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Healthcare in Life Cycle Economy: Theoretical Model and Simulation

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Abstract

This article aims to develop the theoretical overlapping generation models with the unstable healthcare system due to the problem of missing trading markets between young and old generations. The main healthcare system in Thailand is Universal Coverage (UC) which covers around 48 million Thai people. The costs of the healthcare system in Thailand are rising every year, while Thailand has been in an aging society too early.

The theoretically developed models in this article show the main results that first, the different generations (the young and old households) could not exchange their healthcare assets. Then, the government needs to run a balanced budget to collect lump sum taxes from the current young households and transfer those taxes as healthcare subsidies to the current old households; this system is PAYG (Pay-As-You-Go). The PAYG could be sustainable if the growth rate of the population is greater than or equal to the households' discount rate. However, under the aging society in Thailand, the average growth rate of the population in the last decade has been negative. Therefore, this system is unlikely sustainable in the long run.

Keywords: Theoretical overlapping generation model, healthcare assets, growth rate of population, taxes and subsidies,

JEL Classifications: C6, E6, H2, H5, H6, I1

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1. Introduction

In economics, the risk-pooling is the underlying reason that the health insurance market works, while the risk-aversion is the reason consumers purchase insurance. On the contrary, the adverse selection can lead to the failure of insurance markets. Moral hazard can lead to welfare loss due to excess consumption of health services (Manning et al., 1987).

There are a number of researches about healthcare systems in many fields and in almost every country. However, those studies and researches may focus on some aspects or some points. Only one research cannot explain all problems of healthcare. We may need a variety of researches to clarify healthcare problems. We refer to some related literatures of this study.

First, we begin with the baseline ideas of savings for an infinite horizon. The savings may be in real terms. Ramsey (1928), Cass (1965), and Koopmans (1965) developed the models of identical or homogenous households who live forever. With the infinite horizon, or avoiding all market imperfections, heterogeneous households, and links among generations, when households have infinite lives, the steady-state capital is less than the golden rule level. In other words, savings are too low to make households reach the maximum consumption or welfare. Ramsey, Cass, and Koopmans' model may not be realistic but are used as the baseline to compare with another more advanced model.

Second, for the heterogenous households, not identical but different households, particularly in overlapping generation models, Phelps (1961) showed that capital stock exceeds its golden rule level. A Pareto improvement can be achieved by allowing the current generation to devour a portion of the capital stock and holding constant the consumption of all future generations. An economy is dynamic efficiency if it invests less than the return to capital and is inefficient if it invests more than the return to capital.

Similar to Phelps's (1961) concepts, Diamond's (1965) concepts indicate that a competitive economy can reach a steady state in which there is too much capital. In other words, the economy invests more than it earns profits, or equivalently, the population growth rate exceeds the steady state marginal product of capital. Therefore, the economy is dynamic inefficiency.

Third, for the healthcare system based on overlapping generation models, Minchung & Yamada (2019) quantitatively studied the influence of a rapidly aging population on the financing of a public universal health insurance system and the corresponding fiscal policies. The author uses a general equilibrium life-cycle model to investigate the effects of aging and evaluate various policy alternatives designed to lessen the negative influence of aging.

The authors show that although the potential reforms significantly improve the welfare of future generations, political implementation of such reforms is difficult because of the large welfare costs for the current population. The analysis suggests that a gradual reform with intergenerational redistribution will be more implementable politically than a sudden reform.

2. Healthcare systems in Thailand and other countries

2.1 Healthcare system in Thailand

For the healthcare systems in Thailand, the important event was the establishment of the Universal Coverage System (UC) in 2003.

At present, there are several healthcare systems in Thailand. The three main healthcare systems in Thailand are the Universal Coverage (UC), the Social Security Scheme (SSS), and the Civil Servant Medical Benefit Scheme (CSMBS). In addition to the three main healthcare systems, other healthcare systems, probably for small groups of people, are healthcare systems for local government employees (local administrative officers).

In general, there are several main differences between those four systems that we need to mention here. In the fiscal year 2022, those four healthcare systems covering people from highest to lowest were the UC (47,179,787 million people), the SSS (12,754,427 million people), the CSMBS (5,297,740 million people), and LAOs (Local Administrative Officers) (639,557 million people). In addition, the UC covers around 50 million people in the country. (National Health Security Office (NHSO), 2022). Second, each healthcare system is managed by different government agencies or organizations. Furthermore, the budgets for each system are not equal. Third, each healthcare system whose people are covered provides different treatment services. Some systems cover not only people who have their rights but also their families. Other systems cover only people who have their rights. In addition to those healthcare systems, private healthcare insurance is another alternative that some private companies provide to their employees. Normally, Thai people who have one right to a healthcare system are excluded from another healthcare system. In general, the Universal Coverage System (UCS) covers the majority of Thai people.

Healthcare has both private and public goods characteristics, to some extent. The model in this article, therefore, includes both the role of private healthcare services and the role of government intervention to solve the market failure problem arising from the nonexistence of asset market trading between the young and the old people. The government uses tax and subsidy to overcome such market failure and to improve the social welfare of both generations. Without such government intervention, the younger people are likely to overconsume in the first period but underinvest in their lifetime health services due to the nonexistence of asset market trading between the young and old people. The healthcare asset in the model in this article represents the young's claims on the full cost of next-period healthcare services, including full living expenses. These private claims of the young are purchased at the first period by using the young's wage income. Young people tend to underinvest in this type of private claims on healthcare services due to the nonexistence of asset market trading between young and old people. The government's policies on tax and subsidy can, therefore, fill the gap and help private agents to capture all the possible positive externalities that affect both generations of people.

The main policy suggestion is for Thailand to be more cautious about her stable long-term healthcare subsidized plans, especially for the time of an aging society. All those feasible long-term healthcare subsidized plans need to be reevaluated under the different feasible balanced growth paths, having at least some sufficient growth rates of the more productive younger population, as being presented in our simulation results.

Figure 1 shows the budget of the National Health Security Fund, whose one important responsibility is managing the UCS. The budget, excluding personnel and administrative costs, indirectly reflects the budget for the healthcare of 50 million Thai people, rising, particularly from 2017 to 2022, before Covid 19.

In Thailand, the increasing budget for healthcare (Figure 1) and the aging society (Figure 2) have been critical problems in the future. The UC covers approximately 70% of Thai people. People in SSS and CSMBS normally must work for certain years in their own companies or government organizations. People in SSS have their pension funds after 55 years old, while people in CSMBS have their pension funds after 60 years old for CSMBS, respectively. However, unlike people in SSS and CSMBS, people in UCS generally do not work in private companies or government organizations and have no pension; people in UCS may be informal workers. Moreover, in the aging society, the number of old households is increasing while the number of newborns is decreasing. However, the costs of the healthcare system tend to increase each year.

2.2 Healthcare System in Singapore

Healthcare systems in Singapore are similar to the healthcare models created in this article.

The Singaporean public health insurance system is based on programs run by the Central Provident Fund (CPF), primarily MediSave, a mandatory medical savings account scheme. The Central Provident Fund (CPF) also manages the MediShield and MediFund insurance schemes, which cover people with insufficient savings or those who have depleted their savings. In addition, the government provides subsidies for the medical expenses of citizens and permanent residents who receive treatment in public hospitals.

The Central Provident Fund (CPF) is a key pillar of Singapore's social security system. CPF helps Singaporean citizens and permanent residents to set aside funds to build a strong foundation for retirement.

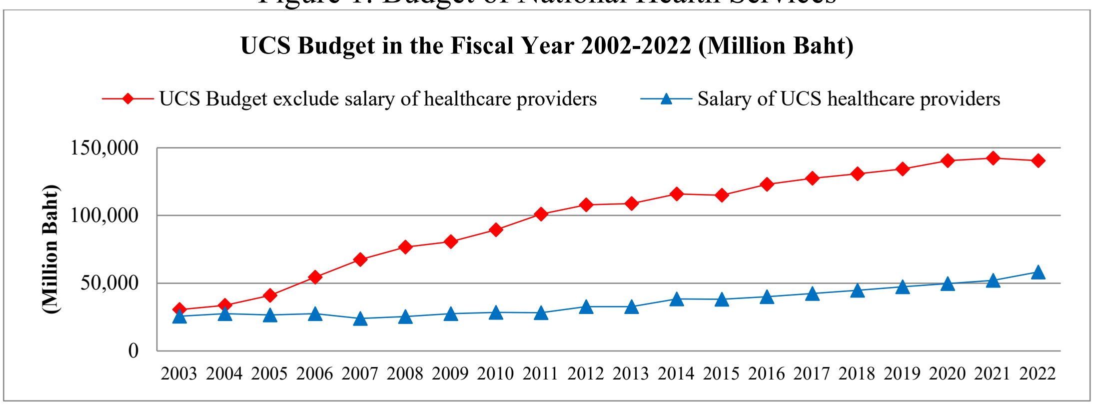
As people work and make CPF contributions, they accumulate savings in these three accounts: Ordinary Account (OA), MediSave Account (MA), and Special Account (SA).

Depending on people's ages, CPF contribution rates can range from 12.5% to 37% of your monthly wages. For example, people whose ages 50 – 55 years old pay 0.4055%, 0.3108%, and 0.2837% of their income to Ordinary Account (OA), Special Account (SA), and MediSave Account (MA), respectively.

At age 55, a Retirement Account (RA) is created for those people.

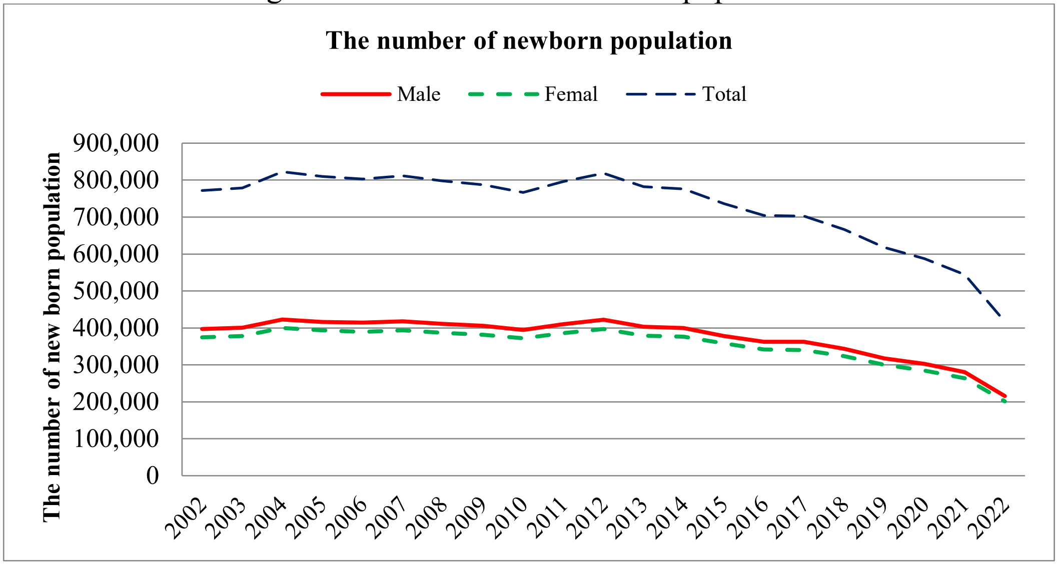
MediSave, CareShield Life, and MediShield Life are three important national schemes that offer people protection for their healthcare needs.

Figure 1: Budget of National Health Services



Note: The graph is made by the author. The data are from the Office of National Health Security.
Source: National Health Security Office (NHSO).

Figure 2: The number of newborn population



Note: The graph is made and calculated by the author. The data are from the Department of Provincial Administration.

Source: *Department of Provincial Administration*.

Singapore encourages its people to invest or save more by owning part of government assets. Singapore has Special Discounted Shares (SDS) Scheme for people's investments. The SDS scheme is part of the government's asset enhancement program to make Singapore a share-owning society, giving Singaporeans a greater stake in the country. In other words, an asset enhancement program makes Singaporean a share-owning society.

Singaporean CPF members were able to buy discounted Singapore Telecom (Singtel) shares in 1993 (ST "A" shares) and 1996 (ST2 shares). Members who held on to their discounted Singtel shares were entitled to loyalty shares.

People can sell their discounted Singtel shares in three ways. Proceeds from the sale will be refunded to their CPF Ordinary Account (OA). You can apply to withdraw the proceeds from your OA if you've met your CPF withdrawal conditions.

2.3 Healthcare System in the US

In the US, people who work with government agencies generally receive some healthcare benefit programs. We show healthcare benefits for federal employees.

The Federal Employee's Health Benefit (FEHB) program offers federal employees a choice of multiple health insurance plans at a reduced rate and paid with pre-tax dollars. The U.S. government pays 72-75% of the premiums for each plan, and employees are responsible for the remainder of the premium. The employee's portion of the premium is taken from their pay, and following IRS guidance, that payment can be made before the salary is taxed.

If an employee maintains their FEHB for five years before retirement (although they can switch insurance companies during that time), they are eligible to carry their health insurance into retirement. The government will continue to pay their portion of the premiums, but the retiree's portion will be taken from their annuity payments and will no longer be tax-free. If their spouse is included in their plan, the spouse is eligible to continue their coverage upon the retiree's death.

Most federal employees are eligible for FEHB unless law or regulation excludes their position. Even part-time, intermittent, and seasonal employees may be eligible if they are expected to work 130 hours per month or more for at least 90 days.

Employees who receive worker's compensation are also eligible for FEHB coverage. While receiving worker's compensation, an individual is still considered a government employee and is entitled to the associated benefits. Federal employee reservists who are placed in leave without pay status when called to active duty for more than 30 days can also keep their FEHB coverage for up to 24 months.

After retirement, employees who have had FEHB continuously for 5 years before retirement can continue their coverage into retirement. OPM will deduct premiums, after tax directly from the employee's annuity. At age 65, retirees have the choice of signing up for Medicare coverage. They can decide to just keep their FEHB and not sign up for Medicare, or sign up for Medicare and keep their FEHB, or they can suspend their FEHB and elect a Medicare Advantage plan. If they decide to suspend their FEHB, they can reinstate it at any future open season.

2.4 Healthcare System in Sweden

The health care system in Sweden is a universal welfare service, with predominantly public financing (86%) and public provision (83%), and covers almost everyone who lives or works in Sweden. The health care system in Sweden is decentralized to the regions and municipalities, but overall policy and high-level oversight are national responsibilities. Broken down by government body, national government spending in 2020 is 25%, regional spending is 42%, and municipality spending is 19%. Total healthcare expenditure accounted for 11.4% of Sweden's gross domestic product in 2020, ranking Sweden fourth in the EU. Public expenditures are funded through taxes, and both the regions and the municipalities levy proportional income taxes on their respective populations. However, financing by local taxes is supplemented by the national government grants and by user charges.

Private health financing represented about 14%, where the majority (93%) came from households' out-of-pocket (OOP) payments. The proportion financed via OOPs has decreased over the last 10 years, especially during the pandemic. But even before the pandemic, financing via OOPs was about 1% lower in Sweden than the EU average. Voluntary health insurance has mainly a complementary role in the publicly financed system, representing less than 1% of total health expenditures in Sweden and about 4% of private expenditures.

The Swedish healthcare system is generous in terms of both breadth and scope, as coverage is based on registered residence and all cost-effective treatments should be included. The Health and Medical Services Act states that responsible healthcare authorities are obliged to provide care based on need to all residents.

Patient fees are charged for almost all types of services and medical products, except, for example, child and maternity care, dental care up to 24 years, and a wide range of services for people aged 85+. For physical visits and treatments within outpatient care, patients pay flat-rate fees up to a maximum ceiling of 1 300 Swedish kronor (SEK) 1 300 [117 euros (EUR)] per 12-month period. As a result, there are relatively few people who forgo care due to patient fees, but this is more common regarding dental care.

2.5 Evidence base of the models

From sections 2.1 to 2.4, together with the theoretical models we develop late in this article, we can draw the following conclusions.

The healthcare system in Singapore is nearly the same as the theoretical models developed in this article. In other words, the healthcare system in Singapore requires employees or their people to deduct some of their income or salaries to government funds. The government subsidizes healthcare expenses for those employees or their people. The same concepts in theoretical models are developed in Sections 3.5.3 and 3.5.5. After people retire, people's savings will be changed to retirement accounts. The same concepts in theoretical models are developed in Section 3.5.3. The Singapore government encourages its people to save more by increasing higher interest rates for more savings.

The healthcare systems for federal employees in the US are similar to the theoretical models developed in this article. In other words, both healthcare systems require employees or their people to deduct some of their income or salaries from government funds. The government subsidizes healthcare expenses for those employees or their people.

The healthcare system in Sweden is a universal welfare service, with predominantly public financing (86%) and public provision (83%), and covers almost everyone who lives or works in Sweden. Therefore, the healthcare system in Sweden does not require public or private employees or people to deduct some of their income to save in any government funds. Eventually, government budgets used for the healthcare system are from taxes, directly or indirectly, and managed by local and national governments. Thus, the healthcare system (universal welfare service) in Sweden is not similar to or close to some of our theoretical models. This is a counterfactual model.

3. Theoretical Models

In this section, we develop the theoretical overlapping generation model with healthcare assets. The first part of this section is the basic model. The second part extends the first part with government intervention by collecting the taxes from the young households and transferring them to the current old households.

3.1 General assumptions

In these models, we assume that people are poor and have to work for both periods. The wage incomes are used for consumption goods (c_T^y or c_{T+1}^o), while healthcare assets (h_T^y or h_{T+1}^o) are used for healthcare services. Moreover, there exist healthcare funds for households to save only for healthcare services. Furthermore, the government forces households to send some of their incomes to healthcare funds. We assume that households in these models need to work both periods. Finally, households in these models may imply informal sectors.

3.2 Definitions

We define the following terms, which are used for the whole article.

3.2.1 Healthcare assets (a_T^h or a_{T+1}^h) are the assets that the government provides their people when young (a_T^h) and forces their people to purchase (a_{T+1}^h) into the healthcare funds. However, when young households became old households in the second period, the old households received those healthcare assets bought when young with their dividends (d_{T+1}^h).

3.2.2 Healthcare goods (h_T^y or h_{T+1}^o) are the goods and services for medical services. For example, when people go to hospitals, they could use healthcare assets (a_T^h) to pay for medical services, drugs, etc., rather than money.

3.2.3 Lump sum taxes (T_T^y) are the lump sum taxes that the government collects from the current young households (T_T^y) and transfers to the current old households to use for healthcare services.

3.2.4 Healthcare pensions ($Healthcare\ Pension_T^o$) are the healthcare pension fund that the government established to enforce people who do not have their healthcare privilege, such as people who are not in Section 33 or 39 in SSS, or not in CSMBS. The healthcare pension fund would return healthcare subsidies like pensions to those people to use for healthcare services.

3.2.5 Healthcare subsidies ($Healthcare\ Subsidies_T^o$) are the healthcare subsidies that the government provides the current old households to use for healthcare services.

3.3 Government

The government set up the healthcare fund. The healthcare fund has healthcare assets. The healthcare assets are used only for medical goods and services.

On the one hand, the government forces to collect healthcare assets from young households but gives young households healthcare assets only for medical services. On the other hand, when households are old, the government returns healthcare assets with dividends to the old households.

3.4 Households' problem

The model is a typical overlapping generations model with a private saving plan. To simplify the mathematical model, this study assumes that all savings of the young people are invested in the claims of next-period healthcare services, including full living expenses. The inclusion of additional traditional assets, therefore, will not be able to overcome the market failure problem and, hence, cannot alter the main results of this study.

The representative households live for two periods. Each period, new households enter the economy, while the old households leave the economy after the second period of their lives.

Suppose that at time T, new households were born, while old households live at the last period.

At time T , when households are young, they work and invest in healthcare assets. For households' income, when young households work, they have wage income (w_T^y), while the government gives young households healthcare assets [$\left(p_T^h + d_T^h\right) a_T^h$] that are used only for healthcare goods. For households' expenditures, young households allocate their total income to consumption goods (c_T^y) and healthcare services (h_T^y). Moreover, households purchase healthcare assets (a_{T+1}^h) for their savings.

At time $T+1$, when households are old, assume that they still work. On the one hand, the old households have income from wage income (w_{T+1}^O) and their healthcare assets are purchased when young [$\left(p_{T+1}^h + d_{T+1}^h\right) a_{T+1}^h$]. On the other hand, since this is their last period of life, the old households do not need to save anything. The old households allocate their total income to consumption goods (c_{T+1}^o) and healthcare goods (h_{T+1}^o).

The healthcare assets generate dividends (d_{T+1}^h at time $T+1$ and d_T^h at time T). The prices of healthcare assets are p_{T+1}^h at time $T+1$ and p_T^h at time T . The values of healthcare assets are $\left(p^h_{T+1} + d^h_{T+1} \right) a^h_{T+1}$ at time $T+1$ and $\left(p^h_T + d^h_T \right) a^h_T$ at time T.

3.4.1 The Households' problem

The households live for two periods – young and old periods – and need to maximize their lifetime utility subject to their lifetime budget constraints.

Suppose that the households' utility function depends on consumption goods (c^y_T) and healthcare goods (h^y_T) or $u\left(c^y_T , h^y_T\right)$. Suppose further that the households' utility function, $u(c_T , h_T)$, is time separable. In other words, households' utility at the first period when young at time T is separable and independent on their utility at the second period when old at time $T+1$. Moreover, if the discount factor is β, the whole lifetime utility of households in present value is

$$u\left(c^y_T , h^y_T\right) + \beta \; u\left(c^o_{T+1} , h^o_{T+1}\right) \quad , \tag{1}$$

We can formulate a representative household's problem by using the Bellman equation.

$$\begin{aligned} v_T \left[\left(p^h_T + d^h_T \right) a^h_T + w_T \right] &= \max_{\{c_T , h_T\}} \left\{ u\left(c^y_T , h^y_T\right) \beta \; E_T \left\{ v_{T+1} \left[\left(p^h_{T+1} + d^h_{T+1} \right) a^h_{T+1} \right] \right\} \right. \\ &= \max_{\{c_T , h_T\}} \left\{ u\left(c^y_T , h^y_T\right) \beta \; E_T \left\{ v_{T+1} \left[\left(p^h_{T+1} + d^h_{T+1} \right) a^h_{T+1} \right] \right\} \right\} \quad , \end{aligned} \tag{2}$$

subject to

The budget constraint when young at the time T:

$$c^y_T + h^y_T + p^h_T \, a^h_{T+1} = \left(p^h_T + d^h_T \right) a^h_T + w^y_T \quad , \tag{3}$$

The budget constraint when old at the time $T+1$:

$$c^o_{T+1} + h^o_{T+1} = \left(p^h_{T+1} + d^h_{T+1} \right) a^h_{T+1} + w^o_{T+1} \quad , \tag{4}$$

where $c^h_T > 0, h^y_T > 0 \, , c^o_{T+1} > 0, h^o_{T+1} > 0 \, , \; a^h_{T+1} \; and \; a^h_T \; > \; 0$;

The variables in the models have the meaning as follows.

c^y_T and c^o_{T+1} are consumption goods when households are young and old or at a time T and $T+1$, respectively.

h^o_T and h^o_{T+1} are healthcare goods when households are young and old or at a time T and $T+1$, respectively.

w^y_T and w^o_{T+1} is the real wage or labor income when households are young and old or at a time T and $T+1$, respectively.

p^h_T and p^h_{T+1} are the price, measured in healthcare goods, of healthcare assets that households purchase or invest when young and old at a time T and $T+1$, respectively.

d^h_T and d^h_{T+1} are dividends, measured in healthcare goods, from healthcare assets that households purchase or invest when young and old at a time T and $T+1$, respectively. They are random variables that depend on the states of the world.

a_T^h and a_{T+1}^h are healthcare assets, measured in healthcare goods, that households purchase or invest when young and old at a time T and $T+1$, respectively.

The value function $v_T\left[\left(p_T^h+d_T^h\right)a_T^h+w_T\right]$ is a function of the group of state variables $\left(p_T^h+d_T^h\right)a_T^h+w_T$. Households' utility at time T may depend on the households' total income (the state variable), $\left(p_T^h+d_T^h\right)a_T^h+w_T$, which is composed of the wage income (w_T) and the income from healthcare assets ($\left(p_T^h+d_T^h\right)a_T^h$) at the time T.

The income from healthcare assets [$\left(p_T^h+d_T^h\right)a_T^h$] would be provided by the government to help households with healthcare services when households are young and work at the time T. However, the government forces households to save healthcare assets for the future ($p_T^h\ a_{T+1}^h$).

3.4.2 Pricing equation

From the optimization problem of equation (2) subject to the resource constraints of Equations (3) and (4), we can show that the old households value zero for the price of healthcare assets ($p_{T+1}^h=0$) at the last period of life (at the time $T+1$).

Therefore, we have

$$p_{T+1}^h=0 \tag{5}$$

Thus, this shows that in households' view, if they have finite lives or two periods in this model, they will value zero for their healthcare asset prices in the last period.

The reason that the young households do not buy the healthcare asset from the old is because the young households will not be able to claim their healthcare services, which were backed by the issuers, who will surely be gone in the next period. Hence, this missing of intergenerational asset market trading between the young and the old is the type of market failure problem in the overlapping generations model.

3.4.3 The optimal conditions

From the optimization problem of Equation (2) subject to the resource constraints of Equations (3) and (4), suppose for simplicity that the young households purchase or invest only one unit of healthcare assets ($a_{T+1}^h=1$) and the government provides each household only one unit of healthcare assets ($a_T^h=1$) at time$T$.

The budget constraint when young at the time T becomes

$$c_T^y+h_T^y=d_T^h+w_T^y \tag{6}$$

The budget constraint when old at time $T+1$, since households value zero for their healthcare asset prices in the last period at time $T+1$ ($p_{T+1}^h=0$), the old budget constraint Equation (4) becomes

$$c_{T+1}^o+h_{T+1}^o=d_{T+1}^h+w_{T+1}^o \tag{7}$$

From the Equations (2), (6), and (7), we find the optimal conditions of households' optimization problem in Equation (2) subject to (6) and (7) by a backward recursive method.

Suppose that households' utility function is constant elasticity of substitution with $\sigma\to 1$, the utility function becomes the logarithmic utility function as

$$u\,(c_T\,, h_T\,) \quad = \quad \ln(c_T) \; + b\ln(\,h_T\,) \tag{8}$$

b is a degree to which households tend to employ h_T.

Suppose that the group of income which is wage rate (w_{T+1}) and healthcare dividends (d^h_{T+1}) follows the first-order autoregressive process.

$$\ln\left(d^h_{T+1} + w_{T+1}\right) \quad = \quad \phi\,\ln\left(d^h_T + w_T\right) + \varepsilon_{T+1} \quad , \tag{9}$$

where $-1 < \phi < 1$.

Assume that the dividends (d^h_T) and wage are greater than zero ($w^y_T > 0$, $d^h_T > 0$).

Assume further that ε_{T+1} is the white noise distribution with $\varepsilon_{T+1} \sim N(0, \sigma^2)$.

The optimal conditions for the households' problem at time T are

$$(\,c^y_T\,)^* \quad = \quad \left(\frac{1}{1+b}\right)\left[\,d^h_T \; + \; w^y_T\,\right] \tag{10}$$

$$(\,h^y_T\,)^* \quad = \quad \left(\frac{b}{1+b}\right)\left[\,d^h_T \; + \; w^y_T\,\right] \tag{11}$$

$$(\,c^y_T\,)^* + (\,h^y_T\,)^* \quad = \quad d^h_T \; + \; w^y_T \tag{12}$$

3.4.4 Government as an intermediary

From Equation (5), the old households value zero for the price of healthcare assets ($p^h_{T+1} = 0$) at the last period of lives (at the time $T+1$). If we need to correct this problem, one possible solution is to set up the intermediaries that exist forever. The intermediary could be a central unit that trades or exchanges healthcare assets (a^h_T , a^h_{T+1} , ...) between different generations or between the current young and current old households.

3.5 Healthcare Funds for Healthcare System

3.5.1 Growth rate of population

Suppose for simplicity that each period, each generation who was born at the time T would grow to the next period at a constant rate (n) and all of them would survive to the next period. Thus, we have the growth of households as $N_{T+1} = (\,1+n\,)\,N_T$, where N_T is the number of population who were born at the time T , N_{T+1} is the total number of population at the time $T+1$ who was born at time T, and n is a constant growth rate of the population.

3.5.2 Government intervention

Suppose that the government wants to set up the healthcare fund, but the government is afraid of fiscal burden and wants to improve the incumbent healthcare system, such as UCS. The concept is that current young households pay the taxes to the government. Then the government transfers those taxes to the current old households as healthcare pensions. Moreover, the government runs a balanced budget for the expenditure. We can write the government budget constraint as follows:

$$Healthcare\ Subsidies^o_T \quad = \left(\frac{N_T}{N_{T-1}}\right) T^y_T \; = \; (1+n)\,T^y_T \tag{13}$$

3.5.3 The Households' problem

a) Young households

If the taxes are imposed on the young households who were born at time T , we can write the modified budget constraint of the young generations at the time T as follows:

$$c_T^y + h_T^y + p_T^h a_{T+1}^h + T_T^y = \left(p_T^h + d_T^h \right) a_T^h + w_T^y \tag{14}$$

Since $a_{T+1}^h = a_T^h = 1$, we can write the equation (14) as

$$c_T^y + h_T^y = d_T^h + \left[w_T^y - T_T^y \right] , \tag{15}$$

where $T_T^y > 0 , \forall T_T^y$

First, suppose for simplicity that the government collects equal lump sum taxes for young households each period ($T_{T-1}^y = T_T^y = T_{T+1}^y \dots = \hat{T}$). From the equation (15), we replace $T_T^y = \hat{T}$. Thus, we have → Something missing here?

$$c_T^y + h_T^y = d_T^h + \left[w_T^y - \hat{T} \right] , \tag{16}$$

where $T_T^y = \hat{T} > 0 , \forall T$

Second, since $T_T^y = \hat{T}$ is given and depends on the government, the lump sum taxes ($T_T^y = \hat{T}$) are exogenous for those young households. We replace $w_T^y - \hat{T}$ with $\widehat{w}_T^y$. Therefore, we can write the Equation (16) as

$$c_T^y + h_T^y = d_T^h + \widehat{w}_T^y , \tag{17}$$

where $\widehat{w}_T^y = w_T^y - \hat{T}$, $\widehat{w}_T > 0$, and $T_T^y = \hat{T} > 0$, $\forall T_T^y$

Therefore, we have the following optimal conditions for the young generations who were born at the time T.

$$\left(c_T^y\right)^* = \left(\frac{1}{1+b}\right)\left[d_T^h + \widehat{w}_T^y \right] \tag{18}$$

$$\left(h_T^y\right)^* = \left(\frac{b}{1+b}\right)\left[d_T^h + \widehat{w}_T^y \right] \tag{19}$$

$$\left(c_T^y\right)^* + \left(h_T^y\right)^* = \left[d_T^h + \widehat{w}_T^y \right] \tag{20}$$

where $\widehat{w}_T = w_T - \hat{T} , \widehat{w}_T > 0$ and $T_T^y = \hat{T} > 0 , \forall T_T^y$

b) The Old Households

If the healthcare subsidies are paid to the old households at time T, we can write the modified budget constraint of the old generation at time T as follows:

$$c_T^o + h_T^o = w_T^o + \left(p_T^h + d_T^h \right) a_T^h + Healthcare\ Subsidy_T^o \tag{21}$$

We replace $Healthcare\ Subsidy_T^o = (1+n)\,T_T^y$ from Equation (13) in Equation (21). Thus, we have

$$c_T^o + h_T^o = w_T^o + \left(p_T^h + d_T^h\right) a_T^h + (1+n) T_T^y \tag{22}$$

From our assumptions, since $p_T^h = 0$ for the old households, and we assume $a_T^h = 1$ at the time T, we can write the Equation (22) as

$$c_T^o + h_T^o = w_T^o + d_T^h + (1+n)\,T_T^y \tag{23}$$

Since we assume the lump sum taxes ($T_{T-1}^y = T_T^y = T_{T+1}^y \ldots = \hat{T}$) are exogenous and equal in each period for those young households, we replace $d_T^h + (1+n)\,T_T^y$ with $\hat{d}_T^h$. Therefore, we can write the equation (23) as

$$\begin{aligned} c_T^o + h_T^o &= w_T^o + \left[\, d_T^h + (1+n)\,T_T^y \,\right] \\ &= w_T^o + \hat{d}_T^h \end{aligned} \tag{24}$$

where $\hat{d}_T^h = d_T^h + (1+n)\,\hat{T}$, $\hat{d}_T^h > 0$

and $T_T^y = \hat{T} > 0$, $\forall\, T_T^y$

The Equation (24) is the same as Equation (7), except that we replace d_{T+1}^h in the equation (7) with $\hat{d}_T^h$ since we consider at time T instead of at time $T+1$, since we assume that $a_T^h = 1$ for the old generations at time T and $p_T^h = 0$ for the old generations at time T, we have the following optimal conditions for the old generations who were born at time $T-1$, so at time T , those who were born at time $T-1$ would be old.

$$(c_T^o)^* = \left(\frac{1}{1+b}\right)\left[\, w_T^o + \hat{d}_T^h \,\right] \tag{25}$$

$$(h_T^o)^* = \left(\frac{b}{1+b}\right)\left[\, w_T^o + \hat{d}_T^h \,\right] \tag{26}$$

$$(c_T^o)^* + (h_T^o)^* = w_T^o + \hat{d}_T^h \tag{27}$$

3.5.4 Market Equilibrium

The developed models are composed of 2 sectors: households and government. However, these developed models do not include production sectors or firms. Therefore, the market equilibrium exists only in the market of consumption goods (c_T^y, c_T^o), healthcare goods (h_T^y, h_T^o), and healthcare assets (a_T^h, a_{T+1}^h).

The following expressions show the market equilibrium.

1) Market equilibrium conditions for consumption goods at time T.

$$N_T\, c_T^y + N_{T-1}\, c_T^o = N_T\, w_T^y + N_{T-1}\, w_T^o \tag{28}$$

or

$$c_T^y + (1+n)\, c_T^o = w_T^y + (1+n)\, w_T^o \tag{29}$$

2) Market equilibrium conditions for healthcare goods at time T.

$$N_T\, h_T^y \;+\; N_{T-1}\, h_T^o = N_T\,\left[\,(p_T^h + d_T^h)\,a_T^h\,\right]^y - N_T\,\left[p_T^h\, a_{T+1}^h\,\right]^y + N_{T-1}\left[\,(p_T^h + d_T^h)\,a_T^h\,\right]^o \;, \tag{30}$$

As before, suppose that $a_T^h = a_{T+1}^h = 1$, $\left[d_T^h\right]^y = \left[d_T^h\right]^o$, and the old values $p_T^h = 0$.

Therefore, we have

$$h_T^y \;+\; (1+n)\,h_T^o \;=\; (2+n)\left[\,d_T^h\,\right] \tag{31}$$

3) The government uses balanced budget constraint for healthcare pensions at time T.

$$Healthcare\ Pensions_T^o \;=\; \left(\frac{N_T}{N_{T-1}}\right) T_T^y \;=\; (1\;+\;n)\,T_T^y \tag{32}$$

To simplify the model, the economy in this model is a pure-exchange economy. Therefore, we don't have to solve for the additional equilibrium solution of the good-producing sector. The young and old people can always buy consumption goods by using their lifetime income (See Equations (3) and (4)).

3.5.5 Healthcare funds – pay-as-you-go system

In the models we develop, the young generations who were born at the time T pay the lump sum taxes ($T_T^y = \hat{T}$), and then at time $T+1$, those young generations would become old and receive the healthcare subsidies ($Healthcare\ Subsidies_{T+1}^o$) which are discounted to the present values at the time T which is equal to $\beta\,(1+n)\,\hat{T}$, where $0 < \beta < 1$, and β is a discount factor.

We could compare the discounted healthcare subsidies.

$\beta\,[\,Healthcare\ Subsidies_{T+1}^o] = \beta\,[\,(1+n)\,\hat{T})\,]$ or the gains that the young generations would receive when they become old at time $T+1$ with the lump sum taxes ($T_T^y = \hat{T}$) or the losses that they pay when they work at time T.

Let the discount factor $0 < \beta < 1$ be $\beta = \frac{1}{1+\rho}$, where ρ is a discount rate. For the comparison, we have three cases.

First, the discounted subsidies ($\beta\,[\,Subsidy_{T+1}^o\,] = \beta[\,(1+n)\,\hat{T}\,]$) or the gains are greater than the lump sum taxes ($T_T^y = \hat{T}$) or the losses. We have

$$\beta\,(1+n)\,\hat{T} \;>\; \hat{T} \tag{33}$$

or

$$n \;>\; \rho \;>\; 0 \tag{34}$$

Equation (34) implies that although the government levies the lump sum taxes ($T_T^y = \hat{T}$) on the young generations but repays the healthcare subsidies ($Healthcare\ Subsidy_{T+1}^o$) to those young generations when they become old, those young generations could be better off if the growth rate of population in their generation is greater than the discount rate (ρ) or their patience for sacrificing their current benefits to receive higher future benefits instead.

Second, the discounted healthcare subsidies ($\beta\ [\ Healthcare\ Subsidy^{o}_{T+1}\ ] = \beta\ (\ 1+n\ )\ \hat{T}$) or the gains are equal to the lump sum taxes ($T^{y}_{T}\ =\ \hat{T}$) or the losses.

We have

$$\beta\ (\ 1+n\ )\ \hat{T} \quad = \quad \hat{T} \tag{35}$$

or

$$n \quad = \quad \rho \ > \ 0 \tag{36}$$

Th Equation (36) implies that if the growth rate of the population in the young generation is equal to the discount rate (ρ) or their patience for sacrificing their current benefits to receive higher future benefits instead, the policy that the government levies the lump sum taxes ($T^{y}_{T}\ =\ \hat{T}$) on the young generations but repays the healthcare subsidies ($Healthcare\ Subsidy^{o}_{T+1}$) to those young generations when they would become old would not be different, since those young generations would be the same, neither better nor worse off.

Third, the discounted healthcare subsidies ($\beta\ [\ Healthcare\ Subsidy^{o}_{T+1}\ ] = \beta[\ (\ 1+n\ )\ \hat{T})$] or the gains are less than the lump sum taxes ($T^{y}_{T}\ =\ \hat{T}$) or the losses. We have

$$\beta\ (\ 1+n\ )\ \hat{T} \quad < \quad \hat{T} \tag{37}$$

or

$$0 \ < \ n \ < \ \rho \tag{38}$$

The Equation (38) implies that if the growth rate of population in the young generation is less than the discount rate (ρ) or their patience sacrifices their current benefits to receive higher future benefits instead, the policy that the government levies the lump sum taxes ($T^{y}_{T}\ =\ \hat{T}$) on the young generations but repays the healthcare subsidies ($Healthcare\ Subsidies^{o}_{T+1}$) to those young generations when they become old would not be achieved, since those young generations could be worse off.

In summary, the policy that the government levies the lump sum taxes ($T^{y}_{T}\ =\ \hat{T}$) on the young generations when they work but repays the healthcare subsidies ($Healthcare\ Subsidies^{o}_{T+1}$) to those young generations when they become old would be successful if the growth rate of the population of those young generations (n) is greater than the discount rate (δ) or their patience for sacrificing their current. Otherwise, this policy would not be successful.

4. Numerical Simulation

In Section 3, we develop the theoretical overlapping generation models with healthcare assets and find the optimal conditions. Then we extend the models with taxes on young households and subsidies on old households. This section shows some results of numerical simulation based on the healthcare funds – the pay-as-you-go system.

Numerical simulation in this section will extend the theoretical models in Section 3. In the theoretical model section, we do not explain or develop some issues. Moreover, we cannot conclude some important results.

First, we use only lump sum taxes in our models but do not explain the case of proportional taxes. For the numerical simulation, we will run both lump-sum taxes and proportional taxes (labor income taxes). Therefore, we can compare both results.

Second, in theoretical models, we do not include consider the cases when the economy encounters shocks, such as the immediate impacts of dividends, the growth rate of the population, etc.

Third, in theoretical models, we do not explain the steady states. Thus, we cannot see the results of those important variables in the long run.

Fourth, we need to see the simulated scenarios that the theoretical models cannot explain. We need to see the patterns of results and how long the economy converges to steady states.

In Section 4.1, we indicate the calibration of the model.

In Section 4.2, we explain the simulation the case of lump sum taxes and proportional taxes (labor income taxes) and find the steady-state values.

In Section 4.3, we will simulate the effects of dividends (d^y_{T+1}).

4.1 Calibration of the Model

In the simulation, for simplicity, because the model is linear and the assumptions of one unit of healthcare assets for each period ($a^h_{T+1} = a^h_T = 1$), we use almost all hypothetical data. The models are simply two of one period models separately. Therefore, any numerical simulation should converge to one point. Whether the real or hypothetical numerical parameters are not important.

For the discount factor (β), let $\beta = 0.97$. Suppose that households work for 30 years. For one period in this overlapping generation model, $\beta^{30} \approx 0.45$.

4.2 Steady-state values of tax systems

4.2.1 Effects of lump sum tax system (T^y_T)

The young households' budget constraint is

$$c^y_T + h^y_T = d^h_T + [w^y_T - T^y_T] \tag{39}$$

The old households' budget constraint is

$$c^o_{T+1} + h^o_{T+1} = w^0_{T+1} + d^h_{T+1} + (1+n)\, T^y_{T+1} \tag{40}$$

T^y_T is a lump sum tax and $T^y_T > 0$.

Table 1 shows the steady state values of endogenous variables in the model for lump-sum taxes (T^y_T).

Table 1: Steady-state Values of Endogenous Variables with Lump Sum Tax

Endogenous variables	**Steady state values**
c^y	0.980830
c^o	0.040822
h^y	0.287684
h^o	-0.652325
d	5.55112e-16
p^h	-4.44089e-16

Source: Simulation from MatLabs Author's Compilations

In the long run, the steady state values of five main endogenous variables (c^y, c^o , h^y , h^o , d) show that:

1. The results of consumption goods indicate that households need to consume current consumption goods (c^y) more when young but consume consumption goods (c^o) less when old. The households consume some healthcare goods when young (h^y = 0.287684) but a negative amount of healthcare (h^o = -0.652325) when old.

2. The steady-state stochastic healthcare prices converge to zero (p_T^h = -4.44089e-16), while the steady-state dividends converge to zero (d = 5.55112e-16). In other words, in the long run, the additional benefits of healthcare assets are zero, since the dividends of healthcare assets follow the first-order autoregressive process with zero mean and constant variance, or $\ln(d_{T+1}^h) = \phi \ln(d_T^h) + \varepsilon_{T+1}$.

4.2.2) Effects of labor income tax rate system ($Tax\ Rate_T^y$)

The young households' budget constraint is

$$c_T^y + h_T^y = d_T^h + [1 - Tax\ Rate_T^y] w_T^y \quad (41)$$

The old households' budget constraint is

$$c_{T+1}^o + h_{T+1}^o = w_{T+1}^0 + d_{T+1}^h (1+n) (Tax\ Rate_{T+1}^y\ w_T^y) \quad (42)$$

$Tax\ Rate_T^y$ is a labor income tax rate and $Tax\ Rate_T^y > 0$.

Table 2 shows the steady state values of endogenous variables in the model for labor income tax rate ($Tax\ Rate_T^y$).

Table 2: Steady-state Values of Endogenous Variables with Labor Income Tax Rate

Endogenous variables	**Steady state values**
c^y	0.4054650
c^o	0.4726060
h^y	-0.287682
h^o	-0.220543
d	5.55112e-16
p^h	1.11022e-15

Source: Simulation from MatLabs Author's Compilations

In the long run, the steady state values of five main endogenous variables ($c^y,\ c^o,\ h^y, h^o, d$) show that:

1. The results of consumption goods when young and old are nearly the same amount and indicate that the households need to consume current consumption goods (c^y) approximately equal to future consumption goods (c^o). The households consume negative healthcare goods when young (h^y = -0.287682) and old (h^o = -0.220543). In other words, the amount of negative healthcare assets could increase the consumption of goods.

2. The steady-state stochastic healthcare prices converge to zero (p_T^h = 1.11022e-15), while the steady-state dividends converge to zero (d = 5.55112e-16). In other words, in the long run, the additional benefits of healthcare assets are zero, since the dividends of healthcare assets follow the first-order autoregressive process with zero mean and constant variance, or $\ln(d_{T+1}^h) = \phi \ln(d_T^h) + \varepsilon_{T+1}$.

4.3 Effects of dividends

Suppose that the dividends (d_{T+1}^y) of healthcare assets follow the first-order autoregressive process.

$$\ln(d_{T+1}^y) = \rho \ln(d_T^y) + \varepsilon_{T+1} , \quad (43)$$

or our calibration, suppose that $\rho = 0.95$ and see the effects of dividends on the consumption goods (c_T^y and c_{T+1}^o) and the healthcare goods (h_T^y and h_{T+1}^o) for young and old households.

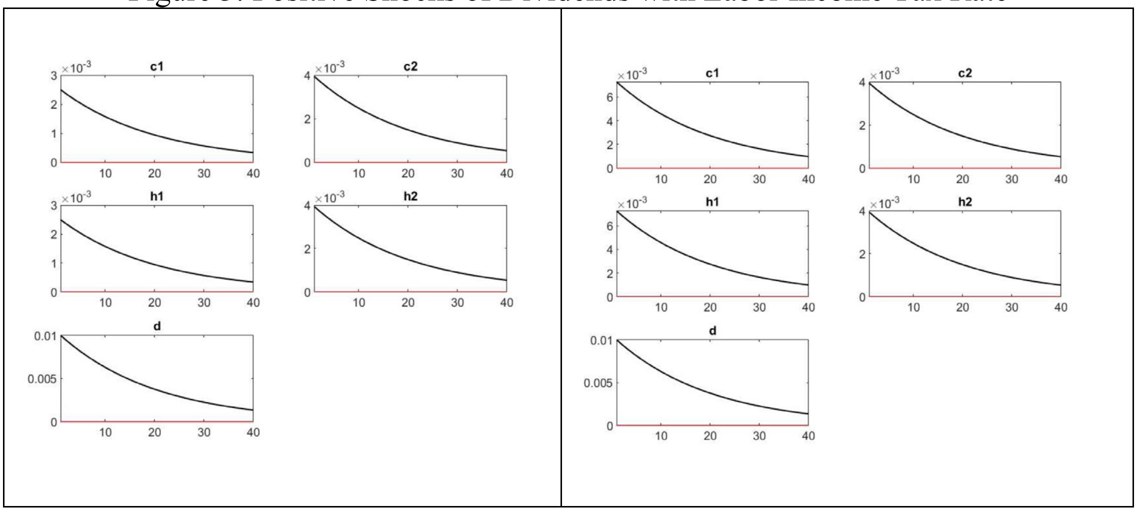
$$\ln\left(d_{T+1}^y\right) = 0.95\ln\left(d_T^y\right) + \varepsilon_{T+1} \quad , \qquad (44)$$

The graph shows the effects of dividends for 40 periods. Other things being equal, the effects from dividends (d_T^h) are similar to either lump sum tax or labor income tax rate. whether the healthcare prices are zero ($p_T^h = 0$).

The effects of healthcare dividends (d_T^h) cause a fall in the consumption goods (c_T^y and c_{T+1}^o) and the fall in healthcare goods (h_T^y and h_{T+1}^o) when households are young and old. The effects decrease by exponential pattern but do not converge to zero at the end of 40 periods. The trend declines and converges to zero finally.

As Figure 4 shows, the main difference between using the lump sum tax and labor income tax rate in the model is the beginning amount of the consumption goods (c_T^y) and healthcare goods (h_T^y). However, in the long run, those effects decline and converge to zero.

Figure 3: Positive Shocks of Dividends with Labor Income Tax Rate



Source: Simulation from MatLabs Author's Compilations

5. Conclusions

We develop the basic overlapping generation models with healthcare assets and find the important results. Then we extend the models, including the government intervention. In other words, households are taxed when young but receive healthcare subsidies when old. It is the PAYG. Then we modify the models by government enforcing households to save for their healthcare services rather than taxing. Finally, we run the numerical simulation to test our developed theoretical models.

The important problem is that the different generations could not trade their healthcare assets (a_{T+1}^h and a_T^h). In other words, suppose that, at time $T+1$, the current young households who were born at time $T+1$ value their prices of healthcare assets greater than zero [$\left(p_{T+1}^h\right)^y > 0$], while the old households who were born at time T value zero for their prices of healthcare assets ($\left(p_{T+1}^h\right)^o = 0$). Therefore, with different values, the trade or the exchange of healthcare assets could not exist. The market for healthcare assets could not function.

The PAYG system could be sustainable as long as the growth rate of the population (n) is greater than or equal to the households' discount rate ($n \geq \rho$). Otherwise, this system would fail.

If the healthcare savings that the government forces young households to save are equal to the lump sum taxes that the government collects from the young households ($Healthcare\ Saving_{T+1}^{y} = T_{T}^{y}$), whether PAYG or a fully funded system is better depends on the growth rate of the population (n) and the rate of return on healthcare savings (r_{T+1}).

The numerical simulation shows several implications.

First, in the long run, when the system is in steady states, the consumption goods and healthcare goods when young and old (c_{T}^{y} , c_{T+1}^{o} , h_{T}^{h}, h_{T+1}^{h}) converge to some points, but not zero.

Second, in the long run, at steady states, the dividends (d_{T+1}^{h}) and the prices (p_{T}^{h}) of healthcare assets converge to zero.

Third, the shocks on dividends (d_{T+1}^{h}) affect consumption goods and healthcare goods when young and old. Those four variables (c_{T}^{y}, c_{T+1}^{o}, h_{T}^{h}, h_{T+1}^{h}) start with the one highest point and decline exponentially to some point at steady states. The lump sum taxes or labor income tax rate do not matter and have no effect in general.

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