Optimal Tax Burden Ratio in Korea

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Abstract

We attempt to predict the optimal tax burden ratio in Korea, using an altruistic family model. As of 2005, the optimal level of the tax burden ratio, defined as the ratio of the total tax burden to GDP, is shown to be higher than the actual tax burden ratio. However, the optimal ratio will fall substantially to reach 23%-24% by around 2070. This downward trend reflects the fact that current social insurance policies redistribute the resources from future generations to the current generations, implying that tax policies should be designed to mitigate the intergenerational inequity resulting from social insurance policies. We also show that, in contrast to the optimal tax burden ratio, the actual tax burden ratio will rise for a considerable time, to exceed the optimal tax burden ratio from the mid-2010s, assuming the Korean economy follows the paths of economic development and fiscal policy which the developed countries have over the past several decades. This discrepancy between the actual and the optimal tax burden ratios implies that the current fiscal policies are not effective in mitigating intergenerational inequity resulting from the social insurance policies, and that the Korean government therefore needs to maintain a cautious position in decision making on fiscal policies likely to result in substantial increases in government expenditure in the future.

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Key words: Optimal tax burden ratio, intergenerational equity, tax burden ratio, government expenditure

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I. Introduction

Recent debates on the fiscal policy reform in Korea show the coexistence of two contradicting views on the current tax burden ratio, which is defined as the ratio of the total tax burden to GDP: (i) the government expenditure level and the tax burden ratio in Korea are currently the lowest among the OECD countries except for a few countries, therefore, the Korean government needs to raise the tax burden ratio and the expenditure level to reinforce the role of the government; and (ii) the increase in the tax burden ratio accompanied with further expansion of the role of the government is not recommendable, because even under the current fiscal policies, the government expenditure will substantially increase due to the population aging and the maturing of social welfare policies. However, the two views on the tax burden ratio of Korea overlook the fact that the optimal tax burden ratio can change overtime. The adjustment of the tax burden ratio is needed to accommodate the impacts in the form of the change in the socio-economic environment such as the decrease in the economic participation rate, change in the proportion of tax bases due to the population aging, the change in the macroeconomic variables such as national savings rate, and the change in the demand for public goods. In addition, the change in the tax burden ratio is needed to mitigate the intergenerational inequity resulting from the intergenerational redistribution through the social welfare policies such as public pensions.

The tax burden ratio has been used as an index for the magnitude of the government tax revenue compared with the level of the economic development. For this reason, the ratio is one of the most important issues of interest in the public finance economics. In spite of the interest in the tax burden ratio, the previous researches did not succeed in the provision of the theoretical solutions to the issue. Instead, they have had only limited success in finding the determinants of the tax burden ratio.

The determinations of the tax burden ratio have been studied with a close relationship with those of the government expenditure. The debate on the relationship between the tax burden and the government expenditure is represented with the coexistence of the following three hypotheses on the relationship: (i) the tax burden and the government expenditure are determined simultaneously (Lindahl (1958), Black (1948)); (ii) the government expenditure determines the tax burden (Niskanen (1976)); and (iii) the tax revenue determines the government expenditure (Buchanan (1960)). Many empirical researches to test these hypotheses have been tried since 1980s, with two representative studies: von Furstenberg, Green & Jeong (1986), which showed that the government expenditure determines the tax burden; and Holtz-Eakin, Newey & Rosen(1989), which shows that the tax revenue determines the government expenditure.

The researches in Korea tended to focus on the determinants of the government tax revenue and the government expenditure rather than on their interrelationship. Son and An (1993) and Gee (2001) studied the determinants of the tax burden ratio using OECD inter-country data under the assumption that the government expenditure determines the tax burden. Na and Lee (2002) and Park (2004) tried the inter-country comparison of the tax burden ratio using the tax-expenditure determination model. An (2003) and An (2004) extended Son and An (1993) to study the effects of the population aging on the tax burden ratio.

The previous researches have not tried the analysis on the determination of the optimal tax burden ratio, which is changing overtime: to correct for the intergenerational inequity resulting from the intergenerational redistribution through the social welfare policies; and to accommodate the socio-economic changes such as population aging and changing demand for the public goods.

Taking this problem into account, we attempt to provide some theoretical framework to analyze the optimal tax burden ratio, and to predict the trend of the optimal tax burden ratio overtime. Our theoretical framework to analyze the optimal tax burden ratio is an altruistic family model where the social planner maximizes the social welfare represented by a social welfare function defined as the weighted average of the lifetime expected utility of the cohorts existing at present and in the future.

We take three steps to predict the trend of the optimal tax burden ratio. First, we compute the optimal resource allocation such as the optimal consumption level by sex and age overtime. Second, we compute the profiles of the optimal tax burden across generations, which enable the realization of the optimal resource allocation. The structure of the optimal tax burden across generations is designed to correct the intergenerational inequity and to induce the realization of the optimal resource allocation computed in the first step. The intergenerational inequity is resulting from the intergenerational redistribution by social welfare policies quantified by the differing magnitude of the net transfer wealth across generations, defined as the present value of the net transfer income from the government, which are the benefits from the social insurance policies and the public aid programs minus the social insurance contribution, for the remaining lifetime. Finally, we compute the optimal tax burden ratio by allocating each generation's optimal tax burden to each year and adding up the optimal tax burden across age groups. We also predict the path of the actual tax burden ratio, under the hypothetical assumption that the Korean economy will follow the path of the economic development and the fiscal policies that the currently developed countries experienced, in order to compare this with the path of optimal tax burden ratio and to evaluate the current fiscal policies and the recent trend of fiscal reforms.

We found that as of 2005, the optimal level of the tax burden ratio is higher than the actual tax burden ratio, however, the optimal ratio will fall substantially to reach 23%-24% by around 2070. This downward trend reflects the fact that current social insurance policies redistribute the resources from future generations to the current generations, implying that tax policies should be designed to mitigate the intergenerational inequity resulting from social insurance policies. We also found that, in contrast to the optimal tax burden ratio, the actual tax burden ratio will rise for a considerable time, to exceed the optimal tax burden ratio from the mid-2010s. This discrepancy between the actual and the optimal tax burden ratios implies that the current fiscal policies are not effective in mitigating the intergenerational inequity, and that the Korean government therefore needs to maintain a cautious position in decision making on fiscal policies likely to result in substantial increases in government expenditure in the future.

The remainder of the paper is organized as follows. In section II, we construct an altruistic family model, where the social planner makes decisions to maximize the social welfare, to derive the conditions for the optimal resource allocation and the optimal tax structure, and we predict the path of the optimal tax burden ratio with the calibrated model. The parameters of the preference on the private and the public goods are chosen based on the estimated public demand function, which is explained in the Appendix. In section III, we predict the path of the actual tax burden ratio overtime to compare this with the predicted optimal path of the tax burden ratio overtime and to evaluate the current fiscal policy position. Finally, in section IV, we conclude our discussion.

II. Projection of Optimal Tax Burden Ratio

1. Model

Our prediction of the optimal tax burden ratio is based on an altruistic family model where the social planner allocates the resources to maximize the social welfare represented by a utilitarian social welfare function. The economic agents in the economy are divided into different groups according to their sex and the time of birth, which determine the labor productivity.[1)]

Each individual makes a decision on labor supply, savings, and demand for public goods to maximize the lifetime expected utility. The lifetime discounted expected utility of the cohort born at period p (cohort p, henceforth) is expressed as follows:

$$V(p) = \sum_{a=1}^{D} \left(\frac{1}{1+\delta} \right)^{a-1} s(p,a)\ v(C_{a,p+a-1}, g_{p+a-1}, g_{1,p+a-1}, g_{2,p+a-1}, g_{3,p+a-1}) \qquad (1)$$

where c and $s(p,a)$ are the private consumption and the unconditional probability that an individual of cohort p survives until the age of a. g, g_1, g_2, g_3 represent the consumption of public goods, each of which represents the level of non-age specific public good, and age specific public goods (age 0-19 specific, age 20-64 specific, and age 65 and older specific public good, respectively). And D and δ are the maximum age and the individual's time preference.

The utilitarian social welfare function is defined as the weighted average of all the cohorts living in the economy at present and in the future.[2)]

$$\overline{U} = \sum_{p=-D+1}^{\infty} \left(\frac{1}{1+\beta} \right)^{p} P_p V(p) \qquad (2)$$

$$= \sum_{p=-D+1}^{\infty} \sum_{t=\max(p,0)}^{p+D} \left(\frac{1}{1+\beta} \right)^{p} \left(\frac{1}{1+\delta} \right)^{t-p} P_p s(p,t-p+1) v(C_{t-p+1}, g_t, g_{1,t}, g_{2,t}, g_{3,t})$$

1) We omit the subscript for the sex for simplicity of notation.

2) The altruistic family model was originally constructed by Barr (1974) which addresses the effects of government fiscal deficit and increase in government bond on consumption and savings. Barr(1974)'s 2-generation model was extended to multi-cohort models by Calvo and Obsfeld (1988) and Chun (2001) to seek the optimal time-consistent fiscal policy and to analyze the role of intra-household risk-sharing in the presence of the uncertainty on tax policy. Auerbach et al. (1991) and Chun (2007) specified the altruistic family model of the same type as the model of this paper, to study the effect of population aging on national savings.

$$= \sum_{t=0}^{\infty} \sum_{p=t-D+1}^{t} \left(\frac{1}{1+\beta}\right)^{p} \left(\frac{1}{1+\delta}\right)^{t-p} p_{p}s(p,t-p+1)v(C_{t-p+1}, g_{t}, g_{1,t}, g_{2,t}, g_{3,t})$$

$$= \sum_{t=0}^{\infty} \sum_{a=1}^{D} \left(\frac{1}{1+\beta}\right)^{t} \left(\frac{1}{1+\beta}\right)^{-a+1} \left(\frac{1}{1+\delta}\right)^{a-1} p_{a,t}\, v(C_{a,t}, g_{t}, g_{1t}, g_{2t}, g_{3t})$$

$$= \sum_{t=0}^{\infty} \sum_{a=1}^{D} \left(\frac{1}{1+\beta}\right)^{t} \left(\frac{1+\beta}{1+\delta}\right)^{a-1} p_{a,t}\, v(C_{a,t}, g_{t}, g_{1t}, g_{2t}, g_{3t})$$

$$= \sum_{t=0}^{\infty} \sum_{a=1}^{D} \left(\frac{1}{1+\beta}\right)^{t} \theta_{a} p_{a,t}\, v\,(C_{a,t}, g_{t}, g_{1t}, g_{2t}, g_{3t})$$

where β, θ_a, $P_{a,t}$ and P_p are the discount rate, with which the social planner discount against the future cohorts' welfare, the social planer's weight on each age group's welfare in the social welfare function, the population of each age group at the year t, and the number of the newborns at the year p.

The first line of equation (2) is the definition of the social welfare function, and the second line is derived from the definition of each cohort's lifetime expected utility. By changing the order of the indices for the year and the year of cohort, the third line is derived, and the fourth line is derived by rearranging the index for the year of birth in terms of the age at each year. The last line of the equation defines the weight on each cohort’s welfare in the social welfare function (θ_a). The weight relies on the relative magnitude of the individual's time preference and the discount rate of the social planner. If the two discount rates are the same, the weight is the same for all the cohorts.[3)]

We assume that the preference for the private consumption and the public goods is separable for the simplicity of the analysis. The utility function v(·) and social welfare function can be expressed as equation (3) and equation (4), respectively.

$$v\,(C, g, g_1, g_2, g_3) = u(C) + z(g) + z_1(g_1) + z_2(g_2) + z_3(g_3) \tag{3}$$

$$\overline{U} \equiv \sum_{t=0}^{\infty} \sum_{a=0}^{D} \theta_a\, P_{a,t}\, (u(C) + z(g_t) + z_1(g_{1t}) + z_2(g_{2t}) + z_3(g_{3t}))(1+\beta)^{-t} \tag{4}$$

3) The utilitarian social welfare function which adds each cohort's welfare, generates the same level of consumption for all the cohorts adjusted productivity growth, which is the same resource allocation as under the Rawlsian type social welfare function, since the social welfare function does not take into account the intra-cohort hetetrogeneity in terms of labor productivity.

We assume that the utility functions for the private consumption and public goods are as follows.

$$u(C) = \frac{1}{1-\gamma} C^{1-\gamma} \tag{5}$$

$$z(g) = \frac{1}{1-\eta} \left(A \cdot g \Big/ \left(\sum_{a=1}^{D} P_a\right)^{\emptyset}\right)^{1-\eta} \tag{6}$$

$$z_1(g_1) = \frac{1}{1-\varepsilon_1} \left(B_1 \cdot g_1 \Big/ \left(\sum_{a=1}^{19} P_a\right)^{\zeta_1}\right)^{1-\varepsilon_1} \tag{7}$$

$$z_2(g_2) = \frac{1}{1-\varepsilon_2} \left(B_2 \cdot g_2 \Big/ \left(\sum_{a=20}^{64} P_a\right)^{\zeta_2}\right)^{1-\varepsilon_2} \tag{8}$$

$$z_3(g_3) = \frac{1}{1-\varepsilon_3} \left(B_3 \cdot g_3 \Big/ \left(\sum_{a=65}^{D} P_a\right)^{\zeta_3}\right)^{1-\varepsilon_3} \tag{9}$$

where γ, η, ε_1, ε_2 and ε_3 are the risk aversion parameters in the utility functions of private consumption, and public consumption, and A, B_1, B_2, and B_3 are the intensity of preference for each public good. $\emptyset$, ζ_1, ζ_2 and ζ_3 are the degree of non-rivalry (rivalry coefficient, henceforth) of each public good. The value 0 for these parameters represents the perfect non-rivalry of the public goods, the positive value represents the existence of the rivalry, and the value 1 means that the degree of the rivalry of the public goods is the same as private consumption.

The social planner's resource constraint and government intertemporal budget constraint are as follows.

$$\sum_{t=0}^{\infty}\sum_{a=1}^{D} \frac{p_{a,t}\, C_{a,t}}{(1+r)^t} \le \sum_{t=0}^{\infty}\sum_{a=1}^{D} \frac{p_{a,t}\,(w_{a,t} + TR_{a,t} - \tau_{a,t})}{(1+r)^t} + W_t \tag{10}$$

$$\sum_{t=0}^{\infty} \frac{1}{(1+r)^t} \left(g_t + g_{1,t} + g_{2,t} + g_{3,t} + \sum_{a=1}^{D} p_{a,t}\,(TR_{a,t} - \tau_{a,t})\right) - Wg_t \le 0 \tag{11}$$

where r, w, TR, τ, W, and W_g are interest rate, wage, government transfer payment, tax, household wealth and government net wealth, respectively.

The social planner's resource constraint is that the present value of the total consumption has to be not less than the sum of net wealth accumulated and the present value of total non-capital income, in the form of labor income and the net transfer income from the government (=transfer from the government minus tax burden). The government budget constraint means that the present value of the sum of government purchase and transfer payment, the negative value of government transfer income, has to be not less than the present value of government tax revenue and government net wealth.

The conditions for the social optimal resource allocation are as follows,

$$\frac{C_{i,t}}{C_{j,t}} = \left(\frac{\theta_i}{\theta_j}\right)^{\frac{1}{\gamma}} \tag{12}$$

$$\frac{C_{a,t+1}}{C_{a,t}} = \left(\frac{1+r}{1+\beta}\right)^{\frac{1}{\gamma}} \tag{13}$$

$$g_t = \frac{1}{A}\left(\theta_a \Big/ \sum_{a=1}^{D}\theta_a P_{a,t}\right)^{-\frac{1}{\eta}} C_{a,t}^{\frac{\gamma}{\eta}}\left(\sum_{a=1}^{D}\theta_a P_{a,t}\right)^{\text{Ø}} \tag{14}$$

$$g_{1t} = \frac{1}{B_1}\left(\theta_a \Big/ \sum_{a=1}^{D}\theta_a P_{a,t}\right)^{-\frac{1}{\varepsilon_1}} C_{a,t}^{\frac{\gamma}{\varepsilon_1}}\left(\sum_{a=1}^{19}\theta_a P_{a,t}\right)^{\zeta_1} \tag{15}$$

$$g_{2t} = \frac{1}{B_2}\left(\theta_a \Big/ \sum_{a=1}^{D}\theta_a P_{a,t}\right)^{-\frac{1}{\varepsilon_2}} C_{a,t}^{\frac{\gamma}{\varepsilon_2}}\left(\sum_{a=20}^{64}\theta_a P_{a,t}\right)^{\zeta_2} \tag{16}$$

$$g_{3t} = \frac{1}{B_3}\left(\theta_a \Big/ \sum_{a=1}^{D}\theta_a P_{a,t}\right)^{-\frac{1}{\varepsilon_3}} C_{a,t}^{\frac{\gamma}{\varepsilon_3}}\left(\sum_{a=65}^{D}\theta_a P_{a,t}\right)^{\zeta_3} \tag{17}$$

Equations (12)-(13) show the optimal conditions for private consumption. Equation (12) shows that each individual's consumption level at each period is the same across age groups, at the social optimal allocation if the social planner values each cohort's welfare the same. Equation (13) implies that the optimal consumption path for an age group overtime depends on the relative magnitude of the social planner's discount rate and interest rate. Equations (14)-(17) are the optimal conditions for the non-age-specific and age-specific public good provision. The optimal level of public good provision depends on the relative magnitude of the risk aversion coefficients of public goods (η, ε_1, ε_2, ε_3) and that of private consumption (γ), the preference intensity for public goods (A, B_1, B_2, B_3), and rivalry coefficients (Ø, ζ_1, ζ_2, ζ_3). The risk aversion coefficients affect the relative per capita level of public provisions and private consumption overtime, the preference intensity affects the absolute level of optimal public good provision at a given period, and rivalry coefficients determines the optimal time path of total public good provision along the path of demographic transition.

2. Optimal Tax Structure

We define the optimal tax structure as the tax structure that induces the optimal resource allocation, derived in section II.1, in the economy that consists of individuals without any altruistic linkage with other generation: i.e. the optimal tax structure induces the selfish individuals, who maximize their own lifetime expected utility, to make decisions on consumption and savings that result in the socially optimal resource allocation.

The optimal tax structure consists of the optimal tax burden ratio and the optimal effective tax rates across tax bases such as consumption, labor income, and capital income. The optimal tax burden ratio relies on the level of the optimal level of public good provision, which will be discussed in section II.4 and transfer payments paid mainly through the entitlement programs, such as public pensions and public health insurance, whose reform affects the magnitude of its own expenditure with a substantial time lag. Therefore, we focus on the optimal effective tax rate structure in this section, under the assumption that the level of public good provision and the amount of transfer payments are already determined. Once the optimal level of public good provision and transfer payments is given, the optimal effective tax rate structure results in the socially optimal consumption path overtime and the optimal consumption profile across age groups at each period.

The optimization problem of the selfish individuals can be formulated as follows.

$$\max \sum_{a=1}^{D}\left(\frac{1}{1+\delta}\right)^{a-1} u(C_{a,t+a-1}) \tag{18}$$

Subject to

$$\sum_{a=1}^{D}\left(\prod_{s=0}^{a}\left(\frac{1}{1+r(1-\tau_{kt+s-1})}\right)\right)(C_{a,t+a-1}(1+\tau_{ca,t+a-1})-w_{a,t+a-1}(1-\tau_{la,t+a-1})+TR_{a,t+a-1})\leq 0 \tag{19}$$

where τ_l, τ_k, and τ_c are labor income tax rate, capital income tax rate, and consumption tax rate, respectively, and δ is the individual's time preference.

The lifetime expected utility maximization condition is as follows.

$$\frac{C_{a+1,t+a}}{C_{a,t+a-1}}=\left(\frac{1+r\,(1-\tau_{ka,t+a})}{1+\delta}\right)^{\frac{1}{\gamma}}\left(\frac{1+\tau_{ca+1,t+a}}{1+\tau_{ca,t+a-1}}\right)^{\frac{1}{\gamma}} \tag{20}$$

The socially optimal conditions for private consumption, equations (12)-(13), can be rearranged as the following equation (21).

$$\frac{C_{a+1,\,t+1}}{C_{a,t}} = \left(\frac{C_{a+1,\,t+1}}{C_{a,t+1}}\,\frac{C_{a,t+1}}{C_{a,t}}\right) = \left(\frac{1+r}{1+\beta}\right)^{\frac{1}{\gamma}} \left(\frac{\theta_{a+1}}{\theta_a}\right)^{\frac{1}{\gamma}} \tag{21}$$

The optimal effective tax rate structure, under the assumption that the social planner puts the same value for all the individuals' welfare, can be derived by comparison of equation (21) with equation (20). The optimal tax structure consists of equations (19), (22), and (23).

$$\tau_{ka,t+a-1} = 0 \tag{22}$$

$$\tau_{ca,t+a-1} = \tau_{ca+1,t+a} \tag{23}$$

The characteristics of the optimal effective tax rate structure are summarized as follows. First, there should be no distortion of the inter-temporal resource allocation, which is satisfied by two conditions: (i) capital income tax rate is 0; and (ii) the effective consumption tax rate is the same for each individual’s remaining lifetime. It is remarkable that the labor income tax is lump-sum tax under the assumption of inelastic labor supply, which implies that there is no intra-temporal distortion between labor supply and consumption.[4] Therefore, only the efficiency of the inter-temporal resource allocation needs to be considered to derive the optimal consumption tax structure. Another feature of the optimal effective tax rate structure is that the tax burden of the cohort with larger net transfer income (=transfer income - social insurance contribution) from the government should have heavier tax burden. In other words, even though each individual's consumption tax rate should be the same for her remaining lifetime, the tax burden across generations should be differentiated depending on the magnitude of her net government transfer income (see equation (19)).

4) The conditions for no intra-temporal distortion between consumption and labor supply, under the assumption of elastic labor supply, is that the sum of consumption tax rate and labor income tax rate should be 0: i.e. imposition of consumption tax (labor income tax) should be accompanied by the subsidy for labor supply (consumption) with effective subsidy rate which is the same as the tax rate. This optimal tax structure is hardly sustainable if the required tax revenue is large

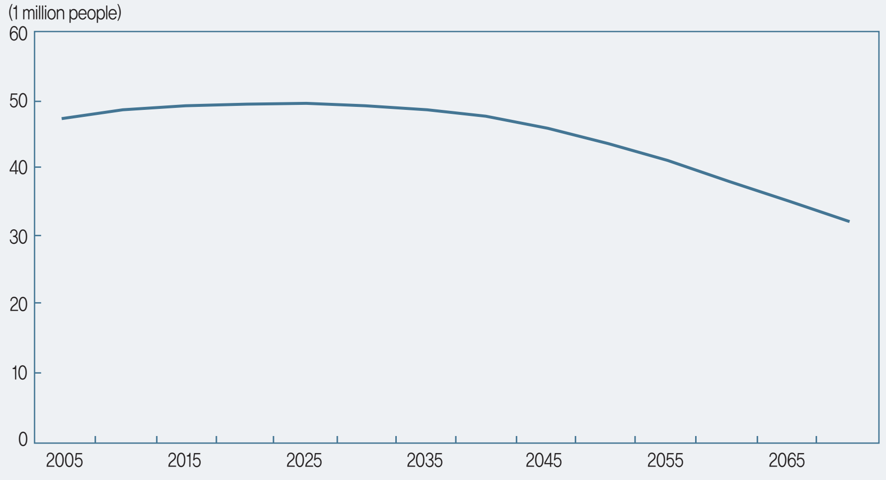
3. Calibration

This section explains the projection procedure of demographic structure, the wage structure, the net government transfer, and the parameterization of preference for private goods and public goods.

A. population projection

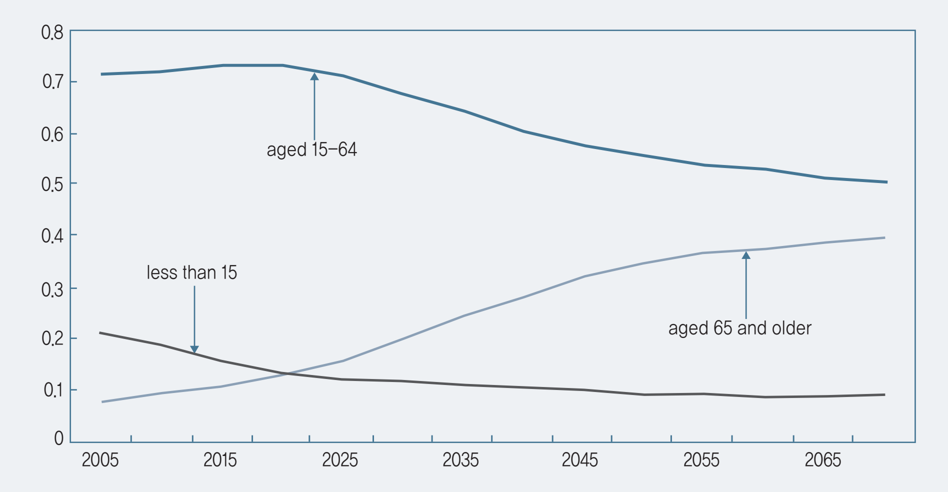
The population by age and sex overtime, which will be used in the projection of government transfer payment, the optimal level of public good provision, and social insurance contribution, is projected based on the 2005 population projection model of the National Statistics Office (NSO). For the period until 2050, we reproduce the population projection results of the NSO's 2005 projection, and we extend the projection until 2070,[5] assuming that fertility rate, survival rate, and the rate of international population movement rates remain at the year 2050's levels. The projected total population and age structure for the period until 2070 are shown in Figures 1-2.

Figure 1 Total Population (unit: 1 million people)



5) We extend the projection until the year 2070, when the population proportion across age group becomes stable, because the prediction of the optimal tax burden ration requires the extension of the period of the analysis until the economy converges the balanced growth path, where the demographic structure is stable.

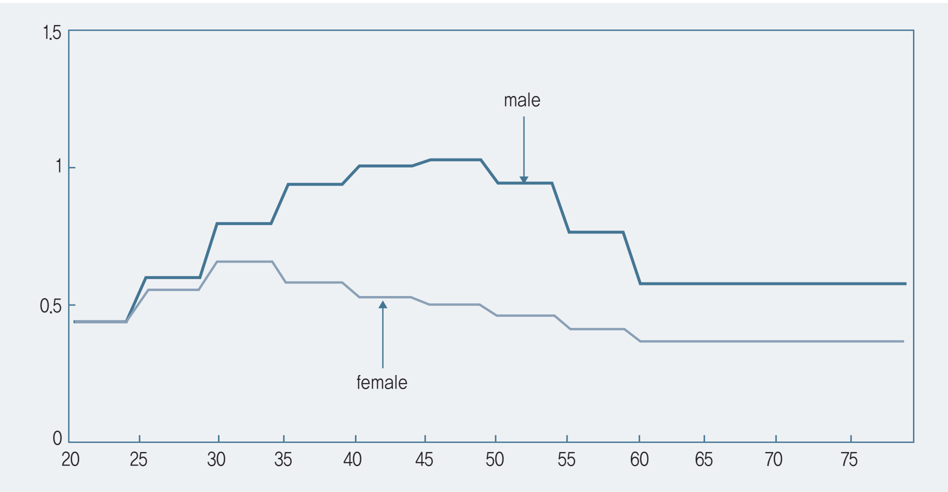
Figure 2 Population Proportion by Age Groups



B. Wage Structure Projection

The wage level by sex and age overtime determines the resource constraint of the social planner (see equation (10)). We take 2 steps to project the wage structure overtime. First, we estimate the wage structure at the benchmark year, by assuming that the sex-age wage profile is the same as that reported in Ministry of Labor (2003). We allocate the total wage income of the year 2003,

Figure 3 Wage Profile



assumed 60% of GDP, across sex and age groups according the assumed wage profile. Then, we compute the wage by sex and age for the period after the benchmark year, assuming that the wage growth rate is 1.5% per annum and that the wage profile remains the same as that at the benchmark year.

C. Preference Parameters

We specify the parameters of preference for the private consumption and public goods based on the assumption of the balanced growth path and the estimation results of public good demand function explained in the appendix. The demand function, specified in the appendix, is derived from the median voter theorem. The optimization problem of the median voter is as follows.

$$\max u(C) + z(g) + z_1(g_1) + z_2(g_2) + z_3(g_3) \tag{24}$$

Subject to

$$C + P_g(g + g_1 + g_2 + g_3) \leq Y \tag{25}$$

where P_g and Y are the price of public goods and the median voter's income, respectively.

The median voter's optimization conditions are the following equations (25)-(28).

$$g = \frac{1}{A} P_g^{-\frac{1}{\eta}} C^{\frac{\gamma}{\eta}} \left(\sum_{a=1}^{D} P_a \right)^{\varnothing} \tag{25}$$

$$g_1 = \frac{1}{B_1} P_g^{-\frac{1}{\varepsilon_1}} C^{\frac{\gamma}{\varepsilon_1}} \left(\sum_{a=1}^{19} P_a \right)^{\zeta_1} \tag{26}$$

$$g_2 = \frac{1}{B_2} P_g^{-\frac{1}{\varepsilon_2}} C^{\frac{\gamma}{\varepsilon_2}} \left(\sum_{a=20}^{64} P_a \right)^{\zeta_2} \tag{27}$$

$$g_3 = \frac{1}{B_3} P_g^{-\frac{1}{\varepsilon_3}} C^{\frac{\gamma}{\varepsilon_3}} \left(\sum_{a=65}^{D} P_a \right)^{\zeta_3} \tag{28}$$

Assuming that the price elasticity of public goods are the same $\left(\frac{1}{\eta} = \frac{1}{\varepsilon_1} = \frac{1}{\varepsilon_2} = \frac{1}{\varepsilon_3}\right)$, we set the value of the risk aversion parameters (η, ε_1, ε_2, ε_3) as 2.8, based on the estimated price elasticity of public good, 0.36. In the balanced growth path, where the private consumption grows at the same speed of income, $\frac{\gamma}{\eta}\left(= \frac{\gamma}{\varepsilon_1} = \frac{\gamma}{\varepsilon_2} = \frac{\gamma}{\varepsilon_3}\right)$ is the income elasticity of public good consumption. We set the value of γ as 2.2, based on the fact that the estimated income elasticity of public good, is about 0.8.[6)]

We assume the value of parameters of preference intensity (A, B_1, B_2, B_3) and rivalry coefficients (Ø, ζ_1, ζ_2, ζ_3) based on the estimated elasticities of public good demand with respect to the demographic variables. The estimation results show that the elasticity with respect to the total population is 0.9 and that change in the population proportion across age groups, with the total population unchanged, does not affect the demand elasticity, which implies that the changes in the demand for g_1, g_2, g_3 due to the population proportion change offset each other so that the sum of on the age-specific public good demand does not change. Considering these results and the equations (25)-(28), we set the rivalry coefficient of the non-age-specific public good (Ø) as 0.82 and those of age-specific public goods (ζ_1, ζ_2, ζ_3) as 1, and we set the same values for the preference intensity (B_1, B_2, B_3). The value for Ø, 0.82 is chosen, considering the fact that the proportion of non-age-specific public good expenditure as of 2004 is 57% and the elasticity of age-specific public goods is 1, so that the weighted average of the demand elasticities of public goods with their weight being the expenditure proportions is 0.9. The preference intensity parameters (A, B_1, B_2, B_3) are chosen so that the proportion of non-age-specific public good as of 2004 is reproduced in the model constructed.[7)]

6) We assume higher value for the income elasticity (0.8) than the estimated value (0.78, taking into account the measurement error in the explanatory variables used in the estimation of the public good demand function (see Appendix), that might cause the downward bias. The value assumed risk-aversion parameter, 2.2, is lower than the standard value adopted in the lifecycle models with the time unit being one year (4). The lower value is a reasonable compromise because the majority of the existing empirical researches showed that the coefficient of the risk aversion in Korea is lower than 4.

7) We classify the government purchase on education, social welfare, and health care as age-specific and the other government purchase as non-age-specific. The incidence of the benefit from the age-specific public good provision is allocated according to the estimated age-sex profiles of the benefits from the public goods estimated in Auerbach and Chun (2006).

We set the optimal level of public good provision at the benchmark year is the same as that as of 2004, considering the fact that drastic change in the public good provision is not usually possible and the provision level usually change gradually overtime. In addition, the predicted optimal level for the recent years, predicted with the estimated demand function and the recent years' realized explanatory variables, is not much different from the actual values of recent years.

The discount rate of the social planner, β, is chosen using the following equation (29) derived from the assumption of the balanced growth path.

$$\beta = (1 + g_w)^{-\gamma}(1 + r) - 1 \tag{29}$$

where the real interest rate (r) is assumed 3.5% per annum based on the recent realized value of the rate of return of government bonds.

Finally, we assume that the time preference of individuals, δ, is the same as the discount rate of the social planner, β, so that the weight of each cohort's utility in the social welfare function is the same.

D. Projection of net government transfers

We assume that the current government transfer programs maintain for the future period, since they are mainly composed of the entitlement programs, the revision of which affects the government budget with sustaintial time lag in many cases such as public pensions. Therefore, it is not realistic to assume that the optimal level of government transfers is realized at present.

The scope of government transfer program covers the social insurance programs, which consist of public pensions, public health insurance, employement insurance, and worker's compensation, and social transfer programs related with social welfare and health care. The net transfer payment by the social insurance program is defined as the transfer payment minus social insurance contribution. In the case of the social transfers by the social welfare and health care programs, financed by the tax revenue, we treat their expenditure as the net transfer payment itself.

We project the net transfer payment to each age-sex group overtime using the method of Auerbach and Chun (2007). The projection consists of two parts: (i) projection for public pensions; and (ii) projection for the other programs. For (i), we construct the projection model in order to take explicit account the changing age-sex profile of the public pension benefits and the pension contributions overtime due to the maturation of public pensions, whose history is very short at present, and the population aging. For most of the programs belonging to the group (ii), per capital expenditure levels of the relevant age-sex groups are assumed to increase at the rate of the productivity growth. The exceptions are the benefits of the public health insurance and other social welfare benefits such as public aid to lower income classes and social welfare services to the elderly, women and children. Their per capita levels of relevant age-sex groups are assumed to increase at the rate of per capita GDP growth multiplied by the income elasticity (1.2)[8], until the ration of the aggregate amount to GDP reaches the OECD average as of 1995, and then at the rate of the productivity growth.

4. Projection Results

A. Optimal Consumption Level

The Equations (12)-(13) imply that at the social optimum, the consumption level needs to be the same for every age-sex group, under our calibration, which provides the same weight on every individual's welfare. And, the assumption of the balanced growth path implies that the optimal consumption level by age and sex grows overtime at the labor productivity growth rate.

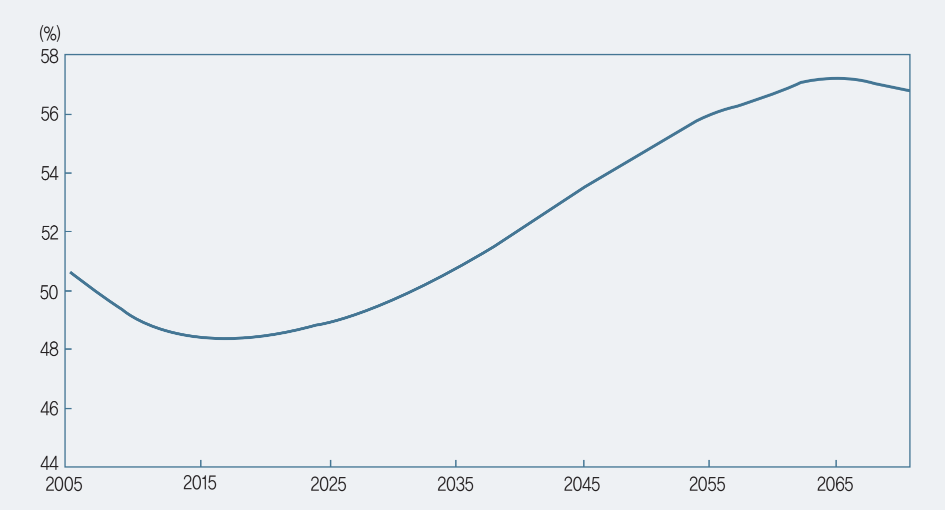
The optimal consumption profiles and the demographic transition overtime produce the optimal aggregate consumption level overtime (see Figure 4). The optimal aggregate consumption level, measured as percentage of GDP, is closely related with demographic structure. Figure 4 shows that the consumption ratio, defined as the private consumption proportion out of GDP, rise with population aging, reflecting the fact that the decline in the proportion of working age groups due to the population aging implies slower increase in production than that of consumption.

B. Optimal Public Good Provision

The optimal level of the public good provision and the proportion by its type, projected with the equations (14)-(17), is shown declining overtime at the base case (see Figures 5-6). This is primarily due to the fact that the assumed income elasticity of public good demand is lower than 1 (0.8), which implies that optimal level of public good provision grows slower than GDP.

8) The income elasticity of government expenditure on health care is based on estimates by Newhouse (1997), Leu (1983, 1986), Gertham et al. (1998, 1992) and the OECD (1993), whose values range between 1.2 and 1.4. Exceptionally low or high estimates are produced by Gerdtham (1991, 1992) (0.74), Moon (2000) (1.75) and the OECD (1993) (1.6). In the case of government expenditure on social security and welfare services, Moon (2000) produced a high income elasticity estimate (1.54). We make a very conservative assumption about the income elasticity (1.2) in order to avoid over-projection of government expenditure in these sectors.

Figure 4 Optimal Aggregate Consumption (% of GDP)



The optimal level of the non-age-specific public good provision, measured as percentage of GDP is declining, but less rapidly than the total population (see Figure 1 and Figure 5), because its assumed rivalry coefficient is less than 1, 0.82. In other words, because of the non-rivalry of the public good, the magnitude of the optimal public good provision decreases less rapidly than the total population.

The optimal level of the age-specific public good provision changes for a considerable time along with the change in the demographic structure. The optimal level of the public good provision for the aged 65 and older is projected to increase until around 2060, due to the population aging. However, the optimal level is projected to decline eventually, because the income elasticity of the public good demand is lower than 1.

The optimal level of public good provision is quite sensitive to the level of the rivalry coefficient and the income elasticities. As mentioned in the Appendix, the estimation of the income elasticities and the rivalry coefficient might be involved with measurement error. We tried a sensitivity analysis, under an alternative assumption that the income elasticities are 1's and the rivalry coefficient is 1, which is the same as the case of the private consumption. Under the alternative assumption, the optimal level of the public good provision is projected to rise up to 27% of GDP, which is much higher than that in the base case. The higher optimal level is primary due to the increase in the age-specific public good for the aged 65 and older resulting from the population aging.

Figure 5 Optimal Public Good Provision (base case, % of GDP)

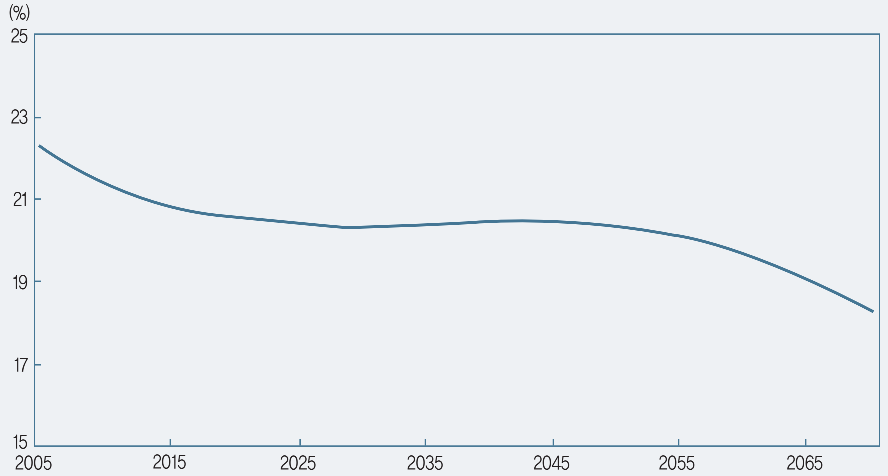


Figure 6 Optimal Public Good Provision by Type (base case, % of GDP)

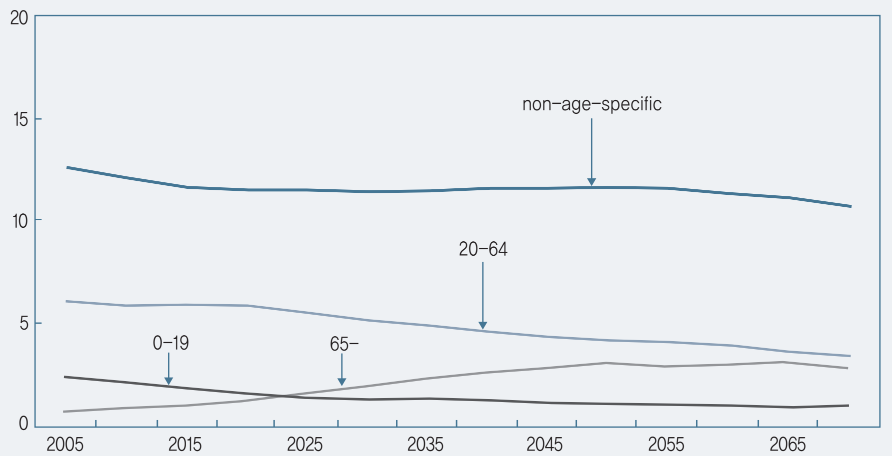


Figure 7 Optimal Public Good Provision (sensitivity analysis, % of GDP)

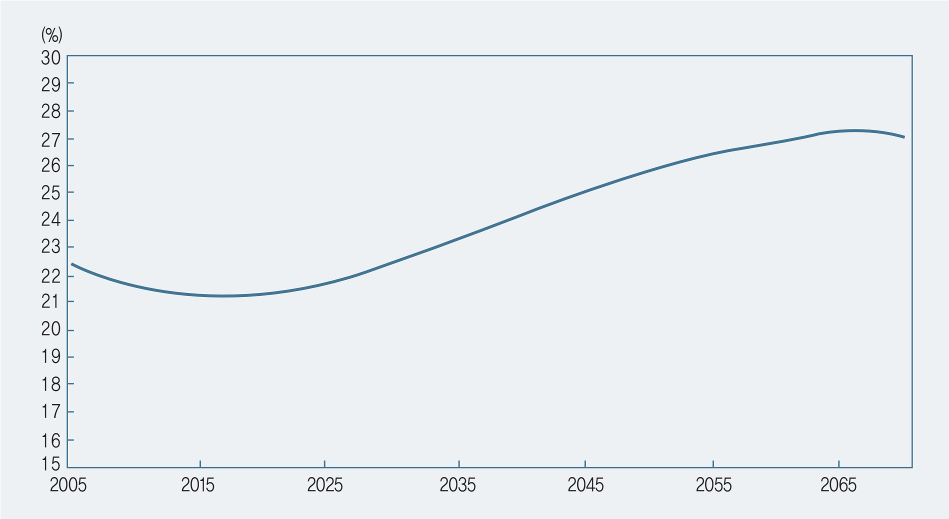
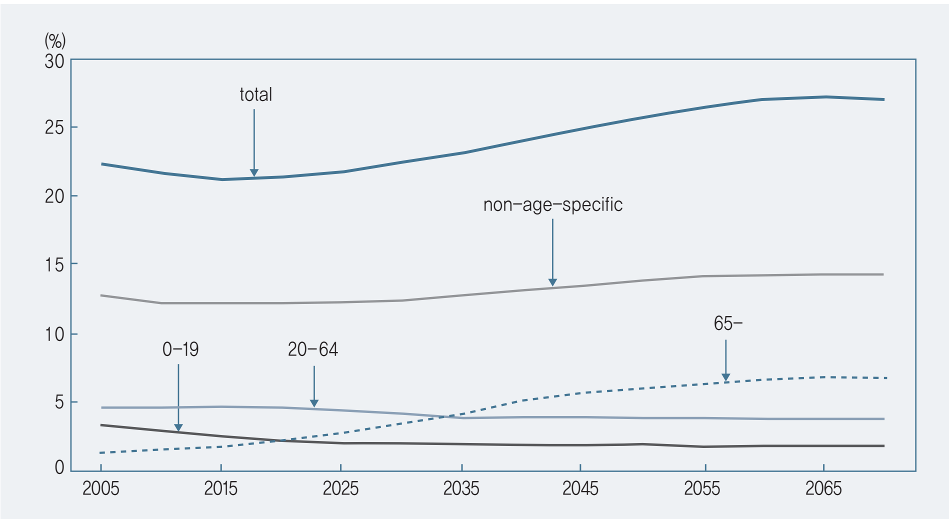


Figure 8 Optimal Public Good Provision by Type (sensitivity analysis, % of GDP)



C. Optimal Tax Burden by Cohort

The optimal tax structure derived in section II.1 has the following features: (i) the capital income tax rate is 0; (ii) the effective consumption tax rate is the same for each individual's remaining lifetime; and (iii) the tax burden across generations should be differentiated depending on the magnitude of her net government transfer wealth. It is remarkable that the labor income tax is a lump-sum tax, since we assume the inelastic labor supply. Therefore, the optimal tax burden across cohorts is affected by the proportion of the tax burden for each cohort. We assume that the effective tax rates of the two taxes are the same.[9)]

We compute the optimal consumption (labor income) tax rates, across cohorts, satisfying the conditions for the optimal private and public good consumption structure (see equations (12)-(17)), the social planner's resource constraints (equation (10)), the government's intertemporal budget constraint (equation (11)), the indiviaual's lifetime resource constraint (equation (19)), in the presence of differing net government transfer wealth across cohorts due to the intergenerational redistribution resulting from the current social welfare policies.

The optimal tax rates and the present value of the tax burden for the remaining lifetime (PVTBL)[10)], computed with optimal tax rates, are shown in Figures 9-10.[11)] The optimal tax rates and PVTBL for the middle aged groups as of 2004 are relatively high compared with those for the old age groups. This profile of the PVTBL is due to the fact that the transfer payment to the middle-aged groups as of 2004 is very large under the current policies. The low level of the PVTBL for the old age groups is partly due to the fact that their expected remaining lifetime is short and more importantly due to the fact that their transfer income from the government is very low under the current policies.[12)] For example, the National Pension (NPS), which is one of the most important policies in the Korean social welfare policies, does not cover most of the currently aged 65 or older, while the NPS makes substantial transfer payments to the current middle-aged groups through the combination of the small pension contribution burden and the large pension benefits. The PVTBL is higher for the cohorts born later, because we assume the balanced growth path, where the consumption is rising with the labor productivity growth.

The optimal tax burden across cohorts is closely related with the level of the optimal public good provision, which affects the optimal level of government purchase. The sensitivity analysis, under the alternative assumption that the

9) We assume that a part of the tax revenue is raised from the labor income, because taxing only consumption tax might cause liquidity constraint for the aged population groups without any labor income.

10) The present value (PVTBL) is evaluated as of the benchmark year for the cohorts alive at the benchmark year. For the cohorts born after the benchmark year, the PVTBL is evaluated as their year of birth.

11) The cohort 1 is the cohort of the newborn in 2004. The indices lower (higher) than 1 are those for the cohort older (younger) than the cohort 1.

12) Figure 9 shows that the effective tax rate for the cohorts older than 80 as of 2004 is rapidly rising as the rise of the age, even though the older cohort PVTBL is quite low, due to the fact that the magnitude of the tax base for these old cohorts without any labor income is very small

income elasticities are 1's and the rivalry coefficient is 1, produces a bit higher optimal effective tax rates and optimal tax burden across generations, however, does not produce any different shapes of optimal effective tax rates and tax burden.

Figure 9 Optimal Tax Rate by Cohort (base case)

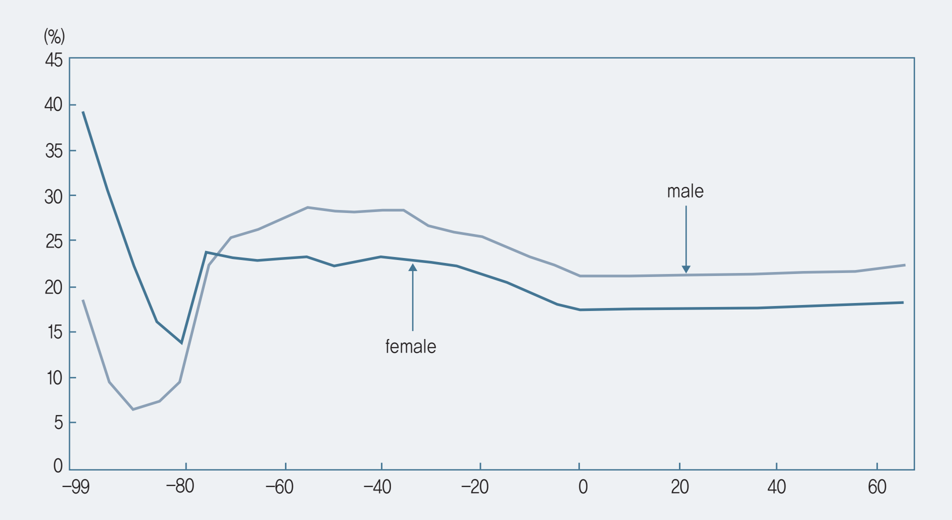


Figure 10 Optimal Per Capita Tax Burden by Cohort (Unit: 1 billion won)

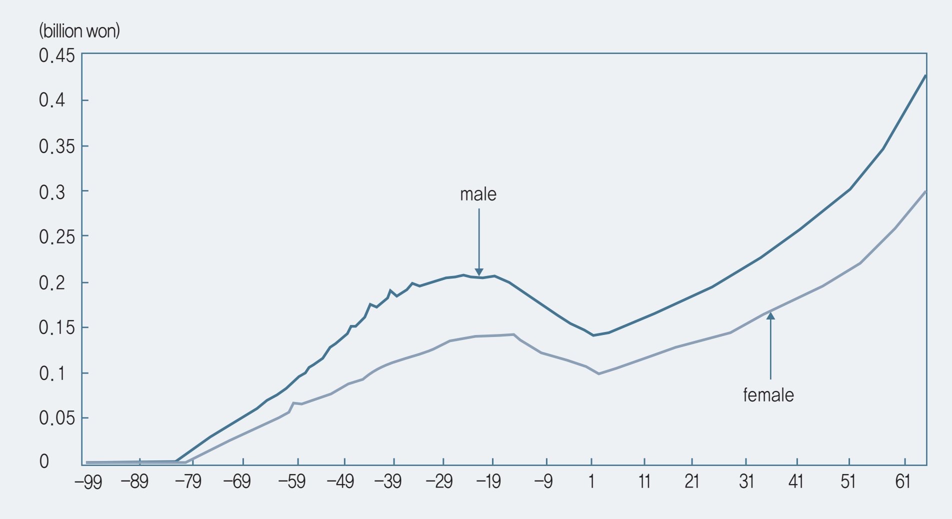


Figure 11 Transfer Income from Goverment (base case, ratio to the transfer income of Cohort 1)

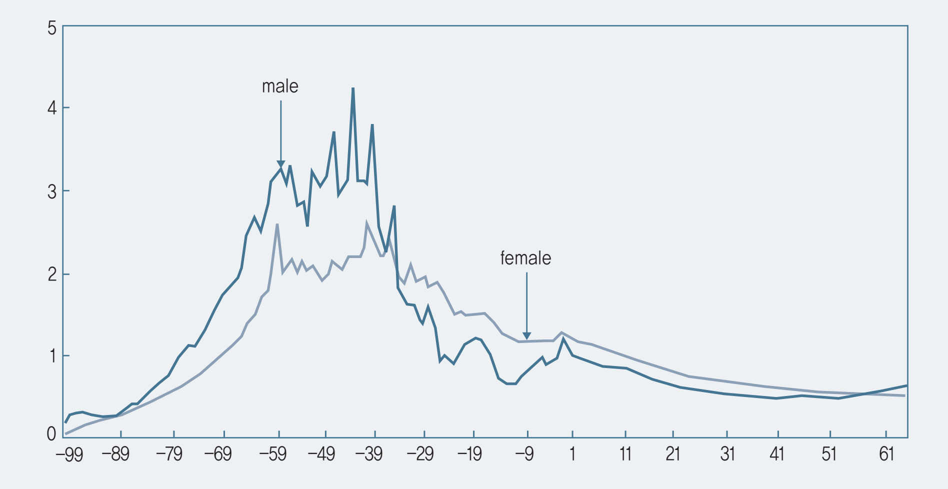
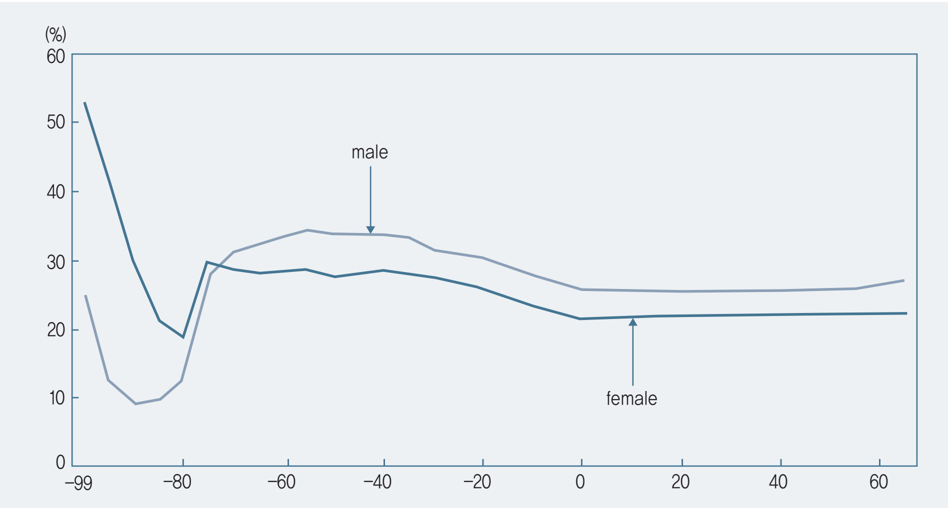


Figure 12 Optimal Tax Rate by Cohort (sensitivity analysis)



D. Optimal Tax Burden Ratio

The optimal tax burden ratio, computed with the projected optimal tax burden across cohorts and the projected demographic structure overtime, is about 27.5% as of 2004, which is higher than the year 2004's actual tax burden ratio (20%). However, the optimal level is projected to decline overtime to reach 23-24% around 2070 (see Figure 13). The declining trend in the optimal tax burden ratio, resulting from the declining optimal effective tax rates across cohorts, suggests that the tax system needs to mitigate the intergenerational inequity resulting from the social insurance policies, such as public pensions: i.e. the cohorts with larger (smaller) transfer wealth from the government should have larger (smaller) tax burden.

As mentioned already, the optimal level of public good provision much affects the optimal level of tax burden across generations. The sensitivity analysis under the alternative assumption that the income elasticities are 1's and the rivalry coefficient is 1, produces a bit higher optimal tax burden ratio, however, does not produce any different shapes of optimal tax burden ratio overtime.

III. Projection of Actual Tax Burden Ratio

In this section, we project the actual tax burden ratio for the future period, and compare this projected trend with the projected optimal tax ratio in order to get policy implications. We take two steps in the projection. First, we estimate the actual tax burden ratio determination equation, using an inter-country panel data which cover the OECD countries' tax and economic structure, under the assumption that the Korean economy will follow the path of economic development, which the currently developed countries experienced. This assumption is based on the convergence hypothesis, derived from the optimal growth theory, which implies that the countries with similar socio-economic structure will eventually converge to the same economy. We also assume that Korea's fiscal policies will follow the path of fiscal policies that the currently developed countries implemented. Second, we predict the actual tax burden ratio based on the estimated actual tax burden ratio determination equation and the predicted Korea's socio-economic structure for the future period.

The estimation equation is specified as the following equation (30).

$$Y_{it} = \alpha_i + \beta_1 X_{1it} + \beta_2 X_{2it} + u_{it} \tag{30}$$

where Y_i, X_{1i}, and X_{2i} are tax burden ratio of country i, the explanatory variables representing the country i's the ability of public good provision, and those representing the demand for public goods, respectively. The constant α_i is introduced to control the country-specific characteristics of tax structure.

The estimation equation (30) implies that the country i's government raises the tax revenue as much as α_i percent of the country's national income first, and then adjust the tax revenue depending on the public good provision ability and the demand for the public goods.[13)]

The public good provision ability can be represented by the stage of economic development, the industrial structure, the degree of economic openness, and the degree of population aging. The index usually used to reflect the stage of economic development is the per capita national income. We expect the positive correlation between the per capita national income and the actual burden ratio, because of the following reasons: (i) the underdeveloped countries usually have limited abilities to raise income tax due to the underdeveloped tax administration system and high degree of the dependency on the small business in income generation; and (ii) these countries have limited abilities to raise indirect tax due to high share of small businesses and informal sector in the distribution industry, which makes the tax administration more difficult.

The index widely used for the industrial structure is the share of agricultural sector in the economy. In the underdeveloped countries, a large part of the agricultural sector income is not monetized. In addition, the agricultural production is performed by the small business, which makes the taxation on the agricultural income difficult. Therefore, a large share of agricultural sector in the underdeveloped countries implies smaller tax burden ratio.

The openness of the economy is expected to increase the tax revenue raising ability, in the sense that the openness usually increases the national wealth. However, once its effect on the national wealth is controlled, the openness of the economy on the tax raising ability depends on the relative degree of the ability to tax on the exports and imports compared that to tax on the domestic sectors. In the case of the underdeveloped countries, taxing on export and import sector is easier than on the domestic sector, the large share of which is taken by the agricultural sector, which is difficult to tax on. The administration of tariff on the import is relatively easy. The tax administration of export taxes is also easier than the non-export sectors, because the most of the exported goods are produced by large corporations. In the case of the developed countries, the positive correlation between the openness of the economy and taxing abilities is hardly expected, because the effective tax rates of tariff is quite low and the export is not taxed more heavily than the domestic sectors.

The population aging affects the tax burden ratio through the effects on the per capita income. Recent empirical research showed that the population aging tended to reduce the per capita income. For example, An and Jeon (2006)

13) The estimation specification is basically the similar to that of An and Son (1996) and An (2004).

showed the inverted U-shaped relationship between the population aging and the GDP per capita: i.e. at the early stage of the population, the GDP per capita tends to increase rapidly, however, the growth rate of the per capita GDP declines once the income level reaches a certain level, and the level of the per capita GDP tends to fall eventually. Therefore we expect the population aging to reduce the tax burden ratio, or at least to decrease its growth rate.

The demand for public goods is reflected in the government consumption and investment, and population aging. The increase in the government consumption and investment increases the required tax revenue, which makes the government inevitably raise tax burden ratio. Increase in the proportion of the aged is likely to raise the tax burden ratio, because the population aging implies the increase in the demand for the social welfare expenditure of public pensions, medical insurance, and public aid to poor households.

Considering these facts, we include the log(per capita GDP), the share of the agricultural sector in GDP, the ratio of exports and imports to GDP (as an index for the openness of the economy), the proportion of government consumption out of GDP, and the population proportion of the aged 65 and older as explanatory variables in the estimation equation. We use the log of tax burden ratio (TBR) and the log of tax and social insurance contribution burden ratio (TBSCR) as the dependent variable. We extract the series of these variables for the 30 OECD countries from the World Development Indicator 2005 (WDI2005) and construct the inter-country panel data, which covers the period 1971-2003.[14)] We include only the statistically significant explanatory variables in order to preclude the problem of the multi-collinearity.

The estimation results (see Table 1) shows that the tax burden ratio is positively related with the per capita income, the ratio of exports and imports to GDP, the government consumption, and the population proportion of the aged 65 and older, which is consistent with our conjecture. Increase in the tax revenue raising ability such as increase in the income and economic openness is shown to raise tax burden ratio. It is remarkable that the absolute value of the coefficient for the ratio of imports and exports to GDP is smaller than those for other variables of the public good provision side. It is due to the tendency that the effective tax rates of tariff become lower and less tax expenditure is provided to the export, as the national income rises. Regarding the demand side of the public goods, the increase in the government consumption raises the tax burden ratio.

14) We exclude Greece from the data set, because WDI2005 does not contain enough information about Greece to estimate the tax burden ratio determination equation.

The proportion of the aged 65 and older has two contradicting effects, because it is related with both the demand and the supply sides of the public goods: (i) increasing effect through the increase in the demand for public expenditure; and (ii) decreasing effect through the decrease in the economic participation rate of the economy wide. The estimation result shows that the demand side effect dominates the supply side effect, which is a similar result as that of An (2004).

We have qualitatively the same results when we use the tax and social insurance contribution burden ratio as the dependent variable. A new result is that the share of agricultural sector is negatively correlated with the tax and social insurance contribution burden ratio, which is consistent with the theoretic implication that in the case of the less developed countries, a large share of the agricultural sector limits the tax administration's tax revenue raising ability.

Table 1 **Estimated Tax Burden Determination Equations**

	Tax Burden Ratio	Tax and Social Insurance Burden Ratio
Constant	−8.7851 (6.6371)	1.0387 (5.7809)
log(GDP per capita)	1.8454** (0.7877)	1.6835*** (0.6108)
Share of Agriculture		−0.2691*** (0.0382)
Ratio of Imports and Exports to GDP	0.0258** (0.0107)	
Share of Government Consumption	0.5350*** (0.0816)	0.83268*** (0.0538)
Proportion of the aged 65 and older	0.4495*** (0.1141)	0.6117*** (0.0828)
Adjusted R^2	0.9317	0.9368

Notes : The figures in the parentheses represent the standard error.
*, **, *** represents statistical significance with confidence levels of 90%, 95%, 99% respectively.

We project the TBR and TBSCR using the estimated TBR (TBSCR) determination equation and the projected explanatory variables for the period 1970-2030 by An (2004). For the period after 2002, the per capita income is projected to rise to reach a peak in 2021 and then to start to fall. The government consumption is projected to rise continuously, but the growth rate is projected to fall from around 2030.

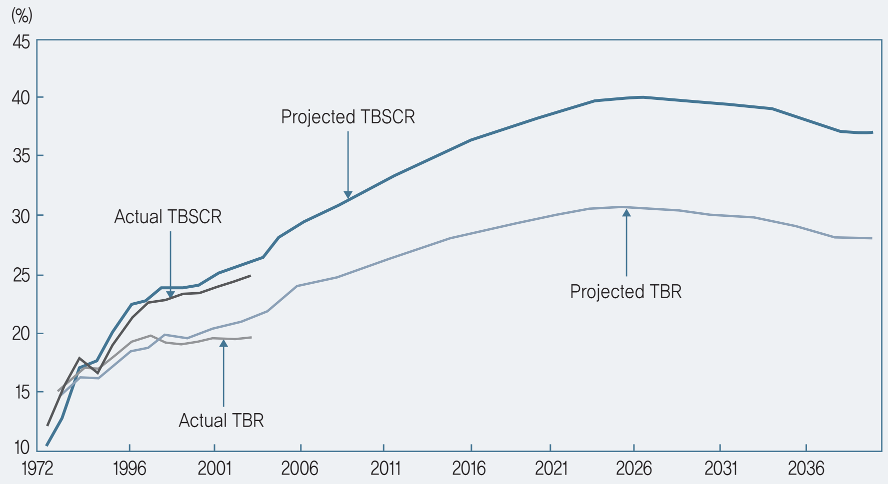
The TBR is projected to rise up to 30.7% around 2026 and then to fall. The TBSCR shows a very similar projected path: projected to rise up to 40.1% around late 2030's and then to fall. The TBR (TBSCR) is projected to rise until 2021, along with the increase in the per capita income, the government consumption, the population proportion of the aged 65 and older. However, the projected growth rate starts to fall around 2021 and it falls around the late 2020's.

It is remarkable that the projected TBR is lower than the optimal TBR projected in section II for a considerable time after the benchmark year (2004). However, the projected actual TBR is rising to exceed the projected optimal TBR after the mid-2010s. The projected optimal TBR for the period 2005-2040 is between 25% and 27%, and then it falls up to 23-24% around 2070.

The projection of the actual tax burden ratio in this section is made under the assumption that Korea will experience the same path of the economic development and the fiscal policies that the currently developed countries experienced. The hypothetical assumption is not totally unrealistic in the sense that the economic growth rate, the path of population aging and economic participation rate tend to follow the developed countries' experience. In addition, the fiscal policies of the developed countries have been usually considered as a benchmark case, when the Korean government is planning fiscal policy revisions. Therefore, it is highly likely that the tax burden ratio will rise rapidly to the level of the currently developed countries.

It is also remarkable that Figure 15 shows a rising tend of the social contribution burden (=TBSCR-TBR) overtime, which implies the fiscal burden, due to the budgetary imbalance of the social insurance, will be shifted to the future generations. The intergenerational inequity resulting from the social insurance policies should be corrected by the adjustment of tax burden ratio. The required adjustment of the tax burden ratio by raising the current generations' tax burden and reducing that of future generation is reflected in the projected path of the optimal tax burden. However, the projected path of the actual tax burden ratio shows the opposite trend of the optimal path, which implies that the current fiscal policies and the path of their development will deteriorate intergenerational inequity.

Figure 15 Projected TBR and TBSCR



IV. Conclusion

We derived the path of the optimal tax burden ratio overtime, which induces the optimal resource allocations that a hypothetical social planner will choose to maximize the social welfare. The optimal tax burden ratio derived using the altruistic family model shows that the optimal tax burden ratio is higher than the actual tax burden ratio for the time being, however, the ratio needs to fall continuously to reach 23-24% around 2070. Even though the optimal ratio is quite sensitive to the preference parameter values, it shows the same downward trend despite the changes of the parameter values.

We also predicted the path of the actual tax burden ratio to compare the trend with the path of the optimal ratio. The actual tax burden, predicted under the assumption that the Korean government maintains the recent tendency of the fiscal policy revisions that make the Korean fiscal policies converge to those of the currently developed countries, shows an upward trend to exceed the optimal ratio around the mid-2010s: i.e. the expected change in the socio-economic environment and the maintenance of the recent tendency that the Korean government consider the case of the currently developed countries as a benchmark case, in the process of revision of fiscal policies, will raise the actual tax burden ratio to the level of the currently developed countries, which is much higher than the predicted the optimal tax burden ratio of Korea. Therefore, the Korean government needs to maintain a cautious position in decision making on fiscal policies likely to result in substantial increases in government expenditure in the future.

Another implication is that the current fiscal policies and the recent tendency of their reform are not effective to correct the intergenerational inequity resulting from the intergenerational redistribution by the social insurance policies. To compensate for the fiscal burden shifted to the future generations through the social insurance, the tax burden for the current generations should be raised while that for the future generations should be reduced, which will result in the downward trend of the tax burden ratio. The predicted trend of the actual tax burden ratio of the opposite direction implies that the maintenance of the recent tendency of the fiscal revision will deteriorate the intergenerational inequity.

For the future research, we plan to extend our projection model, to study the optimal tax structure taking into account the intragenerational equity in addition to the intergenerational equity, which is the focus of this paper. For the analysis of the intragenerational equity, including the fairness of the tax burden across income classes, additional consideration of the effective tax rate structure across tax bases and the progressivity of the tax rate of each tax base is needed. The examination of the reasons to make the discrepancy between the optimal tax structure and the actual tax structure, which will require the investigation of the determinants of the effective tax rates across tax bases and the progressivity, will provide important policy implications.

We also need to revise the estimation of the public good demand determination equation. In particular, the limited availability of data prevented the thorough analysis of the demand for the age-specific public goods in this paper. The improvement of accessibility to microdata sets, such as LIS (Luxemburg Income Study), which covers the wide scope of the countries, will enable the revision of the estimation.

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[Appendix] Estimation of Public Good Demand Equation

We estimate the public good demand function, based on the median voter theorem that under the majority voting system, the public good provision is determined by the preference of the median voter. The demand function can be formulated as follows.

$$\log(Y) = c + a_1\log(pop) + a_2\log(pop\,0019) + a_3\log(pop\,65) + b_1\log(X_1) + b_2\log(X_2) \qquad \text{(A1)}$$

where Y, pop, $pop0019$, $pop65$, X_1, X_2 represent the government purchase (the level of public good provision), total population, the population aged 19 and younger, the population aged 65 and older, the median voter's cost per unit of the public, and the median voter's income, respectively.

To estimate the demand function, we use the inter-country panel data constructed using OECD (2005), containing the information of the revenue and expenditure of the general government on the SNA93 (System of National Accounts 1993) basis, and OECD (2006), containing the information of demographic structure.

The dependent variable, the government purchase, is defined as the expenditure of the general government net of the interest payment, social expenditure cash benefits and the social benefits and social transfers in kind, which is equivalent to the addition of the government consumption and investment. Because the median voter's cost per unit of public good and income are not available from OECD (2005), we instead use the average value of government purchase cost ($\overline{X_1}$) and GDP per capita ($\overline{X_2}$). The biasness due to the measurement error in the $\overline{X_1}$ and $\overline{X_2}$ can be avoided if $\overline{X_1}$ and $\overline{X_2}$ are proportional to X_1 and X_2 ($X_1 = \lambda_1\overline{X_1}$, $X_2 = \lambda_2\overline{X_2}$), because equation (A1) can be transformed to the following equation (A2).

$$\log(Y) = c + b_1\log(\lambda_1) + b_2\log(\lambda_2) + a_1\log(pop) + a_1\log(pop\,0019) + a_1\log(pop\,65) + b_1\log(\overline{X_1}) + b_2\log(\overline{X_2}) \qquad \text{(A2)}$$

Equation (A2) shows that under the proportionality condition ($X_1 = \lambda_1\overline{X_1}$, $X_2 = \lambda_2\overline{X_2}$), the use of $\overline{X_1}$ and $\overline{X_2}$ instead of X_1 and X_2 does not affect the estimates of the price elasticity and income elasticity of the public good demand, but affect the estimate of the constant term. The reliability of this approach depends on the stability of the proportional relationship. We regard the relationship as stable, because the time span of the panel data set that we use is just 11 years, which is not long enough for the relationship to change substantially.

Another technical issue is the existence of the endogeneity bias, resulting from the fact that the explanatory variable X1 is defined as the ratio of the net tax payment to the government purchase, which is affected by the dependent variable. In order to avoid the endogeneity bias, we use the instrumental variable method used in Balestra-Varadharajan-Krishnakumar (1987) and Baltagi (2001).

The estimation results, reported in Table A.1, show that the price elasticity and income elasticity are -0.37 and 0.78, respectively (see model 1). It is remarkable that the income elasticity is below 1, which makes the growth of the public good demand slower than that of income. The elasticity with respect to the population, the rivalry coefficient, is 0.92 which is lower than 1, which implies that the public good is not completely non-rival but that the degree of the non-rivalry is less than that of the private good. The addition of the log(*pop0019*) and log(*pop65*) affects the elasticity with respect to the total population but the magnitude of the change in not very large (see the random effect model 2). It also affects the significance of the price elasticity in the case of the fixed effect model 2, but the significance does not change much: the p-value is 5.9% which is slightly higher than 5%.

It is remarkable that a change in the demographic structure does not change significantly the demand for the public good, if we control the total population. This result implies that the demographic change without change in the total population does not induce a change in the demand for public good as whole, but change only the proportion of the age-specific public goods: i.e. the increase in an age-specific public good demand is completely offset by the decrease in the demand for the other age-specific public goods.

Table A.1 **Estimated Public Good Demand Function (Dependent Variable: log(government purchase))**

Variable	Model 1		Model 2	
	Random	Fixed	Random	Fixed
log(*pop*[1)])	0.924* (0.037)[2)]	0.921* (0.366)	0.841* (0.369)	0.930* (0.668)
log(*pop0019*[1)])	–	–	0.034 (0.311)	0.028 (0.327)
log(*pop65*[1)])	–	–	0.049 (0.104)	0.010 (0.108)
log($\overline{X_1}$[1)])	−0.371* (0.108)	−0.373* (0.119)	−0.356* (0.174)	−0.367** (0.194)
log($\overline{X_2}$[1)])	0.782* (0.055)	0.780* (0.067)	0.781* (0.049)	0.774* (0.094)
Constant	2.024* (0.856)	2.102 (5.633)	2.162* (0.851)	1.443 (6.159)
# of Observations	242	242	240	240

Notes : 1) *pop*: total population, *pop0019*: population of the aged0–19, pop65: population of the aged 65 and older, $\overline{X_1}$: price of public good (= net tax burden / government purchase), $\overline{X_2}$: GDP per capita

2) standard error

* represents statistical significance with confidence level of 95%

** represents statistical significance with confidence level of 90% (p–value is 5.9%).