PHI purchasing, asset holdings, labor supply, and tax burden are similar to our previous results. Because the old have already covered by Medicare prior to the UHI and do not receive any additional benefit when UHI's $\omega \leq 50\%$, the UHI mainly covers the young's medical expenditures but less or none of the old's expenditures, which are more expensive. Therefore, the increased tax burden for financing UHI is smaller than that in the case without Medicare – e.g. only 3.2% additional payroll tax is needed for financing an UHI program with $\omega = 0.5$ (in which Medicare have covered the old with the same coverage rate and the UHI only need to cover the young). See Figure 12 for patterns of impacts of UHI policies with various coverage rate ω (the horizontal axis).

The welfare deviations of the young and the old with various UHI coverage rate ω show different patterns in this case. Figure 13 presents the welfare deviations from the benchmark for the young, the old and social average (which are also measured by CEQ). Since the old already have Medicare covering their medical expenditure shocks, unless the UHI's $\omega > 0.5$, they do not receive additional benefit from the UHI implementation

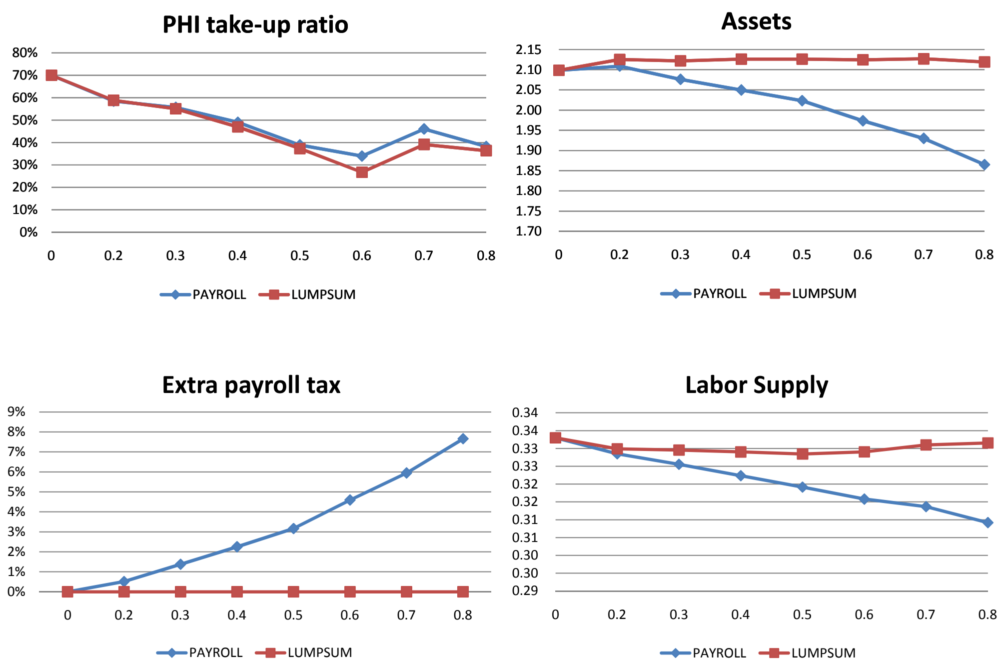


Figure 12: Results with Medicare – various UHI ω

but are still affected by the distortion of additional tax burden. Therefore, we find an U shape welfare pattern with various ω for the old (the middle graph in Figure 13) – it goes down until $\omega = 0.5$ and then goes up. However, even the old can get additional insurance coverage under a UHI program with $\omega > 0.5$, the tax distortion is strong, too. They are in general worse off when an UHI program as we proposed is implemented.[7]

The young's welfare shows a rough inverse U shape pattern with increased ω similar to the welfare pattern in the case without Medicare (the top graph in Figure 13). Because they will take into account the expected welfare in the old age (which has a pattern opposite to the young's), the welfare pattern is not as smooth as that in the case without Medicare. In addition, they start to share additional old people's UHI cost when ω is greater than 50% that has a negative impact on their utility.

The social welfare pattern with various UHI coverage rates ω is presented by the bottom graph in Figure 13. With the payroll tax financing, it shows an inverse U shape as that in the case without Medicare. Compared with the social welfare in the case without Medicare (Figure 9), we find that: 1) the welfare improvement with the UHI provision is smaller than that without Medicare – at most 1% of lifetime consumption (v.s. above 4% without Medicare); 2. the optimal UHI expenditure coverage rate ω is smaller – 20% in this case (v.s. 50% without Medicare).[8] This difference is mainly driven by the existence of Medicare, which has provided an universal health insurance coverage to the old with a 50% expenditure coverage rate. The old are not benefited much from an additional UHI provision and even become worse off due to the tax distortion for financing the UHI. Moreover, medical shocks that young people have to face are much smaller than the old people's (see Tables 1 and 2). Therefore, the UHI provision, which mainly benefits the young, does not improve the social welfare as much as that in the case without Medicare. The experiments of lump-sum tax financing (in the bottom graph of Figure 13) confirm this finding – even with less tax distortion, improvements in social welfare with various UHI policies are in general less than 2% (i.e. CEQ smaller than 102%).

[7]With the lump-sum tax financing, to be consistent with our previous analysis in the case without Medicare, every individual has to make a lump sum payment for financing the UHI including the old. When $\omega \leq 0.5$, although the old do not receive additional benefit from the UHI, they are charged by the lump-sum tax. Therefore, even though a lump-sum tax is less labor-distorting, The old's welfare still shows a U shape pattern with increased ω, and might be even lower than that in the case of payroll financing when $\omega \leq 0.5$.

[8]When $\omega = 0.2$, $CEQ = 101\%$, which is the highest among the alternative UHI policies.

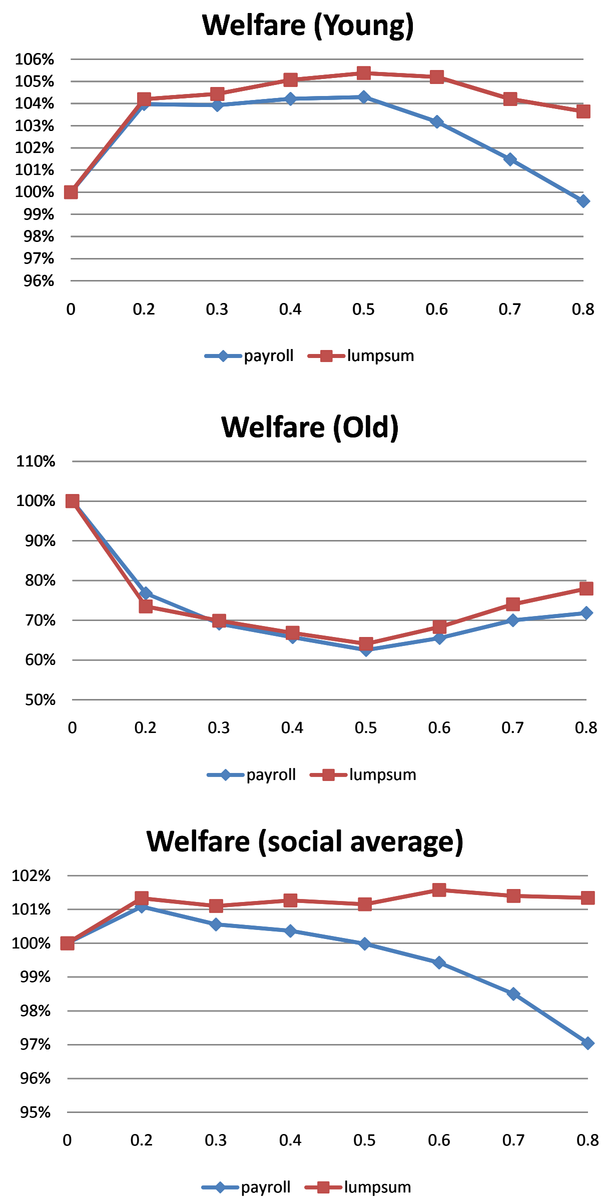


Figure 13: Results with Medicare – welfare comparison (various UHI ω)

5.5 Discussion: Demand of PHI When UHI is Introduced

In the above analysis, when UHI is introduced, the PHI is assumed to be a complementary plan, that reduces out-of-pocket medical expenditures, and we also assume its markup is the same as the primary PHI when UHI is not available. Given the assumptions, the model predicts that complementary PHI take-up ratio of the rich is low and even lower than that of the poor, which is seemingly counter to the common impression. This subsection provides a discussion and releases the assumptions to investigate the demand of PHI when UHI is introduced.

Because the UHI already provides primary coverage to medical expenditures, the out-of-pocket payments become smaller, especially to the rich group. Therefore their incentive to purchase additional insurance for reducing a proportion of out-of-pocket expenditures will not be high because they can easily use their wealth to insure themselves against normal out-of-pocket medical expenditures. It indicates that the rich are more sensitive to the price of the complementary PHI than the poor, because poor individuals do not have the option of accumulating enough assets for self-insurance.

In the relatively new literature of studying health insurance demand in a general equilibrium environment, medical expenditures are modeled as necessary payments for recovery, which are stochastic and exogenously determined according to the data. For example, Jeske and Kitao (2009) and Attanasio, Kitao and Violante (2010) both adopt this setting of medical expenditures. We also study the endogenous health insurance choice and follow the literature to set up the medical expenditure shocks. However, the limit is that there is no quality difference of medical service in the model. In the real world, there exist supplemental insurance plans that cover higher quality services and/or medical treatments, which are not covered by the public UHI. It is true that rich individuals tend to demand more high-quality/advanced medical services and purchase supplemental insurance plans. This aspect is not captured in the current model given that we use data to determine the medical expenditure states.

In this section, we first extend the model and design a catastrophic insurance plan that mimics a supplemental insurance plan, instead of the complementary PHI in our previous analysis, when UHI provides primary coverage.

Second, the model indicates that the rich are sensitive to the price of complementary PHI because they can easily use their assets to substitute the complementary coverage. We investigate a scenario that the markup of PHI becomes can be lowered down after

UHI is implemented.

The above two additional experiments are performed to further examine the demand of supplemental/complementary PHI. Both scenarios present that the PHI take-up ratio of the rich is higher than it of the poor when UHI provides primary coverage. These experiments provide additional implications for private insurance companies. We show that the other results of UHI provision in the previous analysis still hold in these scenarios. We also find that some empirical evidence of supplemental Medicare coverage supports our model prediction.

5.5.1 Complementary v.s. Supplemental: a Catastrophic Insurance

To investigate the impact of a supplemental insurance plan when UHI is implemented, rather than a complementary plan that covers a proportion of out-of-pocket payments, we design a catastrophic health insurance plan that mimics a complementary plan, although we do not have the aspect of quality difference in medical services. This insurance plan potentially attracts the rich, since catastrophic health shocks, even with a small probability, are still harmful to the rich when they really happen, for example, cancer, major burns, and AIDS.

In the model, the private catastrophic health insurance, not like the UHI that covers a proportion of all types of medical expenditures, provides full coverage of the out-of pocket expenditures when the largest medical shock happens ($x = x_{m,i}$, $i \in \{o, y\}$), but zero coverage when other medical expenditures happen. Based on the MEPS data, the highest (catastrophic) state of medical expenditure in our model, is 160% of average annual income for the young, and 227% of average annual income for the elderly. Suppose that when UHI is implemented, private insurance companies provide the above supplemental catastrophic health insurance instead of the complementary insurance. An young agent's problem can be expressed as follows:

$$V(s) = \max_{c,n,a',i'_{HI}} \left\{ u(c,n) + \beta(1-\rho_o) E\left[V(s')\right] + \beta\rho_o E\left[V_o(s')\right] \right\}$$

Table 11: PHI take-up ratio under UHI ($\omega = 0.5$): Complementary v.s. Catastrophic

	No UHI	UHI available	
Wealth group	Benchmark	Complementary PHI	Catastrophic PHI
top 50%	79.04%	13.79%	80.29%
bot'm 50%	61.02%	44.06%	52.20%

subject to

$$
\begin{aligned}
&(1+\tau_c)c + a' + q\,(x)\, i'_{HI} = Wel_y + T \\
&Wel_y \equiv (1-\tau_{ss}-\tau_n)\, wzn + [1+(1-\tau_k)\, r]\, a - (1-\omega)x + (1-\omega)x(i_{HI})(I_{x=x_{m,y}}) - Tax \\
&T = \max\{0,\ (1+\tau_c)\underline{c} - Wel_y\} \\
&i'_{HI} \in \{0,1\};\ \ a' \geq 0;\ \ 1 > n \geq 0;
\end{aligned}
$$

where V_o is the value when the agent becomes old, and $I_{x=x_{m,y}}$ is an indicator, which has a value 1 if the catastrophic medical expenditure $x = x_m$ happens, and 0 otherwise.

The change in an old's budget constraint is similar to the young agent. The catastrophic health insurance will make a payment $(1-\omega)x$ if the value of $I_{x=x_{m,o}}$ is 1.

The premium of the private catastrophic health insurance is defined as

$$q(x) = (1+\psi)(1-\omega)E[x'(I_{x'=x_{m,i}})|x]$$

where $i \in \{y, o\}$ and ψ is the proportional markup.

We then perform experiments to investigate this scenario. The third column in Table 11 presents the result of PHI take-up ratios of the top 50% wealth group and the bottom 50% wealth group when the PHI is a catastrophic insurance plan supplemental to the UHI (with a coverage rate $\omega = 0.5$). We find that the wealth-rich people have a higher tendency to purchase the catastrophic PHI (with a take-up ratio 80.29%) than the poor (with a take-up ratio 52.20%). As we expect, this insurance plan can still attract the rich because catastrophic health shock are also harmful to the rich. Compared with our original assumption of a complementary insurance that covers a proportion of out-of-pocket medical expenditures (the second column in Table 11), the result implies that supplemental insurance would be more attractive when UHI is available. Particularly, it is more

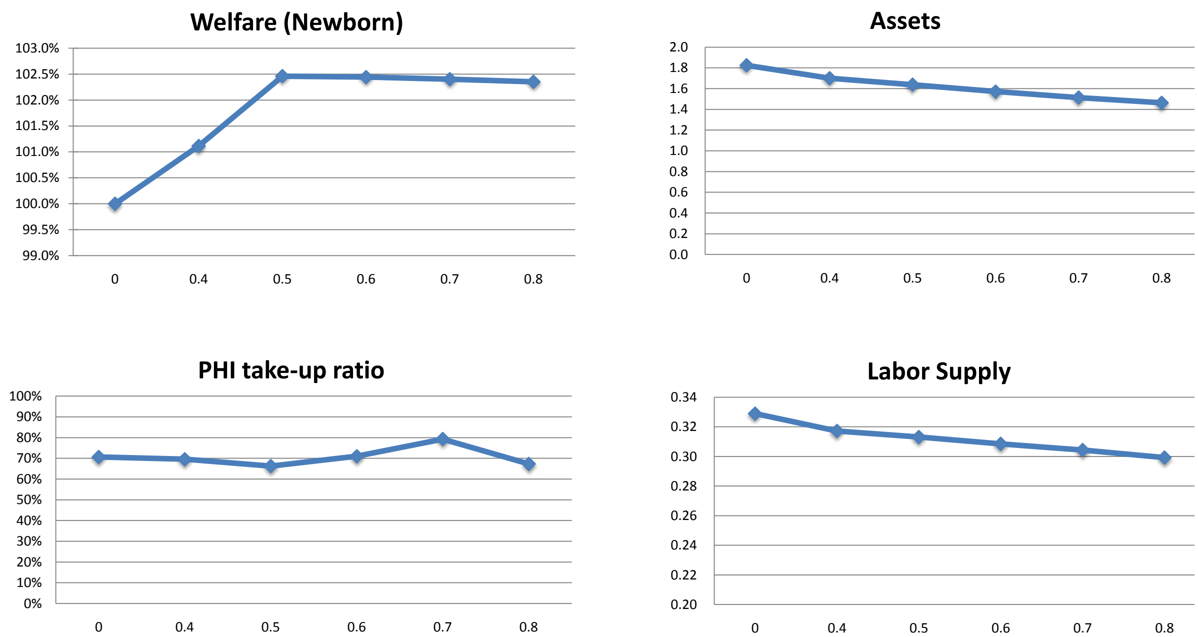


Figure 14: Various policies of UHI with supplemental catastrophic PHI

attractive to the rich than a complementary plan because the rich can easily use their wealth to insure against normal medical expenditure shocks.

Moreover, we also perform an exercise as in our original analysis to examine the impacts of UHI provision with various expenditure coverage rates ω with supplemental catastrophic PHI. The UHI is financed by labor income tax as in the previous analysis. We show in Figure 14 that the the patterns of UHI impacts are similar to the previous analysis even with that the rich have a higher take-up ratio of catastrophic PHI than the poor. As in our previous analysis, we still find that with considering the trade off between risk sharing and tax distortion, the UHI expenditure coverage rate ω should not be high (no higher than 0.5), which is close to the Medicare coverage rate.

Regarding the PHI market, we can see that there are still two channels through which

Table 12: Complementary PHI take-up ratio (UHI $\omega = 0.5$)

	PHI take-up ratio	
Wealth group	Original markup (ψ)	Lower markup (0.5ψ)
top 50%	13.79%	95.57%
bot'm 50%	44.06%	83.83%

the introduction of UHI affects the PHI take-ups. However, the crowding out effect is smaller in this scenario.

5.5.2 Price Change in PHI

Because our model predicts that the rich can more easily substitute PHI with their assets, we expect that they are more sensitive to price changes in PHI. If we assume that after the public UHI provides primary coverage, private insurance companies can reduce their administration cost with only providing complementary insurance, the markup of PHI could be lowered down.

We investigate a scenario that the markup of the complementary PHI to UHI (ψ) is 50% lower than the primary PHI when UHI is not available. The premium of the PHI is:

$$q\left(x\right) = \left(1 + 0.5\psi\right) E\left[\omega_p(x') \cdot (1-\omega)x' | x\right]. \tag{6}$$

We also perform quantitative experiments to investigate this scenario. The second column in Table 12 presents that the complementary PHI take-up ratios of the top 50% wealth group and the bottom 50% wealth group with a lower markup of the complementary PHI to UHI (with a coverage rate $\omega = 0.5$). Compared with our original analysis by assuming the same markup (the first column in Table 12), the cheaper complementary PHI attracts more individuals to purchase it. Particulary the rich now have a higher take-up ratio (95.57%) than it of the poor (83.83%). This result verifies our expectation that the rich is more sensitive to the PHI price changes.

An exercise as in the previous analysis is also performed to examine the impacts of UHI provision with various expenditure coverage rates ω. We show in Figure 15 that the the patterns of UHI impacts are similar to our previous analysis even with that the rich have a higher PHI take-up ratio than the poor. As in our original analysis, we still

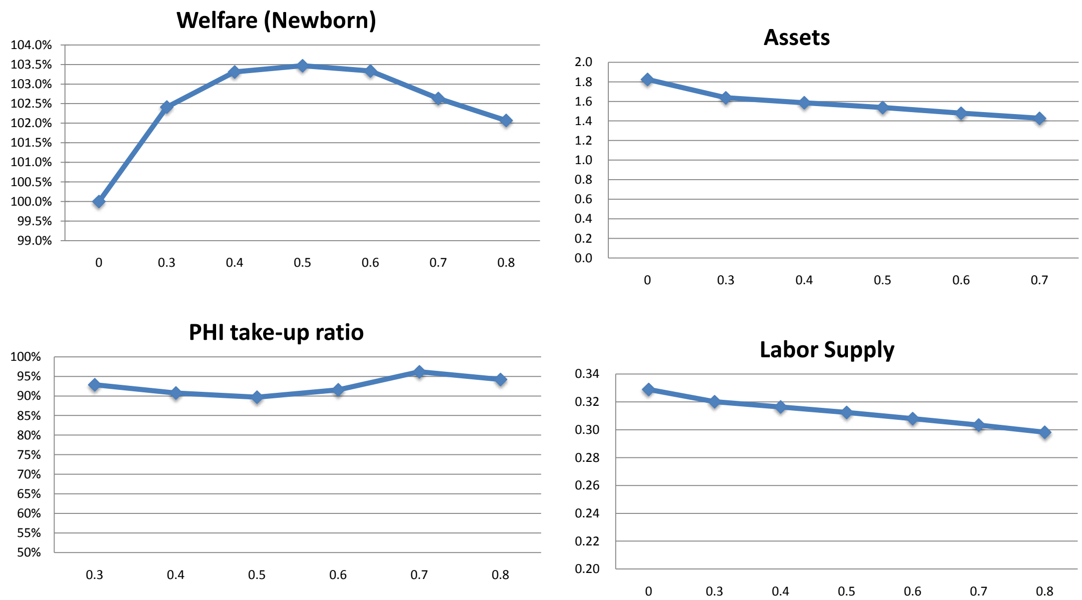


Figure 15: Various policies of UHI with cheaper complementary PHI

find that with considering the trade off between risk sharing and tax distortion, the UHI expenditure coverage rate ω should not be high. The UHI policy with a ω set at 0.5 is still suggested.

Regarding the PHI market, we can see that there are still two channels through which the introduction of UHI affects the PHI take-ups. However, the crowding out effect is smaller in this scenario, and in general the level of take-ups is high because of the cheaper price.

5.5.3 Some Evidence

Because our model predicts that the rich are more sensitive to the price change of complementary PHI than the poor, the data of supplemental/complementary PHI to Medicare would provide an opportunity to test the prediction. Laschober et al. (2002). studied the trend in Medicare supplemental insurance during 1996-1999. During this period, an increased popularity of Medicare HMOs and double-digit increases in Medigap (individually purchased private Medicare supplemental insurance) premiums were observed.[9]. Both Medicare HMOs and Medigap are considered as supplemental insurance to Medicare. They found that the high income group (more than $30,000) experienced a significant decline in total Medicare supplemental insurance coverage, and the significant decline was not found in other lower income groups.[10]

Although we do not focus on the Medicare supplemental insurance market, this empirical finding supports our model prediction on that the rich are more sensitive to the price of PHI because they have an option of self-insurance with assets but the poor do not.

6 Conclusion

In this paper, we provide a quantitative investigation on implications of a public UHI provision in an economy, in which a private insurance market is available. In particular, we analyze impacts on private insurance purchases, asset holding, portfolio choice decisions, labor supply decisions and social welfare. UHI policies with various co-insurance rates are quantitatively compared. In addition, both distortionary (payroll-tax) and non-distortionary (lump-sum tax) methods for financing the UHI are also discussed to address tax distortion and corresponding welfare implications. We allow both endogenous insurance and labor decisions in our analysis. We find that the addition of endogenous labor has important welfare implication when the UHI is financed by the widely used payroll

[9] See page W135 in Laschober et al. (2002).

[10] See the table EXHIBIT 2 in Laschober et al. (2002). In page W129, they explained the trend of the high income group by that the decline in take-up ratio of Medigap (-4.2 percentage points) were not offset by the increased Medicare HMO enrollment (+3.1 percentage points). However, in the same page W129, they stated that the poorest group had only relatively small declines in Medigap and had gains across other resources.

tax – a trade-off between risk sharing and tax distortion.

Our results show that providing UHI has a clear crowding out effect on asset holdings. If the type of PHI and its proportional markup are maintained as in the case without UHI, a significant decline in PHI take-up ratio is suggested because individuals can more easily use assets for self-insurance when UHI already provides primary coverage. The redistribution effects on welfare across generations and across wealth groups are observed – the old gain more than the young, and the poor gain more than the rich that is consistent with the redistribution effect of a payroll tax. We also identify the distortion caused by the payroll tax for financing the UHI, which reduces labor supply and further crowds out PHI and asset holdings. Moreover, we compare UHI policies with various expenditure coverage rates, and the result suggests that the rates in most OECD countries might be too high when taking into account the tax distortion. We find when the UHI expenditure coverage rate is greater than 50%, the additional distortion loss outweighs the additional welfare gain from risk sharing.

We further incorporate Medicare, a public health insurance program for old individuals in the US, in the model to provide a more precise implication of a public UHI provision for the US. Since the old, who need more medical care, have already been covered by Medicare, the welfare improvement from a public UHI provision is smaller than it in the case without Medicare – roughly 1% of lifetime consumption when the UHI is financed by a payroll tax (or equivalently an income-contingent premium). We also find that the UHI will mainly benefit the young (those below 65), and the old might be worse off because of the tax distortion effect.

We also discuss the demand of PHI when UHI is introduced. We find that when UHI provides primary coverage and PHI becomes complementary, wealth-rich individuals can more easily have their assets to substitute the complementary PHI, and therefore have less incentive to purchase the PHI and are more sensitive to its price change. On the other hand, individuals with low wealth do not have this option and are less sensitive to the price change. We illustrate that if the markup of PHI can be lowered down when UHI provides primary coverage, insurance companies can still attract their customers to purchase the complementary PHI. We also find that a supplemental PHI plan, which covers items not covered by UHI, would attract the rich more. We illustrate this by designing a catastrophic PHI. Some empirical finding form the market of Medicare supplemental insurance is consistent with our model prediction, and the issue will worth further empirical studies to provide precise empirical tests.

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Appendix A – Model and Calibration with Medicare

Household's problem

In the US, Medicare provides an universal health insurance coverage to all old individuals. The young is not qualified, and so an young agent's problem is the same as in the text.

For those retired old agents, the state vector is given by $s_o = (a, x)$. They do not supply labor and receive social security payment ss as their main income source. Medicare, which is highly subsidized by the government, automatically covers a proportion ω_m of their medical expenditures, and so there is no need to purchase any primary private insurance by themselves.[11]

An old agent's problem is:

$$W(s_o) = \max_{c,a'} \left\{ u(c, 0) + \beta (1 - \rho_d) E\left[W\left(s_o'\right) \right] \right\}$$

subject to

$$\begin{aligned}
&(1 + \tau_c)c + a' = Wel_o + T; \\
&Wel_o \equiv ss - q_m + [1 + (1 - \tau_k) r] a - [1 - \omega_m] x - Tax; \\
&T = \max\{0, \ (1 + \tau_c)\underline{c} - Wel_o\}; \\
&a' \geq 0.
\end{aligned}$$

When an UHI program is implemented, we suppose the design is that if its $\omega \leq \omega_m$, there is no change in old agents' insurance benefits. They are still covered by Medicare, which provides a higher expenditure coverage rate; if $\omega > \omega_m$, UHI provides them an additional coverage ω_o so that $\omega_m + \omega_o = \omega$.

[11]The old agents, who just retired in the end of the previous period, are distinguished from the other old agents in the computation. The state vector for them is given by $s_o = (a, x, i_{HI})$ because they could purchase PHI in the previous period when they still worked. Since Medicare provides a primary coverage, we assume the PHI they carried from last period covers the rest out-of-pocket payments.

Government budget constraint

The social security is still self-financed by a social security tax. The rest of government expenditures must satisfy

$$\begin{aligned} G + \int [T + \omega x_y + (\phi_m \omega_m + \omega_o) x_o] d\Phi + (1+r)D = \\ \int [\tau_n(wzn) + \tau_k(ra) + \tau_c c + Tax + (1+r)b] d\Phi + D', \end{aligned} \tag{7}$$

where ϕ_m is the fraction of Medicare cost which is subsidized by the government.

Main changes in calibration

Because of the model change with the addition of Medicare, we need to re-calibrate our model to match the US economy. Medicare has no price discrimination among old agents, and on average the premium q_m revenue is 12% of the Medicare cost. It is highly subsidized by the government and so we set $\phi_m = 0.88$. τ_m is set at 0.5 as in Attanasio, Kitao and Violante (2010). In addition, since only young agents purchase primary PHI, we set the PHI markup so that the PHI take-up ratio among young agents is 70%. All other calibration targets are remaining the same.