Public Capital and Government Deficits in an Aging Japan: Simulation Analysis[1]

March 2005

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[1] We all thank Toshihiro Ihori, Satoshi Shimazawa, Yoshifumi Aso, Shin Saito, Yoshiro Tsusui, Mototsugu Fukushige, Yuichi Abiko, Toru Nakazato, Kiyoshi Mitsui, Masayoshi Hayashi, Hiroki Kondo, Takero Doi and Shin-ichi Nishiyama.for their helpful comments. A scholarship from the Ministry of Education, Culture, Sports, Science and Technology (Grant-in-Aid for Scientific Research C, Grant No.15530156) is acknowledged. This research contributes to the research project on social risk at Center for Risk Research of Faculty of Economics, Shiga University, Japan.

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Abstract

This paper examines the effects of several future government policies, particularly the debt policy, the public investment policy, and the tax policy, on future public capital, economic growth, and economic welfare in an aging Japan by using a computational overlapping generations model within a general equilibrium context.

The results obtained in this paper are summarized as follows: Firstly in the short run the reduction of public investment followed by a decrease in outstanding government debts reduces GDP as well as utility, but in the long run the reduction induces an increase in GDP and in utility. Secondly, as long as public investment is efficient, an expansion of future investment financed by an increase in a consumption tax rate is preferred by future generations. Finally, future public investment on production-improving public capital is more preferable rather than that on welfare-improving public capital.

Key words: Intergenerational redistribution, overlapping generations model, simulation.

JEL classification: F H55; E27

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1 Introduction

This paper examines the effects of several future government policies, particularly the debt policy, the public investment policy, and the tax policy, on future public capital, economic growth, and economic welfare in an aging Japan by using a computational overlapping generations model within a general equilibrium context.

This paper expands Kato (2002b) by incorporating the public capital stock into the individual's utility function. Kato (2002b) only discussed the effect of the public capital stock in the private production function. The effect of the decomposition of public investment on between welfare-improving public capital and production-improving public capital is explicitly explored in this paper. The actual data in *Public Capital In Japan* by Cabinet Office (2002) is used for obtaining the past as well as the simulated paths of public investment on welfare-improving and production-improving public capital. In order to comprehensively evaluate public investment, the incorporation of welfare-improving public capital as well as of production-improving public capital is important, as pointed out by Akagi (1996, 2002). This paper also improves Kato (2002b) by obtaining more realistic values for key parameters from the existing empirical research, which has succeeded in tracing the actual values well with the simulated ones. This paper has successfully dealt with distortion caused by taxation by exogenously controlling taxation. Since taxation has endogenously been incorporated in the existing papers, the control of this kind of tax distortion could not be done. By controlling the tax distortion, the evaluation of the government deficits policy can be more crystallized.

The government debts policy and the future schedule of public investment should be evaluated intertemporally, since these policies involve redistributional effect on different generations. On one hand, benefits from public capital generated by public investment are partly transferred for a long time to future generations from current generations if public investment is financed by taxes imposed on current generations. On the other hand, issuing government bonds is the way to avoid paying deficits of current generations back, and thus benefits are transferred form future generations to current generations, since an increase in government deficits must be followed by an increase in taxes imposed on future generations.

In the transition to an aging society, the effects of government policies on each future generation are different, particularly with the existing pay-as-you-go public pension scheme, as pointed out by Auerbach and Kotlikoff (1987). Insight can only be given by numerical examinations if future policies such as the future government debts policy and the future public investment policy are examined specifically in the context of the transition to an aging society. A simulated method based on actual and forecast data could give us as real an evaluation of future government policies as possible. Numerical results could also be used to evaluate the ongoing structural reform facing an aging Japan.

The results obtained in this paper are summarized as follows: Firstly in the short run the reduction of public investment followed by a decrease in outstanding government debts reduces GDP as well as utility, but in the long run the reduction induces an increase in GDP and in utility. This is because an increase in public capital by an expansion of public investment induces an instant increase in GDP, thus also in disposal income, in the short run, but in the long run an increase in outstanding government debts crowds out private capital in the capital market, resulting in the decrease in GDP eventually. In the long run, thus, welfare of future generations can be improved by cutting future public investment in association with a decrease in future outstanding government debts. This result supports Kato (2002b) in a sense that a policy to reduce future government deficits is preferable for almost all generations even though a cut in future government deficits must be followed by a decrease in public investment, thus a decrease in public capital in the future.

Secondly, as long as public investment is efficient, an expansion of future investment financed by an increase in a consumption tax rate is preferred by future generations. Since an expansion of future public investment financed by consumption taxation does not generate a crowding out effect in the capital market, it is more likely for tax financing to be preferred to debt financing. Higher future public investment with a higher consumption tax rate implies less disposal income, and this result is opposite to Kato (2002b). This is because Kato (2002b) only incorporated production-improving public capital, but not welfare-improving public capital. In this paper the magnitude of the effect of the incorporation of welfare-improving public capital and the assumption of efficient public investment substantially matter.

Finally, future public investment on production-improving public capital is more preferable rather than that on welfare-improving public capital. This implies that an expansion of GDP, thus of disposal income, is more efficient than an expansion of the stock of welfare-improving public capital in a sense that it improves utility.

This paper is organized as follows: The next section presents the related literature, and Section 3 presents the basic model employed in the simulation analysis. Section 4 shows the data and parameters used in the simulation analysis, and Section 5 evaluates the simulation results. Section 6 summarizes and concludes the paper.

2 Literature

This paper is related to the following three different literatures; public capital, government deficits, and an aging population.

On the research on public capital in Japan, Kato (1967) and Mera (1973) studied the effect of public capital in 1960s, and several studies, particularly empirical studies in 1990s, have further deepened the literature since Iwamoto (1990) and Aschauer (1989a, b). The studies tried to estimate aggregate production functions, where public capital was incorporated into the aggregate production functions, and also to estimate the actual level of public capital in comparison with the optimal level of public capital. The studies include the estimation of the parameters of production functions (Asako and Sakamoto (1993), Asako et al. (1994), Yoshino and Nakano (1994, 1996)), hypothesis testing of capitalization (Mitsui and Hayashi (2001)), and applications of the convergence theory in macroeconomics to the discussion of the effect of public capital (Shioji (2001), Nakazato (1999))[2]. Akagi (1996, 2002) studied the effect of a certain type of public capital particularly on welfare, by distinguishing

[2] See also Iwamoto (2002) or Murata and Ono (2001) for surveying the literature. Hayashi (2002) reviews the literature from a methodological aspect in terms of estimation of the production function.

it from another type of public capital which stimulates productivity of the private sector. Akagi (1996) concluded that the level of this type of public capital, which was assumed to increase welfare, was too low compared to that of private capital. Akagi (2002) also obtained the result that the level of public investment on this type of public capital had been too high since the bubble period. The common feature of these studies is that they lack an evaluation of public investment as well as public capital financed by issuing government bonds in terms of intergenerational redistribution, although they crystallized the literature in several aspects such as an estimation of the magnitude of the effect of public capital. This paper thus in particular focuses on the intergenerational effect of public capital with a general equilibrium overlapping generations model.

On the literature of government deficits in Japan, the tax-smoothing hypothesis proposed by Barro (1979) and the sustainability of government deficits discussed by Hamilton and Flavin (1986) have been tested with the Japanese data mainly by using econometric methods. Asako et al. (1993) and Nakazato (2000) pointed out that there was a possibility that the past policies had not followed the tax-smoothing hypothesis. Asako et al. (1993), Fukuda and Teruyama (1994), Kato (1997), Doi and Nakazato (1998), and Doi (2000) all examined the sustainability of government deficits, and their results suggest that government deficits in Japan would hardly be sustainable. While all the studies mentioned above conducted econometric analyses, Kato (2000) explored the effect of government deficits based on a simulated method, where the effects on future generations and economic welfare were discussed within the multi-period overlapping generations framework.

On the literature of an aging population in Japan, Homma et al. (1987a) first applied the simulated multi-period overlapping generations model developed by Auerbach and Kotlikoff (1983), in order to discuss the effect of an aging population on the existing public pension scheme as well as on consumption taxation in Japan[3]. Since Homma et al. (1987a), the simulated method has widely been applied and expanded in order to investigate the effect of an aging population on economic policies as well

[3] See also Uemura (2002).

as economic welfare among different generations. Several expansions of the model include an incorporation of a liquidity constraint, and also that of lifetime uncertainty into the model, which could be done by using the actual population data as well as the future forecasted population data. (Iwamoto (1990a), Iwamoto et al. (1991), Iwamoto et al. (1993), Atoda and Kato (1993), Kato (2000, 2002a, b, c), Uemura (2001)). Okamoto (1996), and Miyazato and Kaneko (2000) tried to incorporate intragenerational heterogeneity into their models. There is another stream in the study of an aging population; generational accounting. Aso and Yoshida (1996), Hidaka et al. (1996), Yoshida (1998), and Takayama et al. (1998) tried to estimate the magnitude of burdens of different generations in Japan in terms of generational accounting. Hatta and Oguchi (1999) in particular focused on the effect of the existing public pension scheme on generational accounting.

The outstanding feature of this paper is that this paper employs a multi-period overlapping generations model within the general equilibrium framework, in order to investigate the effect of government deficits as well as public capital on future private production (GDP) and economic welfare of different generations, by proposing several realistic scenarios regarding future government deficits and the future accumulation of public capital. Since accumulation of public capital or public investment on public capital is substantially related to how it can be financed by the future government, comprehensive consideration regarding government deficits and accumulation of public capital is essential. The major difference of this paper from Kato (2002a, b) is an incorporation of a certain type of public capital: public capital which improves welfare. Kato (2002a, b) only considered another type of public capital, which only stimulates production of the private sector. Thus, in this paper, there are two different types of public capital: one type of public capital which improves welfare, and the other type of public capital, which stimulates production of the private sector. Typical examples of the former type of public capital include a public park and a public hall in town. This type of public capital, which directly benefits people in a society, was not considered in Kato (2002a, b). On the other hand, the latter type of public capital, or industrial infrastructure, includes (air) ports and industrial roads, and this type of public capital benefits people through an expansion of production of the private sector. In this paper, welfare-improving public capital is assumed to directly affect the utility function of the household, and production-improving public capital is assumed to directly affect the private production function. The division of public capital based on the different effect on a society into two different types has been made only in empirical studies, and the two different types have independently been explored in the empirical studies (Mitsui and Ota (1995), Akagi (1996, 2002)). In this paper the two different types of public capital will be considered consistently within a rigorous economic framework, where the latest future forecasted population data (estimation in January 2002) is used, and the Solow residual is introduced into a productivity parameter in the private production function. The use of the latest forecasted population data and an introduction of the Solow residual make this simulation analysis as realistic as possible.

3 The Model

The model employs a multi-period overlapping generations model developed by Auerbach and Kotlikoff (1983). Taxes and a public pension scheme are also incorporated into the basic model, in order to reflect the existing Japanese system. An economy of the model consists of the household, the firm, and the government sector, where there is only one good considered for simplicity. The household is assumed to optimize its intertemporal consumption through its lifetime, taking the wage rate, the interest rate, and its own survival rates as given. The tax system and the public pension scheme are also assumed to be taken as given by the household. The household is assumed to obtain its wage by supplying its labor inelastically until it retires, and once it retires it never returns to the labor market. There are no altruistic bequest motives and Ricardian equivalence does not hold. The firm is assumed to maximize its profit, taking the wage rate and the interest rate as given. The wage rate and the interest rate are determined in each factor market with their equilibrium condition. The government sector is assumed to collect taxes from the household, and also to issue government bonds in order to finance its consumption and its expenditure to accumulate public capital. Two different types of public capital are considered explicitly in this paper. The one type of public capital is that which improves welfare, and the other type of public capital is that which stimulates production of the private sector. Typical examples of the former type of public capital include a public park and a public hall in town. This type of public capital, which directly benefits people in a society, was not considered in Kato (2002a, b). On the other hand, the latter type of public capital, or industrial infrastructure, includes (air) ports and industrial roads, and this type of public capital benefits people through an expansion of production of the private sector. In this paper, welfare-improving public capital (the former type) is assumed to directly affect the utility function of the household, and production-improving public capital (the latter type) is assumed to directly affect the private production function. The government sector is also assumed to run a pay-as-you-go public pension scheme, but it is also assumed to accumulate a public pension fund out of the contribution collected from working generations. This assumption reflects the existing Japanese public pension scheme. It is assumed that there is no private life insurance, and thus the household has no mechanism to hedge its risk in terms of a possibility to die in each period. Since the household is assumed to have no bequest motives, this assumption implies that the household leaves an accidental bequest in each period when it dies. However, it is also assumed that there is no uncertainty in the whole economy in terms of an population of each generation, and thus there is no uncertainty in the total (aggregate) amount of bequests inherited in each period.

3.1 The Household

The household is assumed to optimize its intertemporal consumption through its lifetime, taking the wage rate, the interest rate, and its own survival rates as given. The tax system and the public pension scheme are also assumed to be taken as given by the household. The household is assumed to obtain its wage by supplying its labor inelastically until it retires, and once it retires it never returns to the labor market. There are no altruistic bequest motives. It is assumed that there is no intragenerational heterogeneity in terms of labor income, the survival rate and the utility function. The household appears in the economy at age 20 as a decision maker. Although the household faces uncertainty to die in each period, it dies with certainty at 99 years old if it keeps surviving until 99 years old. Denoting the conditional survival rate of $j + 20$-age-old generation to age $j + 21$ by $q_{t,j+1,j}$, the unconditional survival rate to age $s + 20$ of those who appear in year t is given by

$$Q_{t,s} = \prod_{i=1}^{s-1} q_{t,i+1,i}.$$

The survival risk is assumed to be idiosyncratic, and there is no uncertainty in the aggregate population in each period. Each $q_{t,j+1,j}$ is calculated from the life table in *Population Projections for Japan:2001-2050* by the National Institute of Population and Social Security Research.

The household is assumed to maximize its expected lifetime utility. Its expected lifetime utility is assumed to depend on its own consumption and also the stock of public capital. This type of public capital is now on called welfare-improving public capital. The direct inclusion of welfare-improving public capital in the household's utility function is one of the main features of this paper which differs from Kato (2002a, b). The household's expected lifetime utility of generation k is given by[4]

$$E[V_k] = \sum_{s=0}^{79} Q_{s,t+s-1}(1+\delta)^{-(s-1)} U(c_{s,t+s-1}, GKL_{s,t+s-1}), \qquad (1)$$

where $c_{s,t+s-1}$ is consumption at age s, $GKL_{s,t+s-1}$ is the stock of welfare-improving public capital, and δ is the time discount rate. $U(c_{s,t+s-1}, GKL_{s,t+s-1})$,the instantaneous utility function, is assumed to be CES such that

$$U(c_t, GKL_{t-1}) = \left[c_t^{1-\xi} + \gamma GKL_{t-1}^{1-\xi}\right]^{\frac{1}{1-\xi}},$$

where ξ is the inverse of the elasticity of substitution, which is denoted by $\rho = 1/\xi$. γ is a constant coefficient which pins down service flow from welfare-improving public

[4]According to the result by Hayashi (1995), bequest motives are not considered in this paper. Strategic bequest motives (Bernheim et al. (1985)) are also not considered. Since there is no uncertainty in wage income in this paper, a precautionary saving motive for uncertain wage fluctuation is not considered, which was discussed in Horioka and Watanabe (1997).

capital, which expresses the degree of relative importance of welfare-improving public capital, compared to its own consumption in its total utility. Welfare-improving public capital is assumed to be a pure public good, and not to generate any congestion effect. The budget constraint of the s-years-old household is given by

$$a_{s,t+1} = [1 + (1 - \tau_{r,t})r_t]a_{s,t} + (1 - \tau_{y,t} - \tau_{p,t})w_t e_{s,t} + ps_{s,t} + b_{s,t} - (1 + \tau_{c,t})c_{s,t},$$

where $a_{s,t}$ denotes the initial level of its assets of age s, r_t denotes the interest rate, and $e_{s,t}$ denotes the measure of effective labor. Effective labor differs according to its age[5]. The household supplies labor inelastically for simplicity. w_t is the wage rate per efficiency unit of labor, and $w_t e_{s,t}$ is pre-tax labor income. All taxes considered in this paper are proportional. $\tau_{y,t}$, $\tau_{r,t}$, and $\tau_{c,t}$ denote the wage income tax rate, the interest income tax rate, and the consumption tax rate, respectively. The contribution rate to a public pension scheme is denoted by $\tau_{p,t}$, and $ps_{s,t}$ represents public pension benefits. Denoting the age when the household starts obtaining pension benefits by R, and the compensation rate by β_p,the amount of pension benefits is given by

$$ps_{s,t} = \begin{cases} \beta_p H_t \ \ (s \geq R), \\ 0 \ \ (s < R) \end{cases}, \tag{2}$$

where H, the annual amount of standard compensation, is given by

$$H_t = \frac{1}{RH} \sum_{s=0}^{RH-1} w_{s,t} e_s,$$

where $RH + 20$ denotes the household's retirement age[6]. It is assumed that there is no private pension market[7]. The total amount of savings of the household which dies is left as an accidental bequest, and the accidental bequest is assumed to be redistributed to the household which survives at age s, which is denoted by b_s. It

[5] The profile of effective labor follows Kato (2002).

[6] Based on our calculation from the actual data, β_p has been set at 56 % in all simulation scenarios in this paper. It is also assumed that the household contributes to a public pension scheme from age 20 to age 64.

[7] See Iwamoto et al. (1991, 1993) or Friedman and Warshawsky (1988, 1990) for models which include the private pension market.

is assumed through this paper that the household in all generations which survives obtains the equal amount of the accidental bequest in each period[8].

The first order necessary conditions yield the Euler equation such that

$$U'_{s,t}(c_{s,t}, GKL_{t-1}) = \frac{p_{t+1}[1 + (1 - \tau_{r,t+1})r_{t+1}]}{1 + \delta} \frac{1 - \tau_{c,t}}{1 - \tau_{c,t+1}} U'_{s,t+1}(c_{s,t+1}, GKL_t),$$

from which the optimal consumption path can be derived once the initial value of the household's consumption is given.

3.2 The Firm

The firm is assumed to maximize its profit, taking the wage rate and the interest rate as given. The wage rate and the interest rate are determined in the perfectly competitive factor markets with the equilibrium conditions. It is also assumed that production of the private sector depends on the public capital stock. Industrial roads or industrial infrastructure can be categorized in this type of public capital. Public capital which improves production of the private sector is now on called production-improving public capital. It is assumed that the level of the stock of production-improving public capital directly affects production of the private sector. The aggregate private production function is assumed to be Cobb-Douglas such that

$$Y_t = A_{proc,t} L_t^{\alpha} K_t^{1-\alpha} GKP_{t-1}^{\beta}, \tag{3}$$

where Y_t represents aggregate output at the beginning of period t, K_t the aggregate private capital stock, L_t aggregate labor supply measured by effective labor unit. GKP_t denotes the stock of production-improving public capital, and $A_{proc,t}$ represents technology of production of the private sector. Assuming that each factor market is perfectly competitive with the above aggregate production function, output is fully distributed to labor and capital. The first order necessary conditions yield

$$w_t = \alpha A_{proc,t} L_t^{\alpha-1} K_t^{1-\alpha} GKP_{t-1}^{\beta} \tag{4a}$$

$$r_t = (1-\alpha) A_{proc,t} L_t^{\alpha} K_t^{-\alpha} GKP_{t-1}^{\beta} - \delta_k, \tag{4b}$$

[8] Kato (2002) assumed that only the generation of age 65 in each period received bequests. Atoda and Kato (1993) discussed the timing of receiving bequests.

where δ_k denotes the depreciation rate for the private capital stock. Substituting (4a) and (4b) into (3) yields

$$\begin{aligned} w_t &= \alpha \frac{Y_t}{L_t} \\ r_t &= (1-\alpha)\frac{Y_t}{K_t} - \delta_P. \end{aligned}$$

3.3 The Government Sector

The government sector consists of a general account and a public pension account. Expenditure of the general account includes general government expenditure, and transfers to the public pension account. The expenditure of the general account is financed by taxation and issuing government bonds. The general government expenditure includes government consumption, transfers, and public investment. Public investment accumulates both production-improving public capital, welfare-improving public capital, and the other type of public capital. The amount of transfers to the public pension account from the general account is assumed to be constant at η, which is the ratio of the amount of transfers to the total amount of public pension benefits. η is given at the actual value (1/3) in this paper. The government sector is assumed to have no particular objective function which it maximizes, but to control its expenditure to be consistent with the target level of outstanding government bonds in each period. Different target levels of outstanding government bonds are given exogenously in several scenarios discussed in the following sections. The budget constraint of the government sector is

$$\begin{aligned} GE_t &= GR_t + TG\_BOND_t - (1+r_t)BOND_{t-1} \\ CG_t &= r_{CG,t} \cdot Y \\ IG_t &= GE_t - (CG_t + \eta B_t) \\ IG_t &= IGP_t + IGL_t + IGO_t \\ GR_t &= \tau_{c,t}C_t + \tau_{y,t} w L_t + \tau_{r,t} r_t A\text{-}TAX_t + \tau_{h,t} BQ_t \\ GKP_t &= (1-\delta_{GK})GKP_{t-1} + IGP_t \\ GKL_t &= (1-\delta_{GK})GKL_{t-1} + IGL_t, \end{aligned}$$

where $BOND_t$, GR_t, and GE_t denote the amount of outstanding government bonds, the total tax revenue, and the total general government expenditure, respectively. TG_BOND_t is the target level of outstanding government bonds. Transfers to the public pension account are denoted by ηB, where B is the total public pension benefits. $\tau_{r,t}$, $\tau_{y,t}$, $\tau_{c,t}$, and $\tau_{h,t}$ denote the capital income tax rate, the labor income tax rate, the consumption tax rate, and the inheritance tax rate, respectively. CG_t, IGP_t, IGL_t, and IGO_t denote government consumption, public investment on production-improving public capital, public investment on welfare-improving public capital, and public investment on the other type of public capital, respectively. The amount of bequests is represented by BQ_t, and A_TAX_t is the private capital stock. Both production-improving public capital and welfare-improving public capital are assumed to depreciate at the same rate, δ_{GK}.

The budget constraint of the public pension account and the contribution rate of the public pension scheme are defined as

$$F^*_{t+1} = (1+r_t)F_t + P_t - (1-\eta_t)B_t \tag{5}$$

$$\tau_{p,t} = \frac{TGF_t \cdot Y_t - (1-\eta_t)B_t - (1+r_t)F_{t-1}}{w_t L_t}, \tag{6}$$

where F_t is an accumulated public pension fund at the end of period t, and B_t and P_t denote the total amount of benefits and the total amount of the contributions. The contribution rate is determined endogenously so as to be consistent with the target level of the public pension fund, F^*_{t+1}, which is given exogenously in each scenario.

3.4 Market Equilibrium

The equilibrium condition of the capital market in period-t is that the total amount of savings of the household (A_t) plus the total amount of the public pension fund (F_t) are equal to the private capital stock plus the total amount of outstanding government bonds such that

$$A_t + F_t = K_t + D_t.$$

The equilibrium condition of the goods market is that aggregate output equals to the sum of private consumption (C_t), private investment ($K_{t+1} - (1-\delta_P)K_t$) and government expenditure (GE_t), which is

$$Y_t = C_t + (K_{t+1} - (1 - \delta_k)K_t) + GE_t.$$

4 Data and Parameters

In order to make our simulation analysis as close to the real circumstances as possible, obtainable actual data and existing estimated parameters have been used in the following simulation. In particular, regarding four key variables such as a population, outstanding government bonds, public investment, and public capital, obtainable past data has been used in our simulation. One of the most crucial assumptions on parameters is concerned with the value of a key parameter, γ, which is the degree of a positive effect of welfare-improving public capital on utility. In our simulation analysis, the value estimated by Akagi (1996) has been used basically for γ.

Relevant assumptions for our simulation are on the future values of a population, technological progress, and government policies. Future government policies consist of a government bond policy, a tax policy, a public investment policy, and a public capital policy. The effects of different future government policies on economic growth as well as on economic welfare of different generations are discussed in several scenarios in the following simulation analysis.

On the population data, actual data has been used from 1965 to 2000. Regarding the future population data, the latest version of Projection of Future Population in Japan (Shourai-Jinko-Suikei 2002) has been used in our simulation. Life table (Kanzen-Seimeihyo) and Shourai-Jinko-Suikei 2002 were used for obtaining survival rates. Since Projection of Future Population in Japan (Shourai-Jinko-Suikei 2002) gives estimates of the future population only until 2100, it has been assumed in our simulation that the number of birth and death, and the survival rates after 2100 are fixed at the same levels as those in 2100.

On technological progress, Solow residuals were used for the past growth rate of technological progress in this paper, according to Hayashi and Prescott(2002). Regarding future technological progress, it has been assumed that technological progress is zero, in order to avoid ad hodc strong relations between simulation results and the assumption on technological progress of future private production, since, as discussed in Kato(2000), the assumption on $A_{proc,t}$, the degree of technological progress in private production, substantially affects simulation results.

On the values and the assumptions regarding relevant parameters are as follows: The contribution rate to the public pension scheme is assumed to be determined endogenously in order to satisfy (5) and (6). Note that the future path of an accumulated public pension fund is assumed to be given exogenously in each scenario, and also that the total amount of pension benefits is also calculated based on exogenous assumptions on relevant variables. The past path of a public pension fund was obtained from actual data from *Jigyo-Nenpo,* the annual report of public pension agency. Government transfers to the public pension scheme is set by 1/3 of annual pension benefits according to the existing scheme. The same wage profile as Kato(2002c) was used. β_p, the compensation rate for pension benefits in (2), has been given at 56% through time in the future, which is the average value in the existing scheme. Values of other parameters were obtained from related literatures: The value of δ, time preference, is the average value calculated from the existing literature, which is summarized by Uemura(2002). The value of $\rho = \frac{1}{\zeta}$, the elasticity of temporal substitute, is the same as that in Akagi (1996). γ, the degree of a positive effect of welfare-improving public capital on utility, also depends on Akagi (1996). β, the coefficient of the stock of production-improving public capital in the private production function in (3), was calculated from Yoshino and Nakajima(1999). The depreciation rate of public capital is the same as Kato(2002c). The values of these parameters given in this paper are summarized in the following table.

The Values of Parameters

δ	ρ	γ	α	β	δ_k	δ_{gk}	β_p	η
0.02	2.2409	0.0001	0.75	0.12	0.05	0.0448	0.56	1/3

5 Simulation Analysis

The purpose of this paper is to examine the effects of future government policies. The main concern of this paper is in particular to investigate the effects of the future government deficits policy associated with future public investment on two different types of public capital and of the future tax policy to finance the deficits, which are explored by proposing several scenarios in terms of the following 3 key aspects, outstanding government debts, public investment and public capital, and tax rates[9].

Outstanding Government Debt

Three scenarios are considered in terms of future outstanding government debts in order to study the effects of the deficits policy. In this paper, the amount of net financial debts of central and local governments in SNA has been used as the amount of outstanding government debts. The actual ratio of outstanding government debts to GDP has been used in our simulation until 1998. From 1999, the following three different scenarios are considered: In a benchmark case, the ratio increases to 150% at a steady state. In a high ratio case and in a low ratio case, the ratio increases to 180% and 120%, respectively.

Public Capital and Public Investment

Three scenarios in terms of the future public investment policy are explored by considering different patterns of decomposition of public investment on between production-improving and welfare-improving public capital in the future. Using the actual data in *Public Capital In Japan* by Cabinet Office (2002) and following the conventional decomposition of public capital into two categories (production-improving and welfare-improving public capital), the amount of past public investment on two different types of public capital was calculated, and the ratio of public investment on production-improving public capital, welfare-improving public capital, and other public capital in 1998 was calculated as (29.2 : 41.2 : 29.6). In a benchmark case,

[9] The ratio of general government expenditure to GDP is assumed to be constant from 1999 at the same level as that of 1998. Until 1998 the calculated ratio from the actual data (SNA) has been used. The calculated ratio of 1998 is 10.2%.

this ratio has been assumed to be fixed even after 1998. However, other two more cases are explored as well. As a more welfare-improving public investment case, the ratio changes eventually to (20.3 : 50 : 29.6). And as a more production-improving public investment case, the ratio changes eventually to (50 : 20.3 : 29.6). The public capital stock of 1964 in *Public Capital In Japan* by Cabinet Office (2002) was used as an initial stock level for obtaining the path of the past public investment.

Tax Rates

A consumption tax is only considered explicitly as a future policy instrument, and three scenarios are proposed in terms of the future consumption tax rate. Until 1998 the consumption tax rates are the same in the three scenarios, which are the calculated rates from the actual data (SNA and Zaisei Kinyu Geppo). From 1999, the consumption tax rate differs in each scenario: In a benchmark case, the consumption tax rate increases linearly up to 25% from 2005 to 2050. In order to compare with the benchmark case, two other scenarios are considered. One case is that the consumption tax rate increases up to 20% and the other case is that the tax rate increases up to 30%.

On other taxes such as a labor income tax, an interest income tax, and an inheritance tax, calculated tax rates from the actual data have been used until 1998. From 1999, the tax rates of these 3 taxes are assumed to be fixed at the same rates as those of 1998, and thus the tax rates are constant from 1998 through time.

5.1 Benchmark Simulation

In a benchmark case, the ratio of outstanding government debts to GDP converges to 150% in a steady state, the ratio of public investment on production-improving public capital, welfare-improving public capital, and other public capital in 1998 is fixed at (29.2 : 41.2 : 29.6) through time, and the consumption tax rate increases linearly up to 25% from 2005 to 2050.

Private Production

Figure 1-1 shows actual values of GDP which has been normalized with the value of 1990 and simulated values of GDP. In the figure, the good fit of the simulated values can be found from 1965 to 1998. Figure 1-2 shows normalized actual values of per capita GDP and simulated values of per capita GDP[10].A decrease in the simulated values of GDP from 2000 in Figure 1-1 and 1-2 can be explained by a crowding-out effect of outstanding government debts in the capital market. The decrease can also be explained partly by the assumption of zero technical progress from 1999 as well as by a decrease in the number of labor force in the actual forecasted population data.

Capital Stock

Figure 1-3 shows actual values of the private capital stock, which has been normalized with the value of 1990, and simulated values of the private capital stock. As shown in the figure, the long-run trend of an increase in the past actual values of the private capital stock has been traced with the simulated values until 1998. Temporary decreases in the simulated values of the private capital stock in 1989 and 1997 can be explained by an introduction of and an increase in the consumption tax in the simulated model. The trend of a decrease in the simulated values of the future private capital stock can be explained by the following two reasons: The one reason is due to the crowding-out effect of issuing government bonds in the capital market. This crowding-out effect lasts during the transition to a steady state, where the level of outstanding government debts converges to a 150% level. This effect is on the demand side in the capital market. The other reason is due to an aging population, which appears in supply in the capital market. Since an aging population implies a relative increase in the number of people to dissave, the total amount of supply in the capital market decreases. Both effects reduce the future private capital stock.

Public investment and production-improving public capital are shown in Figure 1-4 and 1-5, respectively, where public investment is shown by the ratio of the level of public investment to GDP in Figure 1-4, and the stock of production-improving public capital has been normalized with the value of 1990. As shown in Figure 1-4, the ratio of public investment to GDP drastically decreases around the beginning of 2000's, and it never recovers to the level of 2000 through time. In the benchmark case, the

[10] Per capita values have been calculated on the number of an over 20 year old population.

level of outstanding government debts is kept moderately at a middle level (150%), followed with a middle level of the consumption tax rate (25%) in a steady state. In the benchmark policy which would correspond to a moderate future government deficits policy, future public investment should be decreased to maintain a 150% level of outstanding government debts in a steady state. This outstanding feature can also be found in the trend of a slow decrease in production-improving public capital in the future in Figure 1-5. The decrease in production-improving public capital and the decrease in private capital induce a decrease in GDP in the future.

Tax Burdens and Contribution Rate

Tax burdens and the contribution rate are shown in Figure 1-6 and 1-7, respectively. In Figure 1-6, the actual value of tax burdens is defined as the ratio of the amount of direct taxes plus the amount of indirect taxes in SNA to GDP, and the simulated value of tax burdens is defined as GR_t/Y_t. In Figure 1-7, the actual value of the contribution rate is defined as the ratio of the contribution to employed income in SNA, and $\tau_{p,t}$ is simply the simulated contribution rate. As shown in both figures, the simulated values trace the actual values in the past. Note that the future contribution rate increases as more than double much as now around 2050 due to an aging population.

Primary Balance

The actual value of the primary balance in this paper is defined as the ratio of the IS balance of the government sector minus net wealth income in SNA to GDP. The simulated value of the primary balance is defined as $(GR_t - GE_t)/Y_t$. As shown in Figure 1-8, the simulated values can trace the actual values well until 1998, even in the bubble period, when the actual primary balance was in the black. The simulated values of the primary balance have been calculated in order to be consistent with the scenario value of outstanding government debts, which is assumed to be a 150% level of the debt-GDP ratio in a steady state. As shown in Figure 1-8, in order to achieve the scenario level of the debt-GDP ratio, the primary balance must go into the black in a short period, and the balance in the black must be around 10% in 2040. However, the actual level of the primary balance in 2001 is still in a deficit, and this implies that the actual deficits are increasing more rapidly than our benchmark scenario.

Compensating Variation

In this paper, the compensating variation has been used to evaluate future government policies. The compensating variation of generation t is defined by

$$CV_t = \frac{e(p_{2000}, u_{2000})}{e(p_{2000}, u_t)},$$

where e is the expenditure function, and u_t represents expected indirect utility of generation t. u_{2000} is expected utility of generation t which is calculated based on the assumption that the generation would have if the generation were born in 2000. p_{2000} denotes the prices that the generation born in 2000 faces.

Figure 1-9 shows the compensating variation in the benchmark case. The figure shows that generations born before 2000 are better off but generations born after 2000 are worse off, and also that the more future generation become the worse off they are.

5.2 Effects of the difference in the debt financing policy

In this section we exanime the effects of the difference in the debt financing policy are explored. There are two ways to affect future public investment on public capital; different consumption tax policies and different debt financing policies. In this section, the future consumption tax rate is maintained at the same level as that in the benchmark case, where the consumption tax rate increases linearly up to 25% from 2005 to 2050. As mentioned in the previous section, three different scenarios in terms of the outstanding government debts policy are considered. In the benchmark simulation, the ratio of outstanding government debts to GDP in a steady state was 150%. As a high ratio case a 180% ratio in a steady state is proposed, and as a low ratio case a 120% ratio is considered. By comparing these two cases with the benchmark case, the effects of the difference in the debt financing policy are investigated.

An expansion of future public investment on public capital followed by debt financing involves several effects. First of all, apart from the effects which are debt financing specific, an expansion of public investment in the future stimulates private production through an increase in the production-improving public capital stock in the private production function. This effect induces an increase in GDP as well as an increase in the interest rate. If these increases induce an increase in savings, then private capital stock will also increase, resulting in a further increase in GDP. Secondly, an increase in the amount of outstanding government debts to finance higher public investment crowds out the private capital stock in the capital market. Thirdly, the increase in outstanding government debts results in an increase in future interest payments, and thus the less amount of resources can be allocated to future public investment in order to satisfy the government budget constraint. This effect reduces the amount of future public capital and future GDP. Thus, an expansion of future public investment on public capital followed by debt financing does necessarily not stimulate GDP. Furthermore, the effect on lifetime utility is more ambiguous, since an expansion of future public investment also increases welfare-improving public capital. Thus, it is still possible to increase lifetime utility even though the expansion of public investment reduces GDP. The overall effects differ depending on time as follows.

In the long run

The long run effect can be seen from around 2050. Figure 2-1 shows that the overall effects result in a decrease in the private capital stock in the long run. This decrease in the private capital stock induces an increase in the interest rate (Figure 2-5) as well as an increase in aggregate savings (Figure 2-4). Furthermore, since an increase in interest payments induces a decrease in public investment in the long run (Figure 2-2), more public capital can be accumulated when outstanding government debts are lower (Figure 2-3). When outstanding government debts are higher, both private and public capital are lower, and thus, lower GDP (Figure 2-6). Since public capital is lower, lifetime utility is also lower when outstanding government debts are higher (Figure 2-7).

In the short run

The effects differ in the short run. In the transition particularly, higher public investment can be achieved by issuing more government bonds (Figure 2-2), thus resulting in higher public capital in the short run (Figure 2-3). The increase in public capital stimulates GDP, and thus results in an increase in savings as well as an increase in the private capital stock (Figure 2-1). Since both private and public capital increase, GDP also increases in the short run (Figure 2-6). However, the positive effect on GDP only lasts until the late 2010's. An increase in the interest rate induces an increase in interest payments incurred, thus resulting in less resources for public investment in the future (Figure 2-2). Although the increase in the interest rate stimulates savings (Figure 2-5), the crowding out effect of debt financing on private capital is relatively getting stronger through time, and the stock levels of private capital in all three scenarios become the same in late 2020's (Figure 2-1). In the middle of 2030's the negative effect of a decrease in public investment also appears in the stock level of public capital, and it finally converges to the situation that public capital is the lowest when outstanding government debts are the highest (Figure 2-3). Since the magnitude of the effect of the decrease in public capital is smaller than that of the effect of the decrease in private capital on the interest rate, the interest rate is the highest when outstanding government debts are the highest (Figure 2-5). The short run effect disappears after the middle of 2030's. When it is evaluated in 2050, GDP with a 180% level of the debt-GDP ratio in a steady state is 1.84% smaller than that with the benchmark case (150%), and GDP with a 120% level is 1.56% larger than that with the benchmark case.

Lifetime utility and redistribution among different generations

In terms of lifetime utility and redistribution among different generations, the evaluation of the effect of the difference in the debt financing policy is more important, particularly when welfare-improving public capital is incorporated. This paper differs from Kato (2002a, b) in two aspects: An incorporation of welfare-improving public capital into the individual's utility function, and the treatment of the tax policy. In Kato (2002a, b) a consumption tax rate was determined endogenously in order to finance interest payments incurred from outstanding government debts in each debt policy, and one of the main results of Kato (2002a, b) was that the policy to achieve the highest GDP was necessarily not most preferable due to the reason that the highest GDP might be followed by the lowest disposal income with the highest consumption tax rate. However, in this paper the consumption tax rate is given exogenously at the same level in all scenarios of the debt policy, and it is not likely to result in the situation that the highest pre-tax income (GDP) is associated with the lowest lifetime utility. Thus, the evaluation of the debt policy based on lifetime utility would be straightforward if welfare-improving public capital is not incorporated, since the evaluation only based on GDP gives an enough insight when disposal income is the same in each scenario. On the other hand, when welfare-improving public capital is taken into account, the exogenous assumption on the consumption tax rate makes the interpretation of simulation results easy. Thus, rather than assuming that the future consumption tax rate is endogenously determined, it has been assumed in this paper that the shortage of money caused by more interest payments incurred from more outstanding government debts results in an endogenous decrease in public investment. In this paper, the effect of the change in the tax rate can be excluded, and the effect of the shortage of money can be considered within the effects on GDP.

Figure 2-7 shows utility levels, where the generations born after 2010 prefer the debt financing policy with the lowest outstanding government debts (120%) to the benchmark policy (150%). Note that in terms of GDP around the beginning of 2030's the policy with the 120% level achieves higher GDP than the policy with the 180% level. It is also shown that the generations born before 2007, which can not obtain lot of benefits from welfare-improving public capital, prefer the debt policy with the highest outstanding government debts. However, the 120% level is most preferable among the generations born in 2001 to 2006. This implies that the preference on the debt financing policy differs depending on when the generation was born, and a Pareto improving debt financing policy does not exist. No existence of a Pareto improving debt policy can also be seen in Figure 2-8, where utility of each generation is normalized with the utility of the generation born in 2000. As shown in the figure, the higher outstanding government debts become, the more are future generations worse off. This implies that more public investment followed by more outstanding government debts can be achieved at the sacrifice of future generations, and thus this kind of a policy transfers benefits from future generations to current generations. On the other hand, a policy with the lowest outstanding government debts minimize the burdens among future generations, implying that this kind of a policy transfers benefits from current generations to future generations.

5.3 Effects of the difference in a tax financing policy

In this section the effects of the difference in financing by taxation. As discussed in the previous section, three different scenarios regarding consumption taxation are explored. Note that in this paper the future consumption tax rate exogenously increases linearly up to 20%, 25% (benchmark), and 30% in a steady state in each scenario, respectively. This assumption is different from that of Kato (2002a, b), where the consumption tax rate was determined endogenously in each scenario in order to satisfy the government budget constraint. A path of a variable which is endogenously determined in this paper is that of future public investment, since future paths of outstanding government debts and the consumption tax rate are exogenously given. Since overall effects are complicated, investigation is given in the long run and short run separately. In this section the benchmark case of outstanding government debts (the 150% debt-GDP ratio) is only considered to highlight the effect of the difference in financing by consumption taxation.

In the long run

Since there is no difference in each scenario in terms of outstanding government debts, the difference does not affect any of the demand side of the capital market. The difference in consumption taxation only appears in the supply side of the capital market; it affects aggregate savings. There are two channels to affect savings: An expansion of public investment financed by a higher consumption tax rate induces an increase in the interest rate through an upward shift of the private production function caused by an increase in production-improving public capital. The increase in the interest rate would stimulate savings by the substitution effect. On the other hand, the increase in the consumption tax rate reduces disposal income, thus resulting in a decrease in savings by the income effect. The effect of a tax financing policy depends on the magnitude of both effects, and private capital would increase (decrease) if the former (the latter) effect is relatively larger than the other. Thus, even though an expansion of public investment increases production-improving public capital, whether GDP increases depends on the magnitude of both income and substitution effects.

The effects of the difference in tax financing can be seen in Figure 3-1 to 3-8. Since higher public investment can be financed by a higher consumption tax rate (Figure 3-2), the policy with a higher consumption tax rate induces an increase in public capital, and thus an increase in the interest rate. The figures show that a positive effect of the increase in the interest rate on savings is larger than a negative effect of on disposal income, and the higher the consumption tax rate, the more private capital. Since both private and public capital are higher when the consumption tax rate is higher in this simulation, GDP is higher when the consumption tax rate is higher. Since a higher consumption tax rate implies lower disposal income, this result is the same as that of Kato (2002b).

In the short run

As long as goods are normal, an increase in the consumption tax rate induces a decrease in savings (Figure 3-4). The decrease in savings reduces the private capital stock, thus resulting in a decrease in GDP even though an expansion of public investment followed by an increase in the consumption tax rate induces an increase in production-improving public capital. This situation lasts until 2014. However, after 2014 a positive effect of an increase in production-improving public capital on private production dominates the negative effect of the decrease in savings through time, and GDP with a higher consumption tax rate becomes smaller than that with a lower rate oppositely. This phenomenon becomes more substantial through time, and GDP with a 30% consumption tax rate in 2050 is 5.63% higher than that with a 25% consumption tax rate, which is 9.05% higher than that with a 20% consumption tax rate in 2050.

Lifetime utility and redistribution among different generations

As has been assumed in (1), the individual's utility depends on its own consumption and welfare-improving public capital. An increase in welfare-improving public capital must be followed by an increase in the consumption tax rate, thus a decrease in disposal income, and the increase in welfare-improving public capital reduces its own consumption. This implies that the total effect of future public investment policy with tax financing on utility substantially depends on the parameter, γ.

Figure 3-7 shows that many future generations prefer the highest investment policy with the highest consumption tax rate, implying that a positive effect of an expansion of welfare-improving public capital is larger than a negative effect of a decrease in disposal income on utility, as long as the value of γ in this paper is applied to our simulation. An introduction of welfare-improving public capital into utility changes the result of Kato (2002b). Even for the generations born before 1975, the benchmark case (the 25% tax rate) is more preferable to the lowest case (the 20% tax rate). Note that more future generations obtain more benefits if the period how long benefits last is longer than that how long the consumption tax is paid. Note also that this result substantially depends on the assumption that public investment is fully efficient. If public investment is not efficient in a sense that it does not improve the individual's welfare as has been assumed in (1), then this result changes. Figure 3-7 shows how much the result depends on the efficiency assumption on public investment, where a 15 % of public investment from 2000 is assumed to be inefficient. The figure shows all generations before 2027 are worse off due to the inefficiency in public investment.

5.4 Effects of the difference in the investment ratio between welfare-improving and production-improving public capital

All the results obtained so far depend on the assumption on the investment ratio between welfare-improving and production-improving public capital. It has been assumed so far that the future ratio is fixed at the same one as that of 1998, which is (29.2 : 41.2 : 29.6) among production-improving, welfare-improving, and other public capitals. As Mitsui (1995) pointed out, the amount of public capital might be biased between urban and local areas. In this section the effect of the change in the ratio is explored by comparing the benchmark case with other two cases. The benchmark case corresponds to the fixed ratio at the same value of 1998 (29.2 : 41.2 : 29.6). Two cases are considered: As a more welfare-improving public investment case, the ratio changes eventually to (20.3 : 50 : 29.6). And as a more production-improving public investment case, the ratio changes eventually to (50 : 20.3 : 29.6).

Figure 4-1 shows the effect of the change in the ratio of future public investment, where all generations prefer the future policy with more production-improving public investment rather than the policy with welfare-improving public investment. An expansion of welfare-improving public investment directly improves the individual's utility through γ. On the other hand, an expansion of production-improving public investment stimulates private production, inducing a direct increase in GDP as well as an increase in the interest rate. The increase in the interest rate also induces an increase in private savings which increases the amount of supply in the capital market, and then an increase in the private capital stock. The further increase in GDP through the increase in private capital results in more increase in GDP. The increase in GDP results in an increase in disposal income, which is preferable to all generations. The result apparently depends on the magnitude of γ. As Figure 4-2 and 4-3 show, the result is unfortunately reversed depending on the magnitude of γ. Thus, the result of this section is not robust, although the value of γ was obtained from the existing empirical papers (Akagi, 1996, 2002).

6 Conclusion

This paper has examined the effects of several future government policies, particularly the debt policy and the tax policy, on future public investment, economic growth, and economic welfare in an aging Japan by using a computational overlapping generations model. One of the main differences from Kato (2002b) is the incorporation of welfare-improving public capital. The actual values until 1998 have been well traced by the simulated values, and differences in future debt financing, future consumption tax financing, and future public investment between production-improving and welfare-improving public capital have been explored.

The results obtained in this paper are summarized as follows: Firstly in the short run the reduction of public investment followed by a decrease in outstanding government debts reduces GDP as well as utility, but in the long run the reduction induces an increase in GDP and in utility. This is because an increase in public capital by an expansion of public investment induces an instant increase in GDP, thus also in disposal income, in the short run, but in the long run an increase in outstanding government debts crowds out private capital in the capital market, resulting in the decrease in GDP eventually. In the long run, thus, welfare of future generations can be improved by cutting future public investment in association with a decrease in future outstanding government debts. This result supports Kato (2002b) in a sense that a policy to reduce future government deficits is preferable for almost all generations even though a cut in future government deficits must be followed by a decrease in public investment, thus a decrease in public capital in the future.

Secondly, as long as public investment is efficient, an expansion of future investment financed by an increase in a consumption tax rate is preferred by future generations. Since an expansion of future public investment financed by consumption taxation does not generate a crowding out effect in the capital market, it is more likely for tax financing to be preferred to debt financing. Higher future public investment with a higher consumption tax rate implies less disposal income, and this result is opposite to Kato (2002b). This is because Kato (2002b) only incorporated production-improving public capital, but not welfare-improving public capital. In this paper the magnitude of the effect of the incorporation of welfare-improving public capital and the assumption of efficient public investment substantially matter, and this result would be changed depending on both γ, the magnitude of a positive effect on utility, and how much public investment is efficient. If a 15 % of future public investment is inefficient, then many future generations will be worse off by the expansion of public investment financed by consumption taxation.

Finally, future public investment on production-improving public capital is more preferable rather than that on welfare-improving public capital. This implies that an expansion of GDP, thus of disposal income, is more efficient than an expansion of the stock of welfare-improving public capital in a sense that it improves utility.

It should be noted that all results obtained in this paper depend on the values of parameters, particularly of β, the coefficient of production-improving public capital in the private production function, and γ, the degree of welfare-improving public capital in the individual's utility. The values of both parameters were obtained from the existing empirical research, and actual values of important variables have been well traced by simulated ones. However, further analysis on parameters or more sophisticated calibration would improve the interpretation of simulated results.

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Figure 1-1: GDP (Benchmark Case)

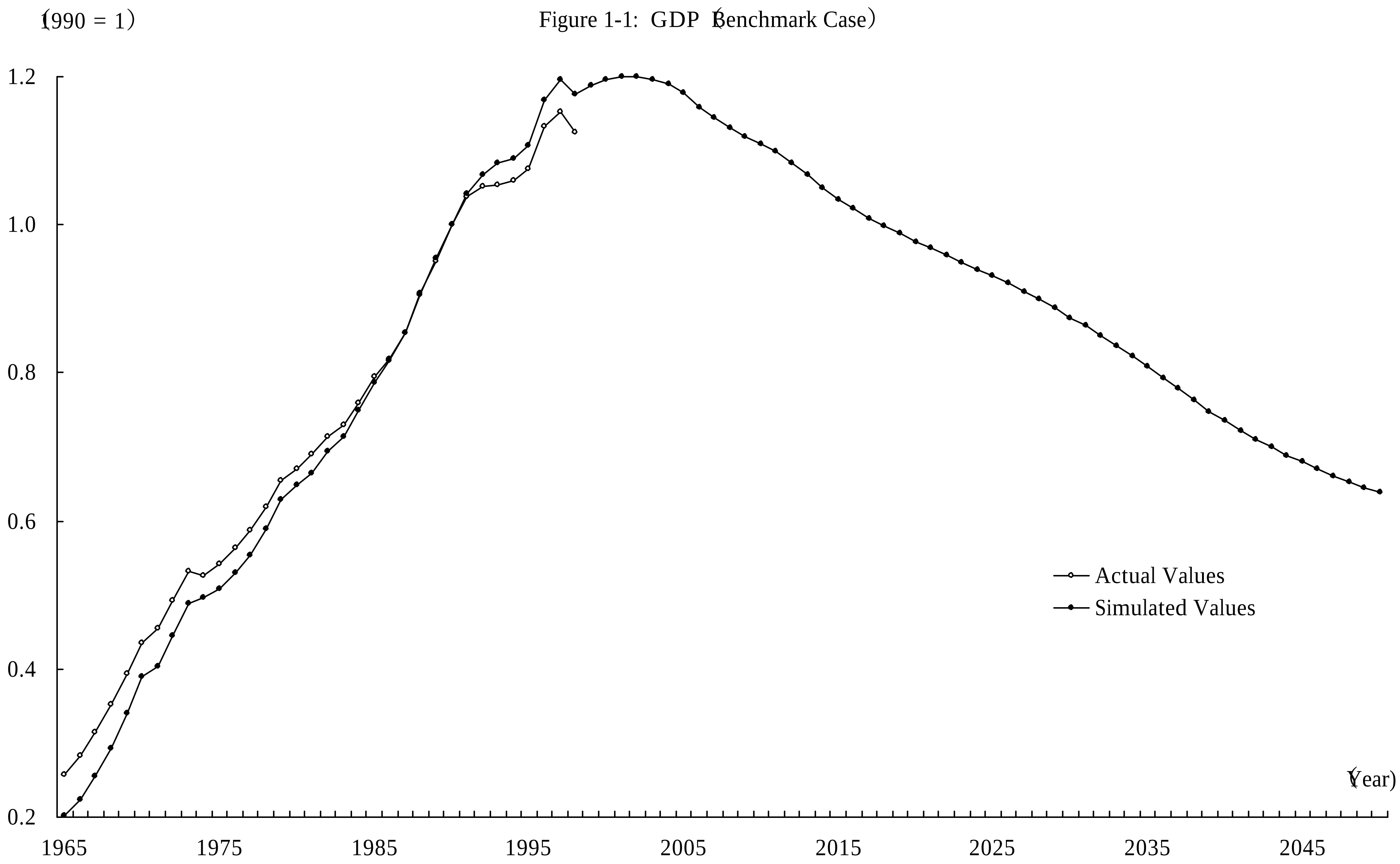

Figure 1-2: Per Capita GDP (Benchmark Case)

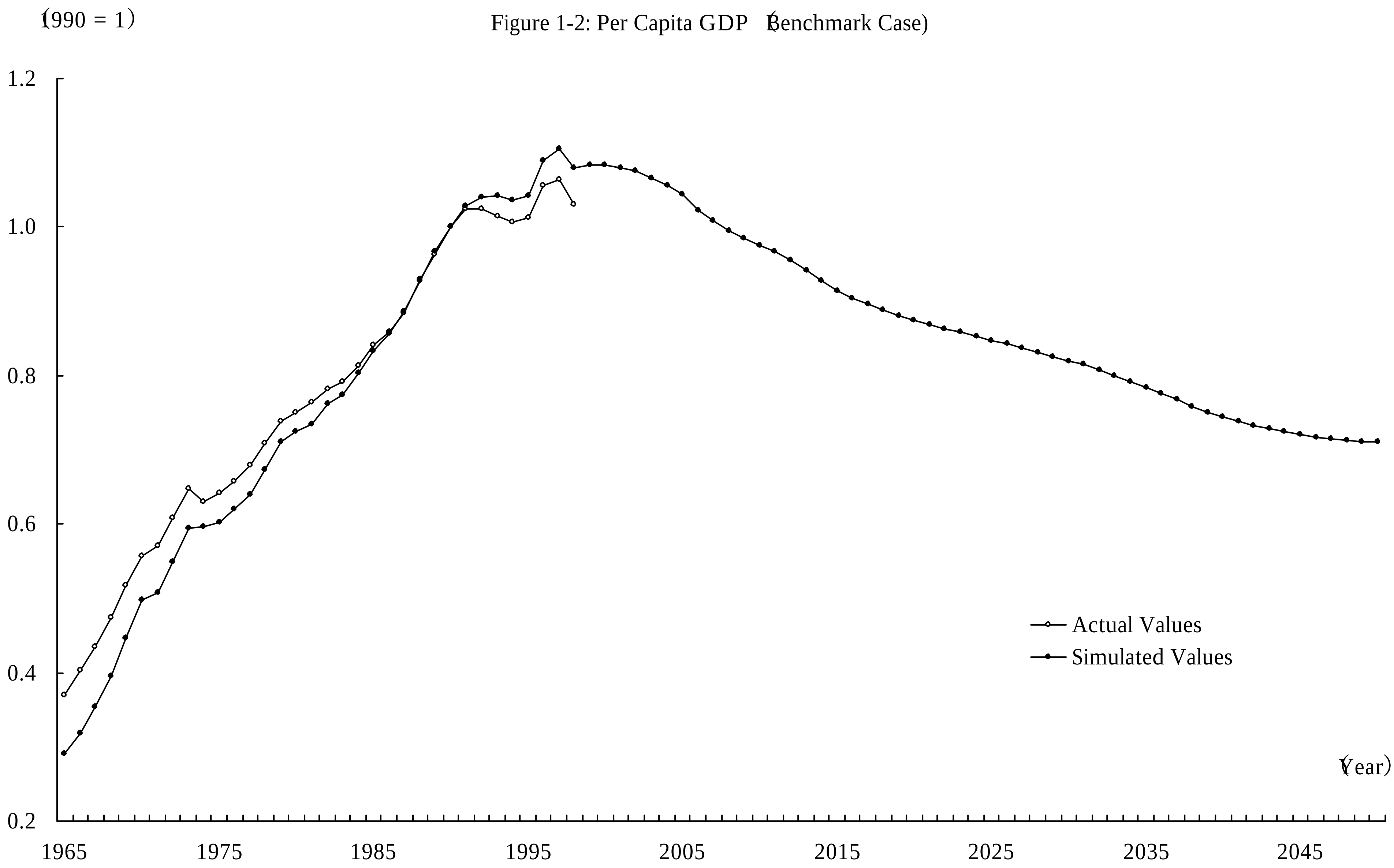

Figure 1-3: Private Capital Stock (Benchmark Case)

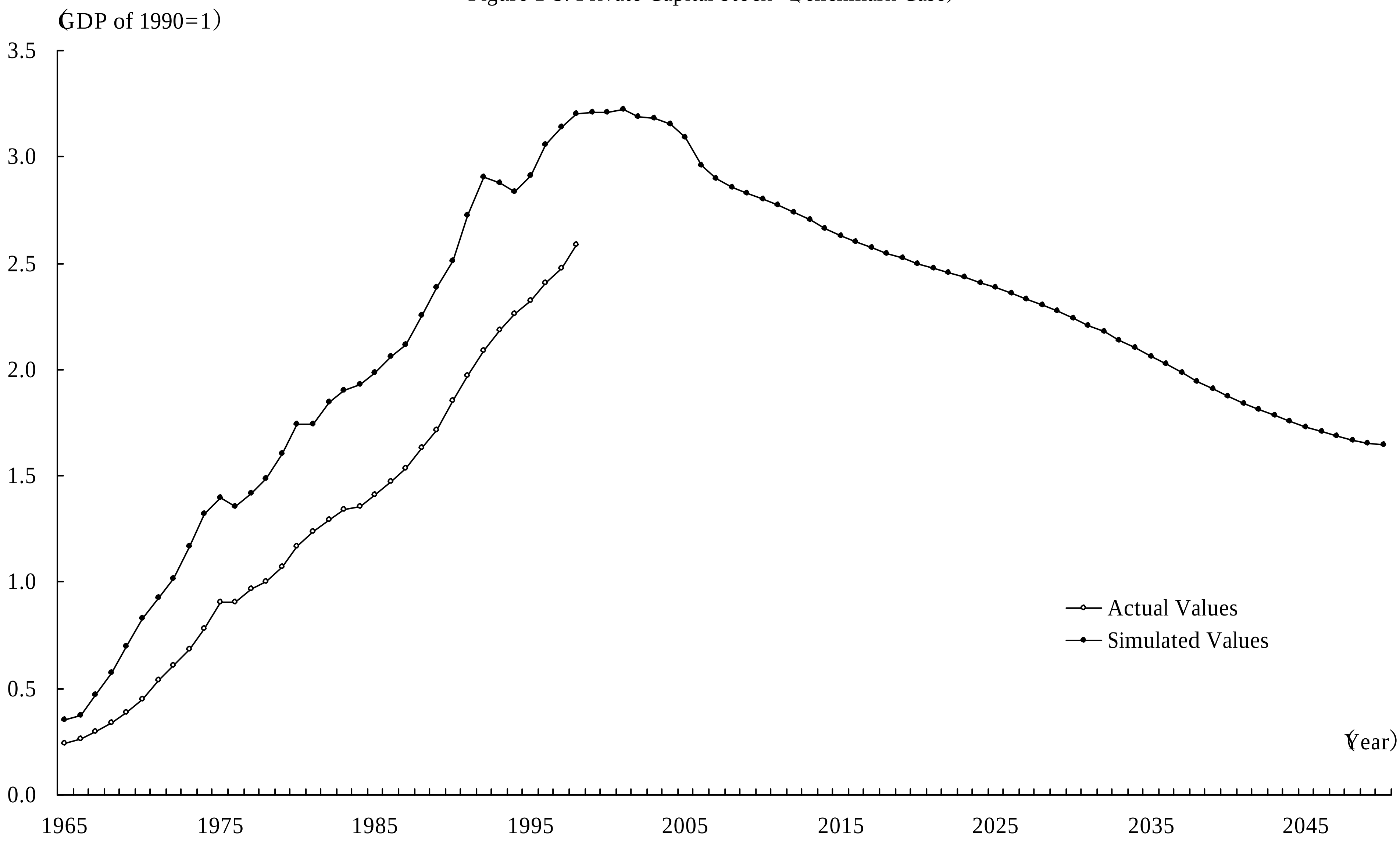

Figure 1-4: Public Investment (Benchmark Case)

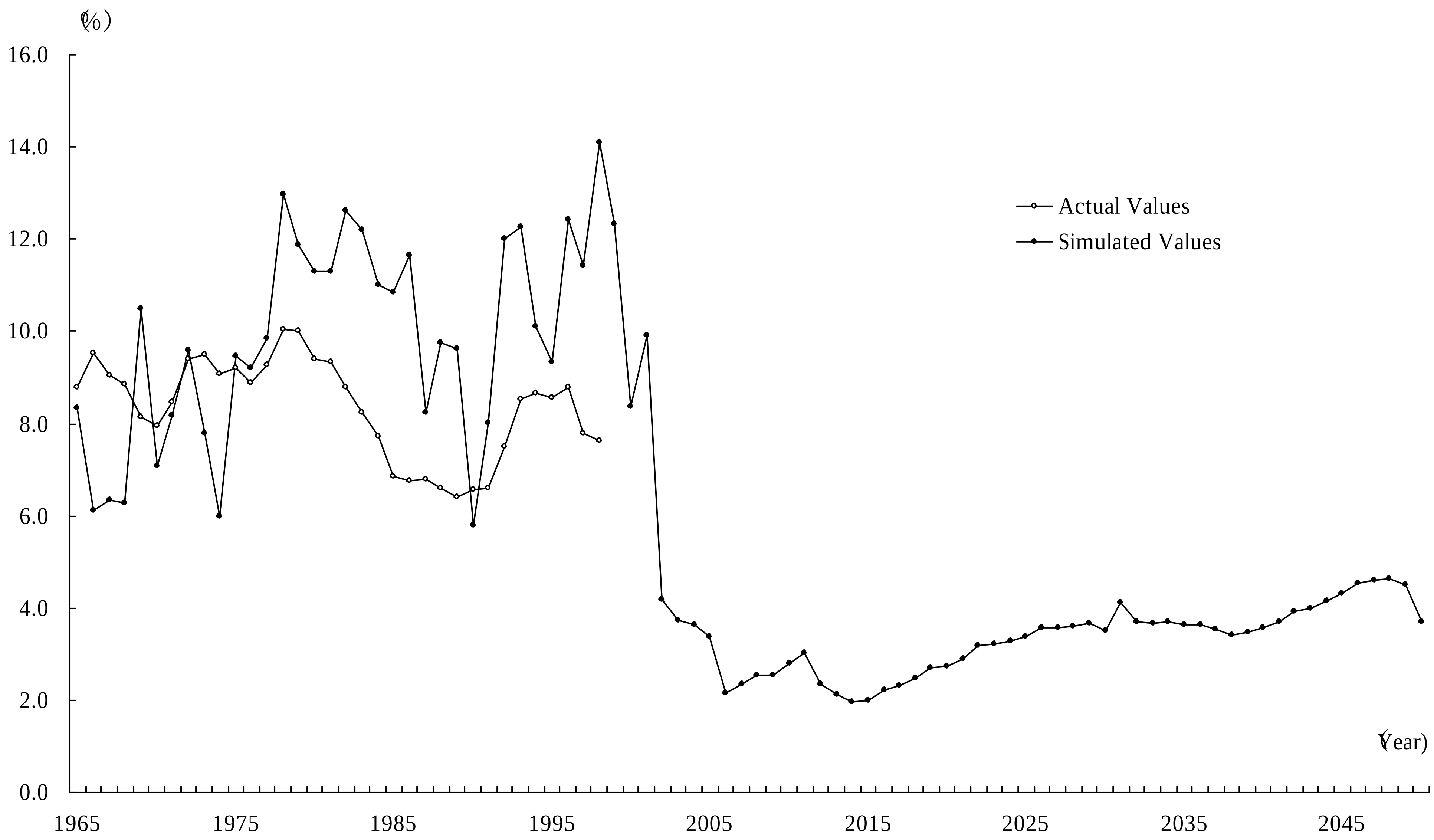

Figure 1-5: Production-Improving Public Capital
(Benchmark Case)

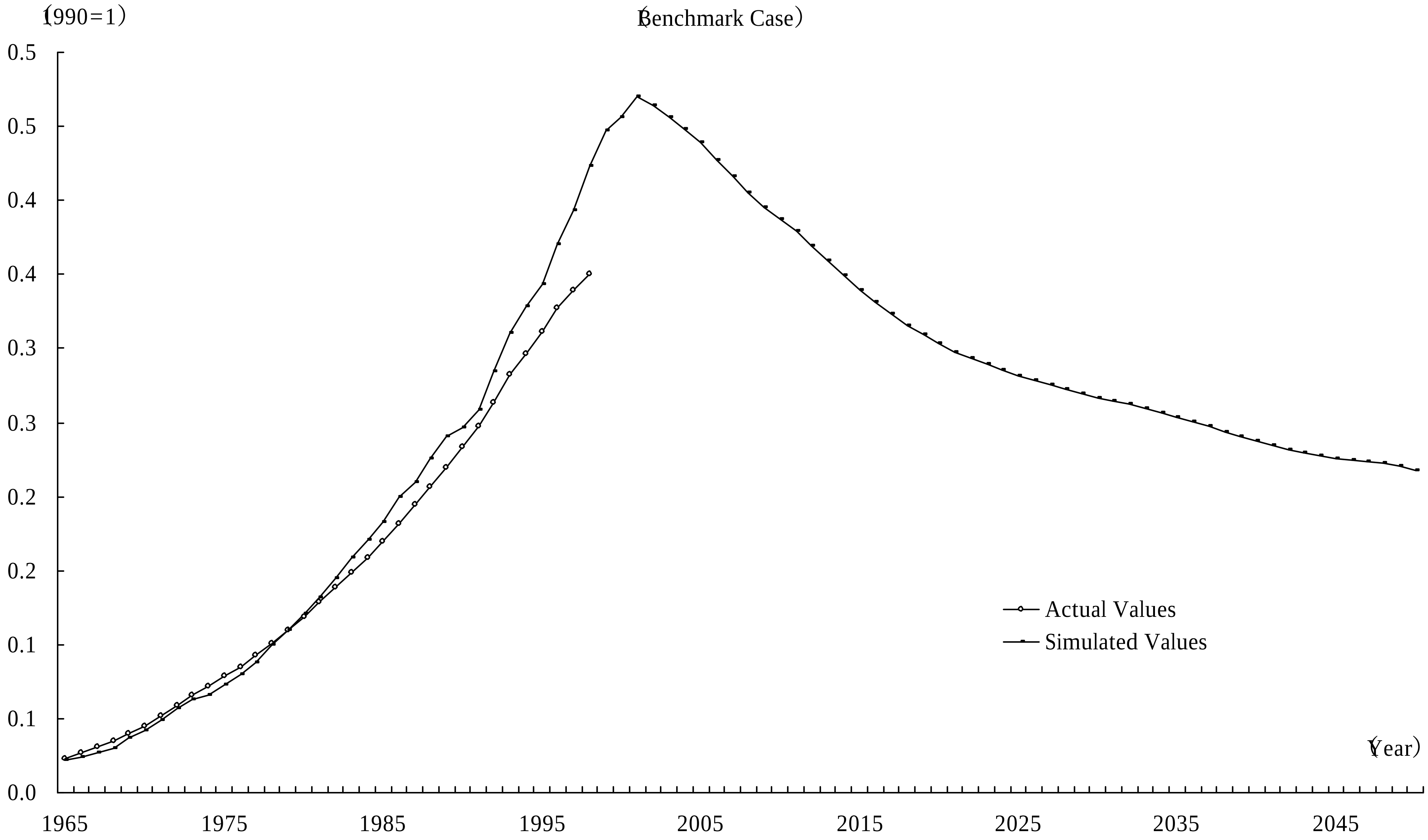

Figure 1-6: Tax Burdens Ratio (Benchmark Case)

Figure 1-7: Contribution Rate (Benchmark Case)

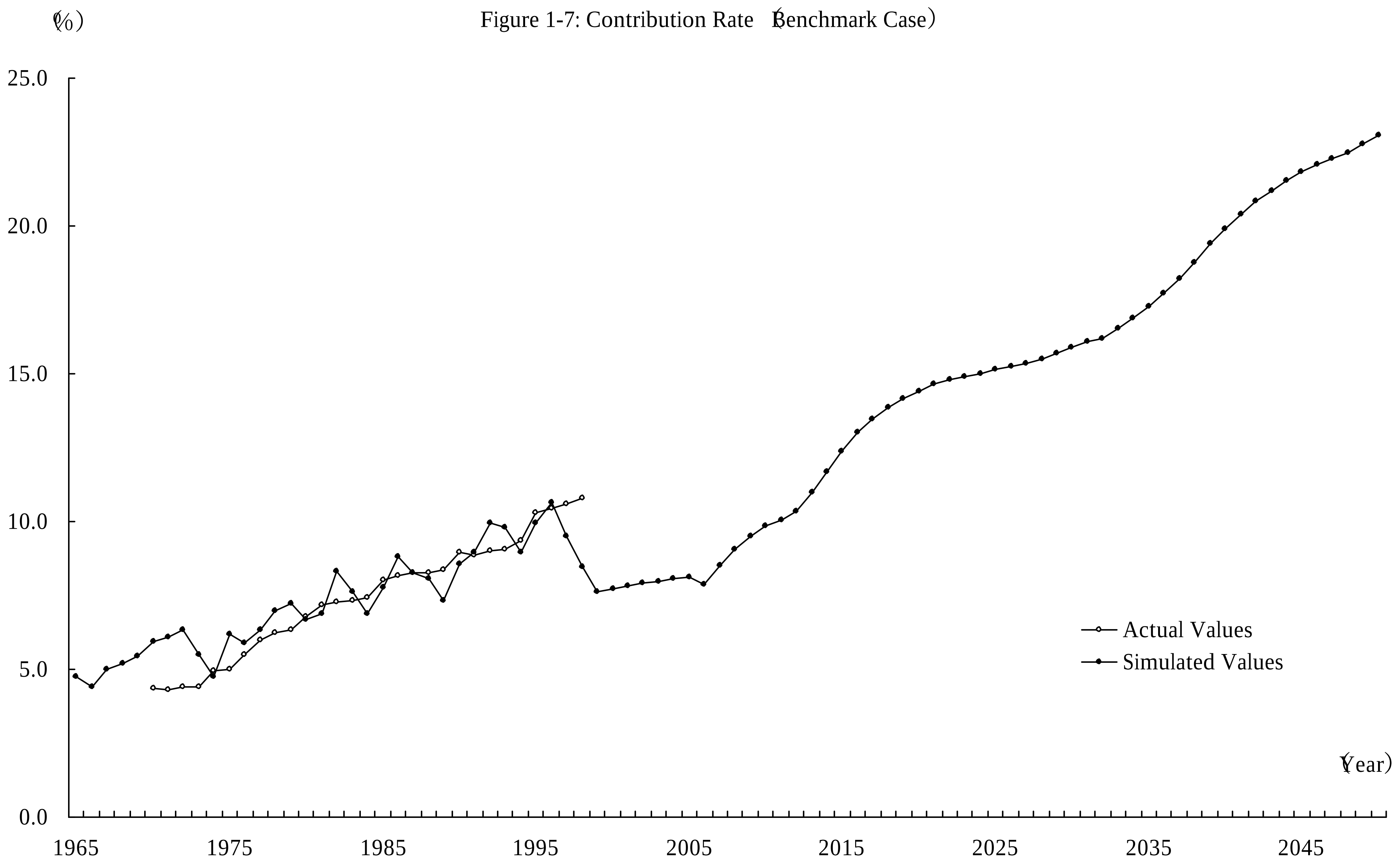

Figure 1-8: Primary Balance (Benchmark Case)

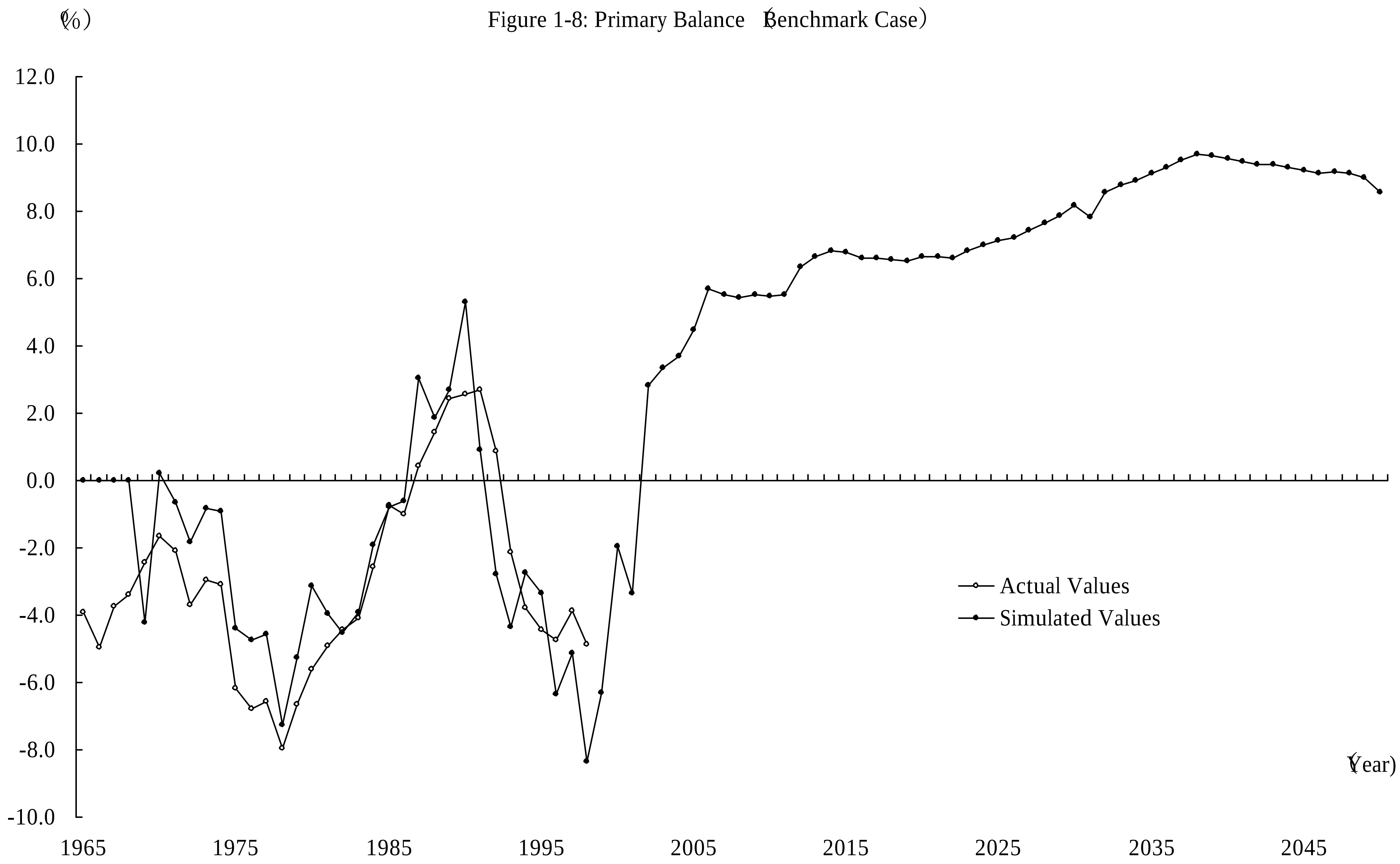

Figure 1-9: Compensating Variation （Benchmark Case）

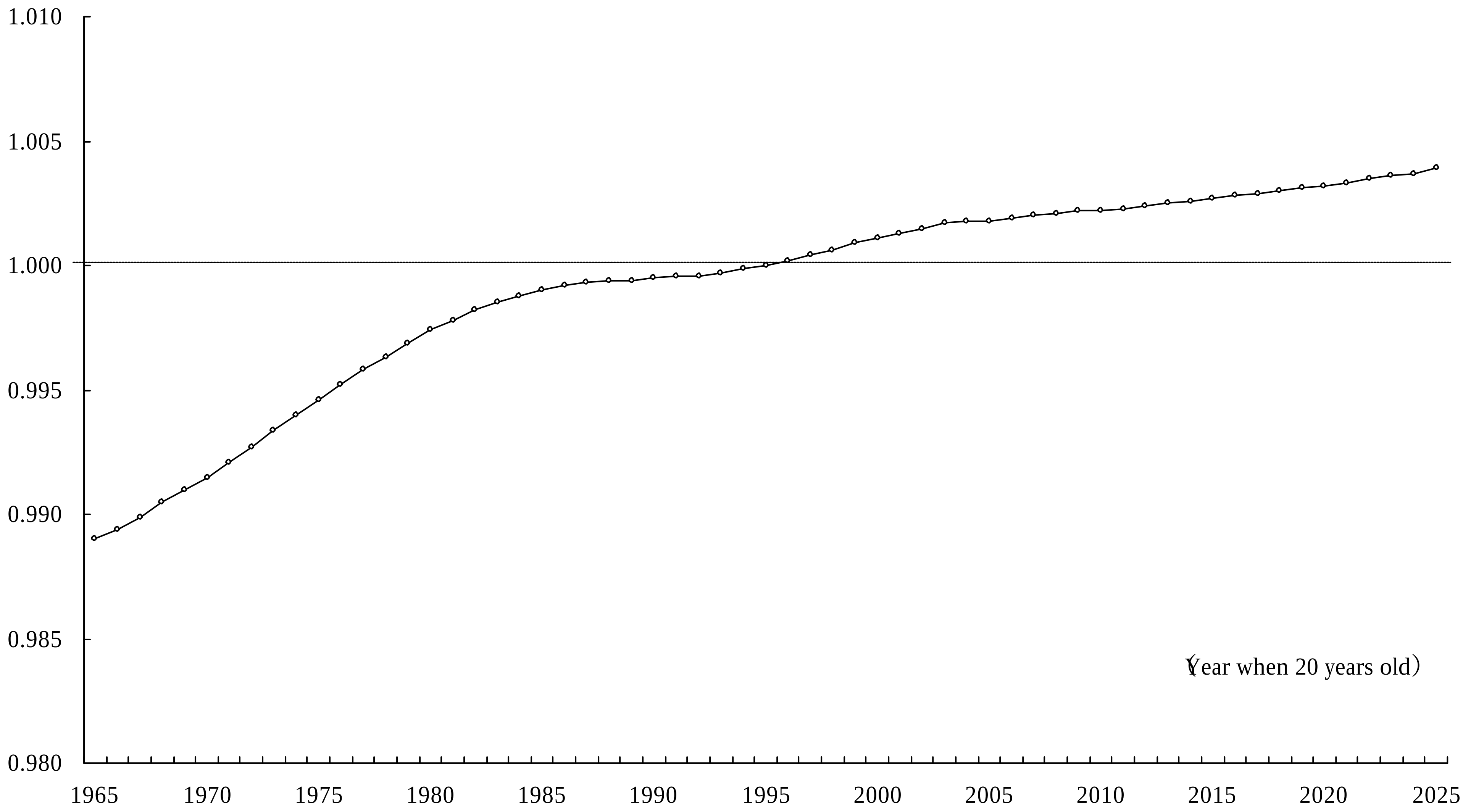

Figure 2-1: Private Capital Stock (Consumption Tax Rate = 25%)

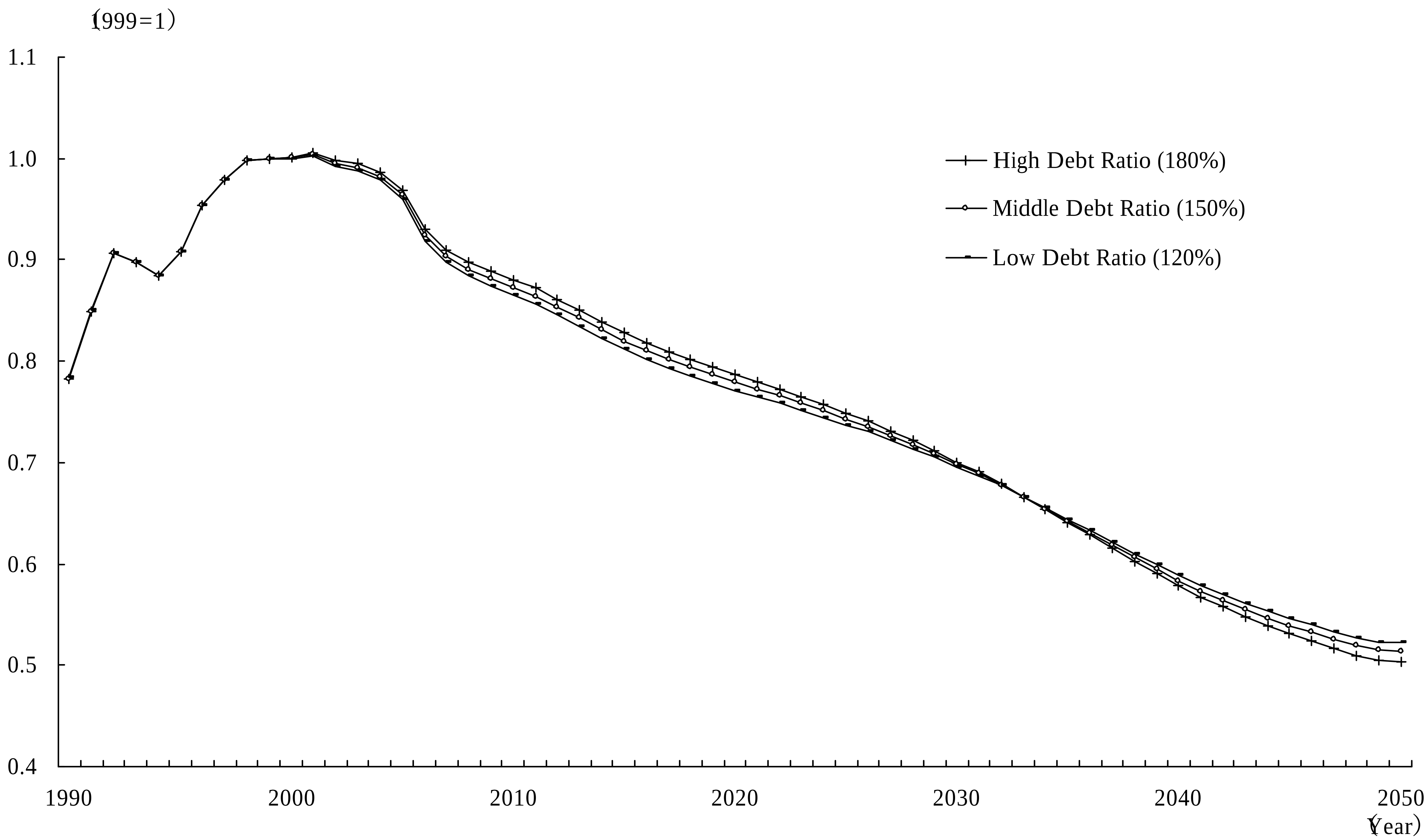

Figure 2-2: Raios of Public Investment to GDP
(Consumption Tax Rate = 25%)

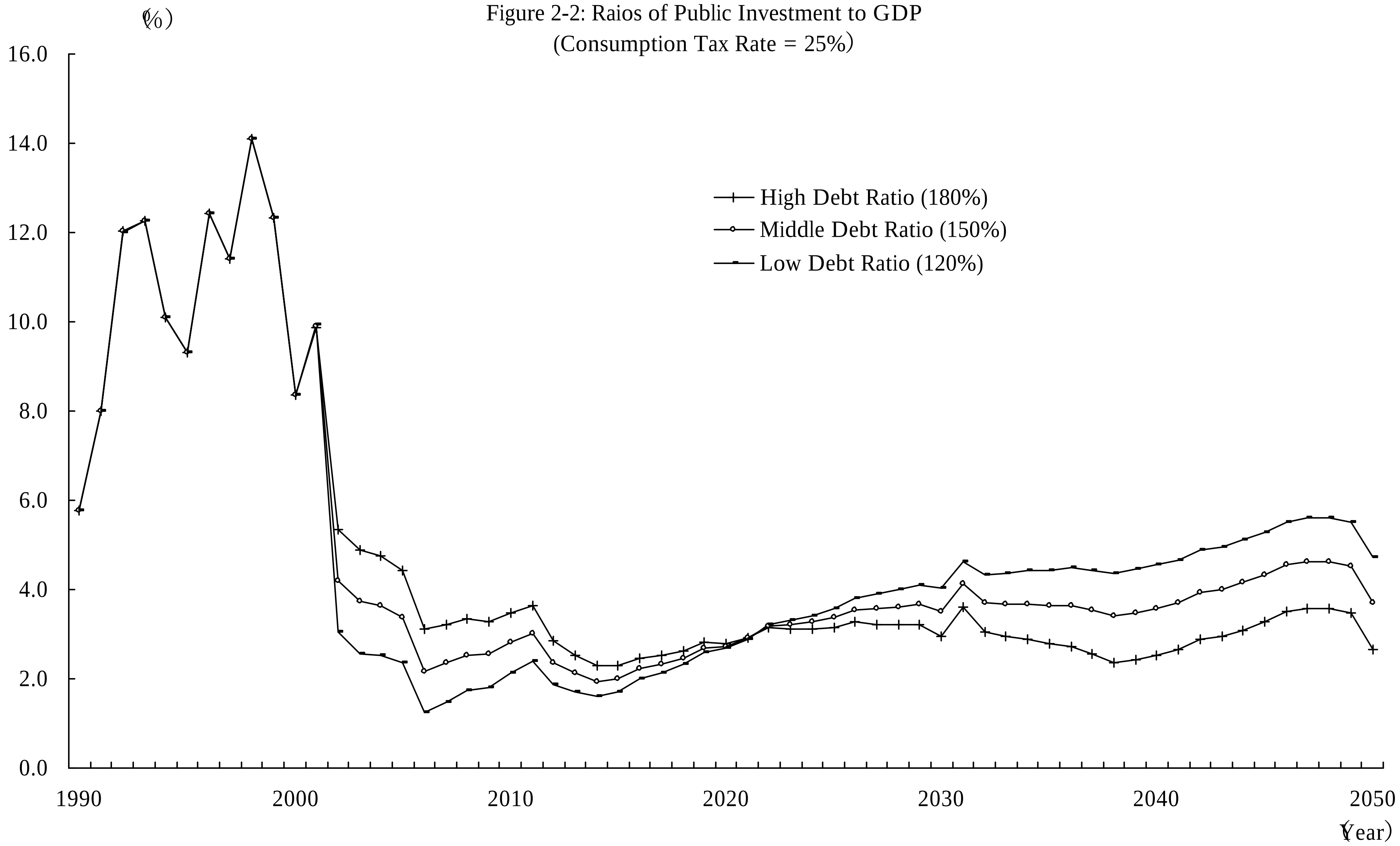

Figure 2-3: Production-Improving Public Capital
(Consumption Tax Rate = 25%)

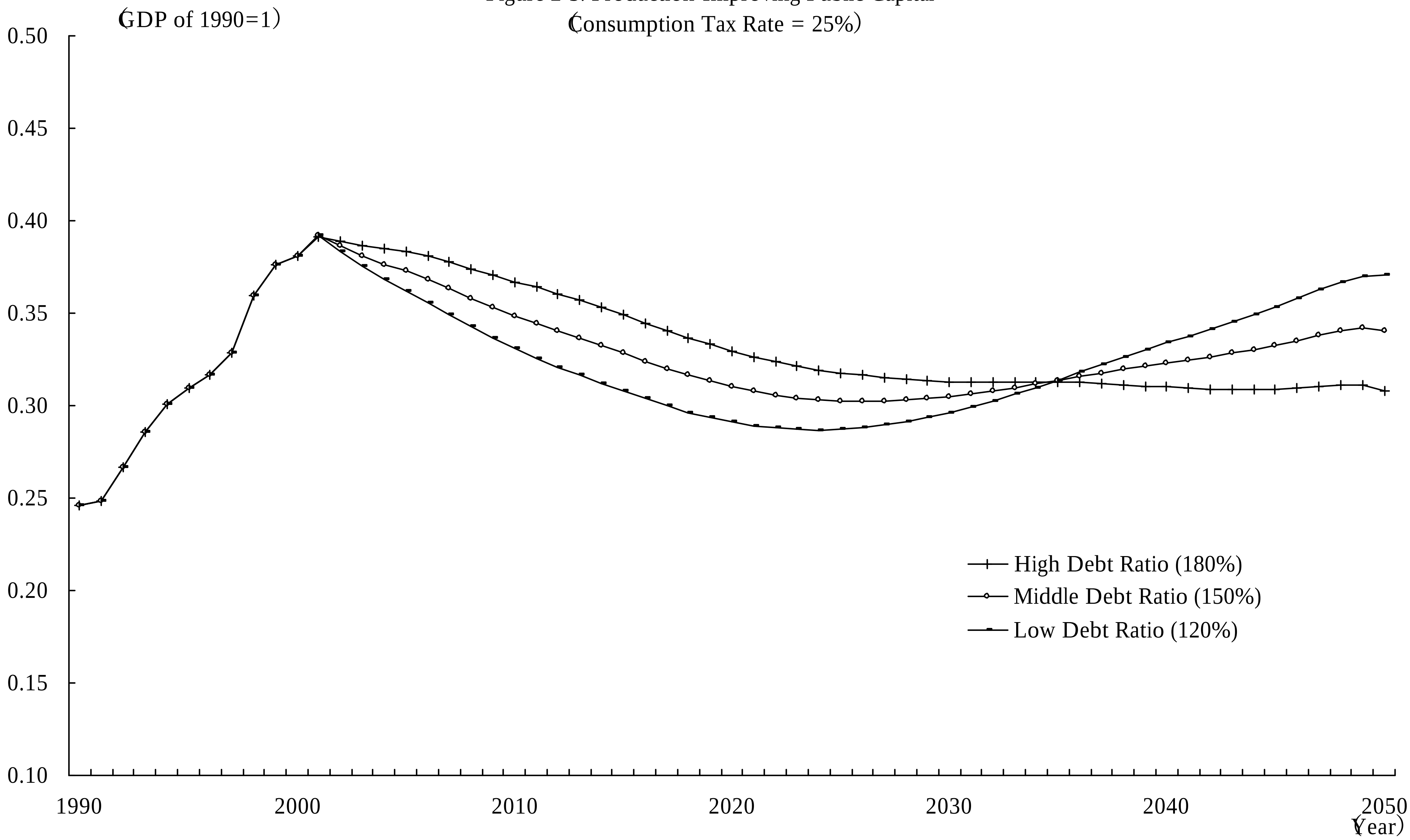

Figure 2-4: Aggregate Savings (Consumption Tax Rate = 25%)

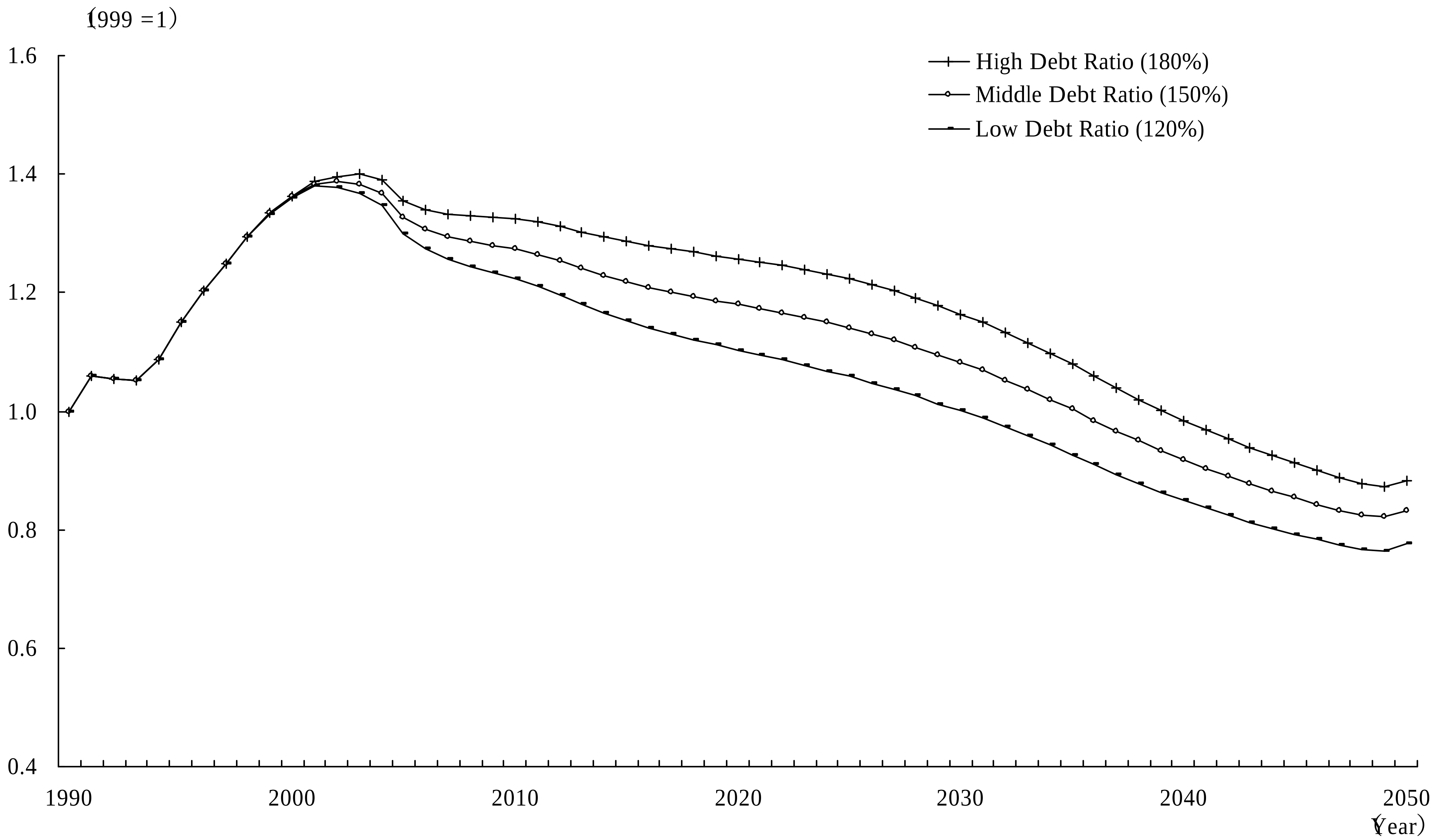

Figure 2-5: Pre-Taxed Interest Rate
(Consumption Tax Rate = 25%)

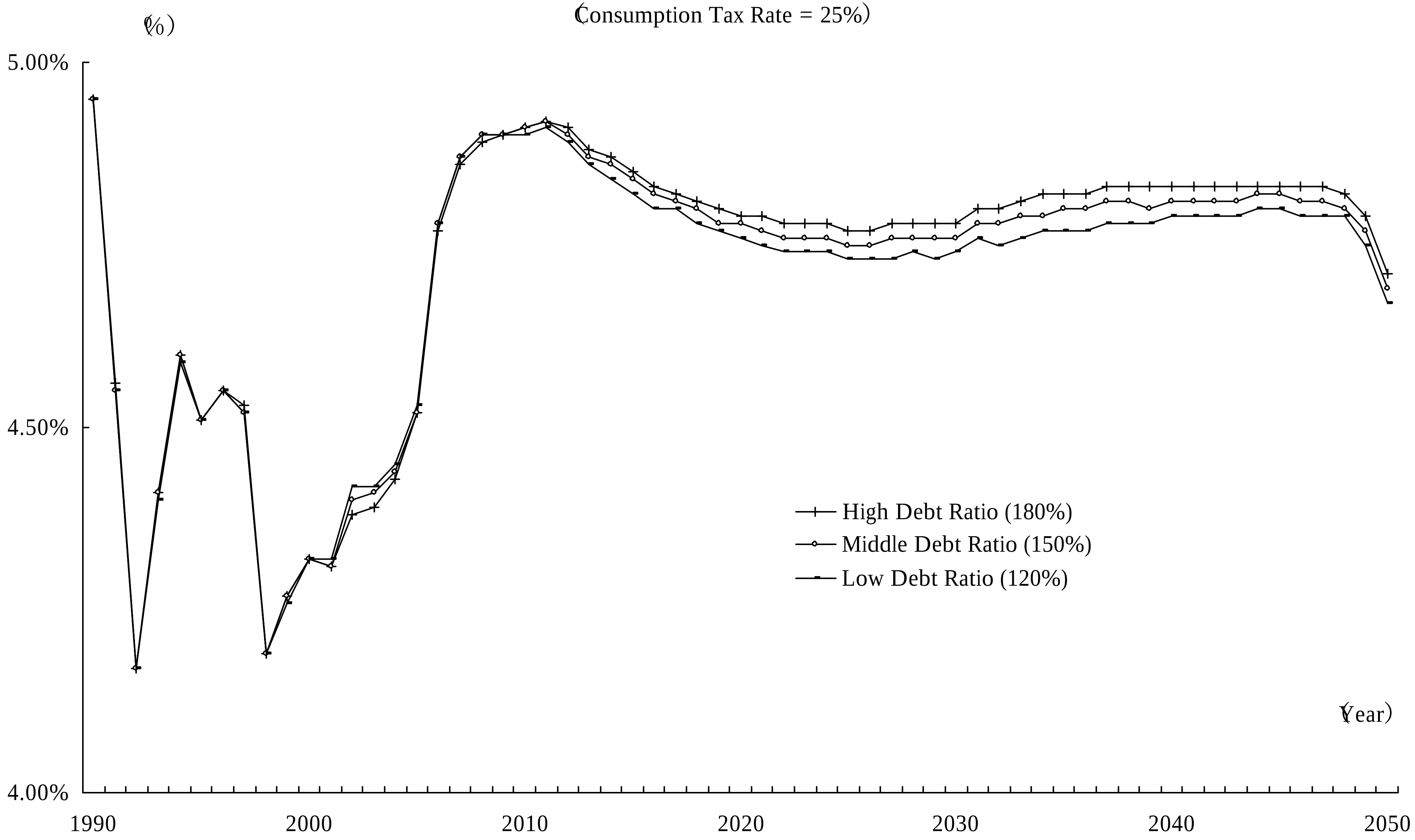

Figure 2-6: GDP (Consumption Tax Rate = 25%)

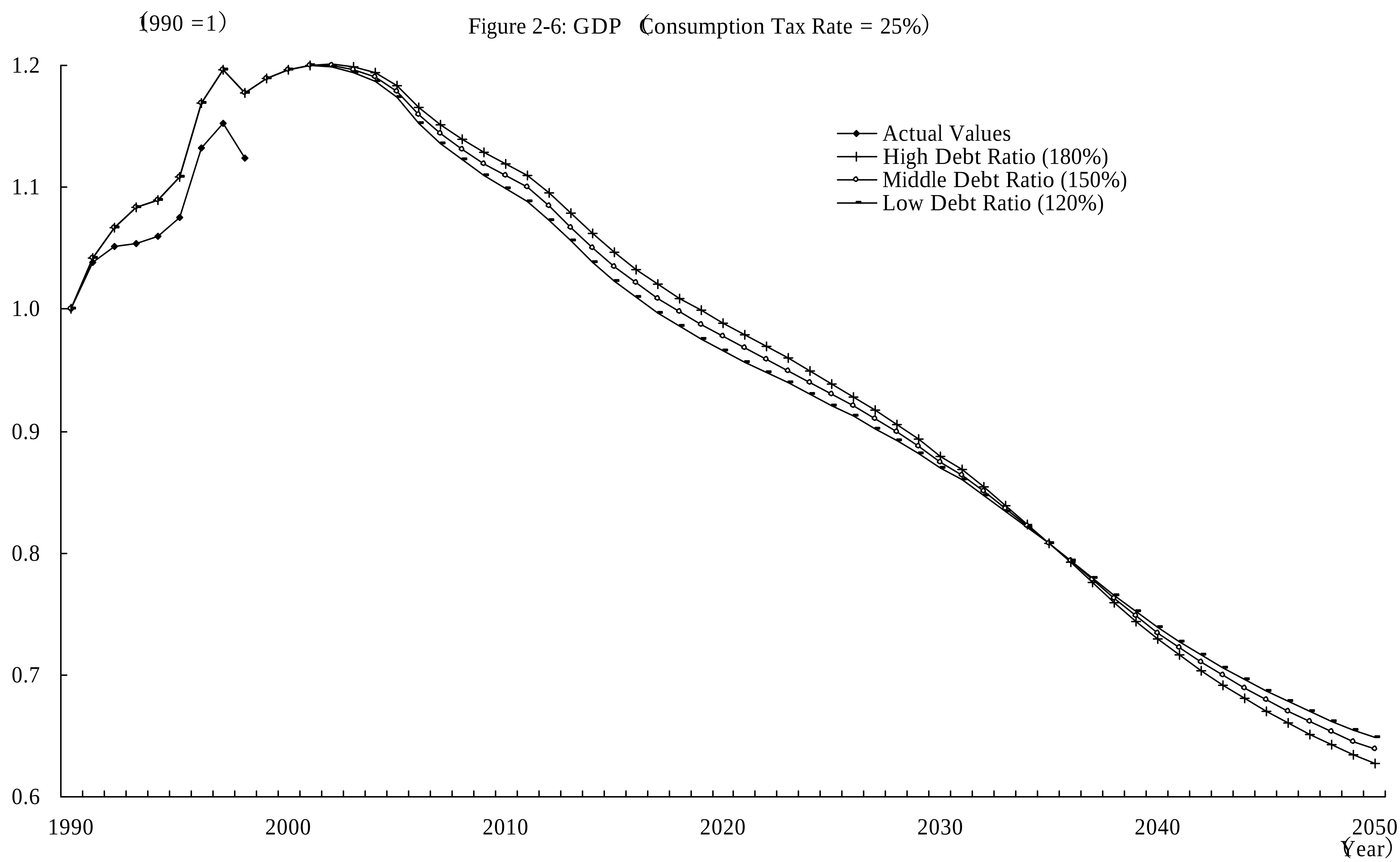

Figure 2-7: Utility Levels
(Consumption Tax Rate = 25%)

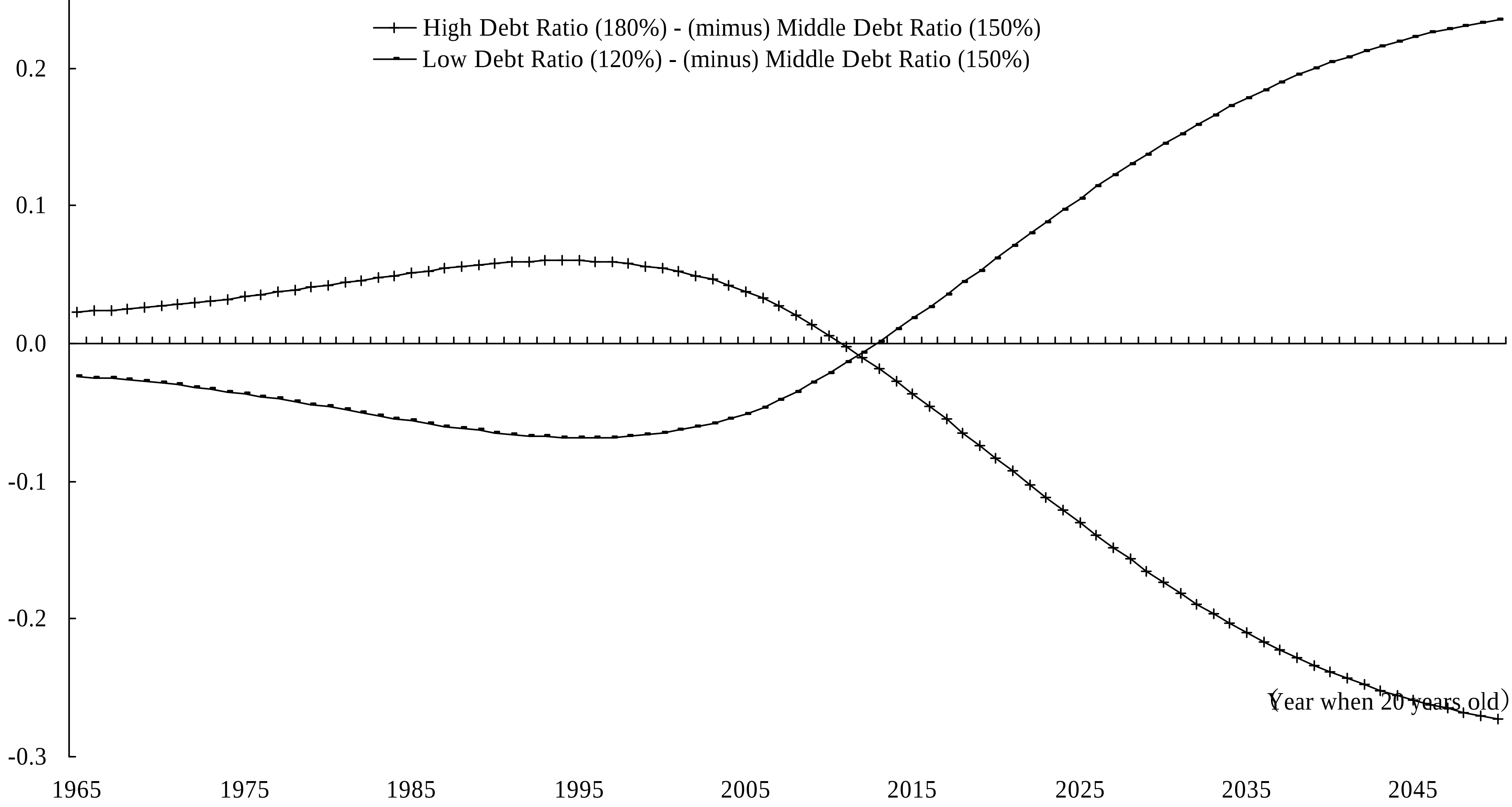

Figure 2-8: Compensating Variation
(Consumption Tax Rate = 25%)

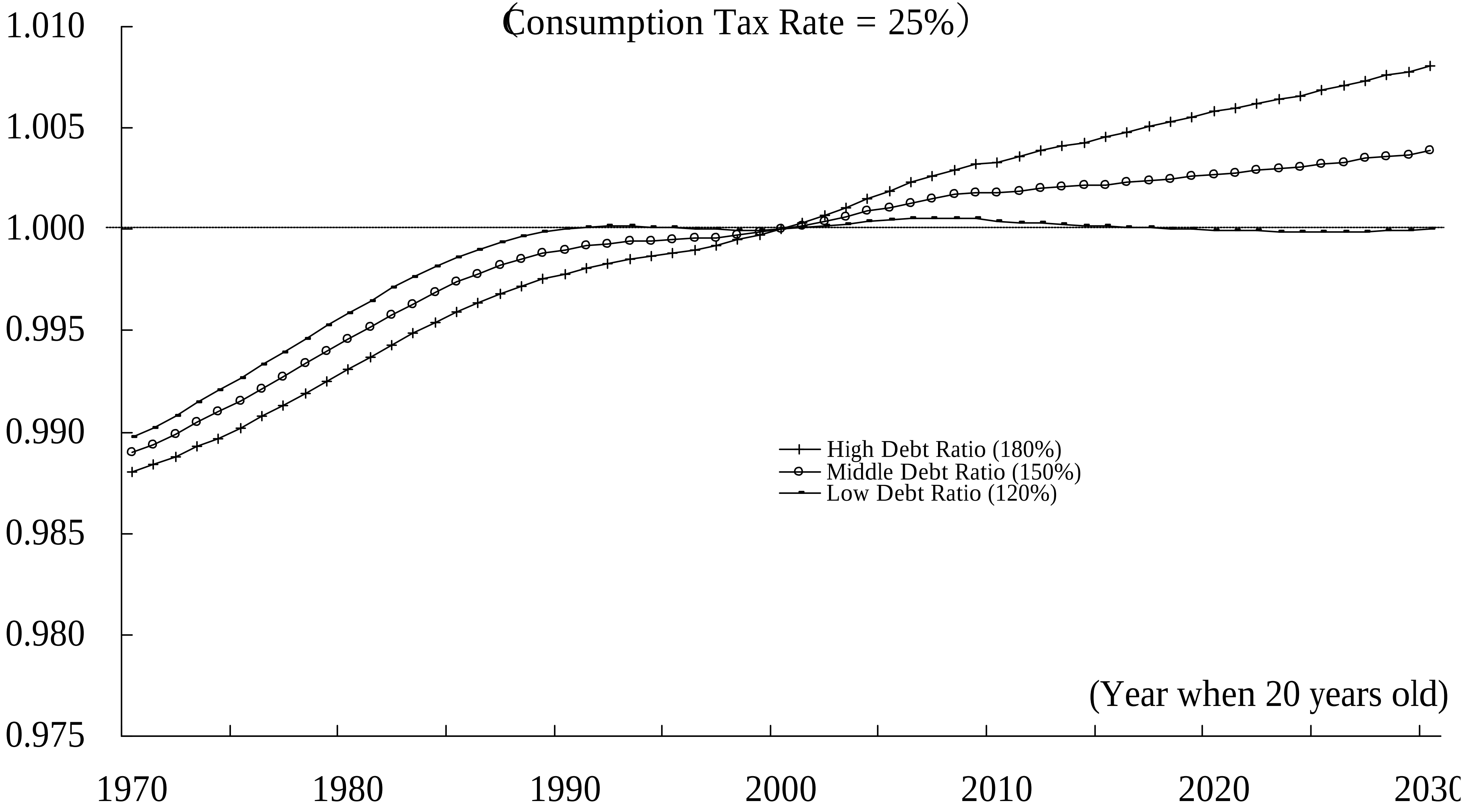

Figure 3-1: Private Capital Stock
(Debt-GDP Ratio = 150%)

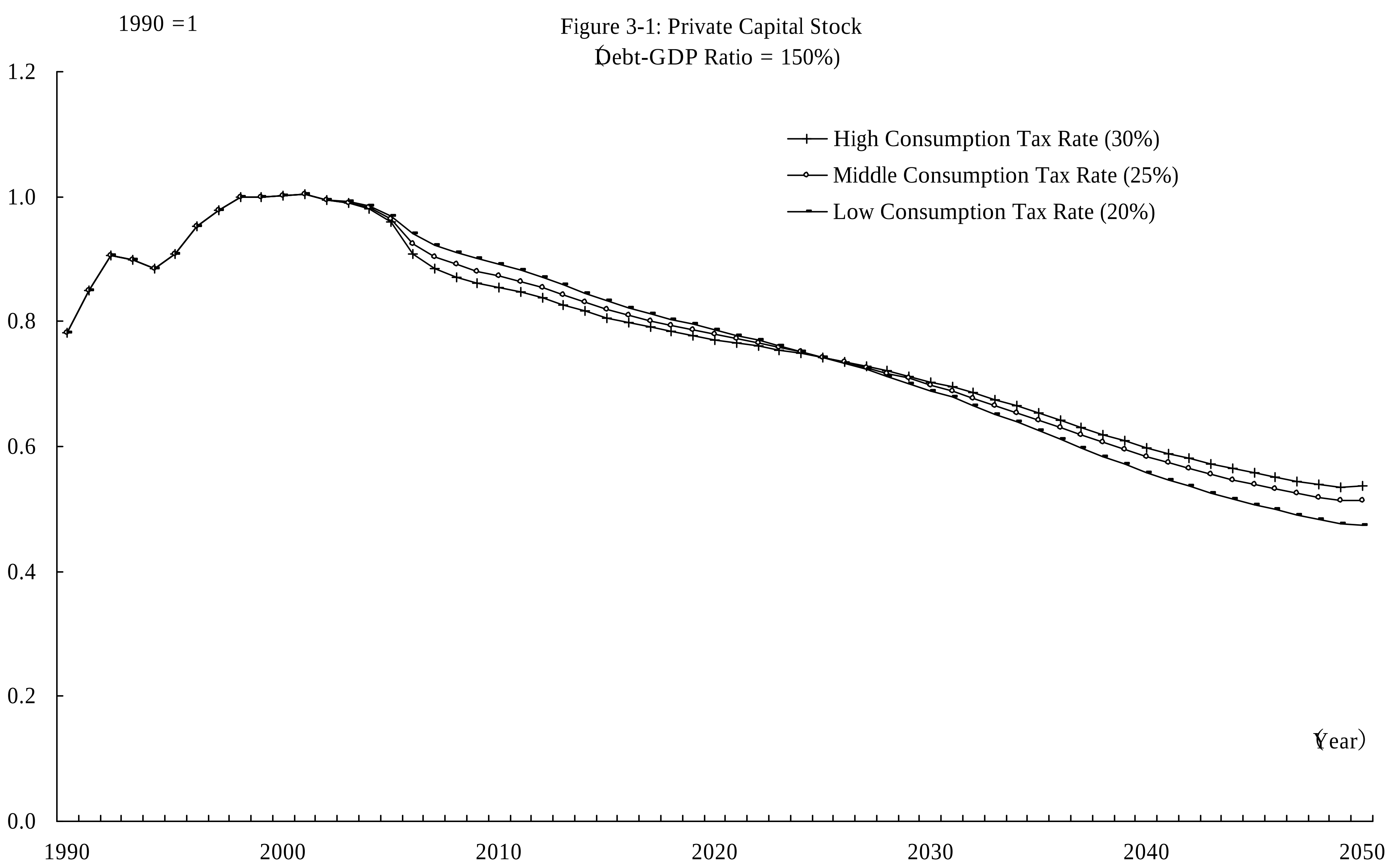

Figure 3-2: Ratios of Public Investment to GDP
(Debt-GDP Ratio = 150%)

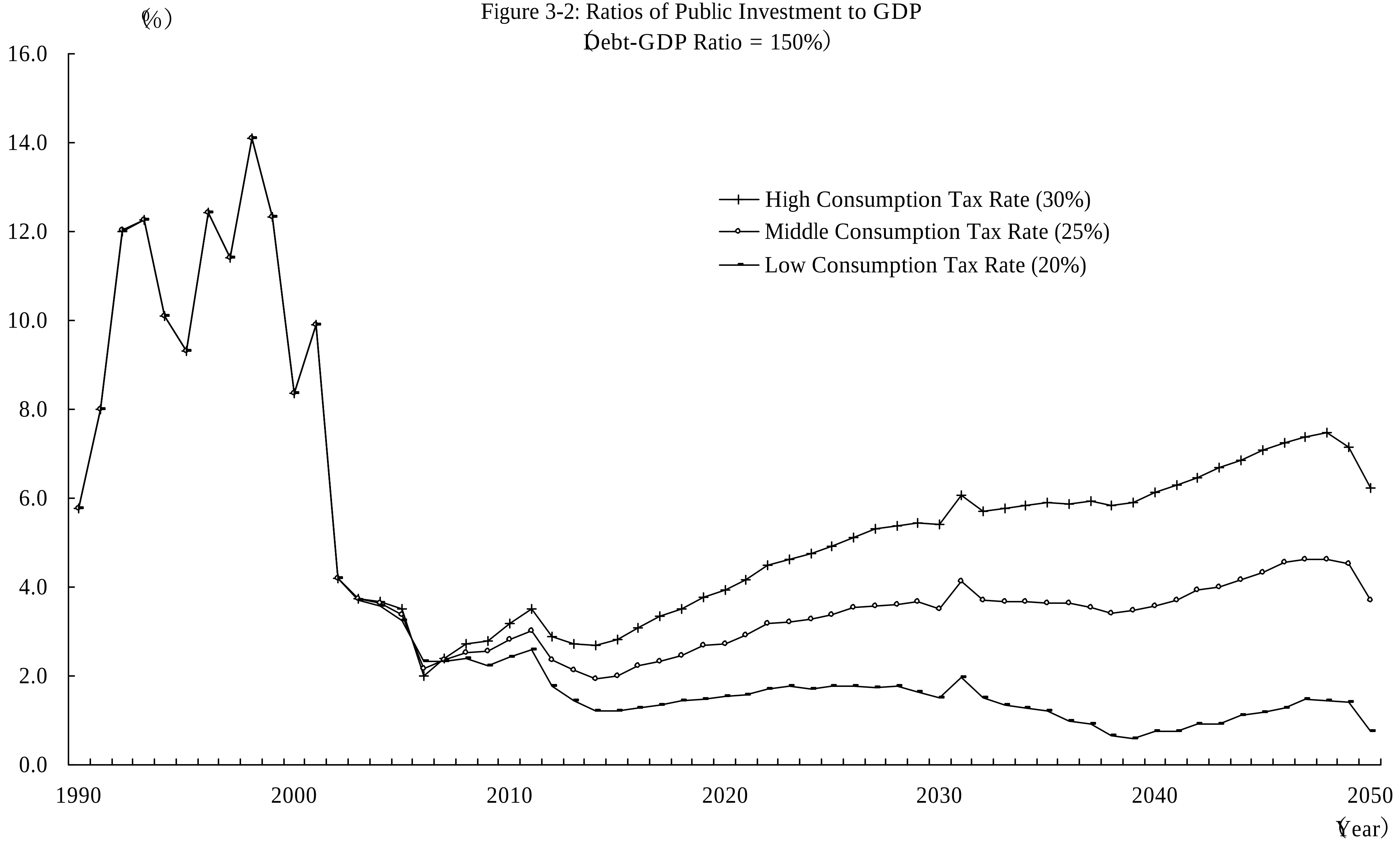

Figure 3-3: Production-Improving Public Capital
(Debt-GDP Ratio = 150%)

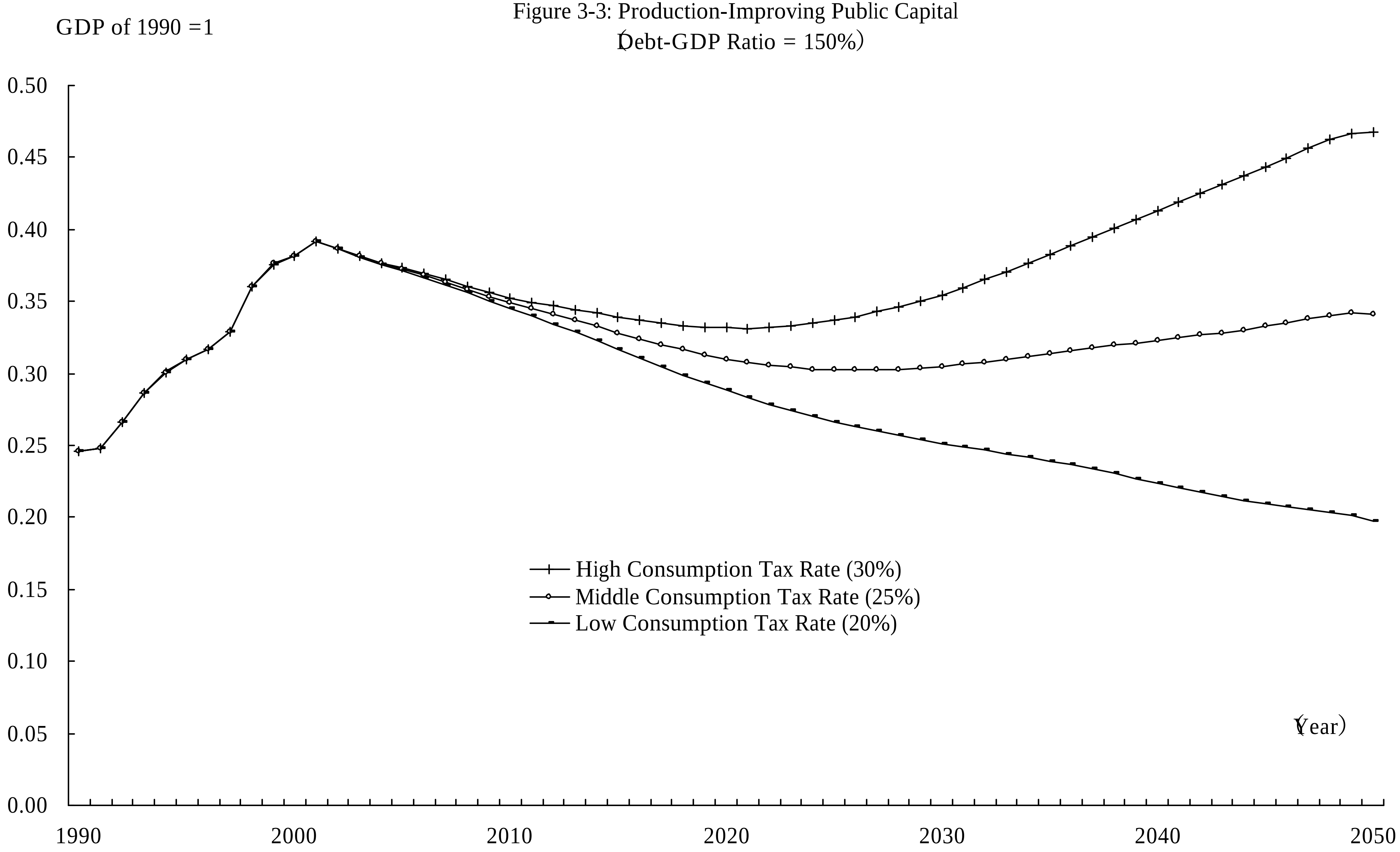

Figure 3-4: Aggegate Savings (Debt-GDP Ratio = 150%)

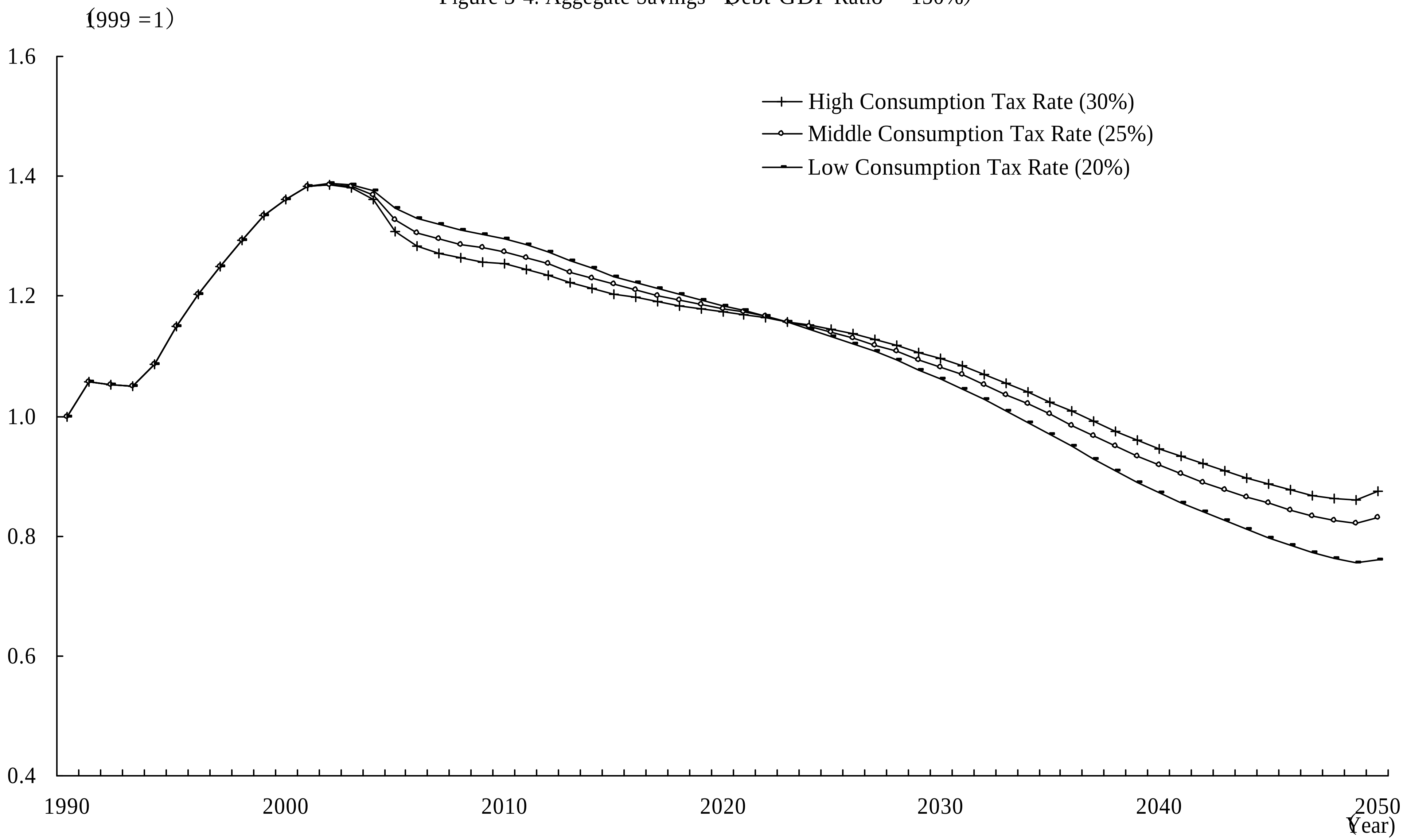

Figure 3-5: Pre-Taxed Interest Rate
(Debt-GDP Ratio = 150%)

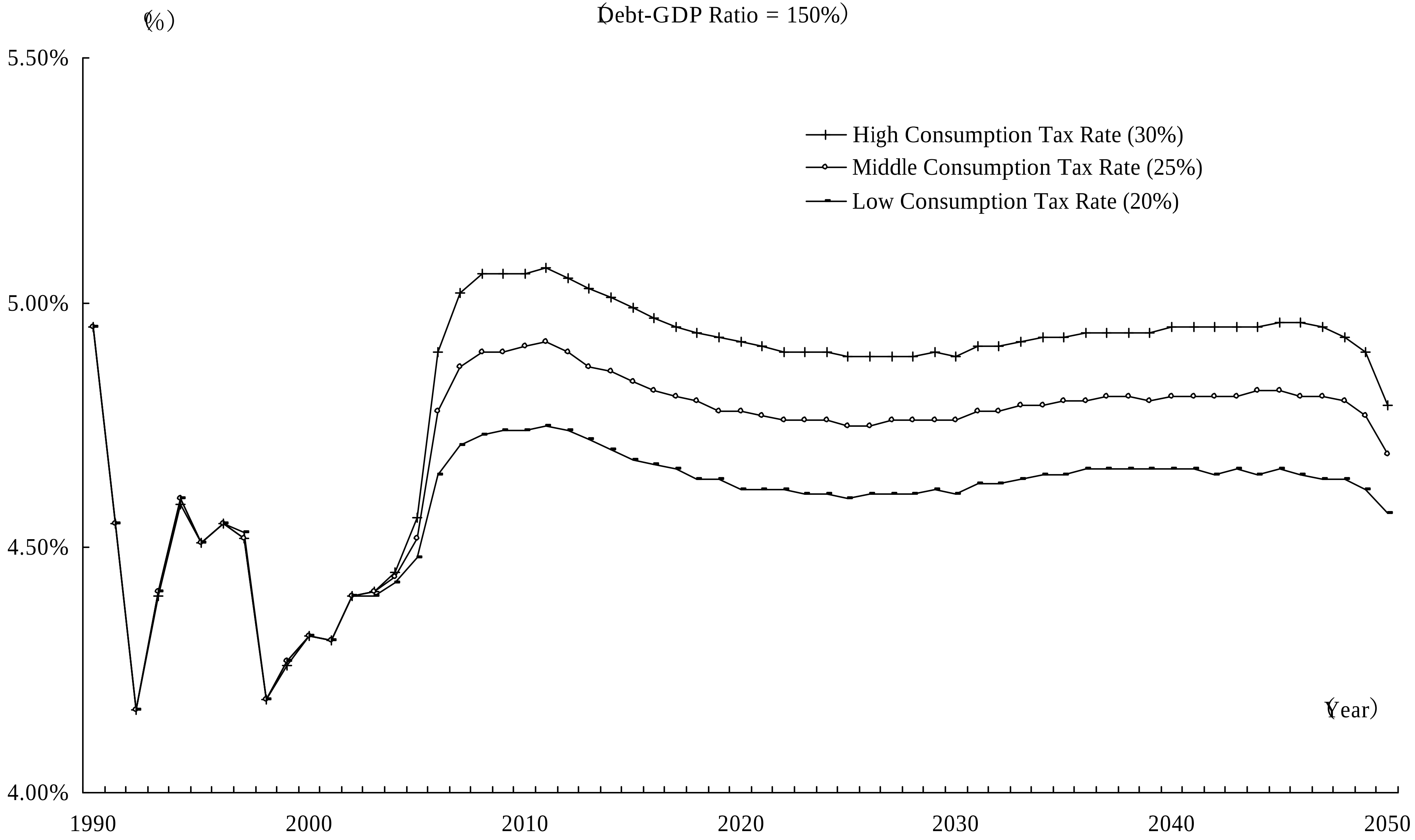

Figure 3-6: GDP (Debt-GDP Ratio = 150%)

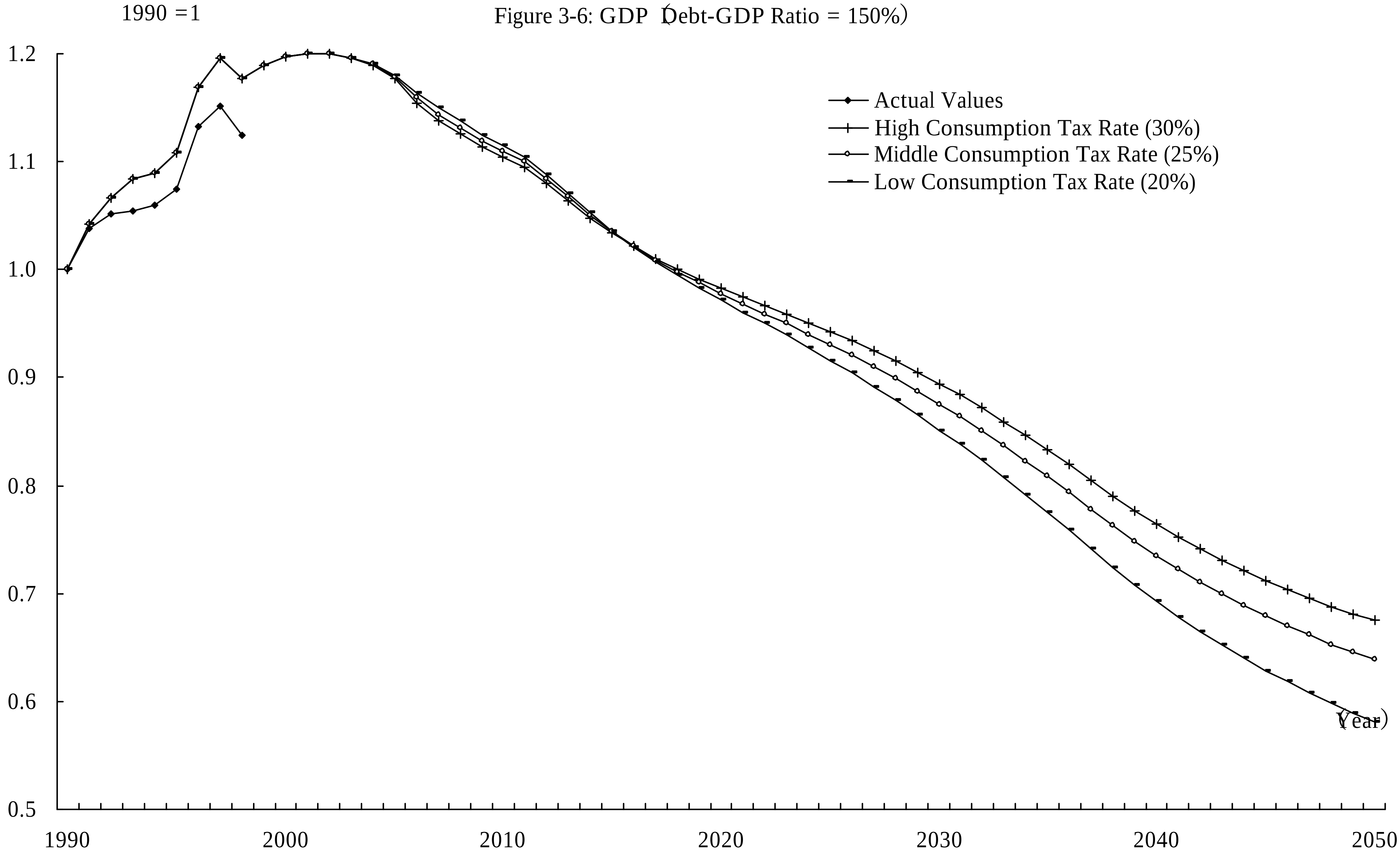

Figure 3-7: Utility Levels
(Debt-GDP Ratio = 150%)

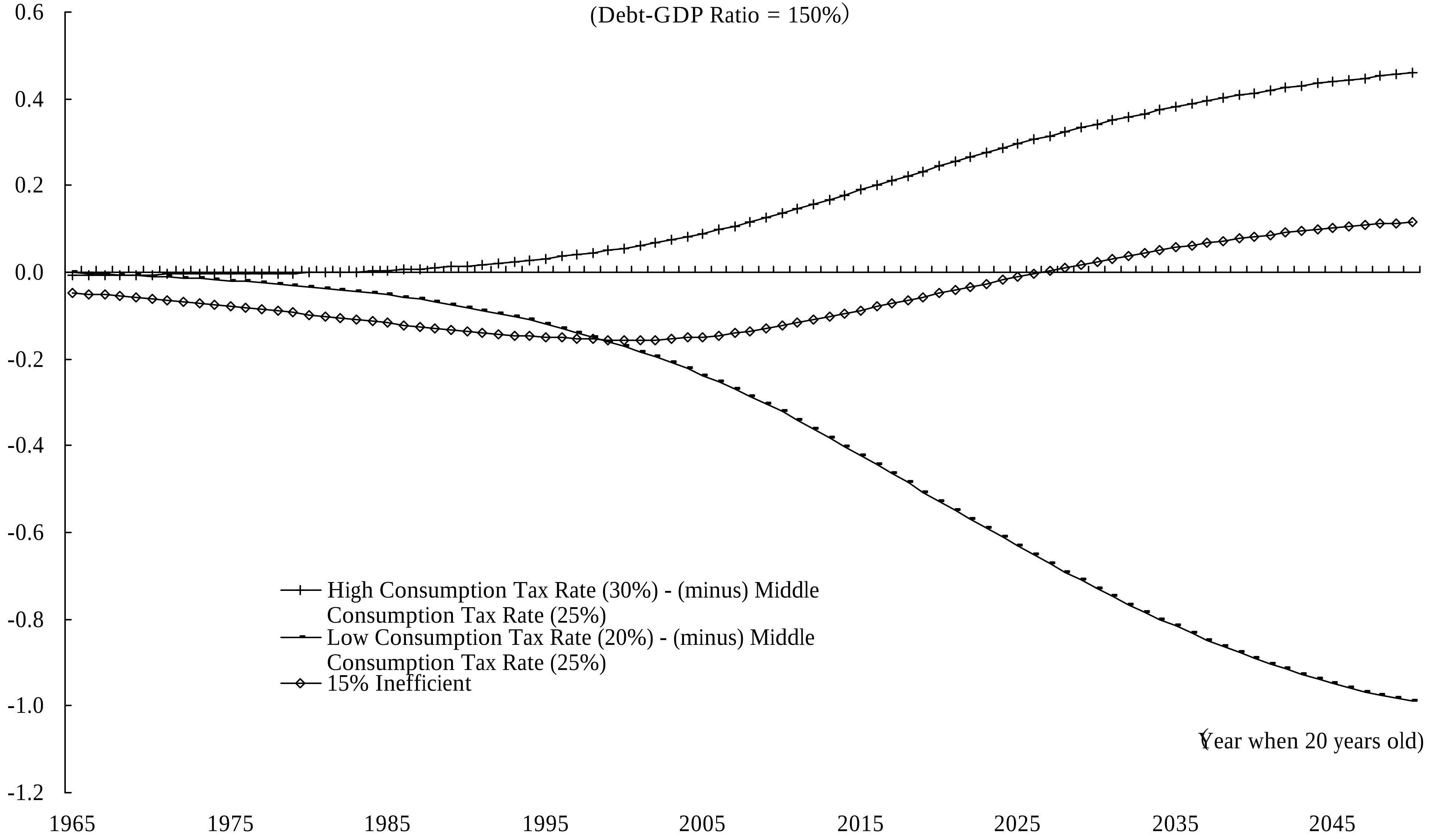

Figure 3-8: Compensating Variation
(Debt-GDP Ratio = 150%)

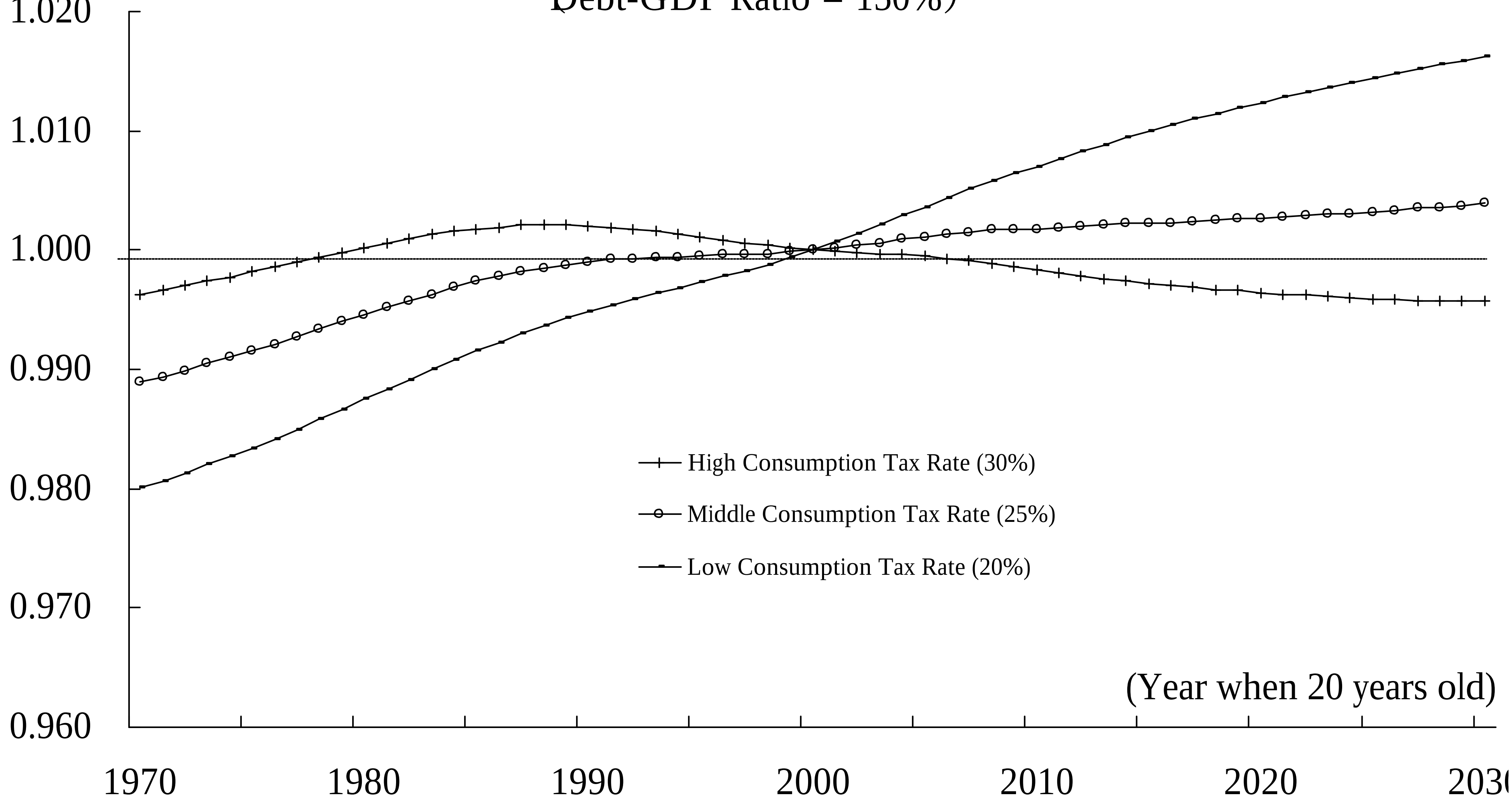

Figure 4-1: Utility Levels
(Consumption Tax Rate = 25%)

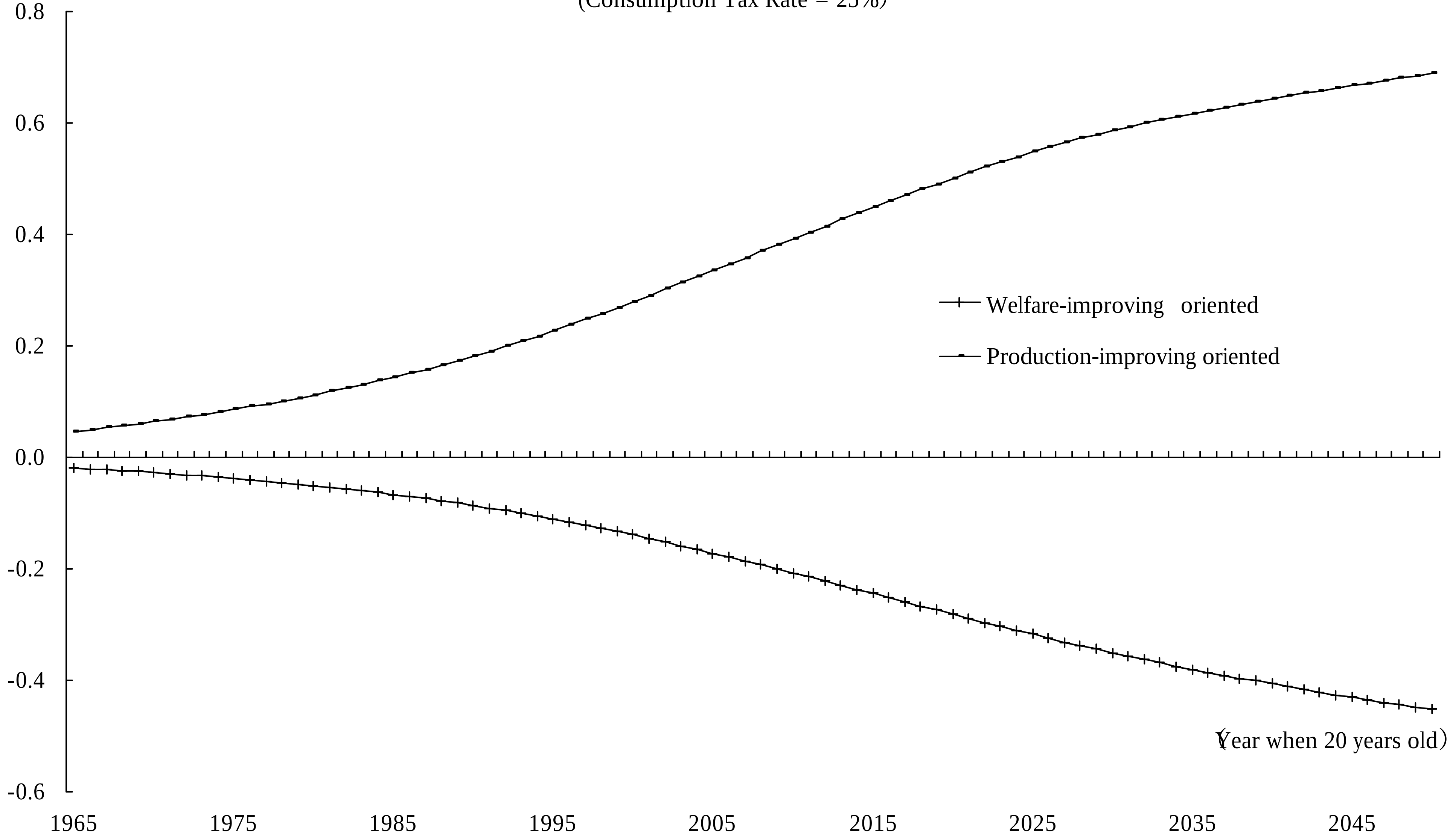

Figure 4-2: Utility Levels
(Consumption Tax Rate = 25%: ?=0.01)

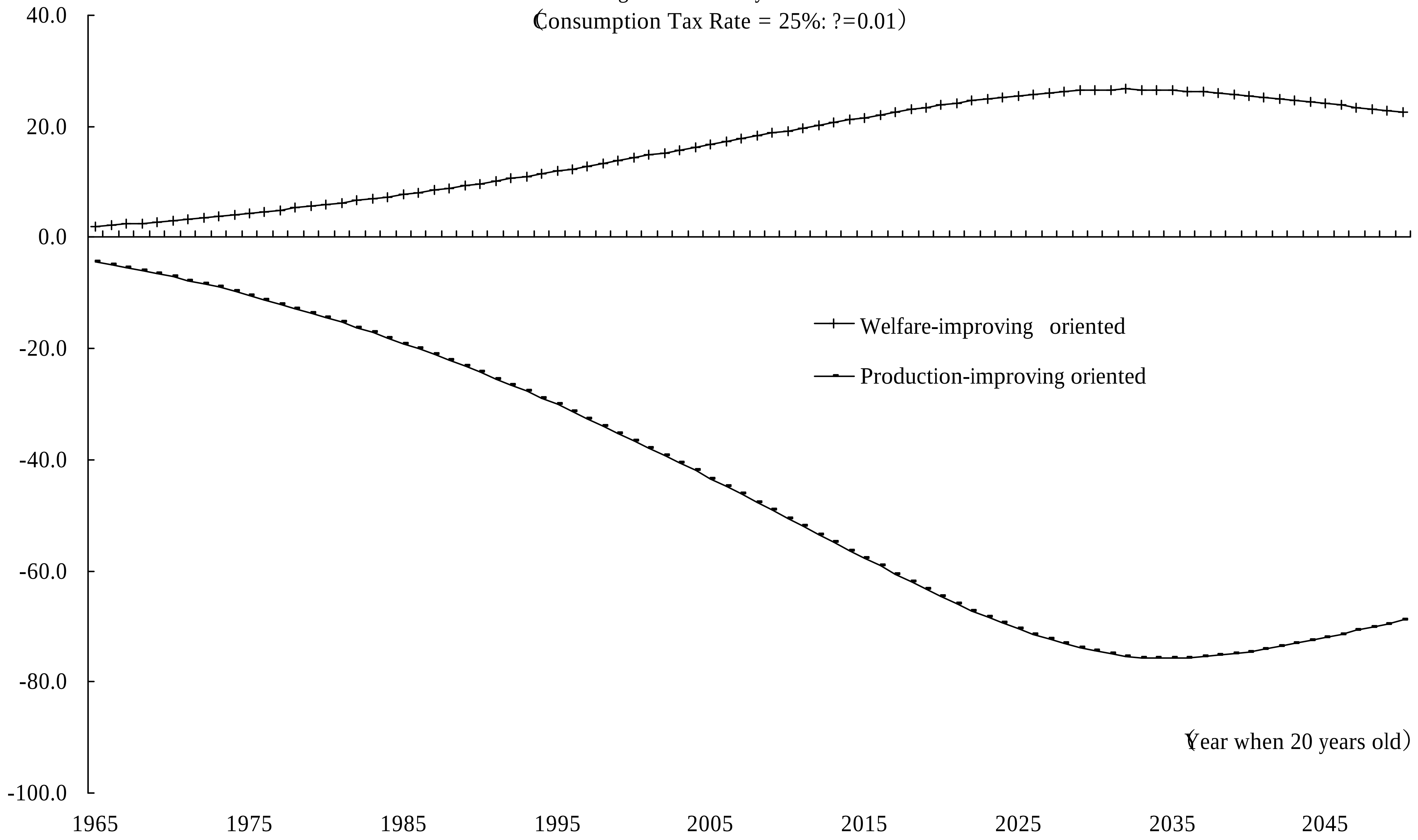

Figure 4-3: Conpensating Variation
(Debt-GDP Ratio = 150%, Consumption Tax Rate = 25%)