

Demographic Changes, Economic Growth, and Fiscal Rules in a General Equilibrium Model of Overlapping Generations*

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1 Introduction

According to Statistics Korea's projections, Korea will face dramatic demographic changes over the next fifty years. The population is expected to grow much more slowly than ever before and age rapidly. This paper analyzes the medium- and long-run effect of the fiscal rules for Korea facing demographic changes due to population aging and slow workforce growth as well as slow long-run economic growth. A general equilibrium model of overlapping generations is built to understand and quantify the long-run and transitional impacts of different fiscal rules that impose a long-lasting constraint on fiscal policy through numerical limits on budgetary aggregates.¹

Households are heterogeneous in age, wealth, and earnings ability. Especially, earning ability depends on age-specific labor productivity and time-varying productivity. Given a fiscal rule, households make optimal decisions on consumption, saving and labor supply over the life-cycle. There are mortality risks and the household's length of life is uncertain. The asset markets are assumed to be incomplete and households can accumulate

*This version is a minor extension of Moon and Lee (2013), an published article in the *Korean Journal of Public Finance*.

¹See Schaechter, et al. (2012).

riskless assets to insure themselves against mortality risks and income shocks caused by unexpected negative labor productivity shocks.

When it comes to the fiscal rules, three different types of fiscal rules are investigated. The first type of rule is a debt rule which sets an explicit limit for public debt as percent of GDP. The second type of rule is a budget balance rule which literally requires a balanced budget in this paper. Assuming that the government expenditures measured as the ratio of GDP, consumption tax, and capital gains tax are exogenously given, the quantitative effects of each fiscal rule that the model economy adopts on output, factors of production, and policy variables such as tax rates and national pension contributions are examined.

In the model economy with the debt rule, among others, the income tax rate rises from 26.5 percent in 2010 to 60.7 percent in 2050 because of a decrease in workforce consisting of taxpayers and a rapid growth of government expenditures. For the budget balance rule, the debt-to-GDP ratio falls from 36.1 percent in 2010 to 15.6 percent in 2050. For the next two decades, the income tax rate is higher under the budget balance rule than under the debt rule, but the gap shrinks after 2030 due to the reduced debt-to-GDP ratio under the budget balance rule. Finally, lower tax rates reduce distortions to labor supply, saving and investment, and then increase output. The results suggest that it is possible to increase welfare by reducing distortions created by higher income tax rates if we have stricter fiscal rules in place before dramatic demographic changes take place.

This paper complements the existing studies quantifying the long-run effect of demographic changes. While the existing studies rely on the accounting methods which do not require households' rational behaviors, this study is based on a general equilibrium model of overlapping generations in which households make optimal decisions on consumption and saving. Since income taxes distorting household's work incentives are introduced and asset markets are assumed to be incomplete, the Ricardian equivalence fails to hold. In this sense, this work is in line with Auerbach and Kotlikoff (1987), Trostel (1993), and McGrattan (1994). Following Hubbard and Judd (1986), Altig and Davis (1989), and Heathcote (2005), borrowing constraint is introduced into the model economy in this paper. Following Castañeda, et al. (1999), Nishiyama and Smetters (2005), Conesa and Krueger (2006), Cagetti and De Nardi (2009), and Conesa, et al. (2009), a model of incomplete markets with heterogeneous agents, a so-called Bewley-Huggett-Aiyagari model, is constructed. While existing studies focus on the short- and long-run effect of fiscal policy, the focus of this paper is on the medium- and long-run effect of different fiscal rules on the transitional dynamics when population aging and slow workforce growth as well as slow long-run economic growth hit the economy.

The organization of the paper is as follows. Section 2 presents the model of overlapping generations, and calibration details and quantitative results from two different fiscal rules are given in section 3. Concluding remarks are given in section 4.

2 Model

This section presents the model of overlapping generations which consists of the household problem, the firms problem, and the government fiscal rule. The definition of the recursive equilibrium and the description of the transitional dynamics are also discussed.

2.1 Environments

The economy is populated by overlapping generations of households of age $j = 1, 2, \dots, J$. It is assumed that each household consists of one person. The lifespan is uncertain and thus households of age j can survive until the next period with probability ψ_j . Households can remain employed in the market until the mandatory retirement age, denoted by j_w . No altruism is assumed so that all accidental bequests are collected and distributed as a lump-sum transfer to the entire population.

Households have the following utility function

$$E \left[\sum_{j=1}^J \beta^{j-1} \frac{(c_j^\alpha l_j^{1-\alpha})^{1-\sigma}}{1-\sigma} \right]$$

where β is a subject discount factor, c_j consumption, l_j leisure. The expectation is with respect to uncertainty in longevity and labor productivity. In each period, households have an endowment as one unit of time. When a household is working, his or her earnings are given as $wxh_j\ell$ where w is the market wage, x the household's time-varying labor productivity, h_j the household's age-specific labor productivity, and ℓ the household's hours of work that is endogenously chosen. Notice that the labor productivity of households has two different components. The first component is age-specific productivity which varies deterministically over the life-cycle. It is assumed that $h_j = 0$ for retirees at age $j \geq j_w + 1$. The second component is time-varying productivity which follows an AR(1) process in logs:

$$\ln x' = \rho_x \ln x + \varepsilon'$$

where ε is a normal random variable with zero mean and variance of σ_x^2 .

Following Bewley, Huggett (1993), and Aiyagari (1994), markets are assumed to be incomplete, and thus households cannot insure themselves against labor productivity and mortality risks by trading Arrow-type securities. They are allowed to accumulate one-period riskless assets to self-insure against uncertainty. Moreover, households are not allowed to borrow.

Under this environment, a household of age $j \leq j_w$ faces the following budget constraint:

$$\begin{aligned} (1 + \tau_c) c + a' &= [1 + (1 - \tau_k) r] (a + e) + (1 - \tau_h) (1 - \tau_{ss}) w x h_j \ell \\ a' &\geq 0 \end{aligned}$$

where a' denotes savings, a the current asset holdings, r interest rate, e bequests distributed as a lump-sum transfer, $\{\tau_c, \tau_k, \tau_h\}$ the set of tax rates on consumption, capital income, and labor income, respectively, and τ_{ss} the tax rate on the pension system. The second constraint shows that borrowing is not allowed.

On the other hand, a retiree of age $j \geq j_w + 1$ faces the following budget constraint:

$$\begin{aligned} (1 + \tau_c) c + a' &= [1 + (1 - \tau_k) r] (a + e) + s \\ a' &\geq 0 \end{aligned}$$

where s denotes social security benefit for retirees which is identical for all retirees.

Firms are competitive and produce output according to a constant returns to scale technology:

$$Y = K^\theta (zL)^{1-\theta}$$

where Y denotes aggregate output, K aggregate capital input, L aggregate labor input, z the labor augmenting productivity which grows exogenously at rate of γ , and θ is the capital share. Capital depreciates at rate δ . Since the technology exhibits a constant returns to scale, all the firms can be represented by a single firm. The representative firm rents capital and hire labor from households in competitive factor markets. The profit-maximization condition for the representative firm gives

$$\begin{aligned} w &= (1 - \theta) K^\theta (zL)^{-\theta} z \\ r &= \theta K^{\theta-1} (zL)^{1-\theta} - \delta \end{aligned}$$

The government purchases an exogenous amount of goods and services, denoted by G , and supplies an amount of one-period risk-free debt, denoted by D , which carries the same return r in equilibrium. The expenditure, G , and the payment of the principal and interest on the debt, $(1 + r) D$, are financed by the revenue from taxes on income and consumption, T , and newly issued debt, D' . The government should face the following fiscal constraint:

$$G + (1 + r) D = D' + T$$

where the revenue from taxes on income and consumption can be expressed as follows:

$$T = \tau_c C + \tau_k r A + \tau_h (1 - \tau_{ss}) w L$$

where C denotes aggregate consumption and A aggregate assets. In what follows, it is assumed that the tax rates on consumption and capital income are given exogenously, and thus the labor income tax rate is determined to satisfy the fiscal constraint.

Two different fiscal rules are examined. The first type of rule is a debt rule which sets an explicit limit for public debt as percentage of GDP. The second type of rule is a budget balance rule which requires a balanced budget in this paper. The income tax rate that should satisfy the fiscal constraint depends on which rule is adopted.

Finally, the government operates a pay-as-you-go social security system. Under this system, each retiree receives a constant benefit, denoted by s , and each household that supplies labor in the market has to pay a proportional tax τ_{ss} on earnings.

2.2 Transformation and Recursive Equilibrium

It will be convenient to transform the model into a stationary form. To this end, all the variables growing at the rate of γ are divided by aggregate output because aggregate output, Y , also grows at the rate of γ . The transformed model can be expressed as follows. The household's budget constraint is divided by Y and the household's preferences are rewritten by using the definition of $\tilde{c} = c/Y$. The household's problem becomes

$$E \sum_{j=1}^J \left[\beta (1 + \gamma)^{\alpha(1-\sigma)} \right]^{j-1} \frac{(\tilde{c}_j^\alpha l_j^{1-\alpha})^{1-\sigma}}{1-\sigma}$$

subject to

$$(1 + \tau_c) \tilde{c} + (1 + \gamma) \tilde{a}' = [1 + (1 - \tau_k) r] (\tilde{a} + \tilde{e}) + (1 - \tau_h) (1 - \tau_{ss}) \tilde{w} x h_j \ell \quad \text{for } j \leq j_w \quad (1)$$

$$(1 + \tau_c) \tilde{c} + (1 + \gamma) \tilde{a}' = [1 + (1 - \tau_k) r] (\tilde{a} + \tilde{e}) + \tilde{s} \quad \text{for } j \geq j_w + 1 \quad (2)$$

$$a' \geq 0 \quad (3)$$

where $\tilde{a} = a/Y$, $\tilde{e} = e/Y$, $\tilde{w} = w/Y$, and $\tilde{s} = s/Y$. Note that all the variables appearing on the government's fiscal constraint grow at the rate of γ , and they are divided by Y .

$$\begin{aligned} g + (1 + r) d &= (1 + \gamma) d' + t \\ t &= \tau_c \bar{c} + \tau_k r \bar{a} + \tau_h (1 - \tau_{ss}) \tilde{w} L \end{aligned} \quad (4)$$

where $g = G/Y$, $d = D/Y$, $t = T/Y$, $\bar{c} = C/Y$ and $\bar{a} = A/Y$. Dividing the asset market equilibrium condition by Y gives

$$\bar{a} = d + k$$

where $k = K/Y$.

Finally, the representative firm's profit maximization conditions divided by Y become

$$\tilde{w} = \frac{1 - \theta}{L} \quad (5)$$

$$r = \frac{\theta}{k} - \delta \quad (6)$$

Households are heterogeneous in three dimensions summarized by $\omega \equiv \{j, a, x\}$, where j represents age, a assets accumulated and carried over from the previous period, and x time-varying labor productivity. Given ω , in every period households choose consumption, hours worked, and savings to maximize his(her) life-time utility. It is useful to represent the household problem recursively. The household's value function, $V(\omega)$, in state ω is given by

$$V(\omega) = \max_{\{\tilde{c}, \tilde{a}', \ell\}} \left\{ \frac{(\tilde{c}_j^\alpha l_j^{1-\alpha})^{1-\sigma}}{1-\sigma} + \tilde{\beta} \psi_j E[V(\omega') | \omega] \right\} \quad (7)$$

subject to equations (1), (2) and (3). From the above maximization problem, optimal consumption $\tilde{c}(\omega)$, optimal saving $\tilde{a}'(\omega)$ and optimal hours worked $\ell(\omega)$ can be derived.

To characterize the stationary competitive equilibrium, a specific fiscal rule should be assumed. To this end, a debt rule is set as the benchmark rule. If government adopts a debt rule, it must set an explicit limit for public debt as percentage of GDP. Under the benchmark rule of a constant debt-to-GDP ratio with $d = d'$, the government fiscal constraint becomes

$$g + (r - \gamma) d = t \quad (8)$$

The characterization of the transitional dynamics will be discussed in the following section.

A stationary competitive equilibrium under the benchmark fiscal rule of a constant debt-to-GDP ratio consists of the value function $V(\omega)$, the optimal consumption function $\tilde{c}(\omega)$, the optimal saving function $\tilde{a}'(\omega)$, the optimal labor supply function $\ell(\omega)$, the capital stock and the efficiency unit of labor $\{k, L\}$, the factor prices $\{r, \tilde{w}\}$, the government policy variables $\{g, d, \tau_c, \tau_k, \tau_h, \tau_{ss}\}$, and the law of motion for the time invariant measure μ such that

1. Given the factor prices and the policy variables, the optimal consumption, saving and labor supply functions solve equation (7).
2. The representative firm maximizes its profit and thus equations (5) and (6) are satisfied.

3. The government budget constraints, equations (8) and (4), are satisfied.
4. The social security system is self-financed:

$$\tilde{s} \int I(j > j_w) \mathbf{d}\mu = \tau_{ss} \tilde{w} \int x h \ell(\omega) \mathbf{d}\mu$$

where I is an indicator function that takes a value 1 if $j > j_w$ and 0 otherwise.

5. The goods market clears:

$$\int \{\tilde{a}'(\omega) + \tilde{c}(\omega)\} \mathbf{d}\mu + g = 1 + (1 - \delta) k$$

6. The labor and capital markets clear:

$$\begin{aligned} L &= \int x h \ell(\omega) \mathbf{d}\mu \\ k + d &= \int (\tilde{a} + \tilde{e}) \mathbf{d}\mu \end{aligned}$$

where $\tilde{e} = \int (1 - \psi_{j-1}) \tilde{a} \mathbf{d}\mu$.

7. The measure μ is time-invariant and the law of motion for the measure over the state space satisfies $\mu = \Gamma(\mu)$.

2.3 Transitional Dynamics

On the transitional dynamics, the age-dependent conditional survival probabilities ψ_j , the government expenditures as a share of output g , the growth rate of the labor-augmenting productivity γ are not constant, but assumed to follow deterministic trends. Specifically, we assume that the changes in demographics, government spending and productivity happen until 2050, and after 2050 they become constant.²

To see how the model economy operates on the transitional dynamics, we solve the model recursively. We first characterize the stationary state in which all the variables of interest do not vary over time and then allow the model economy to have enough time for the periods after year 2050 to adjust the changes in demographics, government spending and productivity. Our computations on the transitional dynamics focus on finding the time

²For the growth rate of labor-augmenting productivity, it keeps falling until 2080 and after that it remains constant.

paths of the tax rate on labor income, the tax rate on social security benefit, the wage rate, and the growth rate: $\{\tau_h(t), \tau_{ss}(t), \tilde{w}(t), g_Y^*(t)\}_{t_0}^T$. Note that when households solve their problem on the transitional dynamics, they have to know the time path for the growth rate of Y . In equilibrium, therefore, the household's conjectured time path for the growth rate of Y should be equal to the actual time path for the growth rate of Y .

3 Quantitative Analysis

3.1 Calibration

The model operates on annual frequency. Households enter the economy at age 27, retire from work at age 66 and live up to the maximum age of 100. Over the period 2010-2050, the age-dependent conditional survival probabilities $\psi_j(t)$ are assumed to vary over time while it remains constant in the stationary state. First, the conditional survival probabilities are computed to mimic population projections by Statistics Korea. Given the projected population for age j in year t and the projected population for age $j + 1$ in year $t + 1$, denoted by $N_{j,t}$ and $N_{j+1,t+1}$, respectively, the age-dependent conditional survival probability in year t is defined as

$$\psi_j(t) \equiv \frac{N_{j+1,t+1}}{N_{j,t}}$$

Similarly, the number of the new entrants who enter the economy in each year are computed to mimic population projections. Given the projected population for age 1 in year $t - 1$ and the projected population for age 1 in year t , the time t relative share of the new entrants is defined as

$$\nu(t) \equiv \frac{N_{1,t}}{N_{1,t-1}}$$

where age 1 of the model corresponds to age 27 of the real world. After 2050, $\nu(t)$ is set to 1, so that the number of new entrants remain the same.

The process of time-varying labor productivity is determined by two parameters, ρ_x and σ_x . Following Kim and Chang (2008), we set ρ_x to .8, but for σ_x , we choose .2 lower value than .354 because age-specific labor productivity is also introduced. The deterministic process of age-dependent labor productivity comes from Choi (2009) who estimates the relationship between labor productivity and age. The income share of capital θ is set to .3, the annual depreciation rate δ is .1, and σ is set to 4. The tax rates on capital income and consumption are assumed to be exogenous, and thus they are set to .293 and .054, respectively. Social security benefit is set to 40 percent of GDP.

When it comes to government spending, the government expenditures as a share of GDP increase until 2050, and remain constant after 2050. More specifically, we follow the most recent projections by National Assembly Budget Office (2012) in which the ratio of government expenditures to GDP would be 22 percent in 2010, it would increase by .17 percentage point every year, and by 2050 it reaches 28.72 percent and remains constant. The stationary ratio of the government expenditures to GDP is then 28.72 percent. In the stationary state, the debt-to-GDP ratio is set to 36.1 percent.

It is difficult to figure out the exogenous time path for the labor-augmenting productivity because nobody knows what will happen to the path. For that reason, we do not target the time path for the productivity, but the projected path for GDP. Given that the projected growth rate of GDP which comes from Hahn, et al. (2007), we find the time path for productivity such that the model economy accounts for the given growth rate of GDP.

Following Hahn, et al. (2007), the time path for the interest rate is set to 3.6 percent in 2010 and 2011. The interest rate is assumed to fall by .03 percentage point in each year, and thus it reaches 2.3 percent by 2050. After 2050 it remains unchanged at rate of 2.3 percent. Since the interest rate is given exogenously as in a small open economy, the household's subjective discount factor β will be chosen such that the capital market clears.

Unlike the existing studies, we assume each new entrant is endowed with assets. By using the Survey of Household Finance (2006), we find that the average asset holdings for households of age 49 as a ratio of GDP is 2.6, and the average asset holdings for households of age 27 is 8 percent of those for households of age 49. Table 1 summarizes the parameterization of the model both in the stationary state and on the transitional dynamics.

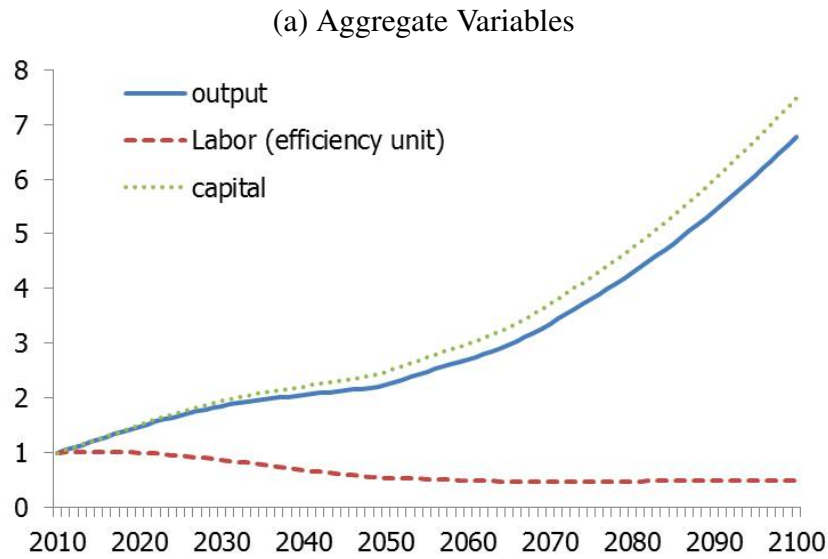
Table 1: Parameters in the Stationary State

<i>pre-determined parameters</i>		
ρ_x	persistence parameter of idiosyncratic productivity shock	.8
σ_x^2	conditional variance of idiosyncratic productivity shock	.2
$\ln h_j$	age-dependent productivity	Choi (2009)
θ	capital share	.3
δ	depreciation rate	.1
σ	the reciprocal of the elasticity of intertemporal substitution	4
τ_c	tax rate on consumption	.054
τ_k	tax rate on capital income	.293
\tilde{s}	social security benefit	.4
γ	exogenous growth rate of aggregate productivity	.022
g	ratio of government expenditures as GDP	.2872
d	Debt-to-GDP ratio	.361
r	interest rate	.023
<i>parameters determined by equilibrium conditions</i>		
τ_h	tax rate on labor income	.4371
τ_{ss}	tax rate on social security benefit	.1958
β	discount factor	1.1182
α	utility function parameter	.6119
\tilde{e}	bequest	.0207
\bar{a}_1	initial wealth endowment	.028

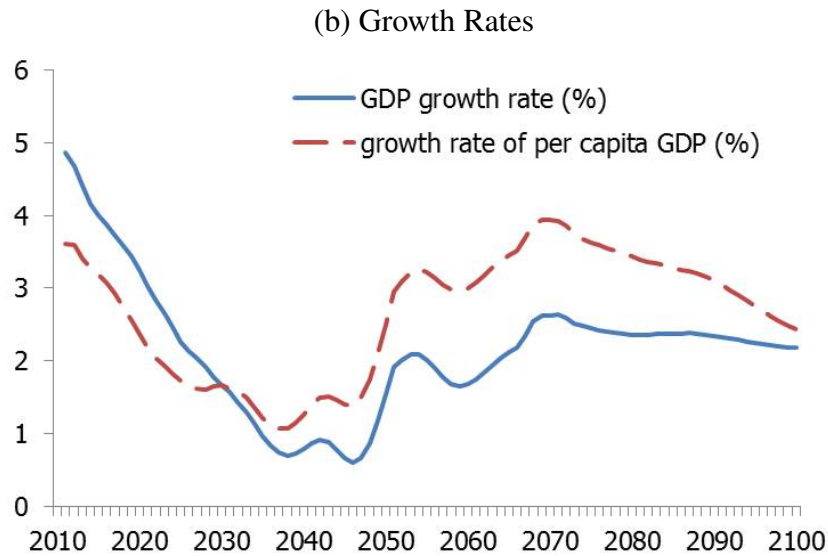
3.2 Benchmark Rule

Under the debt rule as the benchmark rule, the debt-to-GDP ratio should be constant over time. Figure 1 shows the transitional dynamics under the debt rule. Figure 1 demonstrates that aggregate labor keeps falling over 2010-2050 even though the aggregate capital stock and output increase. The second panel of Figure 1 displays the growth rates of aggregate output and per capita output, respectively. Some may argue that the model economy has a very high growth rate of aggregate (labor-augmenting) productivity. Nevertheless, the growth rate of output will drop to below 1 percent, and thus the changes of demographic structure could have a significant impact on the growth rate of the overall output.

Figure 1. Transitional Dynamics under Benchmark Rule



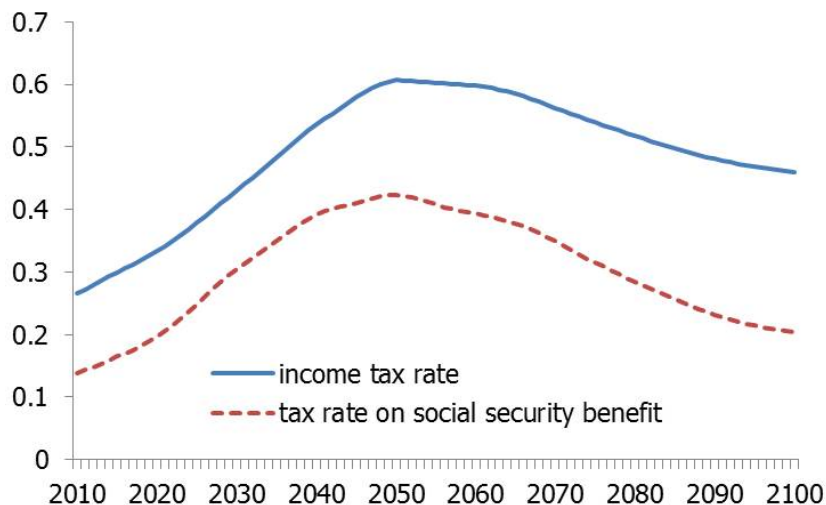
Note: Each aggregate variable is normalized to 1 in 2010.



One of the most striking features of the model economy under the benchmark rule is that the income tax rate and the tax rate on social security benefit increase rapidly as in Figure 2. The stationary equilibrium rates are 43.7 percent for income tax and 19.6 percent for social security benefit, but on the transitional dynamics they rise up to 60.7 percent for

income tax and to 42.2 percent for social security benefit.

Figure 2. Transitional Dynamics under Benchmark Rule



3.3 Balanced Budget Rule

The second rule examined in this section is a budget balance rule which explicitly requires a balanced budget. The government budget constraint can be expressed as follows:

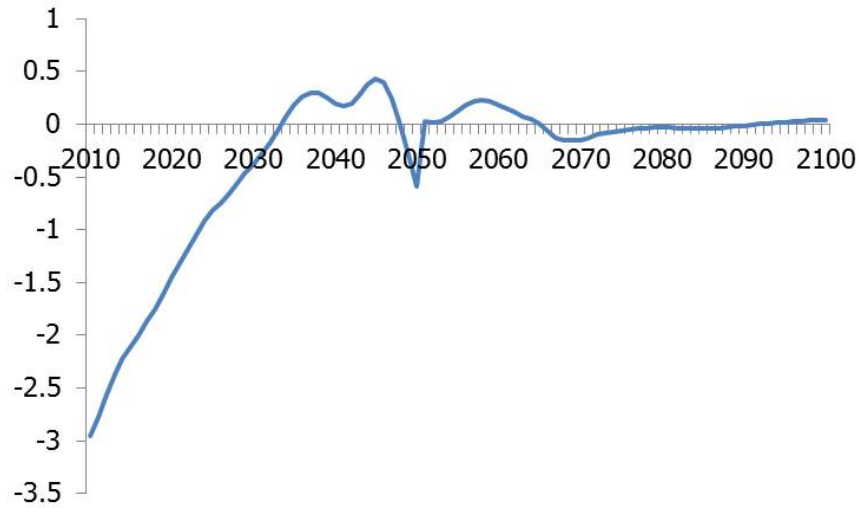
$$d_{t+1} = \frac{d_t}{1 + \gamma_t} + \frac{1}{1 + \gamma_t} (r_t d_t + g_t - t_t) \quad (9)$$

Under the balanced budget rule, revenues should be equal to expenditures:

$$t_t = r_t d_t + g_t \quad (10)$$

If the economy is growing over time, then the debt-to-GDP ratio, d_t , is shrinking. In other words, the size of debt would be constant. Notice that even though the model economy has the balanced budget rule in place, the balanced budget rule applies until 2050 and is replaced with the debt rule after 2050. We call this regime ‘the balanced budget rule’ in this paper.

Figure 3. Differences in Income Tax Rates (%p)

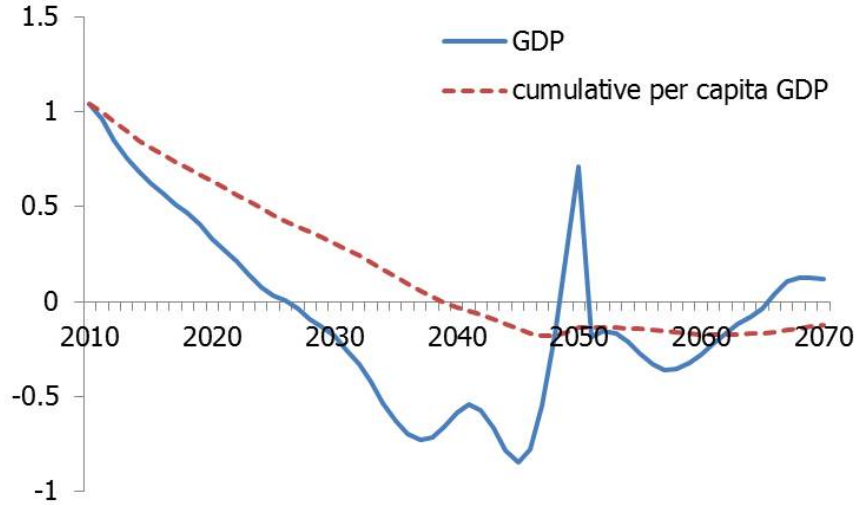


Note: The difference between the labor income tax rates under two different fiscal rules:
Benchmark–Balanced Budget

Figure 3 presents the difference in income tax rates under two different fiscal rules. Since more stringent policies are required by the balanced budget rule under which the income tax rate would be higher. For that reason, the income tax rate is higher under the balanced budget rule than under the debt rule between 2010 and 2030. The difference in income tax rates shrinks around 2030 when the difference is only 0.4 percentage point. Over the period 2035 to 2045, surprisingly, the income tax rate under the balanced budget rule is lower than under the debt rule. This is because there are feedbacks between the tax rate and output. Suppose that the ratio of government expenditures to GDP is exogenous. If the income tax rate is low, then all else being equal, the level of output would be high because there will be less distortions on work incentives. On the other hand, if the level of output is high, then all else being equal, government could have a room to reduce the tax rate to balance its budget.

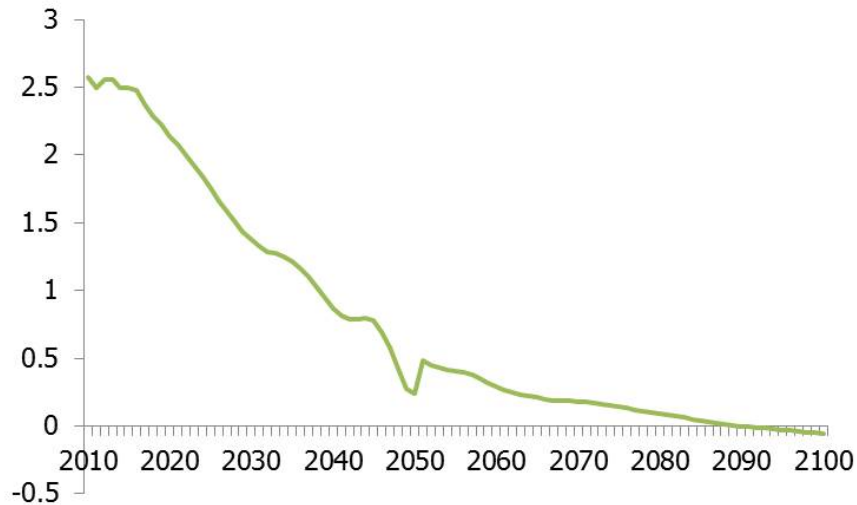
Figure 4. Differences in Levels of Output and Utility

(a) GDP and cumulative per capita GDP



Note: measured by $(X_{benchmark} - X_{balance})/X_{benchmark}$

(b) Representative Household's Spontaneous Utility



Note: measured by $(X_{benchmark} - X_{balance})/X_{benchmark}$

Figure 4 shows the differences in the levels of output as well as in the representative household's temporary utility under two different fiscal rules. Over the period 2025–2030, in panel (a) of Figure 4, the output is higher under the balanced budget rule than the

debt rule. This can happen because the future tax rate under the balanced budget rule is expected to be lower than under the debt rule even though the tax rate at the time is higher.

The cumulative per capita GDP given in panel (a) falls below zero around year 2040. When the balanced budget rule which is more stringent is implemented, the short-run output will be lower than under the debt rule, but after 2040 the level of output under the balanced budget rule surpasses the level of output under the debt rule. As a result, a fiscal rule can be served by the balanced budget rule which can make up the short-run cost of lower output.

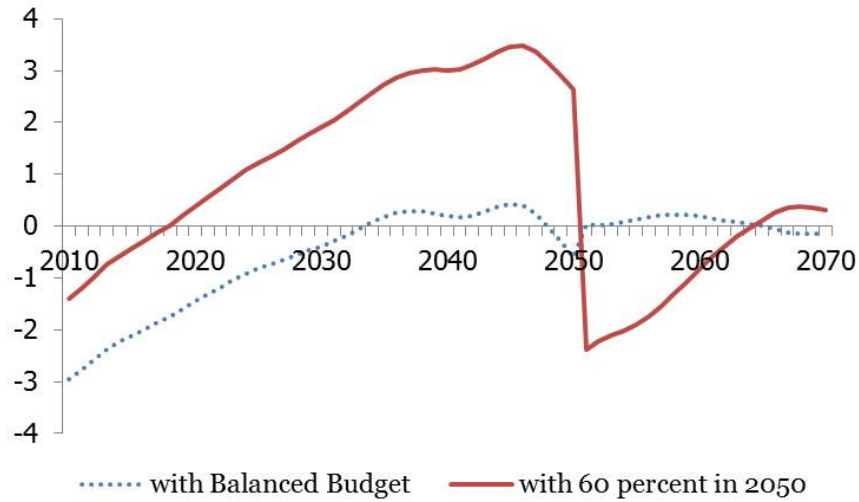
Finally, panel (b) of Figure 4 shows the weighted average of different household's temporaneous utilities derived from both rules. By 2010, the average utility from the debt rule is 2.6 percent higher than the average utility from the balanced budget rule, so that over the period of the transitional dynamics, the debt rule seems to be better than the balanced budget rule. We attempt to measure the difference of 2.6 percent as consumption goods. The difference of 2.6 percent in terms of utilities corresponds to 1.4 percent increase in consumption.

3.4 60 Percent Rule

In this subsection, we examine another fiscal rule, the so-called 60 percent rule, which can be considered as a special case of managing the maximum debt-to-GDP ratio. The current debt-to-GDP ratio is much less than the target ratio, 60 percent of GDP. Under the 60 percent rule, we assume that the debt-to-GDP ratio is allowed to rise up to 60 percent of GDP by 2050, and after 2050 the debt-to-GDP ratio remains constant. Compared to the benchmark rule and the balanced budget rule, the 60 percent rule is the least strict type of fiscal rules.

There are infinitely many sequences of income tax rates to deliver 60 percent of the debt-to-GDP ratio in 2050. We choose the path of equilibrium income tax rates from the balanced budget rule, denoted by $\{\tau_{h,t}^B\}_{t=2010}^{2050}$, and compute a wedge, ϕ , such that given the path of income tax rates, $\{\phi\tau_{h,t}^B\}_{t=2010}^{2050}$ and $\{\tau_{h,t}^{60\%}\}_{t=2050}^T$, and other equilibrium paths such as wage, social security tax, bequest and growth rate, the debt-to-GDP ratio in 2050 becomes .6. The computed wedge is then .9472.

Figure 5. Differences in Income Tax Rates (%p)

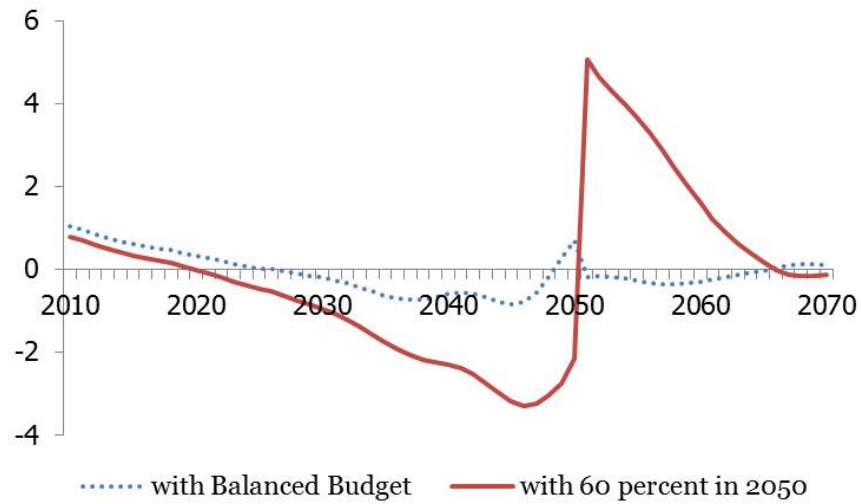


Note: measured by $\tau_h^{benchmark} - \tau_h^{rule}$

Figure 5 presents the differences in income tax rates under the balanced budget rule and the 60 percent rule. Notice that if the tax rate under a certain fiscal rule is higher than under the benchmark rule, then the difference becomes negative. Tax policies required under the 60 percent rule are much less strict than under the balance budget rule and thus the difference in tax rates between the benchmark rule and the 60 percent rule is greater than 2 percentage point for the 2030–2050 period.

The debt rule, however, should be enforced after 2050, which implies that the amount of debt will remain constant at 60 percent of GDP after 2050. For government to manage the high ratio of debt relative to GDP, it has to raise the labor income tax rate. Figure 5 shows that the difference is -2.4 percentage point, that is, the tax rate in 2051 under the debt rule with 60 percent debt-to-GDP ratio is 2.4 percentage point as high as that under the benchmark rule with 36 percent debt-to-GDP ratio.

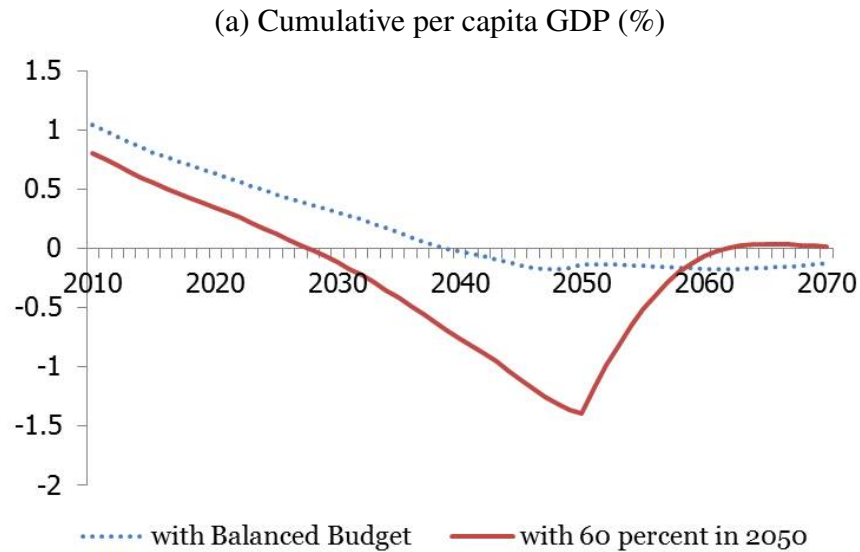
Figure 6. Differences in GDP (%)



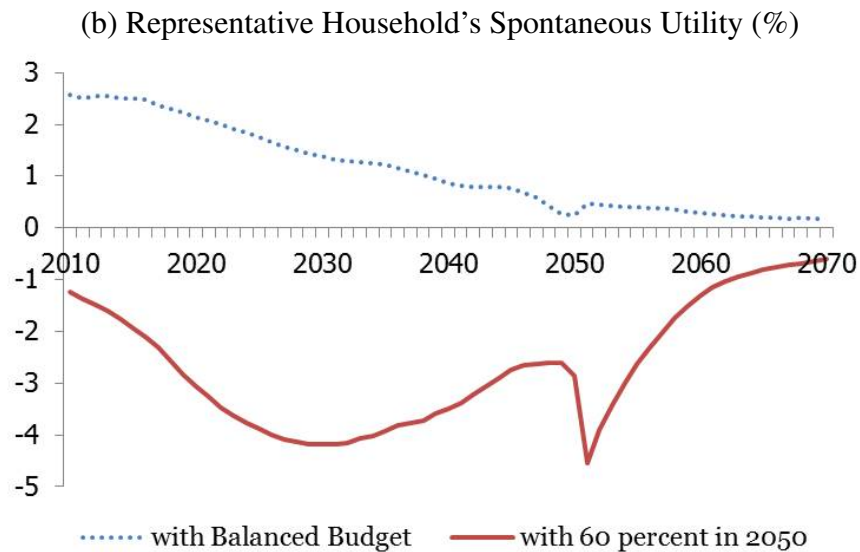
Note: measured by $(Y^{benchmark} - Y^{rule})/Y^{benchmark}$

The sudden changes in tax rates directly affect aggregate output even though they are anticipated by households. Figure 6 demonstrates the negative effects of the changes in tax rates due to the changes in fiscal rules. The significant changes in tax rates happened by the regime change in 2051 decrease output by more than 5 percent, compared to the benchmark rule. Notice this difference persists for about 15 years.

Figure 7. Differences in Levels of per capita GDP and Utility



Note: measured by $(y^{benchmark} - y^{rule})/y^{benchmark}$



Note: measured by $(U^{benchmark} - U^{rule})/U^{benchmark}$

Finally, we also measure cumulative per capita GDP and the representative household's spontaneous utility, and compare the balanced budget rule with the 60 percent rule. Panel (a) of Figure 7 shows that cumulative per capita GDP under the 60 percent rule is much

greater than both the benchmark rule and the balanced budget rule because the required income tax rates are low compared to the other rules. But this strong advantages disappear around 2060. In 2062, the difference in cumulative per capita GDP becomes positive which means cumulative per capita GDP under the benchmark rule is greater than that under the debt rule with 60 percent debt-to-GDP ratio.

The representative household's spontaneous utility is illustrated in panel (b) of Figure 7. One of the interesting features of the model with the 60 percent rule is that people will be better off from the loose fiscal rule. We find that it is not a totally bad idea to allow the debt-to-GDP ratio to rise steadily during the period of structural adjustments such as demographic changes, slow workforce growth and slow long-run economic growth. But we highlight that this result can hold under the assumptions that the interest rate is given exogenously and there are no external shocks related with the debt-to-GDP ratio and the sovereign credit rating.

4 Concluding Remarks

This paper examines the effects of fiscal rules on Korea's budget outlook and macroeconomic performance in the face of aging population and falling long-run growth. We compare two common fiscal rules: a limit to the debt-to-GDP ratio (benchmark or debt rule) and a balanced-budget rule. To simulate the effects of both fiscal rules, we employ an overlapping generations model of general equilibrium. More specifically, we examine the extent to which aging population, falling long-run growth, and rising government expenditure affect economic output, labor supply, and capital stock during the period from 2010 and 2050. Contrary to conventional wisdom, the results indicate that implementing stricter fiscal rules before population aging intensifies can improve long-term economic growth by making room for future tax cuts.

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