Model

1. Demography

In each year, there are $S = 80$ generations alive. Each agent enters the system at 20 years old ($s = 1$), works for $S_r = 40$ years then retire at end of the year. The population in year t can be denoted as:

$$N_t = \sum_{s=1}^{S} N_{s,t}$$

Without income groups, the number of people born in year t is non-increasing:

$$N_{s+1,t+s} = N_{s,t+s-1}\left(1 - F_{s,t+s-1}\right)$$

where $F_{s,t+s-1} \in [0,1)$ is mortal probabilities. The data are profiled by population forecast.

In each working year, agents have 1 time endowment and make their leisure decision $l_{s,t} \in [0,1]$. The total labor supply in year t is:

$$L_t = \sum_{s=1}^{S_r} N_{s,t}\left(1 - l_{s,t}\right)$$

2. Firm

We use a Cobb-Douglas production function:

$$Y_t = A_t {K_t}^{\beta} {L_t}^{1-\beta}$$

When equilibrium reached, the firm makes its optimal decision:

$$r_t = \frac{\partial Y_t}{\partial K_t} - \kappa$$

$$\bar{w}_t = \frac{\partial Y_t}{\partial L_t}$$

where κ is depreciation rate.

Wage level varies by age. A relative relationship $\varepsilon(s)$ and a scaling parameter o_t are used to profile wages for the working people in each year. $\varepsilon(s)$ is profiled by survey data.

$$w_{s,t} = \bar{w}_t o_t \varepsilon(s)$$

$$\bar{w}_t L_t = \sum_{s=1}^{S_r} w_{s,t} N_{s,t}\left(1 - l_{s,t}\right)$$

3. Social Security

There are two social security plans: a pay-as-you-go pension and a mixed social medical security system.

A. Pension

It is convenient to have a simplified, total pay-as-you-go pension in our discussion about medical system. In China, agents and firms contribute to the pension together. In each year of working, the firm pre-contributes $z_t\eta_t$ from agent's wage to the pension and contributes ζ_t to the medical system, where z_t is collection rate of pension:

$$w_{s,t} = (1 + z_t\eta_t + \zeta_t)\widetilde{w}_{s,t}$$

When agents receive their real wage level $\widetilde{w}_{s,t}$, they contribute extra $z_t\theta_t$ to the pension. The θ_t works on $\widetilde{w}_{s,t}$. We use $\pi_t = \frac{z_t(\theta_t+\eta_t)}{1+z_t\eta_t+\zeta_t}$ as the total contribution rate to pension, then the pay-as-you-go pension system can be denoted as:

$$\sum_{s=1}^{S_r} \pi_t w_{s,t} N_{s,t}(1 - l_{s,t}) = \sum_{s=S_r+1}^{S} \Lambda_{s,t} N_{s,t}$$

where $\Lambda_{s,t} = \Lambda_t$ is the pension benefit in year t. We make it distribute even on ages.

B. Medical System

The social medical security system consists of individual accounts for each generation and one pooling account. Each agent opens his/her own individual account when born and closes the account at death. The individual accounts are accumulative. There is also a pay-as-you-go pooling account whose gap is covered by the government budget in each year.

In the medical market, there are two types of medical consumer goods. We assume a well-supplied medical market where agents can consume any amount of medical service as they like[1]. For a specific agent in year t at age s, he/she decides his/her consumption $c_{s,t}$ in a perfect-forward-looking utility optimization (explained in the next section). Meantime, his/her total medical consumption $m_{s,t}$ is also determined by a ratio $q_t = \frac{m_{s,t}}{c_{s,t}}$. The q_t ratios are exogeneous in steady states but time-variant on the transition path. It varies according to a constant income elasticity of medical expenditure: $x = \frac{\partial M_t}{M_t}\frac{Y_t}{\partial Y_t} = 1.6$, where Y_t is GDP and $M_t = \sum_{s=1}^{S} m_{s,t}N_{s,t}$ is the social total medical expenditure in year t. However, we set a cap of q_t to avoid a unreasonable level. When $m_{s,t}$ defined, we use another exogenous

---

[1] We do not model a medical production department and do not clearly distinguish the medical consumer goods from general consumer goods.

ratio $p_{s,t} = \frac{MA_{s,t}}{MB_{s,t}}$ to distinguish the outpatient expenditure $MA_{s,t}$ from the inpatient expenditure $MB_{s,t}$.

The two types of accounts separately cover the two types of medical expenditures. Based on the case of China, we have the pooling account to cover $1 - cp_t^B$ of agents' inpatient expenditures, where cp_t^B is the copayment rate. The left cp_t^B part is paid by agents' personal asset account $a_{s,t}$. The individual medical accounts, together with agents' personal asset accounts, pay for the outpatient expenditures $MA_{s,t}$. An agent will primarily use the money in his/her individual medical account to pay for $MA_{s,t}$. If no money left there, the agent will use his/her personal asset account to pay the bill.

Contributions to the two types of medical accounts are designed to meet the reality of China. In working years, the firm contributes ζ_t of $\widetilde{w}_{s,t}$ to the medical system. Then each agent contributes extra ϕ_t of $\widetilde{w}_{s,t}$ to his/her individual medical account. However, there are $\mathbb{a}_t$ of firm's contribution transferred to individual medical accounts of those working agents, $\mathbb{b}_t$ of firm's contribution transferred to individual medical accounts of those retired agents. The left money is then contributed to the pooling medical account. We use the following figure to intuitively show the relationships in a specific year:

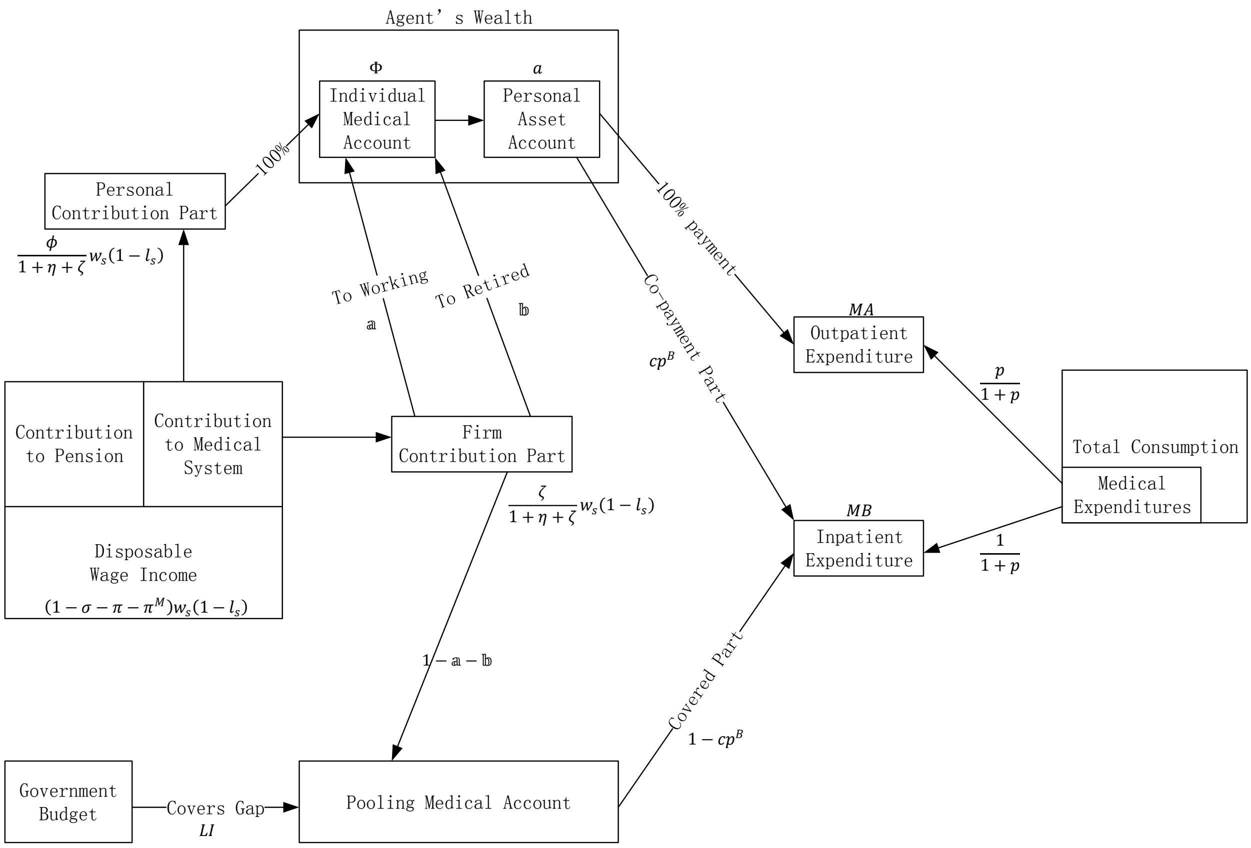

Figure 1 Contributions & Payments of Medical System

where σ is wage tax rate, $\pi_t^M = \frac{\phi_t+\zeta_t}{1+z_t\eta_t+\zeta_t}$ is the total contribution rate to medical system,

LI_t is the gap of pooling medical account, and $\Phi_{s,t}$ is the balance of agents' individual medical account. If we write the pooling medical account in mathematics, we have:

$$\sum_{s=1}^{S}\frac{1-cp_t^B}{1+p_t}q_{s,t}c_{s,t}N_{s,t}=(1-𝕒_t-𝕓_t)\frac{\zeta_t}{1+z_t\eta_t+\zeta_t}\sum_{s=1}^{S_r}w_{s,t}\left(1-l_{s,t}\right)N_{s,t}+LI_t$$

The accumulation of individual medical accounts is similar to personal asset accounts. Agents supply their wealth (both a and Φ) to the capital market and get interest incomes. When agents die before the life limit, their wealth will be redistributed evenly to all agents at the same age. After mathematical simplification, we have:

$$\begin{cases}\left(2-\frac{1}{1-F_s}\right)\Phi_{s+1}=(1+r_s)\Phi_s+\frac{\phi_s+𝕒_s\zeta_s}{1+z_s\eta_s+\zeta_s}w_s(1-l_s)-\frac{q_sp_s}{1+p_s}c_s, s=1,\dots,S_r\\\left(2-\frac{1}{1-F_s}\right)\Phi_{s+1}=(1+r_s)\Phi_s+\mathbb{P}_s-\frac{q_sp_s}{1+p_s}c_s, s=S_r+1,\dots,S\end{cases}$$

where $\frac{q_sp_s}{1+p_s}c_s=MA_s$, and $\mathbb{P}_{\mathrm{s,t}}=\mathbb{P}_t$ is the transfer amount from firm contributions to those retired. This amount is determined by:

$$\mathbb{P}_t\sum_{s=S_r+1}^{S}N_{s,t}=\sum_{\mathrm{s=1}}^{\mathrm{S_r}}𝕓_t\frac{\zeta_t}{1+z_t\eta_t+\zeta_t}w_{s,t}\left(1-l_{s,t}\right)N_{s,t}$$

4. Household

Agents solve a perfect forward-looking utility optimization when born. The cross-section utility function is:

$$u(c,l|q,\alpha,\gamma,\varrho)=\frac{1}{1-\gamma^{-1}}\left[\left((1-q)c\right)^{1-\varrho^{-1}}+\alpha l^{1-\varrho^{-1}}\right]^{\frac{1-\gamma^{-1}}{1-\varrho^{-1}}}$$

where α is the leisure preference than consumption, γ is the inter-temporal substitution elasticity, and ϱ is the consumption substitution elasticity of labour. Here we assume that only non-medical consumptions bring utility to agents. The problem can be written as a Bellman equation:

$$v_s=\max[u(c_s,l_s)+\beta_s^u v_{s+1}]$$

where $\beta_s^u=\frac{1-F_s}{1-\delta}$ is discount factor, and δ is the utility discount rate.

The payment of outpatient expenditures can be seen as a transfer from individual medical account to personal asset account. Agents primarily use the money in their individual medical account Φ to cover the outpatient expenditures. Only if there is no money in the account, agents will use the money in their personal account a to pay the bill. However, for the purpose of generality, the process can be described as: first, agents always transfer

$MA = \frac{p}{(1+p)} qc$ from Φ to a, then use a account to pay the outpatient bill. At last, if $\Phi < 0$, agents transfer money from a back to Φ to make sure $\Phi = 0$. Considering bequests of accident death, we have budget constraints:

$$\begin{cases} \left(2 - \frac{1}{1-F_s}\right) a_{s+1} = (1+r_s)a_s + (1 - \sigma - \pi_s - \pi_s^M) w_s (1 - l_s) - c_s + \frac{1}{1+p_s}[p_s + (1 - cp_s^B)] q_s c_s, s = 1, .., S_r \\ \left(2 - \frac{1}{1-F_s}\right) a_{s+1} = (1+r_s)a_s + \Lambda_s - c_s + \frac{1}{1+p_s}[p_s + (1 - cp_s^B)] q_s c_s, s = S_r + 1, \dots, S \end{cases}$$

Because we distinguish individual medical accounts, the boundary conditions no longer work on personal asset but agents' wealth:

$$\begin{cases} a_{s=1} = \Phi_{s=1} = 0 \\ a_{dead} + \Phi_{dead} = 0 \end{cases}$$

where a_{dead}, Φ_{dead} are the account balances at the end of age year S. If $\Phi_S \neq 0$, we assume there is a transfer in the last year to meet the assumption of no last bequest.

5. Government

The government keeps the following budget constraint:

$$TR_t + D_{t+1} = G_t + LI_t + r_t D_t$$

where $TR_t = \sigma \sum_{s=1}^{S_r} N_{s,t} w_{s,t} (1 - l_{s,t}) + \mu \sum_{s=1}^{S} N_{s,t} c_{s,t}$ is the total tax revenues, σ is wage tax rate, μ is consumption tax rate, D_t is government outstanding debt. Further, we have a soft constraint $\frac{G_t}{Y_t} < \Bbbk_t$, where $\Bbbk_t$ is the cap of debt ratio, a given constant.

6. Equilibrium

For the good market, we have the following clearing condition:

$$Y_t = C_t + I_t + G_t$$

where $C_t = \sum_{s=1}^{S} N_{s,t} c_{s,t}$ is the total consumption, and $I_t = K_{t+1} - (1 - \kappa) K_t$ is the investment.

For the capital market, we have the clearing condition:

$$K_t = \sum_{s=1}^{S} N_{s,t} (a_{s,t} + \Phi_{s,t}) + D_t$$

Notations

Marks	Names
o_t	Scaling coefficient for wage profiling
$\varepsilon(s)$	Relative wage level
LI_t	Gap of pooling medical account
μ, σ	Consumption, Wage tax rate
κ	Depreciation rate
θ, η	Personal, Firm contribution to pension
ϕ, ζ	Personal, Firm contribution to medical
Λ	Pension benefit
π, π^M	Total contribution of pension, medical
F	Mortal probabilities
q	Ratio of medical fee to total consumption
p	Ratio of Outpatient fee to Inpatient fee
a, Φ	Personal asset, Individual medical account
cp^B	Copayment rate of inpatient fee
γ	Inter-temporal substitution elasticity
α	Preference of leisure than consumption
ϱ	Consumption substitution elasticity of labour
$\mathbb{a}$	Transfer rate from firm contribution to individual medical account (working phase)
$\mathbb{b}$	Transfer rate from firm contribution to the individual medical account of those retired
$\mathbb{k}$	Cap of debt to GDP ratio
$\mathbb{P}$	Transferred amount from firm contribution to the individual medical account of the retired

Table 1 Notations