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Analysis of the Korean Pension System and Alternatives Using Stochastic Overlapping Generation General Equilibrium Model[*]

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This study quantitatively analyzes the effects of the current pension system's structure on the Korean economy using a stochastic overlapping generation general equilibrium model (stochastic OLG). Considering the problems of the current pension system, we also analyze the possible impact of alternatives to the current system on the overall macroeconomy. The results concerning the economic structure of Korea from the perspective of the current Korean pension structure shows that it is necessary to collect an additional 7.6% premium rate. Furthermore, an alternative system that guarantees aggressive improvement measures to improve financial soundness may increase the utility of the pension system.

JEL Classification: C63, H55, H75

Keywords: stochastic overlapping generation general equilibrium model, lumpsum redistribution authority, pension system, income replacement rate, premium rate

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1. INTRODUCTION

Recently, problems concerning the Korean public pension system—such as the long-term sustainability of public pension financing—are being discussed extensively in Korea. The issue of long-term sustainability begins with the need to reduce the number of pension subscribers; moreover, according to the National Pension System (2017) the number of subscribers paying premiums toward the National Pension Plan is expected to decrease from 2019 as the working-age population decreases.

The National Pension System expects the number of subscribers to decline from 21.89 million to 21.81 million in 2019. Furthermore, the number of pensioners is expected to increase every year, from 4.46 million in 2007 to 4.78 million in 2013 and 5.61 million in 2019, due to the aging of the baby boomer generation (born 1955–1963). Life expectancy has also been increasing steeply. The estimated life expectancy for men aged 60 years in 2010 was 81.4 years, rising to 82.2 for men aged 60 years in 2015. The decrease in the number of subscribers and the increase in the number of recipients inevitably led to an imbalance of income and expenditure in the pension service, causing financial problems to arise. Because stability is needed in such funds, the replacement rate of 70% in 1988 (when the national pension system was introduced) dropped to 60% with the first pension reform in 1998 and to 50% with the second pension reform in 2007. It has been agreed that the replacement rate will be stepped down to 40% gradually, until 2020.

However, the issue of the depletion of the national pension fund has not been resolved and the public has been demanding a revision of the national pension fund. The Fourth National Pension Budgeting Committee held in August 2018 proposed two solutions. This study analyzes the current economic structure of Korea and identifies the current problems in the pension system by using stochastic overlapping generation general equilibrium models (stochastic OLG). We also quantitatively analyze the impact of the two proposed solutions on the pension system and on the macroeconomy.

There are prior studies on economic analysis from the perspective of the pension system due to population aging that use a stochastic OLG model. First, there are prior studies that apply the OLG model in economic analysis. Kudrna (2015) used an OLG model to analyze the Australian economy and argues that a proposed reform will improve vertical equity and reduce income inequality experienced by lower-income households due to larger welfare gains, income improvements, and a reduced Gini coefficient. Nishiyama (2011) analyzed the budgetary welfare effects of tax-deferred retirement saving accounts using an OLG model. There are also existing studies that analyze the Korean economy using OLG models. Kim and Lee's (2013) work showed the theory of using an OLG model with three generations. The current study, however, differs in that we will use twelve generations. This has the advantage of being able to explain the changes in economic structure by age in more detail. Hong and Kang (2015) used an OLG model to show that the retirement extension policy in an aging economy increases the total labor input and increases the total amount of capital due to retirement savings. This study, however, uses the OLG model and considers the probabilistic characteristics of individuals in the labor market.

Kim's (2010) study extended the working period of individuals with the general equilibrium model and the results showed that the incentive for saving for the retirement period decreases, meaning that the capital input into the economy may decrease and individuals' life and income welfare may decrease in spite of the extension of the retirement age. What differentiates our study from that of Kim, is that the model in our study is able to consider intergenerational transactions. Cho's (2005) study uses the OLG model to show that the pension system is burdened by the rapid aging of the population and that it is necessary to improve the pension system. Nam (2008) analyzed the effect of public pension on private savings in Korea using the OLG model with idiosyncratic shock. The results show that if a pension reform proposal with rising insurance rates was implemented, pension finance could be stabilized, resulting in an increase in the overall savings. The current study differs from both Cho's (2005) and Nam's (2008) studies in that our study suggests an alternative and shows the increases in total utility when an alternative is implemented by using the Lump-Sum Redistribution Authority (LSRA).

Second, there are prior studies that address the pension system using macroeconomic models. Fehr and Uhde's (2012) work aims to quantify the efficiency of the actual social security system to identify an optimal pension system and Jun's (1998) study analyses the recent reform plans for the National Pension System. The results of Jun's study show that due to the difference in the income capturing rate across groups and its redistributive element, the Korean Government's revision plan has an adverse effect of redistribution, according to the cohort. Huh (2007) aimed to identify the economic significance of public pensions in terms of its impact on the macro-financial market. They analyzed the macroeconomic impact of public pensions by using a Dynamic Stochastic General Equilibrium (DSGE) model. Shin and Choi (2010) developed a DSGE model to evaluate the national pension financial policy and analyzed the effects of the financial stabilization or institutional improvement scenarios on the macro economy, as well as changes in the welfare of both households and in different generations. Ahn and Lee (2016) studied the effects of pension on private savings and consumption according to income quintiles with financial indebtedness. Their results show that the financial state of households is an important factor in investigating the effects of public pension on household expenditure, because household indebtedness is likely to change the overall effect of the pension.

This study uses the OLG model to analyze the structure of Korea's current pension system to thereby quantitatively analyze changes in the macroeconomic variables with various generations. We also emphasize the necessity of fiscal soundness by doing a quantitative analysis of the macroeconomic variables. We then compare the two alternatives to the current system recently presented by the government. Beyond merely mentioning the two policies, we implement both reforms in our model, upon which the expected changes in the macro variables and the changes in both policies show certain variations in the utility of each generation. Finally, our analysis quantitatively compares the scale of utility changes and suggests a better alternative to the two reform proposals.

The structure of this study is as follows: section 2 explains the OLG model used to examine the macroeconomic effects of population aging in Korea and examines the components of the model. In section 3, we describe the process of establishing the model parameters for the quantification of models through empirical data. Section 4 explains the results of the model analysis and examines the macroeconomic variables considering the changes in the replacement rate of pensions. We also analyze the expected macroeconomic effects and welfare changes in an aging population economy in section 4, while section 5 concludes our study.

2. MODEL

2.1. Model Description

The OLG model used in this study is one of the major models utilized in modern macroeconomics. It was first modeled by Allais (1947), followed by Samuelson (1958), and Diamond (1965). The model sets up a finite life for individuals and sets new generations to enter the market over time. Moreover, the OLG model assumes that equilibrium is reached in a permanent economic situation. Because of these characteristics, the OLG model has a finite life in the super long-term economy and its structure induces the equilibrium, including individuals with different periods of economic development. The OLG, in particular, has the advantage of being able to derive the directional effects of policy and economic phenomena in the long run and to show the different choices of generations of different ages. These characteristics can be applied when a long-term effect of economic policy or a change of demographic structure is observed for each generation. The stochastic OLG model used in this study is an improvement on the OLG model.

The stochastic OLG model can be regarded as a development of the OLG model used by Aiyagari and Peled (1991) and Chattopadhyay (2001). The characteristics of the model are different from the original OLG model and it can be considered as reflecting the individual characteristics of the individuals within the model. It can therefore be said that the accuracy of the stochastic OLG model is more developed than that of the OLG model that simply unifies all individuals into a collective numerical value by setting the idiosyncratic characteristic of individuals to be reflected in the economic structure. The idiosyncrasy of individuals reflected in this study is based on their labor productivity, and this idiosyncrasy is designed to affect individual income and affect variables such as consumption and saving. This means that real markets are reflected more realistically than in the OLG model, given the volatility of the labor market.

In addition, in this model, the LSRA is used to compare each revision with ease. The direction of utility per household may be different for different policies. In this case, when considering the utility of all households, it is difficult to judge whether an increase or decrease has occurred. Auerbach and Kotlikoff (1987) solved this problem using the LSRA method. This method calculates the total amount of the fluctuation of utility for all households according to the policy change, making it possible to calculate the direction of a policy according to the total utility by aggregating the utility of each cohort in the policy. Therefore, this model analyzes the effects of long-term changes in population structure and changes in pension policies based on the variation of consumption and labor, which reflects individuals' diverse characteristics and compares the changes in utility according to the different alternatives. In this study, we will analyze the macroeconomics using the OLG model, after which we compare different scenarios using the LSRA.

2.1.1. Demographics

$$N_j^{\,t} = \frac{N_{j,t}}{N_{1,t}} = (1+n_p)^{1-j}. \tag{1}$$

N_j^t is the number of people in cohort t at age j and the population is growing at the same rate, n_p. The above function is used as a variable indicating the relative size of the period, as the population growth rate is assumed to be constant over time. This process is normalization, which ensures that the balanced growth path is constant over time.

2.1.2. Firms

Firms use the complete competition function of capital and labor and follows the Cobb-Douglas production function, only producing one commodity.

$$Y_t = \Omega_t K_t^a L_t^{1-a}. \tag{2}$$

Capital is depreciated by δ as time goes by. Moreover, we multiply the next variable by $(1+n_p)$ for normalization. Therefore, capital accumulates over time with the following function:

$$(1+n_p)K_{t+1} = (1-\delta)K_t + I_t. \tag{3}$$

Using the two equations above, we derive a demand function for capital and labor. Under the assumption of a perfectly competitive market, the demand function of firms' capital and labor is expressed as follows:

$$\begin{aligned} r_t &= \alpha\Omega_t \left[\frac{L_t}{K_t}\right]^{1-\alpha} - \delta_k, \\ w_t &= (1-\alpha)\Omega_t \cdot \left[\frac{K_t}{L_t}\right]^{\alpha}. \end{aligned} \tag{4}$$

2.1.3. Households

(1) Labor productivity risk

There are two exogenous variables in this model: labor productivity and age; however, labor productivity is also determined by two factors, a temporary shock factor, η_j, and an influence factor on overall labor productivity, theta. The transient shock element, η_j, is proceeding according to the procedure of AR = 1.

$$\eta_{j+1} = \rho\eta_j + \varepsilon_{j+1}\, with\, \varepsilon_j \sim N\left(0,\sigma_\varepsilon^2\right)\ and\ \eta_1 = 0. \tag{5}$$

Applying this to the labor wage, the following function for the wage is completed. Here, the variable j_r indicates retirement time.

$$w_{j,t} = \begin{cases} w_t e_j \exp\left[\theta + \eta_j\right] & if\ j < j_r \\ 0 & if\ j \geq j_r \end{cases}. \tag{6}$$

Wages before the retirement age are affected by the temporary shock component η and the permanent shock component θ. Considering the permanent shock component, we assume that it can take on two values, $\hat{\theta}_l$ and $\hat{\theta}_u$. Furthermore, we find the mean and the variance of $\exp(\theta)$ to be 1 and σ_θ^2 respectively. Therefore, it is represented by the function below:

$$\exp\left(\hat{\theta}_l\right) = 1 - \sigma_\theta\ and\ \exp\left(\hat{\theta}_u\right) = 1 + \sigma_\theta, \tag{7}$$

where e_i indicates labor productivity by age. The wage is set to zero after the retirement period, because in this model, all agents are set to retire at the age of 60 years old.

(2) Preference

The following is a utility function:

$$E_0\left[\sum_{j=1}^{J}\beta^{j-1}u\left(c_j l_j\right)\right]\ with\ u\left(C_j, l_j\right) = \frac{\left[\left(C_j\right)^{v}\left(l_j\right)^{1-v}\right]^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}}. \tag{8}$$

Here, the discount rate for the future is β and the alternative elasticity of utility of consumption and leisure is always 1. The intergenerational elasticity is $1/\gamma$, which can be explained by individual risk aversion.

(3) Budget constraints

$$a_{j+1} + p_t c_j = \left(1 + r_t^n\right) a_j + w_{j,t}^n \left(1 - l_j\right) + Pen_j. \tag{9}$$

The following is a constraint that exists in households. Individual spending is divided into consumption and saving for the next period, a_{i+1}. Consumption refers to the price multiplied by the consumption tax rate p_t multiplied by c_i. In this case, the initial price is assumed to be 1 and set the price to be $1+\tau_c$, so that the price fluctuates until the balance state is adjusted. The sum of the two elements on the left should be equal to the sum of the current assets—labor earnings and pensions—which represents the disposable income of the individual on the right. The interest rate is r_t^n on the savings that reflects the asset tax rate, which is derived by multiplying $1-\tau_r$ and r which, in turn, is derived from the first term condition of the Cobb-Douglas production function. w_n is derived by multiplying income W derived from the first condition of the Cobb-Douglas production function by the income tax rate $1-\tau_w$. Then, l_i becomes leisure. Additionally, as the remaining resources for time are set to 1, the remaining time minus leisure time is converted to working time. The above equations can be used to summarize one value function. Below is the value function V_t using the above utility function and budget constraint.

$$\begin{aligned} &V_t\left(j,a,\theta,\eta\right) = \max u\left(c,l\right) + \beta E_j\left[V_{t+1}\left(j+1, a^+, \theta, \eta^+ \middle| \eta\right)\right], \\ &s.t.\ a^+ + p_t c = \left(1+r_t^n\right)a + w^n\left(1-l\right) + pen,\ a^+ \geq 0,\ l \leq 1 \\ &\quad and\ \eta^+ = \rho\eta + \varepsilon^+\ with\ \varepsilon \sim N\left(0,\sigma_\varepsilon^2\right). \end{aligned} \tag{10}$$

The first function above represents the total utility over a lifetime as the value function V_t, combining the current utility function with the expected future value function. The second function is the budget constraint expression of the utility function, as shown above. A temporary impulse to labor productivity is also included in the value function through the third function:

$$V_t(J+1,\ a,\ \theta,\ \eta)=0. \tag{11}$$

Finally, we use the final condition to constrain the above function. It is assumed that individuals have no assets after death. Therefore, the time of death of the individual is set as J period and the value function is set to 0 when the period is later.

2.1.4. Distributional measures

Using this model, we aim to analyze the distribution of households in the main space, similar to the Aiyagari model. First, we need to find the space where the state vector exists. To accomplish this, we set the following equation as a potential value:

$$J = 1,2,3,\dots,J,\quad A=R_+,\quad F=R_+,\quad \varepsilon=R_+, \tag{12}$$

where R_+ is a non-negative real number and the object of the space that makes up the state vector is

$$(j,\ a,\ \theta,\ \eta)\in J\times A\times F\times\varepsilon. \tag{13}$$

In this case, when the household is specified at time *t*, the following measurement value is obtained in the measurable space:

$$\begin{gathered}\phi_t : P(J)\times B(R_+)\times B(R_+)\times B(R_+),\\ \left(J\times A\times F\times\varepsilon,\ P(J)\times B(R_+)\times B(R_+)\times B(R_+)\right).\end{gathered} \tag{14}$$

If M is a subset of $J\times A\times F\times\varepsilon$, Then, $\varphi_t(M)$ assigns the size of a particular subset in the state space. It then indicates how many households with the same characteristics as M exist. When the characteristics of all households are combined, the following analysis can be done with the total consumption set as follows:

$$C(E) = \int_M C(j,a,\theta,\eta)\phi_t(dj,da,d\theta,d\eta). \tag{15}$$

2.1.5. Aggregation

The functions presented above are the functions of choice for individuals and the distributions for individuals making choices concerning them. Next, the micro variables determined by the individuals' choices and multiplied by the distributions of choices are added together and converted to macro variables. This means that consumption, labor supply, and assets are converted into macro variables as follows:

$$\begin{aligned} C_t &= \int_{J\times A\times F\times\varepsilon} C_t(j,a,\theta,\eta)\phi_t(djda,d\theta,d\eta), \\ L_t^s &= \int_{J\times A\times F\times\varepsilon} \left(1-l_t(j,a,\theta,\eta)\right)\phi_t(djda,d\theta,d\eta), \\ A_t &= \int_{J\times A\times F\times\varepsilon} a\phi_t(djda,d\theta,d\eta). \end{aligned} \tag{16}$$

The above means that the transition from individual choice to macro variables has been achieved. Next, we will reflect macroeconomic variables in households considering governments and other macro markets.

2.1.6. Government

In this model, government actions consist of two forms: the tax system and the pension system, which are assumed to be based on two budgets.

$$\tau_{c,t}C + \tau_{w,t}w_tL_t^s + \tau_{r,t}r_tA_t + \left(1+n_p\right)B_{t+1} = G_t + \left(1+r_t\right)B_t + D_t. \tag{17}$$

The government collects taxes from consumption, labor income, and capital income to public expenditure G_t and public debt B_t. Moreover, G_t/Y and B_t/Y are set to be constant over time, as government consumption and debt levels are assumed to be constant, relative to the GDP. The left side of the equation assumes the consumption tax rate as τ_c, total consumption as *C*, the labor income tax rate as τ_w, the total amount of labor as L^s, the total capital amount and the capital income tax as τ_r, and government debt for the next period as government income $(1+n_p)B_{t+1}$. The right-hand side represents the amount of public expenditure and government debt to pay back $(1+r_t)B_t$. Furthermore, D_t represents the budget payable by the government in addition to the expenditure to maintain the pension system. Considering these government revenues, the pension policy can determine the influence of the burden on the government.

2.1.7. Pension system

Considering the pension system, the budget balance function for the pension system is presented below. What sets this function apart is that all pension rates are covered by labor income and *pen* is subtracted from the pension rate obtained from labor income to maintain the pension system, while the remainder or deficit is set as D_t. In the pension system, the government imposes the pension rate on the total income of households and deducts the government expenditure amount for pension that the public should be gaining by the replacement rate.

Based on the above, pension reserves in the country should be $\tau_{p,t} w_t L_t^s$, which multiplies income and pension rate. Additionally, the total amount of pensions payable by the government to households is decided by multiplying population and replacement rate $\overline{pen}$. The pension reserves in the country and the pension amount to be paid are therefore not balanced.

$$D_t = \overline{pen}_{j,t} \sum_{j=jr}^{J} \left(1+n_P\right)^{1-j} - \tau_{p,t} w_t L_t^s. \tag{18}$$

Above, $pen_{i,t}$ is the amount of pension paid to the individual. As this factor is time dependent, we added subscript *t*. This means that pen_i in the household and $pen_{i,t}$ are the same in the pension system. The sum of all pension pen_j measured per individual is covered by pension rate $\tau_{p,t} w_t L_t^s$

and a pension deficit occurs. We set this as deficit D_t.

$$\overline{pen}_j = \kappa_t \frac{w_{t-1} L_{t-1}^s}{\sum_{j=1}^{jr-1} \left(1+n_p\right)^{1-j}}. \tag{19}$$

In this function, kappa is the income replacement rate, the numerator is the total labor imports, and the denominator is the size of the workable population.

2.1.8. Markets

It is assumed that there are three markets in this model: labor markets, capital markets, and product lines. The labor and capital markets are balanced in the following equations:

$$K_t + B_t = A_t \text{ and } L_t = L_t^s. \tag{20}$$

The balance of the commodity market is achieved by the following equation:

$$Y_t = C_t + I_t + G_t. \tag{21}$$

2.1.9. Transition paths

The path that converges to the new long-term balance when adjusting the parameters of the model is called the transition path. The sum of the expected utility for consumption and leisure is as follows:

$$V_t\left(j, a, \theta, \eta\right) = E_j \left[\sum_{s=j}^{J} \frac{\left[c_j^{\nu} l_j^{1-\nu}\right]^{1-\frac{1}{\gamma}}}{1-\frac{1}{r}} \right]. \tag{22}$$

Because of additional increases in consumption and leisure due to parameter variations, the value function also varies as follows:

$$E_j\left[\sum_{s=j}^{J}\frac{\left[\left[(1+\varphi)c_j\right]^{\nu}\left[(1+\varphi)l_j\right]^{1-\nu}\right]^{1-\frac{1}{\gamma}}}{1-\frac{1}{r}}\right]. \tag{23}$$

2.1.10. Lump-sum redistribution authority

The LSRA is used to calculate the sum of the above φ and to compare the sum of utility before and after the policy change. z_1, is the transfer to balance the present generation V_0 and future generation V_1 and must satisfy the following:

$$V_1\left(j,a+z_1\left(j,a,\theta,\eta\right),\theta,\eta\right)=V_0\left(j,a,\theta,\eta\right). \tag{24}$$

Because LSRA pays transfers to future generations, the utility level of future generations is equal to *EV*. Moreover, the discounted present value of the transfer has a constraint that must equal zero.

$$\begin{gathered} E_0\left[V_t\left(1,z_t\left(1,0,\cdot,0\right),\theta,0\right)\right]=EV^*, \\ \int_{2,\dots,J} z_i\left(j,a,\theta,\eta\right)\phi_1\left(djda,d\theta,d\eta\right)+\sum_{t=1}^{\infty}z_t\left(1,0,\cdot,0\right)\frac{\left(1+n_P\right)^{t-1}}{\prod_{s=2}^{t}\left(1+r_s\right)}=0. \end{gathered} \tag{25}$$

Above, φ^* reflects the increase and loss of utility of the new policy. This is called a Pareto Enhancement, according to the results after compensation. Therefore, when the redistribution between generations is completed, the increase in utility φ^* associated with EV^* can be presented as

$$\varphi^*=\left[\frac{EV^*}{E_0\left[V_0(j,a,\theta,\eta)\right]}\right]^{\frac{1}{1-\frac{1}{\gamma}}}-1. \tag{26}$$

We can then obtain the Pareto enhancement from these equations. This distribution utilizing LSRA can also reveal which reforms are generating the

Pareto enhancement by comparing φ^*.

3. CALIBRATION

Table 1 Parameters

Parameter	Figure	Parameter	Figure
Labor entry time	20	Intergenerational Discount Rate	0.98
Retirement age	60	Working hours	0.35
Death age	80	Alternative resilience of leisure to consumption	0.8
Population growth rate	0.685	Consumption tax rate	0.054
Factor Price to Capital Ratio	0.36	Government spending ratio	0.26
Depreciation rate of capital	0.08	Government debt ratio	0.337
Premium rate	0.09	Replacement rate	0.45

In our model, workers are assumed to join the model's economy at the age of 20 by entering the labor force and to live to 80 years of age. In addition, considering the policy change to extend retirement age in 2017, the retirement age is set at 60 (extended by three years).

According to Hong's (2015) study on population growth rate, Korea's population growth rate is 0.685. This population growth rate was set to an initial steady state using an average of 10 years, starting from 2000. Furthermore, the capital input ratio—which determines the labor input in Lee's (2019) study—is set at 0.36 and the capital depreciation rate, which is the parameter in Lee's (2019) study, is set to 0.08. The discount rate between generations is 0.98 in the steady state, which derived from the capital-output ratios (K/Y). Finally, according to Lee's (2019) study, the working time is set at 0.35 and the alternative elasticity of leisure for consumption is set at 0.8. The labor time is set as 0.35 and the autocorrelation coefficient of labor productivity shock is set at 0.98.

Lastly, for the alternative elasticity between consumption and leisure and technology advance rate, we compared the parameters of existing studies such

Table 2 Alternative Elasticity between Consumption and Leisure, and Technology Advance Rate

Parameter	Set value	Altig (2001)	Miles (1999)	Hong (2007)	Jeon (1998)
Technology Advance Rate	1.02	1.01	1.02	1.02	1.03
Alternative Elasticity between Consumption and Leisure	0.8	0.8	0.8	0.8	0.83

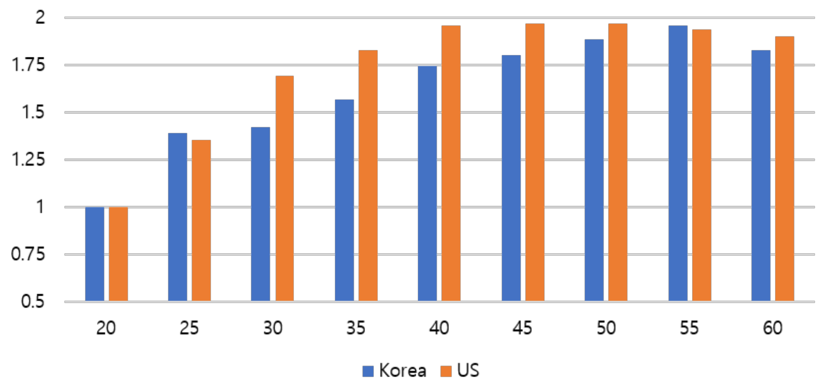
Note: Altig, Miles, Hong, Jeon's parameter.

Table 3 Distribution of Income Distribution by Age

Age	20	25	30	35	40	45	50	55	60
Distribution of Income	1.0	1.39	1.42	1.56	1.74	1.8	1.88	0.95	1.82

Note: Estimate using Korea Labor Panel (KLIPS)'s age-based income data

Figure 1 Distribution of Income Distribution by Age in Korea and US



as Altig (2001), Miles (1999), Hong (2007), and Jeon (1998).

Based on table 2, the technological progress rate was set at 1.02 and the alternative elasticity between consumption and leisure was set at 0.8.

Considering the permanent impact of labor productivity θ, this factor is based on data from the Eighteenth Korea Labor Panel (2015). The data are derived through income distribution by age for labor hours and income divided values. Table 3 presents the data on labor productivity.

In Korea, income distribution is higher among workers in their 20s than it is in the United States. Moreover, income is highly distributed among workers in their 20s, compared with other generations. This may be due to higher college entrance rates and higher employment thresholds. However, the distribution of labor income in Korea is lower than that of the United States for age groups older than the 20s. This may be due to labor inflexibility in Korea. In Korea after retirement, the magnitude of dispersion increased again, reaching a maximum for workers in their 50s. This is set as the age-specific permanent impact of θ in the labor market.

The following are the parameters set in the pension market. According to the 2017 National Statistical Yearbook of National Pension, the government agreed to lower the annual rate by 0.5% every year, up to 2028, aiming at a 40% replacement rate. The replacement rate for 2017 was 45%. Therefore, for the purposes of this study, the replacement rate is 45% and the premium rate of 9% is applied to the model.

Next, we set the parameters concerning the government. According to OECD data, the consumption tax rate is set at 10% and the wage income tax rate at 3%. The ratio of government debt in Korea is 0.337, which is calculated by dividing the average government debt of 2008 and 2016 by Korea's GDP. This data was extracted from the Korean National Statistical Office. The ratio of government expenditure is 0.26, which was determined by dividing the average government spending from 2005 to 2012 by the GDP.

4. ANALYSIS RESULT

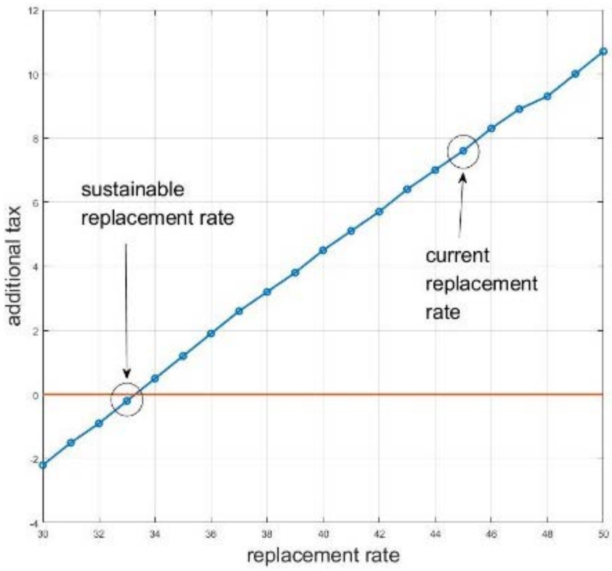
In this section, we examine the economic structure of Korea's current national pension system and compare it with the economic structure that may arise if the replacement rate was set at a financially sound level. For comparison, we set up an additional tax rate to be collected to maintain the structure of the national pension system. Furthermore, the market structure and the total efficiency of each scenario should be compared while considering the alternative or replacement system to overcome the financial shortage of the current national pension system in Korea.

4.1. Optimal Pension Income Replacement Rate Based on Current Income Replacement Rate and Current Premium Rate

The current national pension premium rate in Korea is assumed to be 9% and the replacement rate for the pension is set at 45%. This structure is designed to meet the income replacement rate and to achieve financial soundness, considering the current declining population trend. Therefore, we set the insurance premium rate at 9% and calculate the substitution rate at which financial soundness is satisfied based on the premium rate; then, we compare it with the economic situation in the structure of the current national pension.

Figure 2 shows the tax rate that should be collected additionally according

Figure 2 Additional Tax to Sustain the Premium Rate of 9%



to the pension replacement rate when the premium pension rate is fixed at 9%. Here, it is assumed that—for the sustainability of the pension system—the total amount of pension expenditure should be balanced to meet government income and replacement rate for the insurance premium rate. If it is not balanced, the additional tax is set at an additional tax rate on income. Below is the tax rate to be added to the income tax to sustain a premium rate of 9% and each replacement rate.

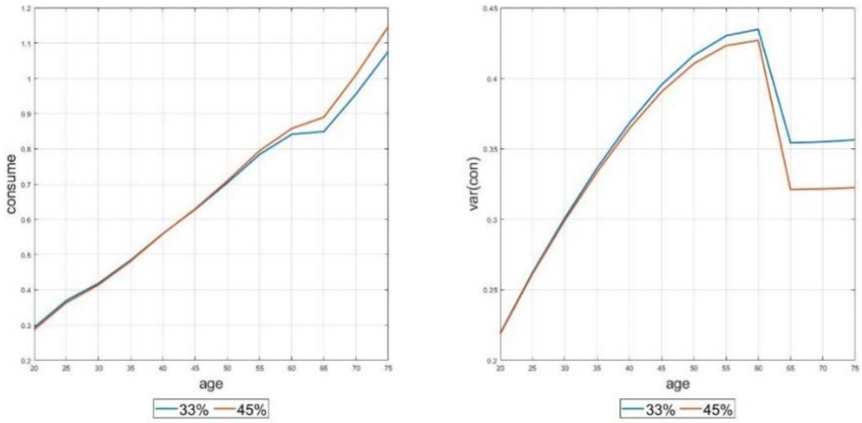
Based on the above graph, if the insurance premium rate is maintained at 9%, the replacement rate should be set to 33% to maintain the pension system. At present, the National Pension Plan aims to maintain the replacement rate at 45%. To sustain this policy, the tax rate should be raised by 7.6%.

Next, we will compare the market structure under a 33% replacement rate, which does not require any further increase if the current premium rate is maintained at a 45% replacement rate, which is current policy.

In terms of consumption, it can be seen among the cohort that there is a decreasing trend in the 10th period, followed by an increase. This can be attributed to earnings based on labor decreasing after retirement. Comparing the two income replacement ratios, the income replacement rate is 33% (blue line), and up to the age of 55, the replacement rate is slightly higher than the 45% (red line) replacement rate. These results show that disposable income is higher than 45%, which leads to increased consumption activity, because the additional tax to maintain the pension is not needed when the replacement rate is 33%. However, this is reversed around the age of 50 when consumption increases at the 45% replacement rate.

The disparity in the consumption rates of the two income substitution rates can be seen to increase with age. This may be because the generation approaching retirement reduces their consumption to individually prepare for aging and retirement, due to the low replacement rate. In particular, the decrease in consumption due to anxiety about the future influences the decline of consumption in middle-aged people (aged 50), which is 10 years prior to retirement, not immediately before retirement.

Figure 3 Consume and Var When Replace Rate is 33%, 45%



Next, we consider the variance in consumption. There is a greater variance in the replacement rate of 33%, which is a bigger gap for older adults. This means that as age increases, they are not protected by the pension system; therefore, they are reliant on their individual savings, which results in greater variance in consumption because the risk is greater than the reliance on the public pension system alone.

Figure 4 Labor and Earning When Replace Rate is 33%, 45%

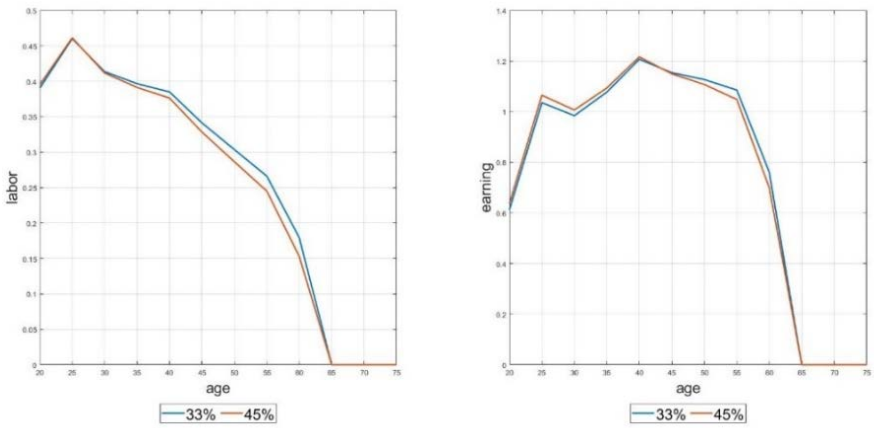
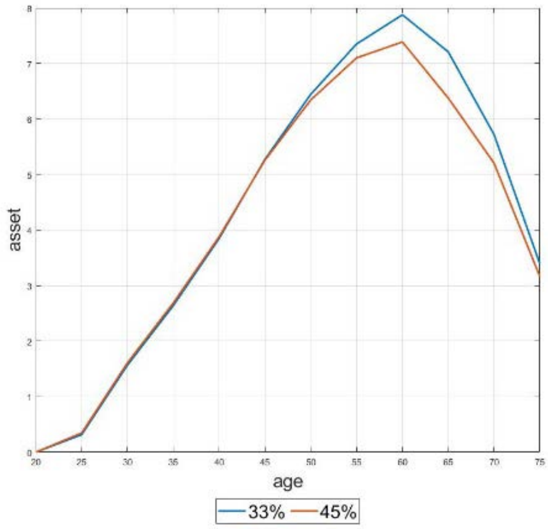


Figure 5 Asset When Replace Rate is 33%, 45%



Next, we analyze the labor market by cohort. First, the results show fewer working hours at pension replacement rate of 45% than at 33%, particularly in younger age groups (20–30). However, as older adults become older, the working hours for the 33% replacement rate becomes longer than at the 45% rate. The increase in working hours may be in preparation for private pension provision because of the low-income replacement rate. In particular, the difference at the age of 60 before retirement is the biggest gap in the replacement rate between 45% and 33%, as the incentive for unstable old age is the largest.

Second, the cohort analysis of wages shows that the incentives for labor at the 33% replacement rate are inevitably lower than those at the 45% rate because disposable income increases due to the low tax rate, compared with the 45% replacement rate. However, there is an incentive for older adults to work, because they have to prepare their future individually. This is reflected in the result of high labor wages.

The difference in capital assets in the capital market shown in Figure 3 shows that the number of assets is initially small at a 33% replacement rate;

however, as the age increases, the amount of capital is larger than for the 45% replacement rate. This may be because younger workers have lower incentives for saving for old age, resulting in higher consumption and therefore less saving. However, as age increases, the incentive for saving to prepare for the individual retirement increases due to the decline in labor income after retirement, leading to more savings.

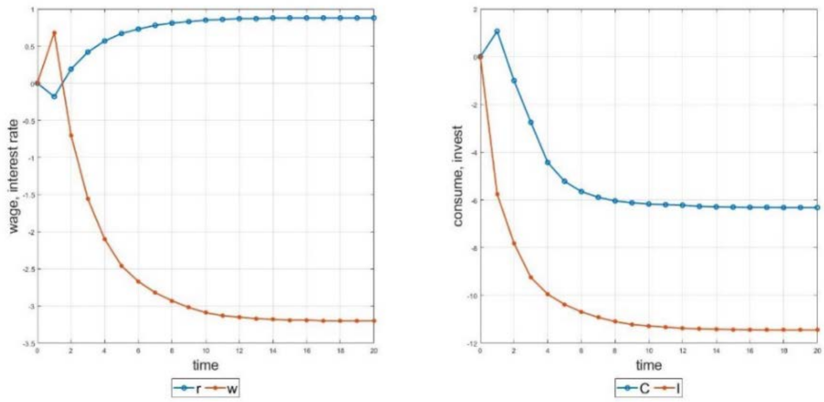
The variables discussed above are the age-dependent macroeconomic variables that would change during the reform. Changes in macroeconomic variables by age are also important to understand the effects of changes in the pension system; however, it is also important to investigate changes in macroeconomic variables over time. We therefore examine the total macro variables that change over time when the replacement rate is 33% to 45% in the next section.

4.2. Macro variables that change over time when the replacement rate is 33% to 45%.

In the previous sections, we investigated the changes in age-specific macro variables. However, to see whether the final goal is a Pareto efficiency improvement, the changes in total macro variables due to changes in the pension system should be investigated. Therefore, in this section, we study the effect of the change in the total pension system variable over time (income replacement rate 33% -> 45%).

First, we consider income and interest rates. When the replacement rate changes from 33% to 45%, the income shows an initial increase of 0.68%, after which it decreases to 3.2%. This leads to an increase in wages in firms whose labor supply has been reduced due to a decrease in the labor force of retirement age. However, due to the fall in the GDP and the burden of increased replacement rates, labor supply will increase in subsequent years, which, in turn, causes wages to decrease. Conversely, interest rates will increase by 0.8%. The increase in interest rates is due to the increased replacement rate that lowers individuals' incentive to save for old age, thus reducing savings.

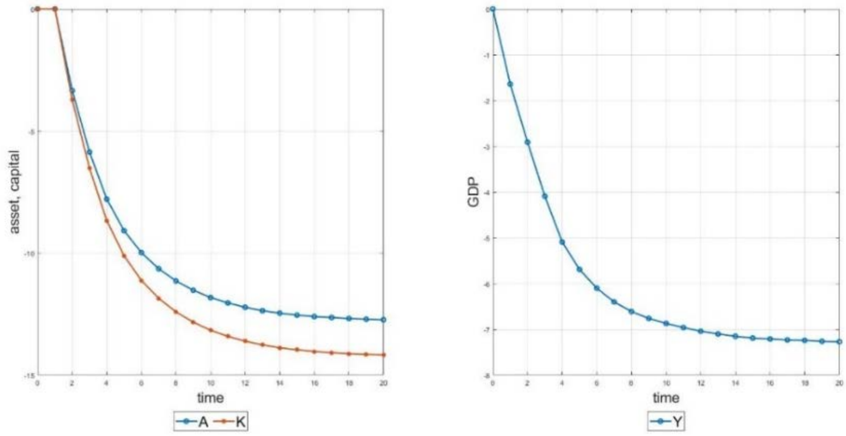
Figure 6 Result of Replace Rate Transition: Wage, Interest Rate, Consumption, Investment



The next two macro variables we discuss are consumption and investment. figure 6 shows that consumption increased by 1.08% in the first period. This increase in consumption takes place immediately before retirement age, in which the replacement rate for aging can be reduced, as described in the previous section. After this initial increase, consumption declined by -7.92%, which means that the increase in the income replacement rate leads to an increased burden on the pension system for working-age households, resulting in a decrease in consumption. Next, considering investment, it can be seen to decrease continuously to 14.22%. This is because the increased replacement rate reduces the incentive to save, meaning that savings decrease.

Next, we consider the change in assets and capital. As explained above, this change does not take place immediately after the change in the pension system, but starts in the following period. Figure 7 shows that capital and assets also decreased. Assets decreased by approximately 12.73% and capital by 14.17%. This decrease in assets and capital is related to the increase in the replacement rate causing a decrease in the incentive to save. Finally, in the case of the GDP, when the replacement rate is increased to 45%, the result is reduced by 7.27%. As explained above, the GDP will fall sharply due to reduced income, consumption, and investment.

Figure 7 Result of Replace Rate Transition: Asset, Capital, GDP



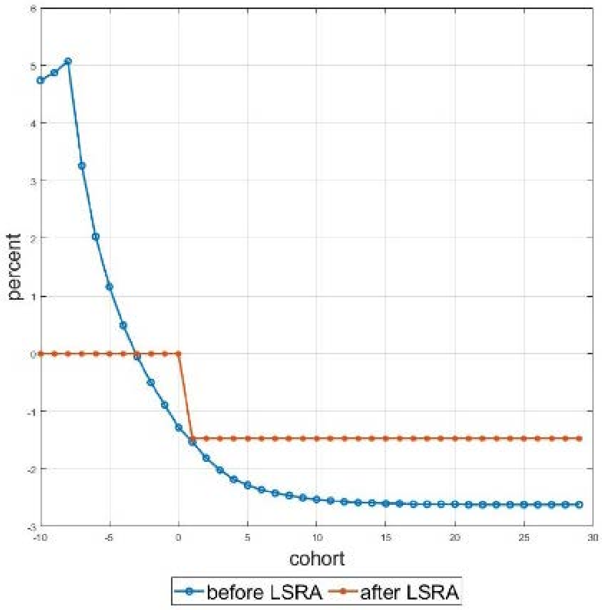
This section examines the changes in macroeconomic variables due to changes in the pension structure based on replacement rates. However, the results of the variables vary from generation to generation and the direction of the variations in the macro variables is also different. This makes it difficult to judge whether changes in the pension structure lead to an increase in utility. Therefore, the next section addresses the changes in the pension structure and whether they ultimately lead to the establishment of Pareto efficiency.

4.3. Comparison of the Total Utility of Two Economic Situations using LSRA

When comparing the two pension policies, it is impossible to directly compare which of the two economic situations are better, because of the differences between generations who gain and generations who lose. Therefore, we compare the utility of households using LSRA to ensure that the two generations are comparable.

The LSRA results presented in figure 8 are based on the transition from a replacement rate of 33% to one of 45%. Older people who benefit from the pension system due to changes in the system show higher utility. Specifically, when the system changes, people of retirement age show the

Figure 8 LSRA Result of Replace Rate Transition



greatest utility. Therefore, at the time when the replacement rate changes from 33% to 45%, older adults aged 60 or above (cohort -8) have the greatest utility. However, the increase in taxes to maintain this pension system will reduce utility from cohort –4—the age of 40—when the replacement rate is changed.

Due to the differences in utility among generations, it is not possible to directly compare the overall size of the utility to be paid when the replacement rate is set at 33% or at 45%. Therefore, to compare the two different replacement rate situations, we compare the magnitude of the total utility resulting from allocating utility from the current generation (–10 to –4) to future generations. The results show that all future generations generate a negative utility of –1.47. This means that the increased utility of older adults when retaining the replacement rate of 45% is smaller than the amount of decreased utility of the taxes to maintain the replacement rate in each generation. Therefore, the replacement rate—which does not meet the insurance premium rate—shows a large burden on future generations.

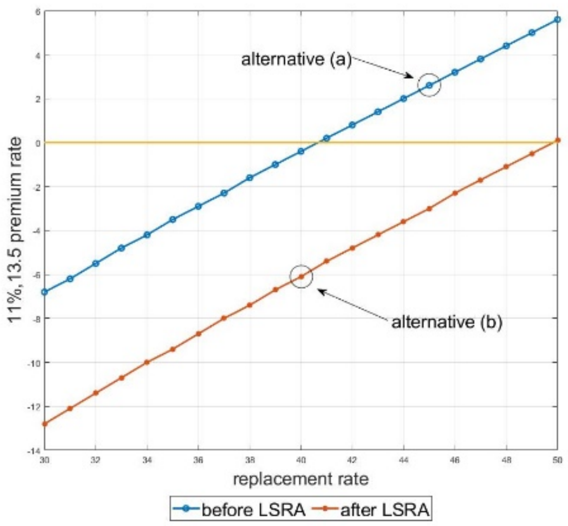
4.4. Analysis of Alternatives to the Current National Pension Scheme

Currently, the burden of future national pension schemes that will be experienced by future generations due to low population growth rates, and insurance premiums will be large, as evidenced above. It is therefore important to change the structure of the current national pension system to reduce the burden on future generations. As a result, the Fourth National Pension Budgeting Committee held in August 2018 proposed two solutions in the National Pension Fourth Fiscal Estimation Results.

Table 4 Comparing National Pension System Improvement Proposals

`Alternative (a)		Alternative (b)
Maintain 45%	Replacement rate	Down to 40%
Raised to 11%	Premium rate	Raised to 13.5%

Figure 9 Additional Tax to Sustain the Premium Rate of 11%, 13.5%

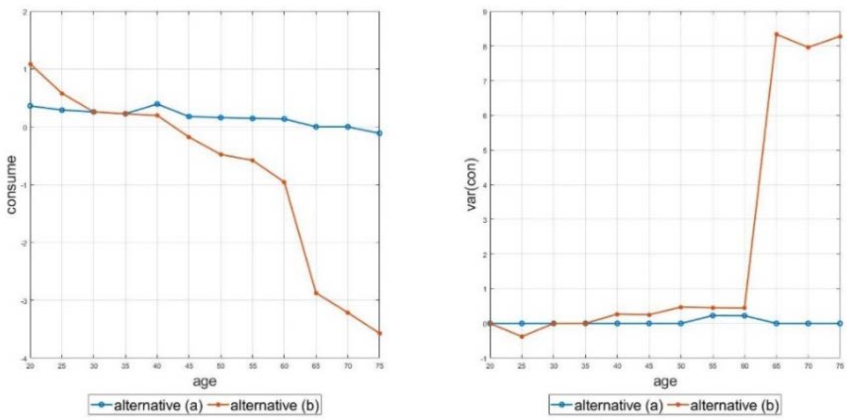


In the first pension reform plan (a), we will maintain the current replacement rate at 45% and increase the insurance premium rate to 11%. This will stabilize the financial system and reduce the shock by slightly increasing the tax burden of the people. Pension reform bill (b) will significantly increase the burden on the public to induce fiscal stabilization by reducing the replacement rate to 40% and increasing the premium rate to 13.5%. If the insurance premium rate is maintained in these two situations, the additional tax rates are as shown in figure 9.

In the case of alternative (a) above, an additional tax rate of 2.6% is required to maintain the replacement rate of 45%. However, if the replacement rate is lowered to 40% and the premium rate is raised to 13.5%, the national pension system can be maintained without additional tax.

Next, we look at the form of the market in alternative (a) that maintains a replacement rate of 45% and reduces the insurance premium rate to 11%, as well as alternative (b) that reduces the replacement rate to 40% and increases the insurance premium rate to 13.5%. Figure 10 shows the percentage of macroeconomic variables that change when each alternative is applied to the current pension system.

Figure 10 Life Cycle with Each Alternative Replacement Rate: Consume Var



Looking at consumption first, alternative (a) does not lead to a significant change from the current situation. However, considering alternative (b), consumption increases slightly in the age group of younger than 40s, but consumption for the age group 40 years and older declines significantly. In the case of the pre-40s age group, if the current state of pension finances is insufficient, the deficit of the pension is covered by the tax. Therefore, increased consumption tax also reduces consumption. However, the increase in the pension rate does not require additional taxation, as it improves financial soundness; therefore, the tax rate on consumption is inevitably lower and the younger generation—who feels that they do not have to prepare for the future—consumes more. Furthermore, consumption decreases rapidly after the age of 40, compared with the current situation. This is because people older than 40 have to choose to reduce consumption to prepare for retirement and aging with reduced income replacement rates and increased pension rates.

The variance in income shows no significant differences between alternative (a) and the current situation; however, alternative (b) shows more significant differences. This infers that the variance is larger because consumption is dependent on individual savings in old age, which is guaranteed with low replacement rates.

Considering the labor market, we can see that the current situation is similar to that of alternative (a), but that working hours are longer in alternative (b). With an increased pension premium and lower replacement rates, there is a clear increase in working hours to prepare for retirement. Figure 11 shows that the labor income graph moves in a similar direction, depending on the increased amount of labor. This is because individuals earn more from increased labor. However, the increase in income is less than the increase in the amount of labor, and labor income has decreased despite the increase in working hours in the 30–45 age group. This can be explained by the increase in the pension rate imposed on labor, which causes the increase in income to be less than the increase in labor.

Figure 11 Life Cycle with Each Alternative Replacement Rate: Labor, Earning

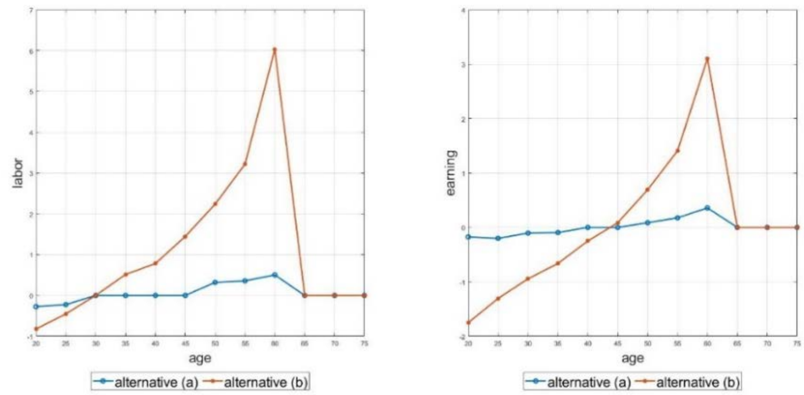
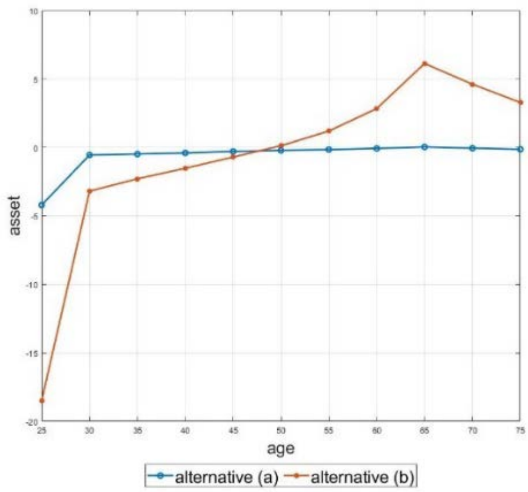


Figure 12 Life Cycle with Each Alternative Replacement Rate: Asset



Next, we consider assets. Alternative (a) does not affect a change in the current situation, except for the age group 25–30 years old. The 2% increase in the pension rate did not have a significant impact on savings in other generations; however, the 20-year-old age group who entered the market would have a significant impact on savings. This results in a decline in savings in the twenties group of 5%. In the case of alternative (b), the pension rate is increased by 4.5% and savings decrease from the current situation before the age of 45. However, after 45 years of age, there is a significant increase in savings. This is due to the fact that the assets are increasing because of the decreasing income replacement rates and because individuals are preparing for retirement and old age.

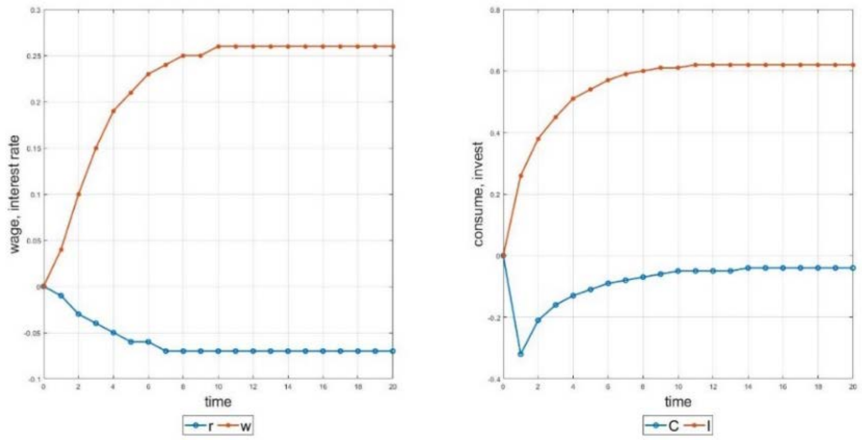
When comparing the effects of the two policies, alternative (a) has little impact on the current pension structure. This is because the increased insurance premium rate does not fully offset the tax burden on the national pension and keeps it as additional national tax revenues. However, alternative (b) shows a marked difference from the present pension structure, because the increased premium rate and the decrease in the replacement rate have a large impact on the market, which greatly contributes to the financial stabilization of the national pension. The variables discussed above are the age-dependent macroeconomic variables that change during the reform. Next, we examine the total macro variables that change over time when alternatives (a) and (b) are implemented in the current state.

4.5. Total Macro Variables that Change Over Time When Alternatives (a) and (b) are Implemented

We examined the changes in macroeconomic variables by age based on alternatives (a) and (b) in the previous section. However, to determine whether Pareto efficiency is reached in this study and to determine which Pareto system has higher efficiency for each alternative, we need to investigate the changes in total macro variables caused by changes in the pension system. Therefore, in this section, we examine the changes in the total macro variables over time based on alternatives (a) and (b).

Referring to figure 13 above, wage increases from the first period. After that, it converges to 0.26% from the 14th period. This is due to the reduced disposable income related to increased pension rates at the beginning of the reform; however, the supply of labor has increased, offsetting the increase in

Figure 13 Macro Variables in Alternative (a): Wage, Interest, Consumption, Investment



labor supply related to the increase in labor demand, which is, in turn, due to the increase in GDP. Moreover, there is a reduction in the government funds injected to secure the financial soundness of the pension fund, leading to a decline in income tax, resulting, in turn, in an increase in wages.

Additionally, the interest rate is reduced by disposable income and savings due to increased pension rates immediately after the implementation of the reform. However, the increase in income due to the increase in GDP as well as the decline in asset tax due to the increased financial soundness of pension system lead to an increase in savings again, resulting in a decline in the interest rate.

The next macro variables to consider are consumption and investment. There is a decrease in consumption when alternative (a) is implemented, a 0.04% reduction in consumption due to the rise in the pension rate. However, consumption then recovers to the current level due to other tax rates that have decreased because of the financial soundness of the pension system. Considering investment, this variable also rose by 0.62% because of the increase in savings due to the declined asset tax.

Figure 14 Macro Variables in Alternative (b): Wage, Interest, Consumption, Investment

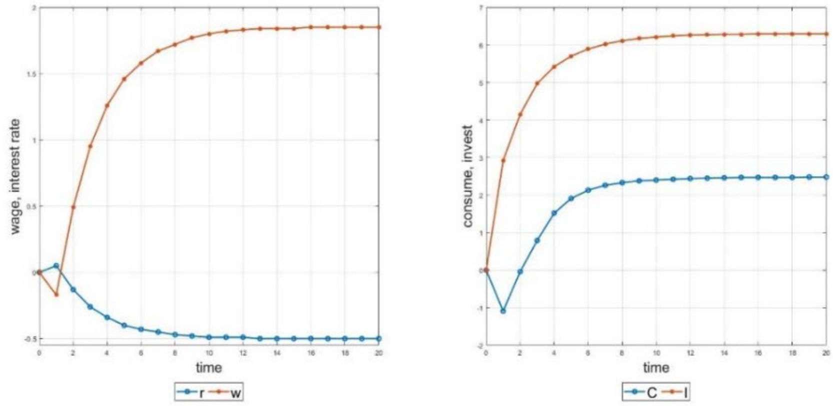
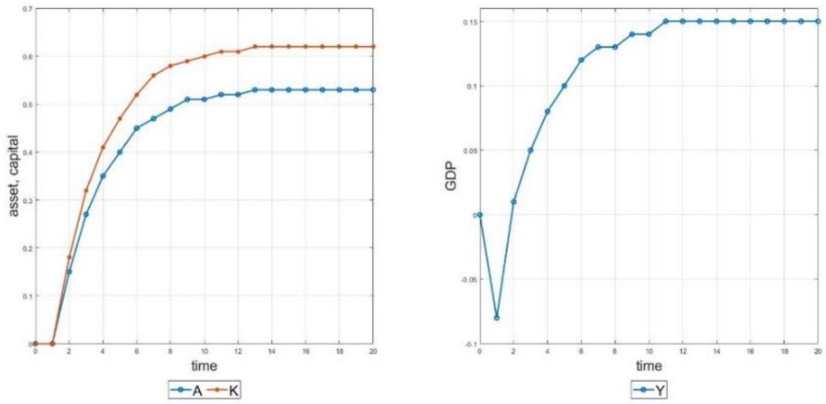


Figure 14 shows that implementing alternative (b) causes an increase in the pension rate from 9% to 13.5% and a decrease in the income replacement rate from 45% to 40%. As a result, wages reached to -0.17% in the initial period. However, wages have increased by 1.85% after this. This is due to the increase in labor supply as the burden of retirement funds increases due to increased pension rates and reduced replacement rates at the beginning of the reform. This reduces wages in the early years of reform. However, as the GDP increases, the demand for labor and secures financial soundness, the additional tax rate in the existing pension system has disappeared, resulting in a decline in income tax, which, in turn, leads to an increase in wages.

Concerning interest rates, both disposable income and savings decrease due to increased pension rates immediately after the implementation of the reform, which can be seen by the 0.05% increase in the interest rate. However, the reduced replacement rate increases the incentive to save and the amount of savings increases, because the additional asset tax collected to maintain the existing pension system due to fiscal soundness has disappeared. The increased savings amount results in a reduction in interest rates, which ultimately leads to a reduction of 0.5%.

Next, we consider consumption and investment. Consumption shows a

Figure 15 Macro Variables in Alternative (a): Asset, Capital, GDP

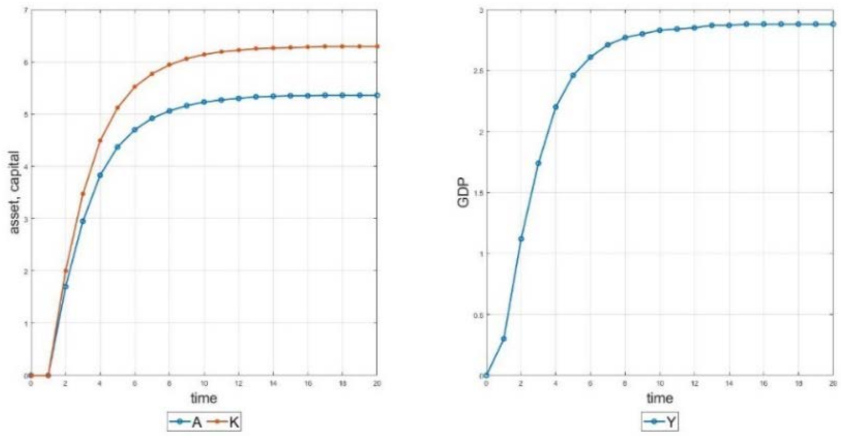


decline at the beginning of reform implementation. As explained earlier, disposable income declines due to increased pension rates, resulting in reduced consumption. However, because of the fiscal soundness of the pension system that can be ascribed to the decline in the replacement rate, the amount of tax that should be added is reduced. This, in turn, results in a reduction in the burden on the workable households to support older adults. This means that consumption is recovering and rising to 2.48%. In the case of investment, savings are increased due to incentives for saving for old age increasing. This is because of the reduced replacement rate, which leads to an increase in investment. As a result, the final figure is increased to 6.29%.

We also look at the changes in assets and capital. As explained earlier, changes in pension plans and asset and capital changes occur from the next period. Figure 15 shows that capital and assets have also increased. In the case of alternative (a), it fluctuates by relatively small margins because there is no large variations from the existing policy. For assets 0.5%, capital 0.59% increased. This can be explained by the increase in income (due to the increased GDP) and the drop in property taxes due to the increase in the fiscal soundness of the pension system, which, in turn, increases savings.

Finally, we examine changes in the GDP when alternative (a) is implemented. The initial GDP decreased to -0.08% because of the sudden

Figure 16 Macro Variables in Alternative (b): Asset, Capital, GDP



increase in the pension rate. However, the GDP rises again by 0.15%, owing to the recovery in consumption and the increase in investment due, in turn, to the increase in income. Next, we examine changes in the macro variables when alternative (b) is implemented in the current state.

Changes in assets and capital are investigated next. Figure 16 above shows that it does not respond immediately to changes in the pension system, but rather changes from the next period. The figure also shows that capital and assets have also increased. This is because as incentives for saving for retirement increase due to reduced replacement rates, assets and savings also increase: assets by about 5.36% and capital by 6.29%.

Similar to alternative (a), alternative (b) also shows an increase in GDP. Alternative (b) shows a 2.92% increase from the previous pension system. This is because the financing system does not require additional government funding as a result of the fiscal soundness of the pension system. This leads to an increase in consumption and a decrease in expenditure on the pension system, at which the GDP increases as a result of increased labor. In alternative (a), the GDP initially declined by -0.08% due to the sudden increase in the tax rate. However, in the case of alternative (b), the increase in the premium as well as the decrease in the substitution rate shows that the initial

GDP does not decrease because the burden on employable generations is offset.

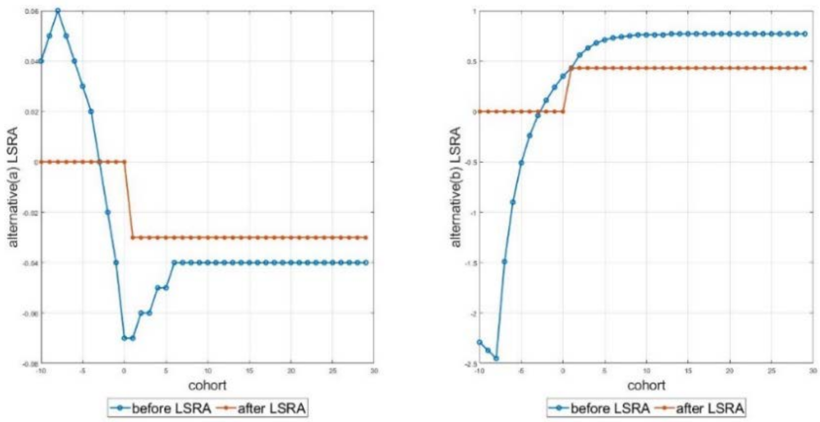
So far, we have examined changes in macroeconomic variables due to changes in the pension structure based on the pension policy. As can be seen, however, it is difficult to judge whether changes in the pension structure will lead to an increase in utility, as the outcomes of the variables vary from generation to generation and the direction of change in the macro variables is also different. Therefore, in the next section, we will examine whether changes in pension policy ultimately result in Pareto efficiency.

4.6. LSRA Analysis for National Pension Plan Structure Alternative

To compare the total amount of utility generated by the alternative two policies, we use LSRA to determine which policies can provide more benefits to all generations. Below, we discuss the results of the impact of LSRA on total utility when used in both policies.

Simply raising the premium rate by 11% will not affect a big change. However, one must keep in mind that each generation has winners and losers. When applying the two variations of LSRA to the utility, it shows high utility

Figure 17 Utility When Applying LSRA to Alternative (a) and (b)



from cohort –10 to –8, as these cohorts do not need to pay for the increased premium rate. However, the size of utility declines from the next generation, which has to bear the increased premium rate. In particular, the decline in utility is shown in the younger generations who need to cover the higher premium rates for fiscal soundness and the insufficient premiums of households that are already retired. The lowest utility is shown in generation 0 after birth. After that, the utility gradually increases until the deficit of the retirement age premium becomes stable over time. From future generations after the 8th period, it is stable because only the insurance premium rate is paid; however, it shows a utility lower than that of the existing policy. As a result, the total utility is –0.03, which is lower than that of the existing policy.

Alternative (b) shows a larger change than alternative (a). In alternative (b), as the premium rate is increased and the replacement rate is lowered, the present age group has lower utility. Specifically, the –8th generation that lost most of their expected pension due to lower replacement rates, shows the greatest decline in utility. However, due to the lower burden on retired households and the stabilization of the financial system, the amount of additional tax on insufficient pensions is reduced and the size of the utility gradually increases. In the long term, the additional tax input to maintain the pension system is highly beneficial from the generation that has been completely offset by the fiscal stabilization policy. Finally, when compared with the existing national pension, there is a total utility gain of 0.43.

When comparing the effects of the two policies using LSRA, alternative (a) shows a lower total utility than the current national pension scheme. This indicates that the slightly increased premium rate is not enough to meet the goal of stabilizing the national pension and that the burden on the public due to the increased premium rate results in a decrease in the total utility. Conversely, alternative (b) shows a higher total utility than the current national pension scheme. This is because the burden on the public due to the increased premium rate is offset by the decrease in the burden due to the lower replacement rate and achieving the goal of stabilizing the national pension financing.

5. CONCLUSION

This study quantitatively analyzes the financial sustainability of the current structure of the national pension system as well as the total utility of two proposed alternatives using the stochastic overlapping generation model. We use the more refined OLG model—which enables a more sophisticated analysis—to analyze the problems of the current pension system in Korea. We also investigate the recent two proposed pension system reforms published by the Korean government and compare the magnitude of utility changes between the two policies. Unlike previous studies that only analyzed individual reform proposals, this study shows that there is a contribution point in the analysis of the reform proposals as well as a comparison of the size of utility when each policy is implemented.

If we assume that the current premium rate is maintained and set the income replacement rate at 33% for the pension system to be financially sound, the utility is lower for older adults than when we set the replacement rate at 45%. However, the total utility is larger due to the relatively small burden on future generations. The results show that it is more desirable to achieve financial stability than to consider the welfare of older adults.

We also analyze the government's two proposals to achieve financial soundness. The first plan, which seems relatively passive concerning financial soundness, is to maintain the income replacement rate and slightly increase the insurance premium rate from 9% to 11%. However, this change does not achieve fiscal soundness; rather, the total utility is reduced. The second proposed measure to achieve financial soundness lowers the replacement rate from 45% to 40% and increases the insurance premium rate from 9% to 13.5%. As a result, the utility of older adults decreased slightly, but the size of the total utility increased as the burden of future generations decreased somewhat. These results show that aggressive policies such as the second option to achieve fiscal soundness offer greater total utility in terms of overall macroeconomic performance. This provides a great deal of knowledge on the future effect of the policy on resolving the financial soundness of the pension system.

A limitation to this study concerns the difference between the consumption structure according to the real market and the consumption structure in our study. In terms of consumption and assets by age taken from the household trend survey (2017) below, as the age increases, assets also increase, but decrease again at the age of 60, after retirement. This result is in line with the real asset market. However, in the case of consumption in the real market, consumption decreases after the age of 50, which differs from this study, in which it increases with age.

Table 5 Consumption and Asset in Real Market

Unit: 1,000won

Age	Consumption	Asset
30	2,503	28,824
40	3,168	39,884
50	2,958	45,697
60	1,811	38,971

Source: 2017 Household Trend Survey

We show the differences between the results of this study and the real market, as this study does not set up a legacy; therefore, households have the choice to consume all of their assets until death. This means that the consumption of older adults is overestimated in this study. The authors recognize the limitation that age-type consumption does not accurately reflect Korea's consumption structure and that this limitation should be addressed in future research.

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