The Korean Economic Review
Volume 32, Number 2, Winter 2016, 355-382.

Population Aging in Korea: Macroeconomic Impacts and Financing National Health Insurance*

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We provided a quantitative model to analyze the impacts of population aging on the Korean economy and National Health Insurance (NHI). We found that the NHI premium rate for workers should be increased by 3.7 percentage points between 2015 and 2060 to finance the augmented burden of the NHI program as a result of the aging population. Within the same period, the aggregate labor would be decreased by 30.9 percent despite the increase in employment ratio by 2.2 percentage points while the aggregate output was decreased by 18.3 percent. To make distinction between the population aging effect and the effect from the increased NHI premium rate, we conducted an experiment where the NHI premium rate for workers was held constant at the level of 2015 along the transition path. The experiment showed that the distortion effect of the increased NHI premium rate would be only minor compared to the direct effect of population aging.

JEL Classification: H51, I13, J11, J21
Keywords: Population Aging, National Health Insurance

I. Introduction

South Korea is among the most rapidly aging nations in the world. As illustrated in Figure 1, the fertility rate of Korea showed a constantly decreasing trend until early 2000s, and it became lower than the average fertility rate of the OECD members in 1983; as of 2013, it was only 1.2 percent. The life expectancy, on the other hand, has increased rapidly, overtaking the average of the OECD members in 2005, and reaching 81 years in 2013. The Statistics Korea (Korea, 2012) projects that the fraction of the elderly, those aged 65 years and over, will increase from 13.2 percent in 2010 to 44.6 percent in 2060.

Received: April 18, 2016. Revised: Sept. 29, 2016. Accepted: Nov. 16, 2016.
* I appreciate the anonymous referees for their valuable suggestions and comments. All remaining errors are of the author's.
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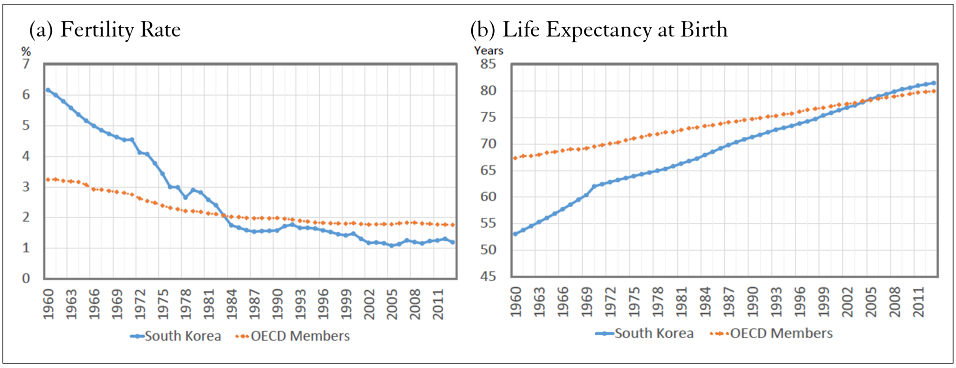
[Figure 1] Fertility Rate and Life Expectancy at Birth in Korea: 1960-2013



Data source: World Bank; World Development Indicators.

Despite the rapidity of population aging in Korea, there are few researches that study its impact on Korean economy. A notable exception is Hong (2007). However, not only does it adopt a partial equilibrium model which suffers from its inherent limitation on macroeconomic analysis, but it also does not seriously consider the household's health expenditure which is one of the crucial aspects of population aging. In this paper, we provide a quantitative model to overcome the drawbacks of Hong (2007). We quantify the impacts of population aging in Korea on macroeconomy and the National Health Insurance (NHI), with a focus on the labor participation decision of the working-age population under shifting circumstances.

As of 2014, the aggregate health expenditure in Korea accounts for 7.1 percent of GDP. Given that one's health expenditure increases in age, it is evident that the increasing health expenditure will shoulder the burden of the NHI program as the economy ages. To make it worse, the revenue of the NHI program relies primarily on the NHI premium which is levied on the working-age population as a form of labor income tax. As a decrease in the working-age population implies a decrease in the revenue from the NHI premium, it is unavoidable to raise the premium rate to balance the budget for the NHI program in a more aged economy. However, the increased premium rate will potentially distort work incentives, which will again put upward pressure on the premium rate. In this paper, we provide information on how much the NHI premium rate for workers is to be raised to balance the NHI program budget after taking into consideration of both the population aging effect and the distortionary impact from the increase in the NHI premium rate.

There is a growing literature that concerns the rapidly increasing burden of financing the national health insurance program because of accelerating population aging. Attanasio et al. (2010) are among the first to study the fiscal pressure that will be generated by hikes in the health expenditure of Medicare in the U.S. as the economy ages. Building on Auerbach and Kotlikoff (1987), they present a dynamic stochastic general equilibrium model in which (i) agents are heterogeneous in age, skill level, and health status, and (ii) the government provides Medicare coverage and Social Security benefits. Due to the increasing number of immigrants, however, population aging in the U.S. is hardly as fast as newly industrialized countries. Using a class of model that resembles Attanasio et al. (2010), Hsu and Liao (2015) examine the case of Taiwan and study the impacts of rapid population aging on financing the national health insurance program that covers the entire population. In addition, Hsu and Yamada (2012) and Hsu et al. (2015) deal with the same issue for the cases of Japan and Thailand, respectively.

Our contributions to the literature are mainly fourfold. First, we introduce the household's disability shock into the model. By jointly estimating the shock processes of the disability and the health expenditure based on the Korean Health Panel, we attempt to capture that households with a higher level of health expenditure are more likely to be subject to work disability from health-related issues.[1] Second, our analysis is centered on the labor participation decision of working-age population, which plays a crucial role in determining the budget-balancing NHI premium rate for workers. Third, while the previous works mostly rely on the comparative statics derived from the steady states of the model economies with different population structures, we explore the transition path of the model economy with the aging population; the results deliver some crucial implications for policy makers. Finally, we provide a policy implication on how to fund the increasing expenditure of the NHI program by comparing two different schemes: increasing the NHI premium rate for workers or increasing government's contributions to supplement the deficit of the NHI program budget with the fixed NHI premium rate for workers.

Our model is a modified version of Hsu and Liao (2015), which is characterized by (i) stochastic aging and dying processes, (ii) idiosyncratic shock processes for individual household's labor productivity and health expenditure, and (iii) a NHI program and a Social insurance program operated by the government. We deviate from Hsu and Liao (2015), however, in three aspects. First, labor is indivisible following Chang and Kim (2006). Second, households confront an additional idiosyncratic shock, the disability shock that stops them from working. Third, the NHI program is financed by itself, independent from the general Social insurance program budget, while Hsu and Liao (2015) allow for a single government budget for both programs.

We calibrate the model economy for Korean economy in 2015. Going one-step further from the literature, we analyze the impact of the population aging on

[1] Although we use the term "disabled", the physical condition that disallows working in our model is not permanent in the sense that there is a positive probability that one can recover and work again in the next period.

macroeconomic variables, including the budget-balancing NHI premium rate, along the transition path during which the population structure evolves according to the projection made by the Statistics Korea. The analysis reveals that the aggregate health expenditure in 2060 increases by 35.2 percent compared to 2015. The NHI premium rate for workers is expected to rise by 3.7 percentage points, from 5.6 percent in 2015 to 9.3 percent in 2060. The aggregate labor decreases by 30.9 percent from 2015 to 2060 in spite of the increase in the employment ratio by 2.2 percentage points. The aggregate capital increases by 5.0 percent within the same period, and the aggregate output decreases by 18.3 percent. For the analysis, we assume that the increasing expenditure of the NHI program is funded by raising the NHI premium rate for workers. The transition path of the economy, thus, is influenced by the distortion resulting from the increased NHI premium rate as well as the population aging.

In order to make distinction between the population aging effect and the effect of the increased NHI premium rate, we perform a counterfactual experiment where (i) the NHI premium rate is held fixed at the level of 2015, and (ii) the government fills deficit in the NHI program budget throughout the transition path. We then compare the results of the counterfactual experiment with the previous experiment. The comparison reveals that the magnitude of the distortionary impact resulting from the increase in the NHI premium rate for workers is only minor. It is not only because the extended life expectancy provides a greater incentive to work to young households who need greater savings for the prolonged retirement period, but because the shrinking working age population also leads to a huge increase in wage, which makes the option to work more attractive to young households.

The remainder of the paper is organized as follows. The next section presents the model, and we describe the calibration of the model in Section 3. In Section 4, we examine the steady state results of the model economies, of which the population structures correspond to 2015 and 2060 (expected) respectively. We then explore how the model economy evolves along the transitional path as the population ages and conduct a counterfactual experiment to make distinction between the population aging effect and the effect of the increase in the NHI premium rate. Section 5 concludes the paper.

II. Model

2.1. Demographics

The economy is populated by a continuum of households, of which the measure is normalized to unity. Households are divided into two generations by age: the Young and the Old. The Young constitute the working age population who have an option to work or not to work, and the Old are assumed to be retirees who have exited the labor market for good. In each period, the Young stochastically become the Old with a probability π_o, and the Old decease with a probability π_d; hence, π_o and π_d govern working life expectancy and life expectancy respectively. The deceased are replaced by newborns who belong to the population of the Young, so that the entire population measure does not change. We abstract the bequest incentive and simply assume that the entire assets once having belonged to the deceased are equally distributed throughout the entire population. In this setting, the measures of the Young and the Old are calculated as $\pi_d/(\pi_o+\pi_d)$ and $\pi_o/(\pi_o+\pi_d)$. Thus, the old-age dependency ratio defined as the ratio of the Old to the Young population becomes π_o/π_d. In our model, population aging is captured by a higher old-age dependency ratio, which is generated by lowering the dying probability π_d while assuming that working life expectancy remains the same.

2.2. Firm

The production sector consists of a single publicly-owned representative firm. The firm produces outputs Y in accordance with a constant-returns-to scale Cobb-Douglas technology:

$$Y = L^{\alpha} K^{1-\alpha} \tag{1}$$

where L and K denote effective units of labor and capital employed in the production sector. Parameter α denotes labor share in the production of outputs, and capital depreciates at the rate of δ in each period.

Given wage and capital rental rate, w_t and $\tilde{r}_t$, the firm maximizes its profit in every period:

$$\max_{L_t, K_t} L_t^{\alpha} K_t^{1-\alpha} - w_t L_t - \tilde{r}_t K_t \tag{2}$$

2.3. Household

The preferences of all households are identical and represented by a standard CRRA utility function, which is commonly applied in the literature:

$$u(c,h) = \frac{c^{1-\sigma}-1}{1-\sigma} - B\frac{h^{1+1/\gamma}}{1+1/\gamma} \tag{3}$$

where c and h are consumption and hours worked.

Parameters σ and γ represent the coefficient of relative risk aversion and the elasticity of labor supply respectively, and B governs the weight of disutility from work in a household's utility.

Households confront an idiosyncratic shock on their health expenditures in every period. In particular, we assume that health expenditure is age-dependent and evolves over time according to a Markov process with transition probability distribution function: $P_{m_g}(m'_g|m_g) = Pr(m_{g,t+1} \leq m'_g \mid m_{g,t} = m_g)$ for $g \in \{y, o\}$ where y and o denote the Young and the Old. In addition, the Young face an idiosyncratic shock on their labor productivity x, which evolves over time according to a Markov process with transition probability distribution function: $P_x(x'|x) = Pr(x_{t+1} \leq x'|x_t = x)$.

The shock processes of the health expenditure and the labor productivity for the Young are assumed to be independent of each other. Importantly, the young households also confront the disability shock d, which takes the value of one in case of being disabled or zero otherwise. Although we use the term "disabled", the physical condition that disallows working is not permanent in the model in the sense that there is a positive probability that one can recover and work again in the next period. In order to reflect that households with a higher level of health expenditure are more likely to be subject to work disability from health-related issues, we maintain the interdependence between the shock processes of the disability and the health expenditure.

2.4. Capital Market

The capital market is incomplete in that households can hold assets only in the form of physical capital a, which yields the real rate r, and in that there is a borrowing constraint $a \geq \underline{a}$ in every period (Aiyagari, 1994). Confronting idiosyncratic shocks, households may accumulate assets in order to smooth their consumption over the following periods.

Through the capital market, the firm rents capital from households and pays the capital rental fee to households in return. The capital rental rate is competitively determined; that is, $r = \tilde{r} - \delta$.

2.5. Government

In our model, the government provides households with social safety nets in two forms: the National Health Insurance (NHI) program and the means-tested Social insurance program. The NHI program covers a fraction f of every household's realized health expenditure: a household with a realized health expenditure m pays only $(1-f)m$ out of her own pocket. The NHI program is funded by compulsory contributions from both workers and non-workers. In particular, a NHI premium $\tau_{\text{NHI}} wx\bar{h}$ is levied on all workers in a form of labor income tax; and all non-workers - the Old and those who decide not to work among the Young - pay an amount of premium p.

For the means-tested Social insurance program, we apply a simple transfer rule proposed by Hubbard et al. (1995): the government transfers a subsidy to each household whose disposable income (after paying out-of-pocket health expenditure) plus assets become less than the minimum level of consumption c_{min}. The amount of the subsidy is determined in such a way that the household's disposable income (including the subsidy) plus assets and net of out-of-pocket health expenditure is exactly equal to c_{min}. The Social insurance program is financed by consumption tax, labor income tax, and capital income tax.

Since one of the purposes of our paper is to calculate a NHI premium rate for workers, τ_{NHI}, that finances the NHI health expenditure in the instance of population aging, we assume that the NHI program has its own budget structure, independent of the Social insurance program budget. As such, τ_{NHI} is endogenously determined at the equilibrium to balance the budget for the NHI program.

2.6. Recursive Representation

2.6.1. The Young

The labor is indivisible. When a young household decides to work, she provides $\bar{h}$ units of labor to firms (Chang and Kim, 2006; Chang and Kim, 2007; and Rogerson, 1988). Given a wage rate for efficient unit of labor w, a young worker with labor productivity x earns $wx\bar{h}$ as compensation for her labor and resulting disutility from it.

In each period, after observing realized shocks x, m_y, and d, young households who can physically work, those with $d=0$, choose either to work or not to work. Thus, the value function of a young household with $(x, m_y, d=0, a)$ prior to making a work decision is represented as follows:

$$V_y(x, m_y, 0, a) = \max_{o \in \{W, NW\}} [V_y^W(x, m_y, 0, a), V_y^{NW}(x, m_y, 0, a)] \tag{4}$$

where V_y^W and V_y^{NW} are the value functions of a working household and a non-working household, respectively. The choice variable o denotes the household's working decision for the period, which takes W for being a worker and NW for being a non-worker. Young households with disability are unable to choose to work. It follows that their occupational choice should always hold: $o(x, m_y, 1, a) = NW$. The value function of a young household with $(x, m_y, d=1, a)$ is represented simply as follows:

$$V_y(x,m_y,1,a)=V_y^{NW}(x,m_y,1,a) \tag{5}$$

If the young household decides to be a worker, the value function V_y^W can be expressed as follows:[2]

$$V_y^W(x,m_y,0,a)=\max_{c,a'}u(c,\bar{h})+\beta\{(1-\pi_o)$$
$$\boldsymbol{E}[V_y(x',m_y',d',a')\,|\,x,m_y,d=0]+\pi_o\boldsymbol{E}[V_o(m_o',a')\,|\,m_y]\} \tag{6}$$

subject to

$$(1+\tau_c)c+a'=W_y^W(x,m_y,0,a)+T_y^W(x,m_y,0,a) \tag{7}$$

$$W_y^W(x,m_y,0,a)\equiv(1-\tau_h-\tau_{NHI})wx\bar{h}$$
$$+\{1+(1-\tau_k)r\}(a+b)-(1-f)m_y \tag{8}$$

$$T_y^W(x,m_y,0,a)\equiv\max\{0,(1+\tau_c)c_{min}-W_y^W(x,m_y,0,a)\} \tag{9}$$

where b denotes the accidental bequest from the deceased.[3]

The young worker maximizes her discounted, expected life time utility by choosing consumption c for the current period and precautionary assets a' for the future under the budget constraint given by (7). In addition to the uncertainty derived from shocks of labor productivity, disability, and health expenditure, the young worker confronts the risk of becoming a member of the aged group with probability π_o, which constitutes a part of a young worker's utility maximization problem. The R.H.S of (7) represents the young worker's entire resource that can be used for consumption and saving. It consists of (i) the sum of her disposable income (after paying out-of-pocket health expenditure) and assets, W_y^W, and (ii) government subsidy, T_y^W. The disposable income again comprises of (i) labor income after paying the labor income tax and the NHI premium, $(1-\tau_h-\tau_{NHI})wx\bar{h}$, and (ii) after-tax capital income, $r(1-\tau_k)(a+b)$. The government subsidy T_y^W is granted only when W_y^W is too small to cover the minimum consumption level c_{min}.

The value function of a young non-worker V_y^{NW} can be represented as follows:

$$V_y^{NW}(x,m_y,d,a)=\max_{c,a'}u(c,0)+\beta\{(1-\pi_o)$$
$$\boldsymbol{E}[V_y(x',m_y',d',a')\,|\,x,m_y,d]+\pi_oE[V_o(m_o',a')\,|\,m_y]\} \tag{10}$$

[2] Only those with $d=0$ can choose to work.

[3] The Old accumulate assets only to insecure themselves against the idiosyncratic shocks they confront, not to bequest for their descendant's welfare. Thus, all bequests are accidental, which arises from the stochastic dying assumption.

subject to

$$(1+\tau_c)c+a'=W_y^{NW}(m_y,d,a)+T_y^{NW}(m_y,d,a) \tag{11}$$

$$W_y^{NW}(m_y,d,a)\equiv\{1+(1-\tau_k)r\}(a+b)-(1-f)m_y-p \tag{11}$$

$$T_y^{NW}(m_y,d,a)\equiv\max\{0,(1+\tau_c)c_{min}-W_y^{NW}(m_y,d,a)\} \tag{13}$$

Similar to the case of a young worker, a young non-worker maximizes her discounted, expected life time utility by splitting the disposable resources after paying out-of-pocket health expenditure into c and a'. Note that she does not suffer from disutility of working for the current period, and she does not earn labor income either. Moreover, she pays the NHI premium, p. The government subsidy T_y^{NW} is granted to young non-workers similar to the young workers' case.

2.6.2. The Old

Unlike the Young who have an option of working, the Old are assumed to have exited the labor market for good. The value function of an old household is represented as follows:

$$V_o(m_o,a)=\max_{c,a'}u(c,0)+\beta(1-\pi_d)\boldsymbol{E}[V_o(m_o',a')\,|\,m_o] \tag{14}$$

subject to

$$(1+\tau_c)c+a'=W_o(m_o,a)+T_o(m_o,a) \tag{15}$$

$$W_o(m_o,a)\equiv\{1+(1-\tau_k)r\}(a+b)-(1-f)m_o-p \tag{16}$$

$$T_o(m_o,a)\equiv\max\{0,(1+\tau_c)c_{min}-W_o(m_o,a)\} \tag{17}$$

A household maximizes the sum of current utility and expected future value by choosing c and a' under the budget constraint (15), which is identical to young non-workers.

2.7. Stationary Equilibrium

A stationary equilibrium consists of (i) value functions of a young household and an old household, $V_y(x,m_y,d,a)$ and $V_o(m_o,a)$, (ii) value functions of a young worker and a young non-worker, $V_y^W(x,m_y,0,a)$ and $V_y^{NW}(x,m_y,d,a)$, (iii) a set of young household's decision rules for employment status, consumption, and asset holdings, $o(x,m_y,d,a)$, $c(x,m_y,d,a)$, and $a'(x,m_y,d,a)$, (iv) a set of old household's decision rules for consumption and asset holdings, $c(m_o,a)$ and $a'(m_o,a)$, (v) distributions of young households and old households, $\Phi_y(x,m_y,d,a)$ and $\Phi_o(m_o,a)$, (vi) a price system, w and r, (vii) a set of the representative firm's decision rules for production factors, K and L, (viii) a NHI premium rate for workers, τ_{NHI}, and a NHI premium for non-workers, p, and (ix) the government consumption, G, such that:

1. Households optimize, given w and r,
   a. the young household's decision rules (o,c,a') and value functions (V_y, V_y^W, V_y^{NW}) solve the Bellman equations (4), (5), (6), and (10).
   b. the old household's decision rules (c,a') and value function V_o solve the Bellman equation (14).

2. The firm maximizes its profit:

$$w = \alpha(K/L)^{1-\alpha}$$

$$r = (1-\alpha)(K/L)^{-\alpha} - \delta$$

3. The factor markets clear:

$$L = \overline{h}\int x1\{o(x,m_y,0,a)=W\}d\Phi_y$$

$$K' = \int a'(x,m_y,d,a)d\Phi_y + \int a'(m_o,a)d\Phi_o$$

   where $1\{\cdot\}$ denotes an indicator function that takes one if the argument inside the parentheses holds true, and zero otherwise.

4. The goods market clear:

$$Y = C + K' - (1-\delta)K + M + G$$

   where C and M are aggregate consumption and aggregate health expenditure, respectively.

5. The government balances the budgets for:
   a. the NHI program:

$$fM = \tau_{NHI}wL + p\{\int 1\{o(x,m_y,d,a)=NW\}d\Phi_y + \int d\Phi_o\}$$

   b. other government expenditures:

$$\tau_c C + \tau_k rK + \tau_h wL = T + G$$

   where T is the aggregate government subsidy that is granted to households who are eligible for the means-tested Social insurance program.[4]

6. Distributions Φ_y and Φ_o are invariant over time.

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[4] T can be expressed as follows:

$$T \equiv \int T_y^W(x,m_y,0,a)1\{o(x,m_y,0,a)=W\}d\Phi_y$$
$$+\int T_y^{NW}(m_y,d,a)1\{o(x,m_y,d,a)=NW\}\ d\Phi_y + \int T_o(m_o,a)d\Phi_o$$

III. Calibration

We calibrate our model to the Korean economy of 2015. The model period is equal to one year. Households are not allowed to borrow; that is, $\underline{a}=0$. Despite the lack of a universally accepted definition, the working-age population is generally defined as those aged between 15 and 64.[5] In our model, the group of young households is equivalent to the working-age population. Thus, we set π_o to 1/49 so that the average working life expectancy in the model is equal to 49 years. We set the value of π_d to 0.114 so that the old-age dependency ratio of our model matches the old-age dependency ratio of 2015 Korea, 17.9%.

The average working hours $\overline{h}$ is set to 1/3.[6] The disutility of working $B=186.9$ is calibrated to match the employment rate among the working-age population ratio of 2015 Korea, 59.4%. The labor income share α is 0.60, and the depreciation of capital δ, 0.06.[7] The risk-aversion parameter σ is set to 1.0, and the elasticity of individual labor supply γ to 0.4, following Chang and Kim (2007). We assume that the logarithm of the labor productivity x follows a first order auto-regressive process: $\log x_{t+1}=\rho_x \log x_t+\varepsilon_{x,t+1}$, where $\varepsilon_{x,t}\sim N(0,\sigma_x^2)$ for all t. Following the procedure suggested in Chang and Kim (2008), we estimate the values based on the Korean Labor and Income Panel Study (KLIPS) 1998-2012: $\rho_x=0.792$ and $\sigma_x=0.354$. We adopt the method proposed by Tauchen (1986) to discretize the AR(1) process of the labor productivity with 17 grid points. The discount factor $\beta=0.96$ is calibrated, so that the real interest rate r becomes 4 percent at the stationary equilibrium. There are three types of taxes imposed on households: consumption tax, labor income tax, and capital income tax. The consumption tax rate, τ_c, is 10 percent and the labor income tax rate, τ_h, is 20 percent.[8] The capital income tax rate, τ_k, is 15.4 percent, which reflects the current Korean tax rate on interest income.

The means-tested Social insurance program in Korea has been recently reformed to improve the protection of the underprivileged population. As a result, the previous program has been sub-categorized into four distinct programs, each designed to reduce the burden of life expense, medical expense, housing expense, or education expense of the low income population. On the contrary, the means-tested Social insurance program in our model takes a unified form without sub-programs. Thus, we set the minimum level of consumption guaranteed by the government's Social insurance program, c_{min}, to 0.0049 so that the fraction of recipients among the entire population in our model matches 4.17 percent, the expected fraction of

[5] We follow the definition of the working-age population by OECD (2014).
[6] It is frequently assumed as the average working hours in the literature.
[7] Both are widely used values in the literature.
[8] The value-added tax (VAT) rate is 10% in Korea.

[Table 1] Calibrated Parameters

Parameter	Value	Targeted moment (or source)	Data/Model
π_o	1/49	average years of newborns' staying young	49yrs/49yrs
π_d	0.114	old-age dependency ratio	17.9%/17.9%
$\bar{h}$	1/3	literature	N.A.
B	186.9	employment rate among the young	59.4%/59.5%
α	0.60	labor income share	60%/60%
δ	0.06	literature	N.A.
σ	1.0	literature	N.A.
γ	0.4	Chang and Kim (2007)	N.A.
ρ_x	0.79	estimated directly from KLIPS	N.A.
σ_x	0.35	estimated directly from KLIPS	N.A.
β	0.96	real interest rate	4.0%/3.97%
τ_c	0.10	value-added tax rate	10%/10%
τ_h	0.20	literature	N.A.
τ_k	0.154	interest income tax rate	15.4%/15.4%
c_{min}	0.0049	share of recipients	4.17%/4.17%
p	0.0084	% of non-workers' contribution in NHI	16.6%/16.6%
f	0.565	% of public resources in current health exp.	56.5%/56.5%

recipients of the reformed Social insurance program in Korea.[9]

While the NHI program is the one and only source of public aids given to households to lessen the burden of health expenditure in our model, there might be multiple public sources - such as direct government expenditures - to reduce the burden of households' health expenditure in reality. Since our goals are to analyze the impacts of population aging and to gauge how challenging it would be to finance the increasing public health expenditure, we set the value of f to 56.5 percent to match the share of public resources in the aggregate health expenditure of Korean in 2014.[10] We set the NHI premium for non-workers, p, to 0.0084 so that the aggregate NHI premium collected from non-workers account for 16.6 percent of the total revenue of the NHI program. It follows the 2015 Health Insurance Statistics provided by the National Health Insurance Service, which reports that those enrolled in the "regional health insurance program" (non-workers in our model) account for 16.6 percent of the aggregate NHI premium.[11] The

[9] According to the calculation from the Ministry of Health and Welfare of Korea, based on 2014 population statistics, the total number of recipients from the four sub-programs of the reformed means-tested Social insurance is expected to be around 2.1 million, which is 4.17% of the total population.

[10] The National Health Insurance Service of Korea reports that the coverage rate of the NHI program in 2013 was 62.0 percent.

[11] Those enrolled in the regional health insurance program account for 32.7 percent of the number

[Table 2] Average Health Expenditure of Each Group in 2008

The Young	$G_{1,y}$	$G_{2,y}$	$G_{3,y}$	$G_{3,y}$
Won (₩)	24,052	398,056	2,035,906	7,068,484
$G_{i,y} / G_{1,y}$	1.0	16.6	84.6	293.9

The Old	$G_{1,o}$	$G_{2,o}$	$G_{3,o}$	$G_{4,o}$
Won (₩)	132,997	1,068,230	4,521,900	13,158,182
$G_{i,o} / G_{1,y}$	5.5	44.4	188.0	547.1
$G_{i,o} / G_{i,y}$	5.5	2.7	2.2	1.9

Note: Won denotes the currency of South Korea; $G_{i,g} / G_{1,y}$ denotes the ratio of the average health expenditure of each group $G_{i,g}$ to that of $G_{1,y}$; and $G_{i,o} / G_{i,y}$ denotes the ratio of the average health expenditure of the group i of the Old to the corresponding group of the Young.

values of these calibrated parameters that are described so far are summarized in Table 1.

Next we discretize the idiosyncratic shock process for the health expenditure with four grid points for each generation; that is, $m_g \in \{m_g^1, m_g^2, m_g^3, m_g^4\}$ for $g \in \{y, o\}$. To calibrate the values of $\{m_g\}$ for $g \in \{y, o\}$ and their corresponding transition matrices, we use the Korean Health Panel for the years of 2008 and 2009. 18,444 households are included in our sample, 15,853 representing the young population (aged between 15 and 64) and 2,591 representing the old population (aged 65 and over). For the years of 2008 and 2009, we divide each population into four groups, $\{G_{1,g}, G_{2,g}, G_{3,g}, G_{4,g}\}$, by the level of the individual household's (annual) health expenditure. In particular, we follow Hsu (2013): for each $g \in \{y, o\}$, (i) $G_{1,g}$: those whose health expenditure belongs to the bottom 60 percent, (ii) $G_{2,g}$: among those not belonging to $G_{1,g}$, whose health expenditure belongs to the bottom 95 percent, (iii) $G_{3,g}$: among those not belonging to $G_{1,g}$ and $G_{2,g}$, those whose health expenditure belongs to the bottom 99 percent, and (iv) $G_{4,g}$: those whose health expenditure belongs to the top 1 percent.

Table 2 shows the average health expenditure of each group in 2008, the Young on the top and the Old on the bottom. As expected, the average health expenditure of the Old is higher than that of the Young for the same group. The average health expenditure of $G_{1,o}$, for example, is 5.5 times as large as that of $G_{1,y}$, and the average health expenditure of $G_{4,o}$, 1.9 times as large as that of $G_{4,y}$. Table 2 also informs the ratio of the average health expenditure of each group to the average health expenditure of $G_{1,y}$. Using this ratio, we set $\{m_y\}$ and $\{m_o\}$ as follows: $\{m_y\} = \{\hat{m}_1, 16.6\hat{m}_1, 84.6\hat{m}_1, 293.9\hat{m}_1\}$ and $\{m_o\} = \{5.5\hat{m}_1, 44.4\hat{m}_1, 188.0\hat{m}_1, 547.1\hat{m}_1\}$.

of enrollments of the entire NHI program.

[Table 3] Inter-group Migrations between 2008 and 2009

The Young	$G_{1,y}$	$G_{2,y}$	$G_{3,y}$	$G_{4,y}$	Total
$G_{1,y}$	7,272	1,970	196	66	9,504
$G_{2,y}$	1,993	3,180	313	59	5,545
$G_{3,y}$	197	319	92	26	634
$G_{4,y}$	42	75	33	20	170

The Old	$G_{1,o}$	$G_{2,o}$	$G_{3,o}$	$G_{4,o}$	Total
$G_{1,o}$	1,226	272	33	15	1,546
$G_{2,o}$	283	546	60	13	902
$G_{3,o}$	30	66	3	4	103
$G_{4,o}$	8	19	7	6	40

Note: The number in i^{th} row and j^{th} column in each matrix represents the number of migration incidents from G_i to G_j between 2008 and 2009.

[Table 4] Transition Matrix for Health Expenditure Shock

The Young, %	$G_{1,y}$	$G_{2,y}$	$G_{3,y}$	$G_{4,y}$
$G_{1,y}$	76.5	20.7	2.1	0.7
$G_{2,y}$	35.9	57.3	5.6	1.1
$G_{3,y}$	31.1	50.3	14.5	4.1
$G_{4,y}$	24.7	44.1	19.4	11.8

The Old, %	$G_{1,o}$	$G_{2,o}$	$G_{3,o}$	$G_{4,o}$
$G_{1,o}$	79.3	17.6	2.1	1.0
$G_{2,o}$	31.4	60.5	6.7	1.4
$G_{3,o}$	29.1	64.1	2.9	3.9
$G_{4,o}$	20.0	47.5	17.5	15.0

Note: The number in i^{th} row and j^{th} column in each matrix represents the probability of transitioning from G_i to G_j.

We then calibrate $\hat{m}_1 = 2.73$, so that the aggregate health expenditure becomes 7.1 percent of GDP as in the 2014 Korea.

Next, we track inter-group mobility and count inter-group migrations between 2008 and 2009, as summarized in Table 3.[12] Based on these results, we estimate the

[12] Table 3 summarizes the number of inter-group migration incidents for every possible transition

[Table 5] Joint Transition Matrix for Health Expenditure and Disability Shocks for the Young

%	$(G_1,0)$	$(G_1,1)$	$(G_2,0)$	$(G_2,1)$	$(G_3,0)$	$(G_3,1)$	$(G_4,0)$	$(G_4,1)$
$(G_1,0)$	76.4	0.1	20.7	0.0	2.1	0.0	0.7	0.0
$(G_1,1)$	21.1	56.3	5.6	14.1	0.0	2.8	0.0	0.0
$(G_2,0)$	36.0	0.1	56.9	0.4	5.6	0.0	1.0	0.0
$(G_2,1)$	7.6	17.4	25.0	37.0	4.3	4.3	0.0	4.3
$(G_3,0)$	31.2	0.3	49.0	1.0	12.8	1.5	4.2	0.0
$(G_3,1)$	12.5	9.4	18.8	37.5	6.3	12.5	0.0	3.1
$(G_4,0)$	26.3	0.0	44.2	1.9	15.4	1.9	6.4	3.8
$(G_4,1)$	0.0	7.1	7.1	14.3	7.1	35.7	7.1	21.4

Note: Each cell represents the probability of transitioning from the current state (G_i, d_j) to the next period's state (G_k, d_l) where the first and the second arguments in the parenthesis denote the health expenditure group and the disability, respectively.

transition matrix for the health expenditure shock of each generation, by dividing every number in each row of Table 3 by the total number of migration incidents for the group represented by the row.

Finally, we jointly estimate the transition matrix for the health expenditure shock and the disability shock for the young households, following the same procedure applied for the estimation of the transition matrix for the health expenditure shock. The Korean Health Panel has information on the working status of every respondent and a specific reason for every non-working respondent. More importantly, one of the listed reasons for not working in the survey is “illness or health-related issues”. Thus, exploiting the information of the Korean Health Panel allows us to jointly estimate the transition matrix for the health expenditure shock and the disability shock, which allows us to capture a realistic connection between the heath expenditure shock and the labor supply decision. The results are shown in Table 4 and 5.

IV. Quantitative Analysis

In this section, we examine the steady state of the calibrated model (hereafter referred to as the benchmark economy corresponding to 2015 Korea). We compare it with the model economy which differs from the benchmark economy only in the old-age dependency ratio. We consider the model economy where the old-age dependency ratio is 80.6 percent, which is the projected value for 2060 Korea. We

from the group represented by the row.

then analyze the impacts of the population aging on macroeconomic variables, including the budget-balancing NHI premium rate, along the transition path. Further, in order to make distinction between the aging effects and the effects of the increase in the NHI premium rate, we perform a counterfactual experiment where (i) the NHI premium rate is held constant at the level of the benchmark economy, and (ii) the government fills deficit in the NHI program budget throughout the transition path.

4.1. Steady State

We investigate how young "abled" households make different labor decisions depending on the levels of their labor productivity, health expenditure, and savings at the individual level.[13] Then, we take a look at the steady states of the calibrated model.

4.1.1. Household's Working Decision

A young household's working decision is influenced by the levels of her labor productivity x and health expenditure m. In particular, the working decision of a young household can be characterized by the the range of savings with which she chooses to work over not to work. The upper and the lower bounds of the savings range depend on the levels of her labor productivity x and health expenditure m.

Given levels of labor productivity and health expenditure, a higher level of savings implies more abundant resources to be used for consumption. Since the marginal utility of consumption decreases in the level of consumption, the marginal benefit of work decreases as a household's savings level increases. On the contrary, the disutility of work has a fixed value. Therefore, given a household's labor productivity and health expenditure, there exists a maximum level of savings above which the household never chooses to work.

Given all else being equal, a higher level of health expenditure leads to a lower level of resources to be used for consumption, which makes a household with a higher level of health expenditure more likely to work than a household with a lower level of health expenditure. The maximum level of savings (the upper bound of the savings range), thus, increases in the level of health expenditure. Likewise, given a fixed level of health expenditure, a household with a higher level of labor productivity has a higher opportunity cost of not working, which results in a higher upper bound of the savings range for the household to be a worker.

Furthermore, due to the presence of the means-tested Social insurance program, some young households with relatively low levels of labor productivity and savings may find themselves better off when not working and receiving the government

[13] We use "savings" and "assets" interchangeably.

[Table 6] The Range of Savings for Young "Abled" Households to be Workers

	m_1	m_2	m_3	m_4
x_1	[0.00, 0.04]	[0.00, 0.06]	[0.05, 0.14]	[0.30, 0.36]
x_2	[0.00, 0.05]	[0.00, 0.07]	[0.04, 0.14]	[0.28, 0.38]
x_3	[0.00, 0.06]	[0.00, 0.08]	[0.02, 0.15]	[0.26, 0.38]
x_4	[0.00, 0.09]	[0.00, 0.11]	[0.00, 0.20]	[0.25, 0.43]
x_5	[0.00, 0.23]	[0.00, 0.26]	[0.00, 0.43]	[0.21, 0.79]
x_6	[0.00, 0.48]	[0.00, 0.53]	[0.00, 0.66]	[0.18, 1.06]
x_7	[0.00, 0.88]	[0.00, 0.95]	[0.00, 1.09]	[0.13, 1.50]
x_8	[0.00, 1.54]	[0.00, 1.63]	[0.00, 1.72]	[0.07, 2.16]
x_9	[0.00, 2.54]	[0.00, 2.54]	[0.00, 2.72]	[0.00, 3.08]
x_{10}	[0.00, 3.87]	[0.00, 3.94]	[0.00, 4.08]	[0.00, 4.45]
x_{11}	[0.00, 5.81]	[0.00, 5.89]	[0.00, 5.98]	[0.00, 6.33]
x_{12}	[0.00, 8.34]	[0.00, 8.45]	[0.00, 8.55]	[0.00, 8.86]
x_{13}	[0.00, 11.58]	[0.00, 11.58]	[0.00, 11.70]	[0.00, 12.07]
x_{14}	[0.00, 15.48]	[0.00, 15.48]	[0.00, 15.62]	[0.00, 16.04]
x_{15}	[0.00, 20.26]	[0.00, 20.26]	[0.00, 20.26]	[0.00, 20.74]
x_{16}	[0.00, 25.87]	[0.00, 26.05]	[0.00, 26.05]	[0.00, 26.41]
x_{17}	[0.00, 32.97]	[0.00, 32.97]	[0.00, 33.17]	[0.00, 33.38]

Note: The subscript of x indicates the rank of grid points that we use to discretize the labor productivity shock; the greater the number, the higher the labor productivity.

subsidy than earning labor income. It implies the existence of the minimum level of savings below which a household of given levels of labor productivity and health expenditure never chooses to become a worker. Given a fixed level of health expenditure, a household with a higher level of labor productivity has to sacrifice a greater labor income from not working. Thus the lower bound of the savings range - with which one chooses to work - is lower for households with greater labor productivity. Also, given a fixed level of labor productivity, a higher level of health expenditure means a lower level of resources for consumption, so that working becomes a less attractive option compared to not working and receiving the government subsidy. Thus the lower bound for the range of savings increases in the level of health expenditure.

Table 6 displays the upper and the lower bounds of the savings range - with which working is a better option than not working - obtained from the calibrated model. It supports that the lower bound for the range increases in the level of health expenditure and decreases in the level of labor productivity, and that the upper bound increases in both the level of health expenditure and the level of labor productivity.

4.1.2. Aggregates: Benchmark Economy

The government budget is summarized in Table 7 where the revenue and expenditure are placed on the right and the left respectively. The total tax revenue is 0.119, which amounts to 19.3 percent of aggregate output. It comprises three types of tax revenue: labor income tax revenue, capital income tax revenue, and consumption tax revenue, and each type takes up 62.7 percent, 12.8 percent, and 24.4 percent of the total tax revenue respectively. Aside from the government consumption, which is mechanically determined at the equilibrium of our model to balance the government budget, 2.2 percent of the total tax revenue is spent on the means-tested Social insurance program. In particular, the subsidy to the young households and the subsidy to the old households account for 1.9 percent and 0.2 percent of the total tax revenue.

[Table 7] Government Budget of Benchmark Economy

Expenditure		Revenue	
Social Insurance Program	.0026 (2.2%)	Labor income tax	.0749 (62.7%)
- Subsidy to the young	.0003 (1.9%)	Capital income tax	.0153 (12.8%)
- Subsidy to the old	.0023 (0.2%)	Consumption tax	.0292 (24.4%)
Government consumption	.1168 (97.8%)		
Total expenditure	.1194 (100%)	Total revenue	.1194 (100%)

Note: Each number in parentheses denotes the share of each item in the total revenue of the government budget.

[Table 8] Budget of Korean Government in 2015

Unit: trillion won

Expenditure		Revenue	
Social Insurance Program	5.9 (1.56%)	Total revenue	377.7 (100.0%)
- Housing expense	1.1 (0.29%)		
- Education expense	0.1 (0.03%)		
- All other expenses	4.7 (1.24%)		

Source: 2015 government finance statistics provided by National Assembly Budget Office.

Note: Each number in parentheses denotes the share of each item in the total revenue of the government budget.

Table 8 summarizes the budget of Korean government in 2015 in a comparable form to the budget of our benchmark economy as in Table 7. According to Table 8, the total revenue is 377.7 trillion won. Since the tax structure of our model is not directly comparable with the real world, the detailed source of the revenue is omitted. However, the comparison between Table 7 and Table 8 shows that the size of government spending on the means-tested Social insurance program is

[Table 9] Macroeconomic Variables: Benchmark Economy vs. 2060 Model Economy

Variable	Benchmark	Rel. to Y_0	2060	Rel. to Y_0	Rel. to Y_1
% of the young	84.8	-	55.4	-	-
% of the old	15.2	-	44.6	-	-
Y	0.62	1.00	0.48	0.77	1.00
K	2.50	4.01	2.30	3.69	4.79
Savings	2.52	4.04	2.31	3.71	4.81
Consumption	0.29	0.47	0.20	0.32	0.41
M	0.04	0.07	0.06	0.10	0.13
L	0.25	-	0.17	-	-
w	1.52	-	1.71	-	-
% of workers	59.5	-	62.9	-	-
τ_{NHI} , %	5.57	-	9.98	-	-

Note: Y_0 and Y_1 denote aggregate outputs of the benchmark economy and the 2060 model economy, respectively.

comparable between the benchmark economy and the 2015 Korea; the Korean government spending on the Social insurance program in 2015 amounts to 1.6 percent of the total tax revenue, compared to 2.2 percent in our model.

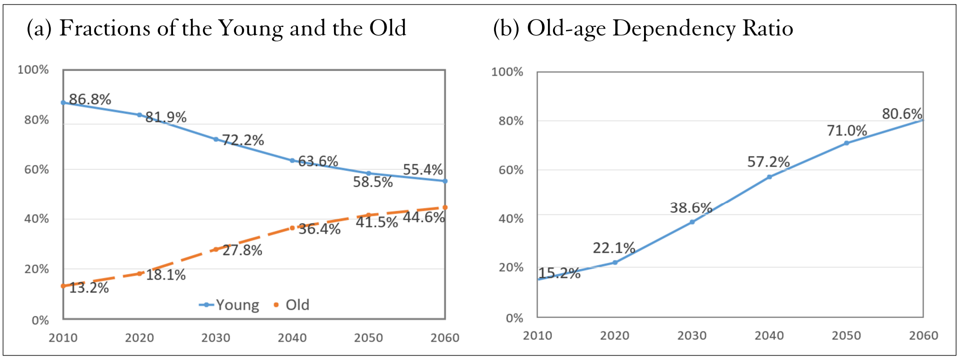
Table 9 summarizes the macroeconomic variables of the benchmark economy. The fractions of young households and old households are 84.8 percent and 15.2 percent respectively, and 59.5 percent of the young households choose to work. The aggregate capital, the aggregate savings, and the aggregate consumption are 4.01, 4.04, and 0.47 times as large as the aggregate output, which is 0.62. The aggregate health expenditure is 0.04, amounting to 7.1 percent of aggregate output. The aggregate labor is 0.25, and wage is 1.52. Finally, the NHI premium rate for workers is 5.57%, which is endogenously determined as an equilibrium outcome that balances the budget of the NHI program.

4.1.2. Aggregates: 2060 Model Economy

According to the Statistics Korea (Statistics Korea, 2012), the fraction of the young is expected to decrease from 86.8 percent in 2010 to 55.4 percent in 2060. Such decrease in the young population drastically elevates the old-age dependency ratio from 15.2 percent to 80.6 percent. (See Figure 2) By changing the value of the dying probability π_d while fixing all other parameter values at the level of the benchmark economy, we generate another model economy (hereafter referred to as the 2060 model economy) which closely reflects the projected population structure of 2060 Korea in terms of the old-age dependency ratio.

Table 9 compares macroeconomic variables of the benchmark economy (the counterpart of 2015 Korea) and the 2060 model economy. To enhance compatibility, aggregate variables are normalized by the aggregate output of the benchmark economy whenever applicable. As the size of the young population shrinks, so does

[Figure 2] Projected Population Structure in Korea: 2010-2060



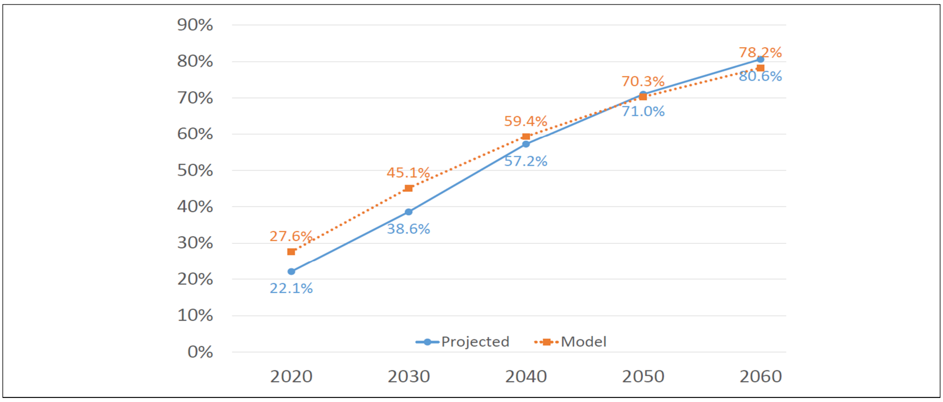
Note: Data source: Statistics Korea, 2012.

the size of the economically active population. The aggregate output decreases as the aggregate labor decreases; the aggregate output of 2060 is 23 percent lower than that of 2015. While the aggregate output decreases with the population aging, the shrinkage in the aggregate output, however, is not as severe as the aggregate labor; Table 9 shows that the aggregate labor is 32 percent lower in 2060 than in 2015. It is because the aggregate capital does not decrease as much as the aggregate labor. The absolute level of the aggregate capital in 2060 is 8 percent lower than in 2015, but once we take into account the size of the economy – in other words, if we normalize the aggregate capital by the aggregate output of each model economy – the aggregate capital of 2060 is 19 percent greater than that of 2015. Such increase in the normalized aggregate capital can somewhat offset the impact of the decrease in the aggregate labor on the aggregate output. In addition, the aggregate consumption in 2060 is 31 percent lower – 13 percent lower if the size of the economy is considered – than in 2015.

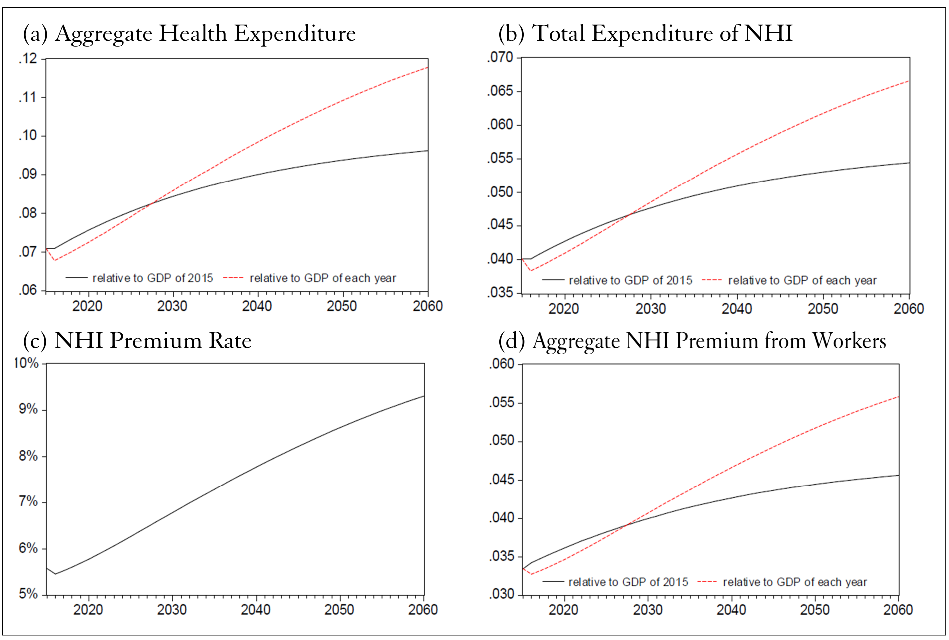
In the aged economy, young households accumulate more savings to prepare for the extended retirement life, and it leads to an increase in capital per unit of effective labor. As a result, wage is 13 percent higher in 2060 than in 2015. A higher wage provides young households with more incentive to work. As such, the employment rate among the young increases from 59.5 percent in 2015 to 62.9 percent in 2060.

Another crucial impact of population aging on the economy is the increase in the aggregate health expenditure. Since old households' health expenditures are higher than young households', it is evident that the aggregate health expenditure is higher in the economy with a higher fraction of the old population. Table 9 shows that the aggregate health expenditure in 2060 increases by 50 percent compared to 2015 and that the ratio of aggregate health expenditure to the aggregate output increases from 7 percent in 2015 to 13 percent in 2060. Consequently, the health expenditure covered by the NHI program is much higher in the 2060 model economy. In order to meet the budget, the NHI premium rate must be raised: the NHI premium rate for workers increases from 5.57 percent in 2015 to 9.98 percent in 2060.

[Figure 3] Old-age Dependency Ratio along Transition Path



[Figure 4] NHI Program along Transition Path



4.2. Transition Path

4.2.1. Benchmark Case

Comparing the steady states of the model economy at different stages of population aging provides some understanding of the macroeconomic impacts of population aging. Yet, the gradual shifting of macroeconomic variables with aging society should bear greater importance for policy makers. As such, we investigate how the benchmark economy evolves along the transition path as its population becomes aged.

In order to obtain the transition path of the aging economy, we assume that the probability of the old's dying, π_d, drops in 2016 and stays constant until the economy converges to a new steady state. In particular, we set the value of the probability of the old's dying π_d to 0.95 so that the transition path of the old-age dependency ratio of our model follows that of the projected population structure in Korea as closely as possible. Figure 3 depicts these projections.[14]

As the population become aged, the aggregate health expenditure increases: Figure 4 (a) shows that the aggregate health expenditure relative to the 2015 aggregate output increases from 7.1 percent in 2015 to 9.6 percent in 2060. The increase in the expenditure of the NHI program elevates the burden of workers through the NHI premium raise: Figure 4 (c) shows that the budget-balancing NHI premium rate for workers rises from 2016 and on, hitting 9.3 percent in 2060.[15]

Figure 5 summarizes how macroeconomic variables of our interest change along the transition path from 2015 to 2060. The analysis is conducted for the 2015-2016 period and the 2016-2060 period separately.

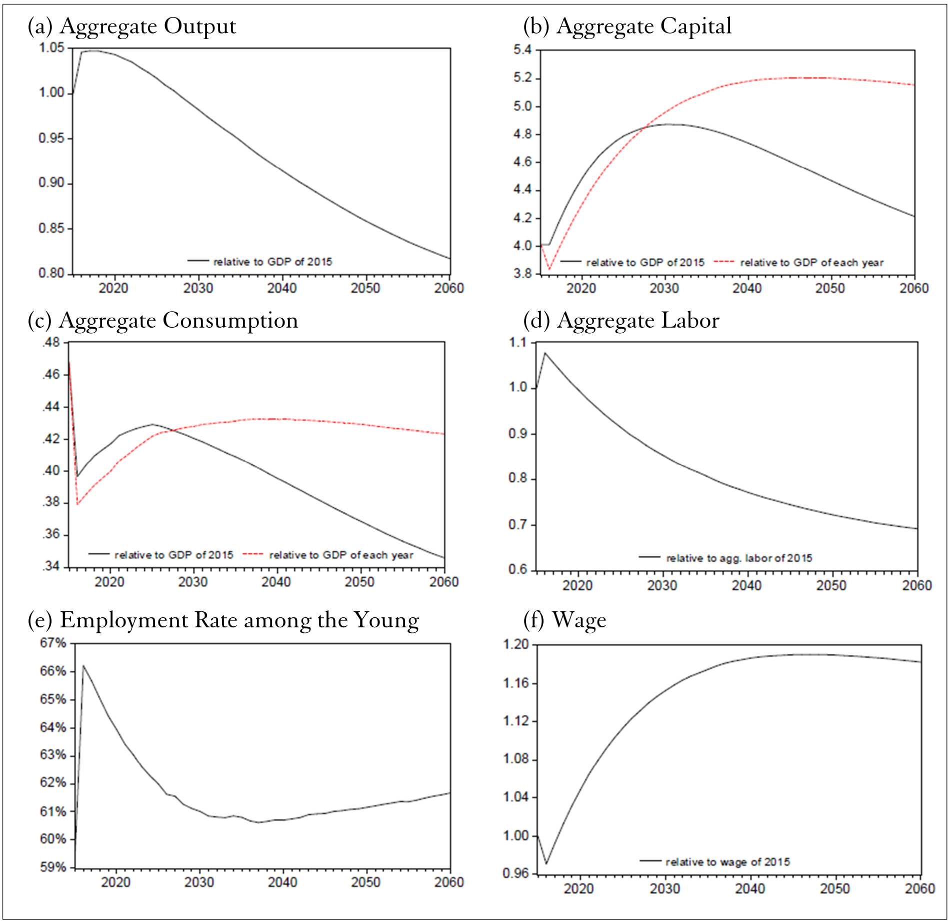
2015-2016

During the earliest period of the transition path, households adjust their savings plan; the prolonged life expectancy induces a higher level of savings for consumption smoothing. In 2016, in order to increase the level of savings, households reduce their consumption significantly and work more willingly. Figure 5 (c) shows that the aggregate consumption drops by more than 15 percent in 2016, and Figure 5 (d) and (e) show that the employment rate of the young jumps from 59.5 percent in 2015 to 66.2 percent in 2016. The aggregate labor increases by 7.7 percent for the same period. The level of the aggregate capital in 2016 stays the same as in 2015 as it takes one period for adjustment. However, due to the increase in the labor supply, the aggregate output increases by 4.6 percent in 2016 despite the decrease in the working age population while wage decreases by 3.0 percent in 2016.

[14] Note that the decrease in the probability of the old's dying results in a consistent increase in the old-age dependency ratio as seen in Figure 3.

[15] In 2016, the fraction of young households who become a worker spikes up since a higher level of savings are needed for young households to prepare for the extended life, which leads to a decrease in the budget-balancing NHI premium rate for workers.

[Figure 5] Changes in Macroeconomic Variables along Transition Path



2016-2060

After the initial drop in 2016, the aggregate consumption rebounds to reach 91.7 percent of the 2015 level in 2025. It can be explained by the increase in the fraction of households who begin to increase their consumption level after having accumulated enough savings for the prolonged life expectancy. However, the fraction of newly born generations, who tend to save more than the old generations, increases over time. Thus, the aggregate consumption continues to decrease from 2025, reaching 73.9 percent of the 2015 level in 2060.

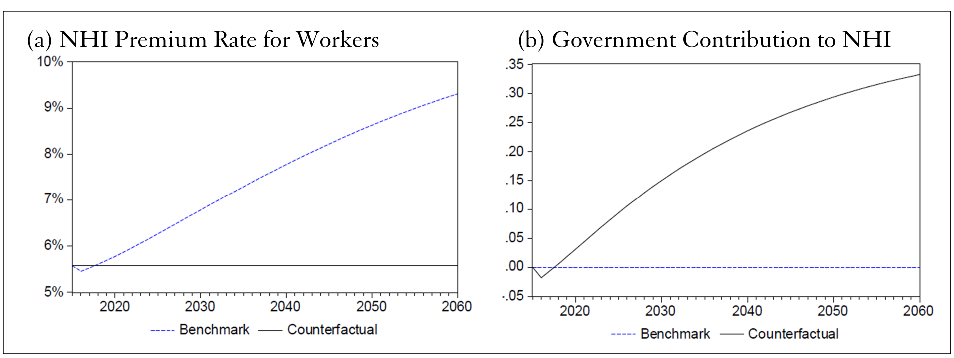
Those who have switched their occupation from non-workers to workers – those who cause the initial spike in the employment rate in 2016 – accumulate their savings to adjust their savings plan to meet the extended life expectancy. As time goes by, some of them return to being non-workers as they believe their savings are large enough to support their remaining life. As a result, the employment ratio continues to decrease until it reaches 60.6 percent, the lowest level along the transition path, in 2037. From then, it gradually increases to reach 61.7 percent in 2060. Such an increase results from the elevation in the fraction of newly born generations who are more willing to work to maintain higher levels of savings, compared to the old generations. On the contrary, the aggregate labor continuously decreases from 2016 and on, due to the shrinking working age population, which leads to constant increase of wage. According to Figure 5 (d) and (f), the aggregate labor in 2060 is only 69.1 percent of the aggregate labor in 2015, but the wage is 18.2 percent higher in 2060 than in 2015.

The aggregate capital keeps increasing from 2016 to 2030, as shown in Figure 5 (b). Yearly, those having experienced the change in the life-expectancy – thus having been forced to adjust their savings plan – are deceased and replaced by newborn generations who are given the prolonged life-expectancy upon birth. As the fraction of these newborn households increases over time, the aggregate capital increases at a slower pace, and it continues to decrease beginning in 2031. The level of the aggregate capital in 2060 becomes 13.5 percent lower compared to the peak year of 2030. Finally, Figure 5 (a) illustrates that the aggregate output keeps going down from 2016; in 2060, the aggregate output is 18.3 percent lower than in 2015.

4.2.2. Counterfactual Case

We have so far studied the transition path of the model economy (hereafter referred to as the benchmark case) along which the NHI premium rate for workers is determined at the equilibrium to balance the budget of the NHI program. However, it is not only population aging that affects the evolution of macroeconomic variables, but the rise of NHI premium rate for workers also has impact on the economy as it distorts households' incentive to work.

[Figure 6] NHI Program along Counterfactual Transition Path



Note: The government contribution to the NHI program is divided by the total expenditure of the NHI program of each year.

In an attempt to identify the distortionary impacts from the increase in NHI premium rate for workers, we compare the benchmark case with the counterfactual case in which we assume that the NHI premium rate for workers is held fixed at 5.57 percent, the level of 2015, throughout the transition path. For the counterfactual case, we assume that the government supports the NHI program to balance the budget. Figure 6 shows that these assumptions result in the increased government contribution to the NHI program in the counterfactual case, which resembles the increased NHI premium rate for workers in the benchmark case.

[Figure 7] Changes in Macroeconomic Variables along Counterfactual Transition Path

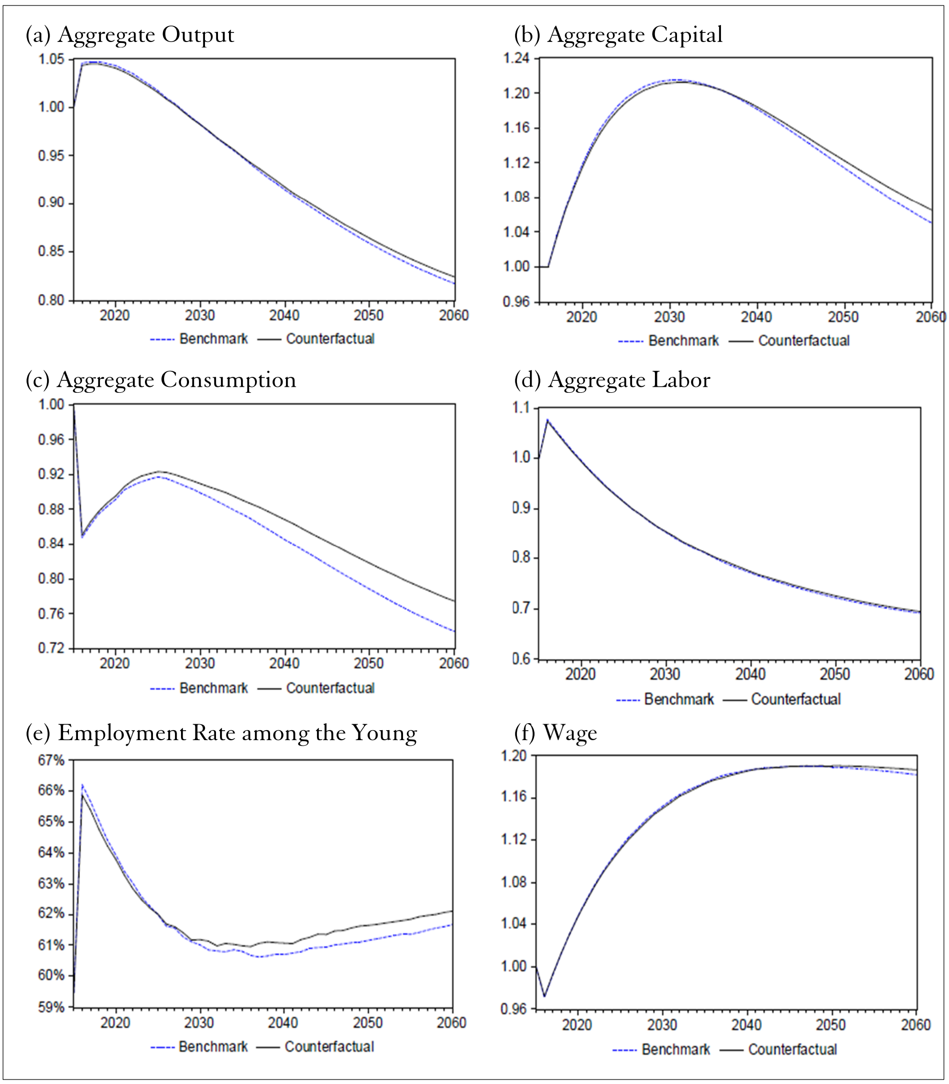


Figure 7 illustrates the transition path of the benchmark case in comparison to the path of the counterfactual case. In the short run, the differences in the changes of the macroeconomic variables are almost negligible between the two cases. Yet, the magnitudes of the differences observed in the macroeconomic variables amplify along the transition path. In the long run, a higher NHI premium rate for workers in the benchmark case lowers the marginal workers' incentive to work, and it leads to a lower employment rate among the Young and thus reduction in the aggregate labor supply, which, in turn, results in the reduced aggregate output. In addition, given all else being equal, a lower level of aggregate labor implies a lower level of marginal productivity of capital, and thus less demand for capital. As such, a lower level of aggregate labor results in the decreased aggregate capital and a lower wage at the equilibrium.

According to Figure 7, in 2060, the employment rate among the Young of the benchmark case is smaller than the counterfactual case by 0.44 percentage points. The levels of the aggregate labor, the aggregate output, the aggregate capital, and the wage of the benchmark case are lower than those of the counterfactual case by 0.84, 0.46, 1.41, and 0.38 percent respectively. However, the differences between the benchmark case and the counterfactual case are relatively small, compared to the magnitudes of the changes of macroeconomic variables along the transition path of the benchmark case. The comparison reveals that the magnitudes of the distortionary impacts resulting from the increase in the NHI premium rate for workers are small. It is not only because the extended life expectancy provides a greater incentive to work to young households who need larger savings for the extended retirement period, but because the shrinking working age population also leads to a huge increase in wage, which makes working more attractive to young households.

V. Conclusion

South Korea is among the most rapidly aging nations in the world. Since health expenditures for households tend to increase with their ages, financing the NHI program would be a challenge for aging nations in the long run. We quantify the macroeconomic effects of population aging and budget-balancing NHI premium rate, applying a heterogeneous agent model. The literature of the population aging mostly focuses on the comparative statics based on the steady states of the model economies with differing population structure. Yet, understanding the evolution of macroeconomic variables would be of more importance to policy makers. Thus, we investigate how macroeconomic variables evolve along the transition path as the population ages from the year of 2015 and on.

The analysis of the transition path of our model economy revealed that the aggregate health expenditure in 2060 soars up by 35.2 percent compared to 2015, and the NHI premium rate for workers must increase by 3.7 percentage points from 5.6 percent in 2015 to 9.3 percent in 2060. The aggregate labor decreases by 30.9 percent from 2015 to 2060, and the employment rate increases by 2.2 percentage points. While the aggregate capital increases by 5.0 percent for the same period, the aggregate output decreases by 18.3 percent.

If the increasing expenditure of the NHI program is funded by raising the NHI premium rate for workers, the economy should be influenced by the distortionary labor tax effects that result directly from the increase in the NHI premium rate as well as population aging. In order to make distinction between the population aging effects and the effects of the increase in the NHI premium rate, we conduct a counterfactual model experiment in which the NHI premium rate for workers is held fixed at the level of 2015, and the government supplements for the deficit of the NHI program budget. Our experiment shows that the magnitude of the distortionary impacts resulting from the increase in the NHI premium rate for workers is small. It is due to the fact that the extended life expectancy provides a greater incentive to work to young households who require greater savings for the prolonged retirement period. The shrinking working age population also plays a role as it leads to a huge increase in wage, which makes the option to work more attractive to young households.

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