

Aging and Capital Flows in Japan and Korea

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I. Introduction.

The saving rates of Korea and Japan are among the highest in the world and these rates have played a valuable role in the development of these two countries. The high saving has provided the funds needed to finance corporate investment in plant and equipment, and helped meet capital shortages abroad. The high investment rates allowed Korea and Japan to incorporate the latest technologies into the production process, and has raised living standards through better public infrastructure, both in cities and in rural areas.

Over the next three or four decades, the populations of Korea and Japan will be aging rapidly. In Japan, the population aging will be occurring earlier; projections imply large increases in the elderly in the next 20 years; by 2015, 25 percent of the population will be 65 or above. In Korea, the population aging will accelerate after 2025; by 2040, around 30 percent of the population will be 65 and above. In both countries, the main reason for this aging is the fall in the total fertility rate (births per family).

In this paper, we revisit the issue of the impact of demographic change on the saving-investment balances and the current accounts of Korea and Japan. There is widespread belief that aging will lead to major shifts in the saving-investment balances, and the current accounts of the two countries. We show that this belief is largely true. Using the latest government demographic projections, we show that the aging of the population underway will steadily lower Japan's total saving (private and government) rate from the current 30 percent of GDP to 19 percent of GDP in 2040. Japan's total investment (private and public) rate will decline from 28 percent of GDP today to about 22 percent of GDP in 2040. Given that the decline in total saving is larger than in total investment, Japan's current account will steadily narrow from its current

level, and turn to deficit around 2025.

We also show that the aging of the population will worsen Japanese government finances, as healthcare and social security spending soar. Unless Japanese government fiscal balances improve from the current minus 7 percent of GDP to almost plus 5 percent of GDP over the next decade or so, the current Japanese government debt is not sustainable. We forecast future Japanese government spending from projected demographics. Given the forecasted government spending, large tax increases will become necessary for the current Japanese government debt to be sustainable. In fact, we show that taxes as a percentage of GDP will need to be raised from the current 28 percent to almost 50 percent by 2050.

For Korea, we show that the population aging will lower both total saving (private and government) and total investment (private and public) rates--especially drastically after 2025. Until sometime after 2025, however, Korea is expected to maintain relatively high total saving rates, and run current account surpluses, thus, accumulating external assets on net. In Japan, total (private and government) saving rates are expected to start falling around 2005. In Korea, total saving rates will start falling about 20 years later, since in Korea, the demographic transition--declining fertility rates--happened two or three decades later than in Japan.

Although after 2025, Korean saving rates are gradually expected to dip below investment rates, the external assets accumulated earlier should provide enough capital income so that Korea is projected to run slight current account surpluses even after 2025. We leave the investigation of the impact of aging on Korean government finances for the future. However, what is remarkable about our projections is that contrary to the usual post-WW II pattern, Korea will be supplying international capital to Japan from around 2025 to perhaps around 2040--a very

surprising turn of events!

This paper is organized as follows. In Section II, we briefly review the literature on, and past trends in, Japanese private and government saving rates and private and public investment rates. In Section III, we review the deteriorating Japanese government fiscal position in the 1990s. In Section IV, we summarize the demographic changes undergoing in Japan, and present the Japanese government's latest government projections. In Section V, we simulate the impact of demographic change on the future Japanese saving and investment rates, government deficits, and the current account. In Section VI, we briefly review the literature on, and past trends in Korean total saving and investment rates. In Section VII, we briefly summarize the demographic changes undergoing in Korea. In Section VIII, we simulate the impact of demographic change on the future Korean saving and investment rates. Section IX concludes.

Japan

II. Japanese Saving and Investment.

It is well-known that the post-war Japanese economy is characterized by very high saving and investment rates. In fact, Japan's saving rates are among the highest in the world—only Italy, Singapore, and Taiwan have higher saving rates. However, these high Japanese saving and investment rates are primarily a post-war phenomenon—in fact a post 1955 phenomenon. If the period of the Korean War is excluded, Japan's saving rate did not make it into the double digits until 1955, a full 10 years into the post-war period. Thus, we can immediately reject the view that Japan's high saving rate is the result of cultural factors such as national character or Confucian and Buddhist teachings, because although cultural factors were stronger in the pre-

war period, the saving rate was lower.

The trends and fluctuations in Japanese saving and investment closely mirror the trends and fluctuations in Japanese GDP (Figure 1). For both saving and investment rates, there is clear positive association with the growth in GDP, especially until 1975. The broad trends in post-war Japanese private and government saving rates, investment rates, and the net export surplus–GDP ratios, are depicted in Table 1.¹²

The *private saving rate* rose steadily between 1955 and the mid-1970s, peaking (first) in 1978. Subsequently, the rate fell until the early 1990s, when it rose (again) to reach its post-war peak in 1998. There is a voluminous literature that seeks to explain the pattern and level of Japanese post-war private saving.³ The literature suggests that the most important reason for Japan's high private saving rate is rapid economic growth. The permanent income/life cycle hypothesis can explain the positive impact of income growth on the private saving rate if income growth is faster than expected. This hypothesis may have been valid until the early 1970s. The surge in private saving from the mid-1970s to the early 1980s is related to the two oil crisis in the 1970s. The explanation given is that these crisis added further fuel to the already rampant

¹We depict gross saving and investment. Gross saving includes the depreciation includes the depreciation on capital. In this paper, we use 'gross', instead of 'net' saving because the latter requires data on depreciation. There is enormous controversy regarding the proper measurement of the capital depreciation rate in Japan, and the use of 'gross' savings allows us to sidestep this controversy (Dekle and Summers, 1991; Hayashi, 1991; Horioka, 1995).

²The private sector includes households, private unincorporated non-financial enterprises, and corporations. Corporate saving is small in Japan, and if households 'pierce the corporate veil,' corporate saving can be considered part of household saving. The government sector includes the central, prefectural, and local governments. Government saving excludes government investment.

³See Horioka (1990), Dekle (1993), and Hayashi (1998) for a catalogue of reasons for Japan's high private saving.

inflation and precipitated a recession, which in turn raised uncertainty about the future and increased the perceived need to save for precautionary purposes. The fall in private saving from the mid-1980s to the early 1990s is because of robust consumption, stimulated by rising stock and land prices. In contrast, the mid- to late-1990s rise in private saving is related to the recessionary economy, increases in unemployment, uncertainty, and pessimism, all raising precautionary saving. Horioka (1991, 1992) finds that the level and growth of Japanese GDP explains about 65 percent of the variation in the private saving rate.⁴

The literature suggests that the second most important reason for Japan's high private saving rate is the favorable age structure of the population. Until the early 1970s, the proportion of the aged (over 65) to the working-age population (20-64)—the so-called 'dependency ratio'—was low in Japan. According to the life-cycle hypothesis, an increase in the dependency ratio has a significant negative effect on the private saving rate. In addition, most other models—including those with dynastic households—predict a negative relationship between the dependency ratio and the private saving rate. Horioka (1991, 1992) finds that adding the dependency ratio to the equation already including the level and growth of GDP raises the proportion of private saving explained from 65 percent to 75 percent. Moreover, he estimates that a 1-percentage point increase in the dependency rate will cause the private saving rate to decline by 1 percentage point. These and similar estimates suggest that the 12-percentage-point increase in the dependency rate between 1975 and 1998 has depressed private saving by about 12 percentage points annually.

⁴Horioka's results, however, must be interpreted with caution, since he includes variables with different orders of integration, $I(\cdot)$, in the same estimating equation. His demographic variables are $I(2)$, but the level and growth of GDP are $I(0)$, and $I(1)$, respectively.

The *government saving rate* rose until the mid-1960s, then gradually fell to its historical low in 1978. Subsequently, the rate rose (again) until the early 1990s, when it started to decline to (almost) its new low in 1998. The trend in Japanese government saving is also closely related to economic growth. Government saving surged until the mid-1960s, as growth rates were consistently above government projections, leading to rising tax revenues. From the mid-1960s, however, the demand for government services increased, dampening the budget surpluses. The recessionary 1970s led to counter-cyclical measures and a further drop in government saving. To halt the decline in government saving, the Japanese government in the early 1980s introduced budget freezes and reformed the tax system. These measures and strong economic growth in the mid- to late 1980s led to rising budget surpluses. However, as the economy slumped in the early 1990s, falling tax revenues and the need for expansionary fiscal policy again depressed government saving rates.

The *investment rate* also rose steadily, peaking in 1973. Since then, it has fallen slightly. Compared to household and government saving rates, the investment rate has remained comparatively stable. The main determinant of Japanese investment has again been economic growth.⁵ As GDP growth surged in the 1950s and 1960s, investment was able to grow to take advantage of newly available technologies. Since the early 1970s, the investment rate dipped somewhat, but has remained at a high level. The surge in investment rates in the late 1980s is related to the cheap financing available to firms, owing to rising stock and land prices. Although private investment has dipped in the 1990s, rising government investment owing to expansionary

⁵Kiyotaki and West (1996) find that Japanese private plant and equipment investment between 1961 and 1994 can be well explained by the ‘flexible accelerator’ model, with lagged output as the sole explanatory variable.

public works projects in the mid- to late 1990s has kept overall investment rates high.

Japanese *net exports* were in persistent deficit until the early 1970s, reflecting strong investment demand, but inadequate saving. However, by the mid-1980s, the surge in saving and decline in investment pushed Japanese net exports (as a percentage of GDP) into record territory. Subsequently, as a result of strong domestic consumption in the late 1980s and strong government investment in the 1990s, the net export surpluses (as a percentage of GDP) declined.

III. The Japanese Fiscal Position in the 1990s.

Government saving declined and public investment rose in the 1990s (Table 1). These trends in government saving and investment in the 1990s were caused by the recession, and also by structural changes. The recession and the decline in the rate of economic growth lowered tax revenues. Structural changes worsening government saving include tax reforms that lowered tax elasticities and tax revenues, and the aging of the population, which raised social security and healthcare expenditures. The deterioration of government finances led to sharp increases in outstanding government bonds, raising concerns about fiscal sustainability, and calls for fiscal reform.

Government saving in the 1990s.

Tax revenues declined because of the recessionary environment of the 1990s. In addition, government consumption increased. Owing to the low cyclical variability of Japanese unemployment and social welfare benefits, however, government consumption increases during the recession were capped. Government saving can be divided into the “full-employment” and

“cyclical” components. We estimate that during the period 1996-99, Japan’s “full-employment” government saving was about 2.6 percent, slightly higher than actual government saving of 2.0 percent, leaving the “cyclical” component of government saving at -0.6 percent.⁶ Thus, much of the decline in Japanese government saving in the late 1990s was not because of “automatic stabilizers,” but because of structural factors, such as tax reductions. This low cyclical variability of government saving is corroborated in a recent IMF study showing that a one-percentage point increase in the output gap translates into an increase of the cyclical deficit by about a third of 1 percent of GDP, which is about half of the deficit response in other OECD countries (Muhleisen, 2000).

Government saving declined since the early to mid-1990s, with tax reductions supporting aggregate demand in the face of an unprecedented economic downturn. Particularly in 1998, when the economy slipped into recession, the government passed tax cut measures that led to a substantial decline in government saving in the following year. Marginal income and capital gains tax rates and health insurance premia were cut, exemptions for gift taxes were raised, and tax deductions for home mortgage holders were introduced. The government also lowered corporate tax rates from 50 percent to 40 percent.

Government saving can be broken down into the social security surplus, the surplus in other categories, and healthcare expenditures (Figure 2). The social security surplus (benefits minus contributions) fell from about 2 percent of GDP in the early 1990s to about 0.5 percent of

⁶We estimate the “full-employment” government saving by regressing government saving on the output gap and a constant. We interpret the estimated value of the constant, which is the government saving rate when the output gap is equal to zero--as “full-employment” government saving.

GDP in 1999, owing to the recession (lowering contributions) and increase in the elderly (raising benefits). Government healthcare expenditures rose from about 3.6 percent of GDP in the early 1990s to about 4.2 percent of GDP in the 1999, mainly owing to increase in the elderly, who use most of the hospital services. However, the healthcare expenditure-GDP ratio in Japan is smaller than in the U.S. (6.6 percent of GDP), or Germany (7.7 percent of GDP). The remaining category of government saving includes usual spending such as education, defense, and policing and firefighting. Saving in this category declined sharply from 9.5 percent of GDP to 4 percent of GDP, owing to the fall in (income and consumption) tax revenues.

Public Investment in the 1990s.

Between 1990 and 1999, the Japanese government passed 10 stimulus packages, in an attempt to jump-start the stalling economy. The most important component of the government stimulus packages were public works, which are included in public investment. However, as shown in Table 1, the actual increases in public investment in the late-1990s were rather moderate, compared to the prominent—and headline grabbing—role of public works in the stimulus packages.

There are two reasons why actual public works fell short of the levels announced in stimulus packages. First, during the 1990s, the central government assigned roughly two-thirds of the increased public works spending to local governments (without providing a commensurate increase in funding). The capacity, however, of local governments to expand public investment was affected by their poor financial situation, and the continued rise in public investment has increasingly been financed through local bond issues. The amount of outstanding local

government bonds increased from 12 percent of GDP in 1990 to 22 percent of GDP in 1997. Many local governments surpassed the legally allowed threshold of bonds-outstanding, and were put under bond issuance restrictions by the central government. Second, some of the public investment funds provided by the stimulus packages remained unused, because of poor project implementation. Ishii and Wada (1998) calculated that only 60-70 percent of the stimulus packages' public works has translated into additional demand during the mid- to late 1990s.

Government Debt and Liabilities in the 1990s.

The late 1990s decline in government saving and rise in public investment led to sharp increases in government debt. Table 2 depicts the fiscal balance-GDP ratio, and several debt to GDP ratios. The fiscal balance-GDP ratio is lower than the difference between the government saving-GDP ratio and the public investment-GDP ratio by about 2 percent, mainly because of the inclusion of net government land purchases in the fiscal balance. During the 1990s, the government bought significant amounts of land from the private sector to prop up land prices. The fiscal surplus declined continuously in the 1990s, reaching about minus 10 percent in 1998. Correspondingly, the ratio of debt to GDP has risen sharply. By international standards, Japan's *gross debt-GDP* in 1999 was the highest among the G-7 countries—Italy's was 115 percent, and the U.S.'s was 62 percent.

Because of the partly funded nature of the Japanese pension system, as well as the government's major role in financial intermediation, the Japanese government holds significant assets, keeping *net debt-GDP* at a moderate level, and lower than in other G-7 countries. However, since the assets of the social security system are more than offset by future pension

obligations, they should be excluded when assessing Japan's debt situation. As a result, Japan's *net debt excluding social security net assets*, at 85 percent, is significantly higher than in the U.S., 60 percent, and in Germany, 53 percent.

The government's true net obligations may be substantially higher than the net debt figures, because of unfunded liabilities. There are three main sources of unfunded liabilities. The first source are the future costs of government social security and health schemes. Estimates of future unfunded social security costs depend on demographic, economic growth, and interest rate assumptions and range widely. In Japan, there are several social security schemes, but the main scheme—the Employees' Pension Scheme—derives one-third of its (benefit) payouts from government subsidies, and two-thirds of its payouts from payroll taxes (contributions). Given current government subsidy and payroll tax rates, Chand and Jaeger (1996) estimate the present (2000) value of Japan's unfunded social security liabilities at 110 percent of GDP. Muhleisen (2000) estimate the present value of net unfunded liabilities at 60 percent of GDP. With regards to government health benefits, on average, government subsidies cover about 1/3 total public health insurance benefits (2 percent of GDP), with the rest covered by health insurance contributions and co-payments. Given that the elderly are exempt from health insurance contributions, and pay only small co-payments, the future aging of the population is expected to significantly raise the proportion of health benefits covered by government subsidies.

The second source of unfunded liabilities are potential losses on government assets. A portion of the government's assets represent soft loans that may not be repaid. Many large public or joint public-private infrastructure projects financed from the Fiscal Investment and Loan Program (FILP) loans generate less revenue than budgeted, which may imply significant

contingent liabilities of the government. For example, much of the substantial debt—3 percent of GDP—of the now privatized Japan National Railways is owed to FILP. Since most of this debt will never be repaid, this debt will eventually have to be covered from the government budget. Other public corporations with large accumulated FILP debt include the Japan Highway (4 percent of GDP) and Housing and Urban Development Corporations (2.5 percent of GDP).

The third source of unfunded liabilities are the explicit and implicit government guarantees of private sector lending. Explicit guarantees are extended by FILP and other government entities to encourage lending by private financial institutions. Examples are guarantees of bank deposits by the Deposit Insurance Corporation, and guarantees of lending by credit cooperatives to small- and medium-sized enterprises. Although these guarantees do not entail fresh government lending, should the guaranteed loans not be repaid, the government must cover the loans from the budget. The total amount of outstanding government-guaranteed bonds and loans amounted to about 10 percent of GDP in 2000. Although historically, only about 1 percent of government-guaranteed loans are never repaid, if the Japanese economy worsens, the percentage of unpaid loans could soar (Bayoumi, 1998).

In addition to the explicitly guaranteed government loans and bonds, there are the *implicitly* guaranteed government loans. Historically, the Japanese government has shown willingness to cover the irrecoverable problem loans of private financial institutions. For example, in 1998, the government authorized 60 trillion yen (12 percent of GDP) in public funding to cover the irrecoverable loans of private banks.⁷ This willingness represents implicit

⁷The total of public funds actually spent—and included in government consumption—in 2000 was about 8 trillion yen (0.16 percent of GDP).

guarantees, and these guarantees are contingent liabilities of the government. In 2000, outstanding loans minus the capital and liquid assets of financial institutions was about 200 percent of GDP. If, as some bank analysts estimate, 10 percent of the loans are irrecoverable, then the cost to the government of these implicit guarantees could be as high as 20 percent of GDP.

IV. Aging and Support Ratios in Japan.

The economic consequences of population aging depend on the nature of underlying demographic change as well as on the relationship between the resource needs of individuals of different ages. Figure 3 plots the Japanese government's projections of the country's population and the percentage of the total population that is elderly.⁸ Japan's population is expected to peak at close to 130 million in 2005, then gradually decline to about 100 million by about 2050. The percentage of the population over the age of 65 has grown rapidly, especially since 1980, and now stands at about 15 per cent. By 2020, that percentage should approach 25 percent, and by 2050, 33 per cent. By 2030, the percentage of the very old (aged over 80) should exceed 10 per cent. These rates of population aging are much higher than in other countries. For example, in the U.S., only about 15 per cent of the population will be above the age of 65 by 2025.

Declining fertility is the principal source of the changing demographic patterns (Takayama, 1998). In the years following the Second World War, the total fertility rate in Japan rose to about 4 by 1950. However, fertility declined sharply during the 1970s and 1980s. It was 2.1 per

⁸The figures for 1955-99 were calculated from data presented in Japan's *Statistical Yearbook*. The figures from 2000-2050 were calculated from the medium projections of the population by age group presented in the Ministry of Health and Welfare (1998).

household in 1974, but 1.4 per household by 1997. The total fertility rate is projected to decline to about 1.2 over the next several decades. Moreover, Japan has allowed almost no immigrants, who, especially in English-speaking countries, have helped to keep the population young. These trends have important implications for the demographic structure of the population over the next half-century.

The Support Ratio.

Demographic shifts affect the economy's consumption opportunities because they change the relative sizes of the self-supporting and dependent populations. Following Cutler, Poterba, Sheiner, and Summers (1990), we summarize these changes by the *support ratio*, denoted by α , which we define as the effective labor force, LF, divided by the number of consumers, CON,

$$\alpha = LF / CON.$$

The first issue in measuring the support ratio concerns the relative consumption needs of people at different ages. We assume that all people have identical resource needs so that:

$$CON = \sum_{i=1}^{99} N_i,$$

where N_i is the number of people of age i .

The second issue concerns the effective labor force. The first measure, LF1, assumes that all people aged 20-64 are in the labor force, while individuals 19 and under or 65 and over are not:

$$LF1 = \sum_{i=20}^{64} N_i.$$

This measure is used by the Japanese government in projecting the future labor force.

The second measure, LF2, recognizes that both human capital and labor force participation rates vary by age. We use data on the average 1990 earnings of people of each age (measured in 5-year intervals) and sex (W_{ij} , where i is age, and $j=M$, male or F , female) along with data on age- and sex-specific labor-force participation rates (PR_{ij}).⁹

$$LF2 = \sum_{i=15}^{80} (W_{iM} * PR_{iM} * N_{iM} + W_{iW} * PR_{iW} * N_{iW}).$$

This measure assumes that earnings accurately reflect a worker's human capital. If age-earnings profiles are hump-shaped, then labor productivity peaks in middle-age. Thus, this measure recognizes that human capital of a society with a high fraction of people in middle age is higher than that of a society with many older workers, whose earnings and labor-force participation rates decline.

The two support ratios using the two measures of the labor force are reported in Figure 4. The two support ratios have very similar patterns, especially after 1995. Using LF1, the support ratio declines from 1 in 1990 to 0.80 in 2050. Using LF2, it declines to 0.78. Between 2005 and

⁹The data on earnings and labor-force participation rates are from the Ministry of Labor (various years).

2030, the second support ratio declines more than the first, owing to the fall in high-earning, prime age males. Given the similarity in the two support ratios, for the remainder of this paper, we focus on the government measure, LF1.

V. Demographic Change, Optimal Saving-Investment, the Current Account, and Government Deficits in Japan.

Here we simulate the impact of demographic change on future Japanese saving and investment rates, and government deficits, using the government's measure of the support ratio, LF1. We adopt the neoclassical framework and assume that consumers maximize (lifetime) utility. Households base their consumption on both current and future income. Thus, consumption can be detached from current income; households adjust their saving to keep consumption growth constant into the future.

In our simulations, we adopt the standard small-country, open capital markets, Ramsey optimal-growth model (Barro and Sala-i-Martin, 1995, Ch. 3). Specifically, we closely follow Cutler, Poterba, Sheiner, and Summers' (1990) modifications to the Ramsey model, in examining the impact of changing demographics on savings and government deficits.¹⁰ With the model, we

¹⁰The Ramsey model assumes that households are dynastic—they care about their children's and grandchildren's welfare (utility) as much as their own. Of course, an important implication of dynastic households is that Ricardian equivalence holds; government debt does not affect the intergenerational distribution of wealth.

There is a large literature testing whether the dynastic model is applicable for Japan (for a review, see Horioka, 2001). The dynastic model can be contrasted with the life-cycle model, in which households do not care about their children. Thus, in the life-cycle model, households bring down their wealth (dissave) in old age. On the whole, the empirical tests support the dynastic model, and reject the life-cycle model. The Japanese elderly, on average, leave large bequests to their children, and this appears to be motivated by altruism towards the next generation.

can examine how a society can adjust its saving, investment, and government deficits in response to changes in demographic variables. We simulate the model using plausible parameter values; and the projected future paths of the support ratio, and the growth in the population and the labor force.

(i) Sketch of the Simulation Results.

As consumers seek to smooth consumption over time, consumption per capita grows at a constant rate. However, as the support ratio falls, GDP per capita grows at a slower rate than consumption per capita, which raises the consumption-GDP ratio. That is, as the number of workers relative to population falls, there are relatively less people sustaining output (GDP), while consumers remain relatively numerous, raising the consumption-GDP ratio. The rise in the consumption-GDP ratio lowers the private saving rate. The private saving rate is projected to decline from about 28 percent today to about 15 percent by 2020, and about 12 percent in 2035-40.

To reduce distortions, the government seeks to maintain a per capita tax level that grows at the rate of per capita consumption growth, implying a *rising tax-GDP ratio* (given slower growth in GDP per capita). The tax-GDP ratio is projected to rise sharply from 28 percent today to about 45 percent in 2020, to reach almost 50 percent in 2040. Although aging raises social security and healthcare spending, increasing the government spending-GDP ratio, the rise in the government spending-GDP ratio is lower than the increase in the tax-GDP ratio. Thus, the *government saving rate gradually rises*. The government saving rate rises from about 2 percent of GDP today to about 10 percent in 2020. However, the decline in the private saving rate is larger

than the rise in the government saving rate, leading to a *fall in the total saving rate*, from 30 percent today to about 24 percent in 2020, and about 20 percent in 2040.

The rising government saving rate eventually offsets today's outstanding government debt-GDP ratio; future government spending, and public investment. Consequently, after initially increasing, the government debt-GDP ratio starts to decline in about 2020.

As the labor force declines (in absolute number), the need to equip workers with capital equipment decreases, and both *private and public investment rates fall*, resulting in a decline in *total investment*. The private investment rate falls from 20 percent today to about 16 percent in 2040; the public investment rate falls from 8 percent today to about 6 percent in 2040.

The fall in total saving is sharper than the fall in total investment, resulting in a *decline in the current account-GDP ratio* from 2 percent of GDP today to -1 percent of GDP in 2020, and eventually to -3 percent of GDP in 2040. Thus, after initially increasing, Japan's *net foreign assets-GDP ratio* starts to *decline* around 2020 and approaches 0 by 2040.

(ii) Behavior of Firms.

We begin with the production function of a representative firm that uses both private and public capital as inputs:

$$y_t = \hat{k}_t^\gamma \hat{m}_t^\gamma \alpha^{1-\lambda} e^{ht} \quad (1)$$

where y_t is gross output per population (capita), \hat{k}_t is the private capital stock per effective population, \hat{m}_t is the public capital stock per effective population, and h is the constant rate of labor augmenting technical progress. We assume constant returns to scale in private and public

capital, so that $(1-\lambda)=2\gamma$. In the above production function, public capital is essential for the productivity of private capital—ie., public capital is not wasteful. This goes against conventional wisdom regarding the wastefulness of recent public investment in Japan. In our production function, we are mostly concerned with the productivity of public capital over the long run (over decades), and public investment was certainly productive in Japan in the past (1960s and '70s), and may be productive again in the future.

Note that when \hat{k}_t , \hat{m}_t and the support ratios are constant, output per capita grows at a constant rate h . When the support ratio is falling, however, output per capita grows at a slower rate than h .

The supply of private capital available to the firm depends on the global capital market; the marginal product of capital must equal $r + \delta$, where r is the gross international real interest rates, and δ is the rate of depreciation. We have:

$$\hat{k}_t = (r + \delta)(a v \alpha_t^{1-\lambda})^{-1} \hat{m}_t^{\frac{v}{1-v}}, \quad (2)$$

and thus private investment per capita is:

$$\hat{i}_t = \dot{\hat{k}}_t + (n_t + h + \delta)\hat{k}_t. \quad (3)$$

where n_t is the population growth rate. Thus, the paths of private capital and private investment are solely determined by the real interest rate, the rates of growth of the labor force and population, technical progress, and the path of public capital.

The government adjusts the level of public capital by changing the public investment rate,

\hat{j}_t :

$$\hat{j}_t = \dot{\hat{m}}_t + \hat{m}_t(n_t + h + \delta) \quad (4)$$

(iii) Behavior of Consumers.

The consumption rate is determined from “forward-looking” household behavior. Assume that households wish to maximize their lifetime utility, U , given by:

$$U = \int_0^{\infty} \frac{c^{1-\theta}}{(1-\theta)} e^{nt} e^{-\rho t} dt \quad (5)$$

where c is consumption per capita, $1/\theta$ is the intertemporal elasticity of substitution, and ρ is the pure rate of time preference.

The budget constraint for households (in per-capita terms) is:

$$\dot{a}_t = \alpha_t w_t + (r - n_t)a_t - \tau_t - \frac{q\tau_t^2}{2} \quad (6)$$

where a_t is total assets per capita, which is comprised of private capital, government bonds, and foreign assets, which are perfect substitutes in international portfolios; w_t are wages; and τ_t is the lump-sum tax imposed on each person each period by the government. This lump-sum tax

also imposes a “deadweight” welfare loss of $\frac{q\tau_t^2}{2}$ per person.

It can be shown (see Appendix) that consumption per capita always grows at h . Thus, while consumption per capita grows at h , when the support ratio is declining, output per capita tends to grow at less than h (see ii). The consumption rate, $\frac{c_t}{y_t}$ is rising, lowering the private saving rate.

(iv) The Government Budget Constraint.

Each period, the government issues government bonds of, \dot{b} to cover shortfalls in tax revenues:

$$\dot{b}_t = (r - n_t)b_t - \tau_t + g_t + j_t \quad (7)$$

where b_t is government bonds outstanding per capita. The increase in government bonds per capita is higher, the larger is the primary fiscal deficit, which is the difference between tax revenues per capita, and the sum of government consumption g_t and public investment j_t per capita.

As in Cutler, *et. al.* (1990), we assume that g_t is determined by age-specific patterns of

government consumption.¹¹ Governments spend different amounts on people of different ages. Spending on education benefit primarily children, while the elderly are the primary beneficiaries of healthcare and social security. Thus, even without changes in the structure of government programs, demographic shifts can affect the level of g_t .

We calculate per capita *age-specific* government spending patterns for Japan, focusing on the three largest social expenditures: social security, healthcare, and education. For social security, we divide average social security expenditures in 1996-99 by the population over age 60. For healthcare, we allocate average healthcare spending in 1996-99 to different ages, using the age-specific expenditure patterns reported in Ishi (2000). For education, we divide total education spending in 2000 by the population between ages 5 and 20.

Demographic shifts can significantly alter government spending. Table 3 shows the projections of total government spending in 1995 yen and as a share of projected GDP. We assume that age-specific per capita expenditure patterns remain at the same *real level* between 2000 and 2040.¹² Consistent with current Japanese government objectives (Ishi, 2000), we are not allowing any real increases in age-specific healthcare and social security spending. That is, if the average 67 year old receives 190 thousand yen in government healthcare in 2000, an average 67 year receives the same inflation adjusted amount in 2035. Other government spending, mainly defense, policing, and administration, are assumed to always equal the average 1996-99 ratio to

¹¹We also assume that g_t either yields no utility to households, or that government benefits do not affect the household's optimal choice of private consumption.

¹²For social security, however, we assume that the age of eligibility increases from 60 to 65 in 2015 (in accordance with current laws); although we assume that per recipient benefits remain the same.

GDP of 5.6 percent.

In our projections, government spending rises from 25 percent of GDP in 2000 to 28 percent in 2015, and 33 percent in 2035. While education spending is projected to decline, healthcare, and especially social security spending, are projected to increase sharply, as the population ages. In particular, in 2035, the population over 65 increases significantly (Figure 3), leading to sharp increases in social security and healthcare spending.

It can be shown (see Appendix) that the government will choose to levy a per capita lump-sum tax of τ_t that grows at the rate of consumption per capita growth, h . The government must then satisfy the following intertemporal budget constraint:

$$\tau_0 \int_0^{\infty} e^{ht} R_t dt = b_0 + \int_0^{\infty} (g_t + j_t) R_t dt \quad (8)$$

where b_0 is the government debt outstanding per person today, and R_t is a discount factor. This budget constraint says that the present value of tax revenues must equal the present value of government consumption plus public investment. If government tax revenues are insufficient to cover government spending today, then in the future, tax revenues must exceed government spending for the government to satisfy its intertemporal budget constraint.

(v) Projections of Optimal Private and Government Saving, Private and Public Investment.

As in Clarida (1993), we assume that the government maximizes lifetime household utility (5), with respect to c_t and \hat{j}_t subject to the constraints. We simulate the model using plausible

parameter values, projected future support ratios (LF1), and future rates of population and labor force growth. In the simulations, we allow support ratios and rates of population and labor force growth to change every five years. Details of the simulation are given in the Appendix. For comparability with actual National Accounts Data, we express our simulations in terms of ratios to GDP. We calibrate our model so that the starting year (2000) corresponds to the average of the actual data between 1996-99 (the data in Tables 1 and 2). For the initial government debt-GDP ratio, we use the ratio of *net* debt-GDP, *inclusive* of the social security net assets (=45 percent of GDP). We account for net future social security unfunded liabilities by explicitly incorporating future social security benefits and contributions into our model. Of course, as alluded to earlier, there are other unfunded and contingent liabilities. Our starting year debt-GDP ratio should be viewed as the lower bound.

There is one exception to this starting year calibration exercise. Between 1996-1999, the total taxes (including social security contributions) collected by the government averaged about 27 percent of GDP. This tax rate was found to be simply too low to be consistent with our model's tax smoothing and the satisfaction of the government budget constraint, (4). This is another way of saying that unless the government starts running primary fiscal surpluses, government debt will not be sustainable. Thus, we depart somewhat from tax smoothing, and allow taxes per capita to gradually increase from the year 2000 rate of 27 percent.¹³ The government's intertemporal budget constraint is still satisfied, which means that future tax rates must be higher than when taxes are perfectly smoothed.

¹³Cutler, *et al.* (1990) show that deadweight losses arising from departures from tax smoothing are small.

Table 4 presents our projections. Private saving rates decline a few percentage points until 2010, and then declines rapidly from 2010 to 2040. This pattern is a result of shifts in the support ratio and increases in tax rates, which reduces disposable income. Although consumption per capita always grows at a constant rate of h (=1.2 percent), as the support ratio falls, output per capita growth is lower. Essentially, consumers are seeking to smooth their consumption when income is growing very slowly by lowering their saving rates.

Under tax smoothing, taxes per capita increase at a constant rate, while output per capita grows at a slower rate; thus the tax-GDP ratio rises over time. However, the actual tax rate in the starting year (average, 1996-99) at 28 percent of GDP, is lower than what is necessitated by tax smoothing (33 percent) and the satisfaction of the government's intertemporal budget constraint. That is, unless current tax rates are increased, the government will not be able to satisfy its intertemporal budget constraint. We allow taxes per capita to increase more rapidly between 2000 to 2015, and then smooth increases in taxes per capita from 2015 onwards. The sharp increases in tax rates between 2000 and 2015 also contributes to the decline in private saving rates, by lowering disposable income. By 2040, tax rates need to increase to almost 50 percent of GDP, for the government to recoup its current outstanding net debt (45 percent), projected future spending (Table 3), and projected public investment (Table 4).

Government saving rates rise from about 1-2 percent of GDP in 2000 to about 10 percent in 2020, owing to the increased tax receipts. Government saving rates decline somewhat in 2035, because the spike in the over 65 population (Figure 3). Private and public investment rates gradually fall over time, as the need to equip workers with capital equipment declines. Because of high government saving and falling public investment, the fiscal surplus (government saving

minus public investment) turns positive after 2020. Consequently, the government net debt-GDP ratio increases until 2020, and falls thereafter. The decline in the net debt-GDP ratio is fairly rapid between 2020 and 2040.

The decrease in private saving is sharper than the increase in government saving, resulting in a fall in total saving. The total saving rate declines from about 30 percent in 2000 to 24 percent in 2015, 21 percent in 2030, and 19 percent in 2040. Total investment declines from 28 percent in 2000 to 25 percent in 2015, 23 percent in 2030, and 22 percent in 2040. Thus, the decline in total saving is sharper than the decline in total investment, leading to declining current account surpluses. Japan's current account surplus is projected to become negative in 2015, and negative from then onwards. Consequently, Japan's net foreign assets, after peaking relative to GDP in 2015, will start to decline, and will approach 0 by 2040.

Korea

VI. Korean Saving and Investment.

Korea is well known for its high saving, and even higher investment rates (Figure 5). *Private saving* (the sum of household and corporate saving) increased sharply from about 19 percent to over 33 percent in the late 1980s and early 1990s, while *government saving* rates have remained steady at about 4-5 percent (Table 5). *Total investment* rates have been impressive, especially in the 1990s (Table 5).

Household saving appears to respond most directly to income (GDP) gains, demographic factors, and real interest rates. Household saving has risen relative to income in ratchet fashion, suggestive of the permanent income model of consumption (Collins and Park, 1989).

Econometric work has shown the importance of high average growth rates of GDP as an explanation for the impressive rise in household saving, and the large swings in real growth rates of GDP as an explanation of the cyclical fluctuations of saving rates (Collins and Park, 1989). The high average real GDP gains of the 1970s and 1980s sharply raised household saving rates, while the sharp dip in real GDP in the 1990s (owing to the currency crisis), decreased saving rates somewhat. The continuous declines in the population growth rates, from 3.0 percent per annum in 1960 to 2.0 percent per annum in the 1970s, lowered dependency ratios, helping boost household saving rates during the 1970s. The surge in domestic saving between 1985 and 1995 was also aided by high domestic after-tax real interest rates. The development of non-bank financial intermediaries replaced the curb market and offered high real returns for savers. The government's policy of applying a low flat tax rate on most interest income raised after-tax real returns (Kim and Leipziger, 1991).

Private saving was also boosted by strong *corporate saving*. Corporate saving (not depicted) averaged around 7 to 8 percent in the 1970s and 1980s, boosted by a lower tax burden and a booming economy. In addition, during the 1970s and early 1980s, corporations were urged by the government to accumulate their own investment funds, through management rationalization and the upward adjustment of consumer prices (Kim and Leipziger, 1991).

Government saving (exclusive of public investment) has remained high in Korea, because of low government expenditures, and buoyant tax revenues. A notable feature of Korea's pattern of government expenditure is the low proportion spent on wages and salaries. Tax revenues increased from 10 percent of GDP in the early 1960s to about 20 percent in the mid-1980s, and thereafter. This growth was helped by the creation of the Office of National Tax Administration,

which was created for effective tax enforcement. The introduction of the Value Added Tax in 1977 also boosted tax revenues significantly (Kim and Leipziger, 1991).

Korean total investment in the 1970s was aided by strong government infrastructure spending, which averaged more than 1/3 of total investment. Total investment was also boosted by the Heavy and Chemical Industry drive of the 1970s. Not only were public resources directly mobilized for Heavy and Chemical Industry financing (so-called, “policy loans”), but even more significantly, banks were directed to lend to industry, often at preferential rates. The high investment rates in the late 1980s to the early 1990s were driven by the *chaebols* strategy of competing for market share in mature industries; and of diversifying in new industries, often unrelated to the core business of the group. In this period, corporations financed their expansion mainly by borrowing in foreign currencies from domestic financial institutions.

Reflecting these developments in saving and investment rates, *net export surpluses* (as a percentage of GDP) were sharply negative in the 1970s, positive in the 1980s, and slightly negative in the 1990s (Table 5).

VII. Aging and Support Ratios in Korea.

Figure 6 plots the United Nation’s projections of Korea’s population; and the percentage of the Korean total population that is elderly. The Korean population is expected to peak at a little over 50 million in 2025, then gradually decline. The percentage of the population over the age of 65 is expected to increase, from about 5 percent in 2000 to over 15 percent in 2025, and

then double to over 28 percent in 2040.¹⁴ As in Japan, declining fertility is the principal source of these changing demographic patterns. The support ratio for Korea using the measure of the labor force that assumes that all people aged 20-64 are in the labor force; while individuals 19 and under or 65 and over are not (LF1) increases from 0.63 in 2000 to 0.62 in 2025, and 0.53 in 2050. Compared to the population aging, the decline in the Korean support ratio between 2000 and 2025 is negligible. Although the fraction of those over the age of 65 is rising, the fraction of those under the age of 20 is falling, thus, keeping the support ratio constant.

VIII. Demographic Change, Optimal Saving-Investment Balance, and the Current Account in Korea.

For Korea, we will focus on projecting the total saving and total investment rates. That is, we will *not* separately project the government saving and public investment rates. The simulation model for Korea is otherwise very similar to the one developed for Japan, except that we do not distinguish between private and public capital for Korea.

We adopt the neoclassical framework and assume that consumers maximize (lifetime) utility, and firms maximize firm value. Households now base their consumption on both current and future income. Thus, consumption can be detached from current income; households adjust their saving to keep consumption growth constant into the future.

(i) Sketch of the Simulation Results.

¹⁴For Korea, we only have labor force projections for 25 years (2025), and 15 years after that (2040).

As Korean consumers seek to smooth consumption over time, consumption per capita grows at a constant rate. However, as the support ratio falls, GDP per capita grows at a slower rate than consumption per capita, which raises the consumption-GDP ratio. That is, as the number of workers relative to population falls, there are relatively less people sustaining output (GDP), while consumers remain relatively numerous, raising the consumption-GDP ratio. The rise in the consumption-GDP ratio lowers the total saving rate. However, given that aging in Korea is very slight until 2025 (support ratios decline from 0.63 to 0.62), *total saving rates remain roughly constant from the 1990-2000 level, at 36 percent of GDP*. As aging accelerates after 2005 (support ratios decline from 0.62 to 0.53), *Korean total saving rates plunge from about 36 percent in 2025 to about 27 percent in 2040*.

As the labor force declines (in absolute number), the need to equip workers with capital equipment decreases, and total investment rates fall. *The total investment rate declines from an average of about 37 percent in 1990-2000 to 35 percent in 2025, and 30 percent in 2040*.

Until about 2025, total saving rates are slightly higher than total investment rates, resulting in *an increase in the current-account-GDP ratio to about 2 percent of GDP*. Thus, *Korea's net foreign assets-GDP ratio rises from about 8 percent in 2000 to about 23 percent in 2025*. Although Korean saving rates start to dip below investment rates after 2025, the interest income from Korea's accumulated net foreign assets are sufficient to keep *the current account in slightly positive territory*. Thus, *Korea's net foreign assets-GDP ratio continues to grow, to reach a peak of about 70 percent in 2040*. (However, Korea's net foreign assets-GDP ratio is projected to fall rapidly after 2040).

(ii) Optimal Investment Rates.

We assume that Korean firms maximize the present discounted value of profits:

$$V = \int_0^{\infty} e^{-rt} [Y_t - w_t \hat{L}_t - \text{adc}_t] dt \quad (9)$$

where Y_t is gross output, r is the world real rate of interest, w_t is wages, \hat{L}_t is the effective labor force, and adc_t are adjustment costs to changing the total (private and public) capital stock, such as retooling, downtime, bureaucratic delay, etc.

The production function for Korea is:

$$Y_t = K_t^{\nu} \hat{L}_t^{1-\nu} \quad (10)$$

where K_t is the total capital stock; ν , the capital share of output is: 0.30 (Young, 1985).

Effective labor and total capital grow according to:

$$\hat{L}_t = L_0 e^{(n_t+g)t} \quad (11)$$

$$\frac{dK_t}{dt} = I_t - \delta K_t \quad (12)$$

and adjustment costs to changing total capital are:

$$\text{adjcost} = I_t * [1 + b/2 * I_t / K_t], \quad (13)$$

where the notation is as before.

We maximize (9), given the constraints (11), (12), and (13), and simulate the model, using plausible parameter values. For g we take 0.012 [=labor share (0.70)*TFP Growth (0.017)], for r , 0.06 , and for δ , 0.13 . Labor-augmenting technical progress of 1.2 per cent implies a growth rate of total factor productivity of 1.7 percent for Korea's labor share of 0.70. For the path of n_t , we use values from the United Nations labor force projections. Details of the simulation are similar to those given in the Appendix. However, for Korea, we only have labor force projections for 25 years (2025), and 15 years after that (2040). Thus, we assume that n_t remains constant within these intervals.

Table 6 depicts the projected Korean investment rates from 2000 to 2040. The values for the investment rates are normalized so that the investment rate for 2000 is equal to the average value of investment between 1990 and 2000. From Table 6, we can see that total investment rates remain close to their current level until 2025. The investment rate is projected to fall more sharply after 2025, as labor force growth rate declines sharply. In general however, the investment rate is not very sensitive to changes in labor force growth rates, although it is quite sensitive to changes in real interest rates (which is assumed constant). A fall in the labor force growth rate lowers both output and the capital needed to equip workers, leaving the capital-labor ratio steady. With a steady capital-labor ratio, the investment rate is also steady.

(iii) Optimal Saving Rates.

As with the case with Japan, the Korean saving rate is determined from “forward-looking”

household behavior. We assume that Korean households maximize their lifetime utility, U , given by the lifetime utility function (5) above.

Since for Korea, we abstract from government spending and taxation, the budget constraint is simpler than for Japan:

$$\dot{a}_t = \alpha_t w_t + r a_t - c_t - z_t a_t \quad (14)$$

From (5) and (14), we explicitly simulate the growth and level of per-capita consumption and the saving rate, using the same utility function parameter values as in Japan. Details are again similar to what is described in the Appendix.

Table 6 depicts the projected optimal total saving rates from 2000 to 2040. The optimal total saving rate remains constant at about 36 percent of GDP until 2025. It then sharply falls to 27 percent of GDP in 2050. This pattern is a result of shifts in the support ratio. As shown in the Appendix, optimal consumption per capita always grows at a constant rate of g (=1.2 percent), but output per capita growth is affected by shifts in the support ratio. The Korean support ratio is constant between 2000 and 2025 at about 0.63, but falls sharply after 2025 to 0.53. As the support ratio declines between 2025 and 2040, output per capita falls, the consumption-output ratio rises, and the saving rate falls.

Taken together, our results overall suggest that future demographic trends will strongly affect Korean optimal saving rates, while Korean investment rates are affected less. In an open economy, investment rates are primarily determined by international real interest rates.

(iv) Net Export Surpluses and Net Foreign Debt.

From our simulated path of Korean saving and investment rates, we can simulate the

future path of Korea's net export surplus, and net foreign debt.

The net export surplus-GDP ratio is equal to:

$$\frac{NX_t}{Y_t} = \frac{S_t}{Y_t} - \frac{I_t}{Y_t},$$

and the current account surplus (change in net foreign debt)-GDP ratio is equal to:

$$\frac{-\dot{D}_t}{Y_t} = \frac{NX_t}{Y_t} - r^* \frac{D_t}{Y_t},$$

where D_t is net foreign debt, and $-rD_t$ is net factor income received from abroad.

Corresponding to the slight rise in total saving rates and the slight fall in total investment rates between 2000 and 2025, the Korean net export surplus to GDP ratio rises slightly between 2025 and 2040 (not depicted). The sharper decline in total saving rates compared to total investment rates between 2025 and 2040, however, results in Korea's net export surplus to GDP ratio turning negative between 2025 and 2040.

Table 6 also depicts the trends in the net foreign assets-GDP ratio, and the current account-GDP ratio. Until 2025, the positive net export surplus and the interest income from the positive net foreign assets boost Korea's current account-GDP ratio to almost 2 percent. After 2025, although net export surpluses turn negative, the interest income from Korea's net foreign assets is still sufficient to bring Korea's current account into positive territory, resulting in increasing net foreign assets. However, after 2040, Korea's net foreign assets are projected to decline rapidly, as total saving rates fall sharply below total investment rates.

IX. Conclusion.

Using the latest government demographic projections, we show that the aging of the population underway will steadily lower Japan's total saving rate from 30 percent of GDP today to 19 percent of GDP in 2040. Japan's total investment rate will decline from 28 percent of GDP today to about 22 percent of GDP in 2040. Given the more rapid decline in total saving, Japan's current account will steadily narrow from its current level, and turn to deficit around 2025.

We also show that the aging of the population will worsen Japanese government finances, as healthcare and social security spending soar. Unless Japanese government fiscal balances improve from the current minus 7 percent of GDP to almost plus 5 percent of GDP over the next decade or so, the current government debt is not sustainable. In the paper, we forecast future government spending from projected demographics. Given the forecasted government spending, large tax increases will become necessary for the current government debt to be sustainable. In fact, we show that taxes as a percentage of GDP will need to be raised from the current 28 percent to almost 50 percent by 2050.

In Korea, the rapid aging of the population underway is expected to lower both total saving and investment rates, especially drastically after 2025. Until sometime after 2025, however, Korea is expected to maintain relatively high total saving rates, and run current account surpluses, thus, accumulating external assets, on net. In Japan, total saving rates are expected to start falling around 2005. In Korea, total saving rates fall much later, since in Korea, the demographic transition—falling fertility rates—happened a two or three decades after Japan. Although after 2025, Korean total saving rates are gradually expected to dip below total investment rates, the external assets accumulated earlier should provide enough capital income so

that Korea is projected to run slight current account surpluses even after 2025. What is remarkable is that Korea will be supplying international capital to Japan from around 2025 to perhaps around 2040!

Admittedly, the assumptions underlying our projections are somewhat stylized and special. For example, in our open economy model, we assumed that real interest rates are determined internationally, and are exogenous. For Korea, which is 1/20th the size of the U.S. and 1/10th the size of Japan, the assumption of exogenous real interest rates may be innocuous. However, Japan is a large capital exporter, and if, say, Japanese saving rates fall, international real interest rates may rise, resulting in endogenous real interest rates. Endogenous real interest rates generally imply that saving and investment rates move closer together, which may imply an upper limit to future Japanese current account deficits.

Appendix : Model Simulation for Japan.

For convenience, we carry out the analysis in terms of effective population. The data for

the population, n_t and the labor force, z_t (and therefore, α_t) are available only every 5 years.

Thus, we assume that n_t and z_t discretely change only every five years; within any 5-year

interval, say 2005 to 2010, n_t and z_t are assumed to be constant. From 2050 onwards, we assume

that the values for 2050 hold.

From (1), real wages per effective population are:

$$\hat{w}_t = (1 - \gamma)\hat{y}_t$$

In addition, we assume that there are adjustment costs to adjusting public capital, reflecting political lobbying costs, and bureaucratic implementation lags,

$$\text{adjcosts} = \hat{j}_t \left(1 + \frac{\gamma}{2} \left(\frac{\hat{j}_t}{\hat{m}_t}\right)\right), \quad (\text{A1})$$

where γ reflects the costs of adjustment.

The government (or optimal planner) maximizes (5), in terms of effective population, with respect to (4), (6), (7), (8), and (A1).

Optimal Consumption.

The optimal path of consumption per effective population is:

$$\frac{\dot{\hat{c}}}{\hat{c}} = \frac{1}{\theta} * (r - \rho - \theta g) .$$

To prevent consumption per effective labor from approaching zero asymptotically, we

assume that $r = \rho + \theta g$, so that consumption per effective population is flat, or that consumption per capita grows at rate h . For h , we take, 0.012 (from Jorgenson and Nishimizu, 1978). Consumption per effective population at time 0, $\hat{c}(0)$, (in our case, the year 2000), depends in a complicated way on the parameters of the lifetime utility function, and the entire future paths of $n_t, \alpha_t, \hat{\tau}_t, \hat{g}_t, \hat{j}_t, \hat{w}_t$, the parameters r, h , and the starting values, \hat{a}_0 , and \hat{b}_0 . Rather than calculating $\hat{c}(0)$, we assume that the actual level of consumption per capita between 1996 and 1999 (in the data) was at or near the optimal level. (Of course, we are not assuming that the Japanese economy was in steady-state between 1990-1999; we are only assuming that consumers were optimizing in 1996-1999).

Optimal public and private investment, output.

The optimal path of public capital per effective population is:

$$\frac{\dot{\hat{m}}_t}{\hat{m}_t} = \left(\frac{1}{\chi} \left(\frac{\phi_t}{\mu_t} - 1 \right) - (n_t + h + \delta) \right), \quad (\text{A2})$$

where μ_t is the marginal utility of total assets, and ϕ_t is the marginal utility of public capital.

Investment in public capital raises utility by raising output; on the other hand, investment in

public capital lowers utility because total assets decline. Thus, $\frac{\phi_t}{\mu_t}$ represents the shadow value of

public investment. μ_t and ϕ_t evolve according to:

$$\dot{\mu}_t = (r - n_t - h)\mu_t \quad (\text{A3})$$

$$\dot{\phi}_t = (h + \delta + n_t)\phi_t - \left(\frac{d\hat{y}_t}{d\hat{m}_t} + \frac{\left(\frac{\phi_t}{\mu_t} - 1\right)^2}{2\chi} \right) \mu_t \quad (\text{A4})$$

where $\frac{d\hat{y}_t}{d\hat{m}_t}$, after substituting the expression for \hat{k}_t , (2), is a function of only \hat{m}_t . To

determine the optimal path of \hat{m}_t , we discretize (A2), (A3), and (A4), and simulate the path of

$\hat{\mu}_t$, $\hat{\phi}_t$, and \hat{m}_t forward, for plausible parameter values. For the parameters used in the

simulations, we take values culled from the literature. For γ , h , δ , r , and χ , we use 0.20, 0.012, 0.13, 0.06, and 6. These values are fairly standard, except that since we have no empirical data for the adjustment speed of public capital, we took the value 6 from the private capital adjustment cost literature (Hayashi, 1982).

Our simulation strategy is to start from 2000 (from the actual values in the data, 1996-99), and simulate forward using the values of n_t and α_t . We imposed the condition that

$\phi(0) = \mu(0)$, and chose a value of $\phi(0)$ so that the path of \hat{m}_t did not vary much from $\hat{m}(0)$.

As mentioned, we assume that the demographic variables change discretely only every 5 years.

As it turned out, given our parameter values, new steady states for \hat{m}_t , ϕ_t , and μ_t were reached in about 5 years for all n_t and α_t .

Finally, from the path of \hat{m}_t ; \hat{j}_t (from (4)), \hat{k}_t (from (2)), \hat{i}_t (from (3)) and \hat{y}_t (from (1)) can be calculated. Thus, we can calculate the private and public investment rates, which are depicted in Table 4.

Optimal Government Taxes.

It can be shown that $\hat{c}(0)$ is maximized when $\hat{\tau}_t$ is constant (Barro, 1979). That is, the government maximizes the path of consumption (and of utility) when lump-sum tax taxes per effective population are constant, or that taxes per capita are growing at the rate h .

Satisfaction of the government's intertemporal budget constraint (8) means that the present value of lump-sum taxes per effective population is equal to the present value of government spending per effective population:

$$\hat{\tau} = \frac{\hat{b}_0 + \int_0^{\infty} \hat{g}_t R_t dt + \int_0^{\infty} \hat{j}_t R_t dt}{\int_0^{\infty} R_t dt}, \quad (\text{A5})$$

where the discount rate, $R_t = \exp(-\int_0^t (r - h - n_v)dv)$. From (A5), we calculate the optimal

value of $\hat{\tau}$, from our estimated (exogenous) path of \hat{g}_t (from Table 3), and our simulated path of

\hat{j}_t (from above). In practice, we truncate the integral at 2050, since beyond that, \hat{g}_t and \hat{j}_t are

discounted to the extent that they are negligibly small. By dividing $\hat{\tau}_t$ by \hat{y}_t , we obtain the tax

rate. Finally, from \hat{c}_t (above), \hat{g}_t , \hat{j}_t , \hat{y}_t and $\hat{\tau}_t$, we can calculate the private and public saving

rates that are depicted in Table 4.

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Saving and Investment Rates (in % of GDP), and Growth Rates (% Changes)

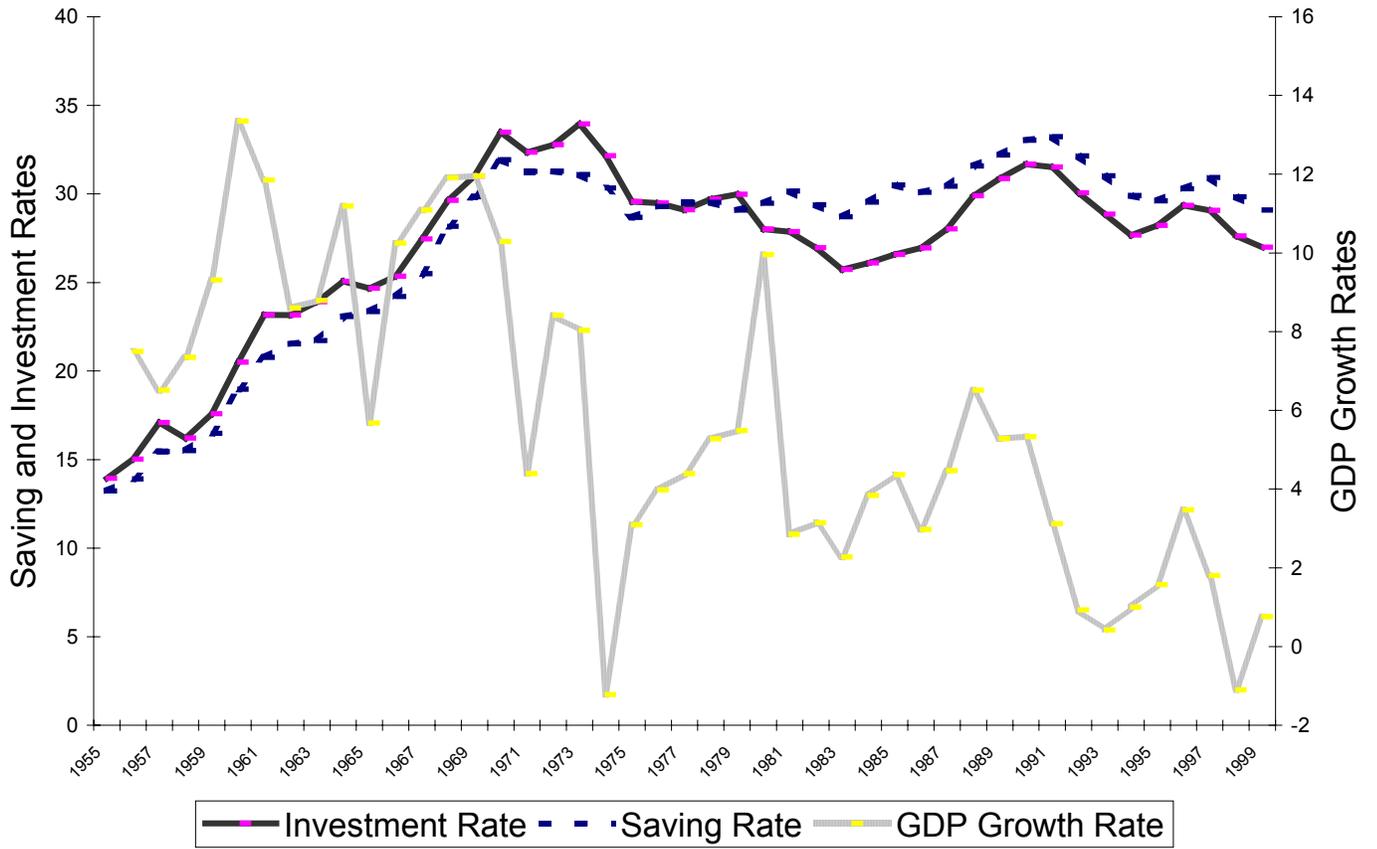


Figure 2: Government Saving (Surplus)/GDP

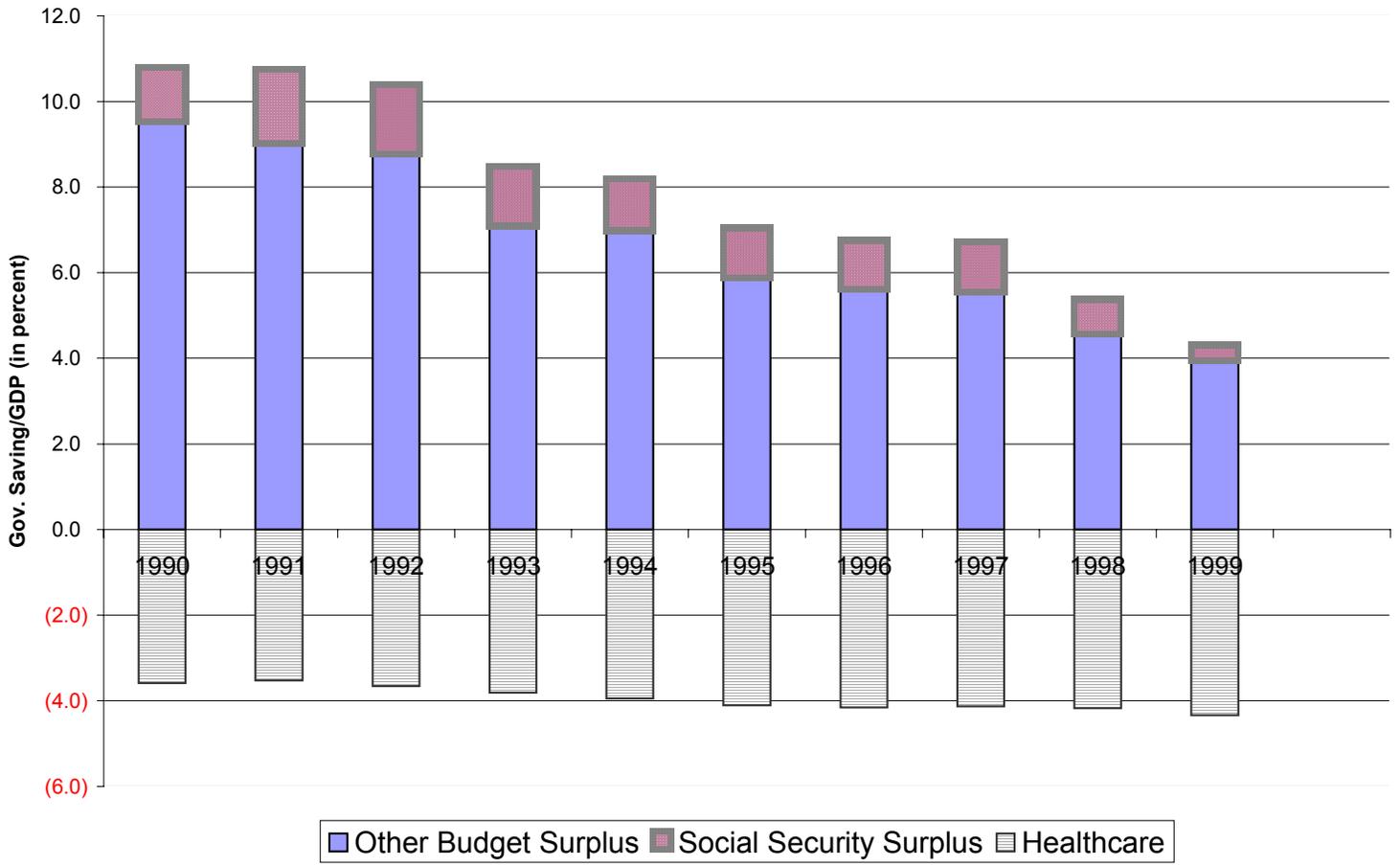


Figure 3: Population and Elderly Projections

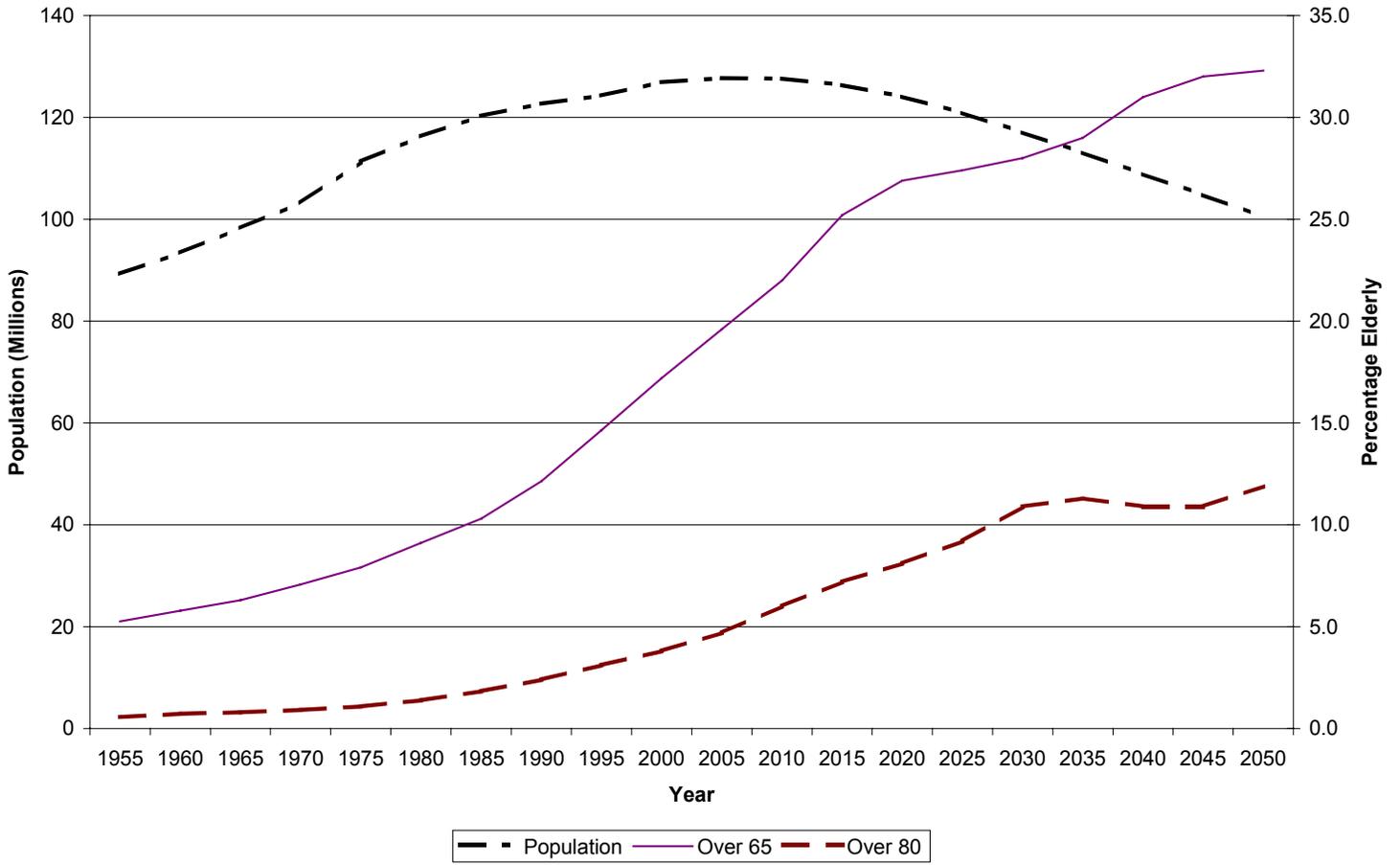


Figure 4: Support Ratios

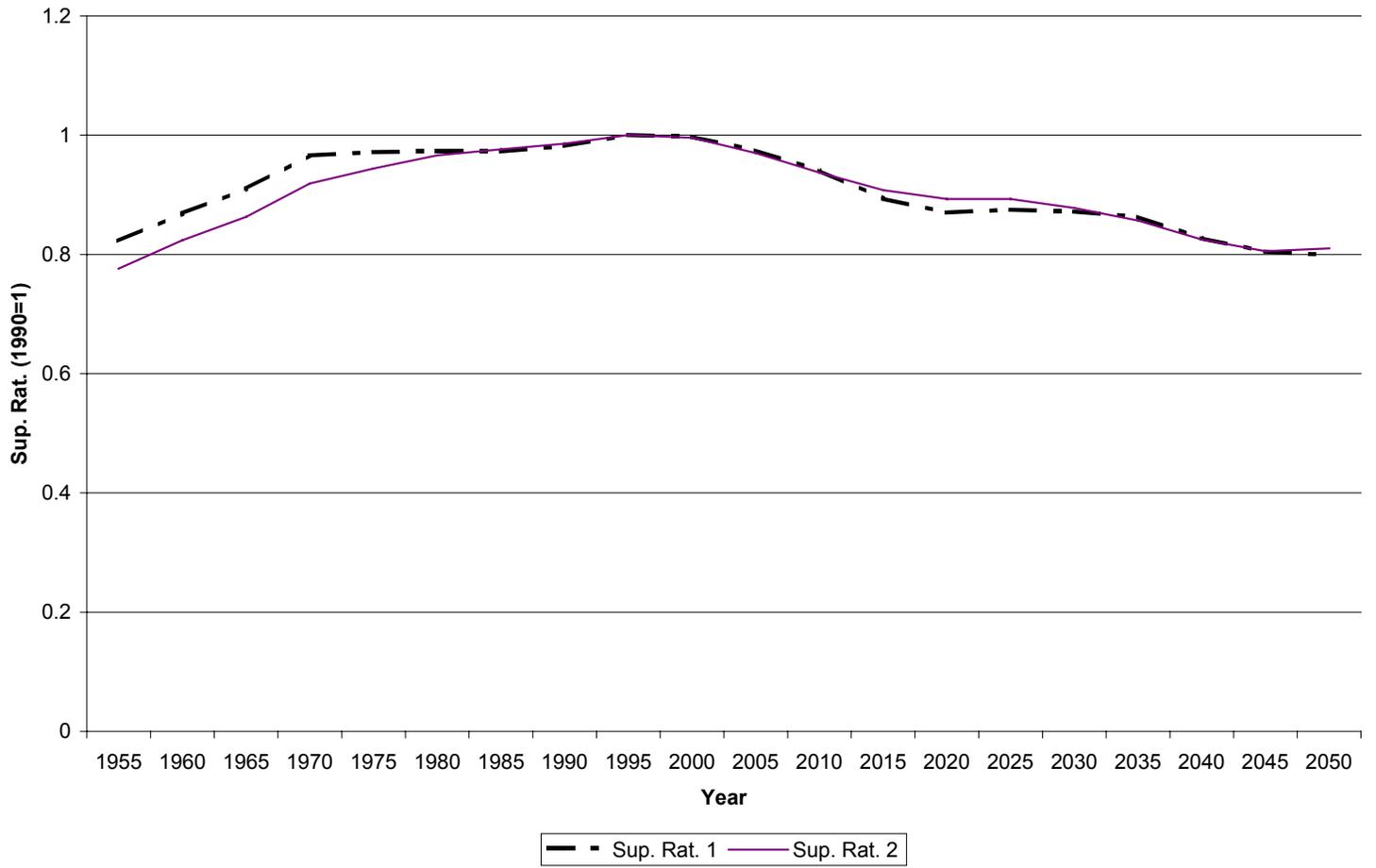


Fig.5: Korea, Saving, Investment and Growth

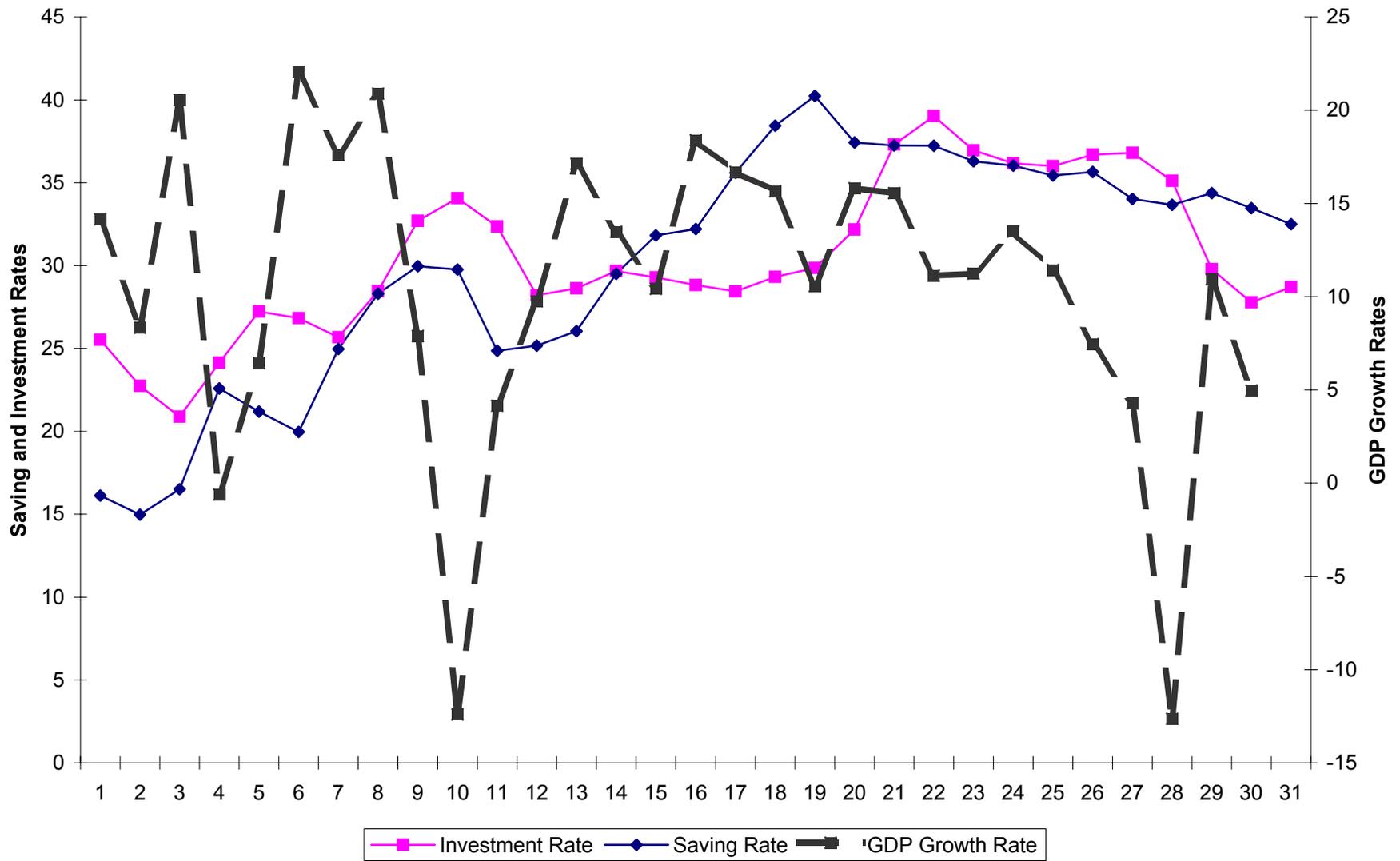


Fig.6: Korea, Population and Elderly Projections

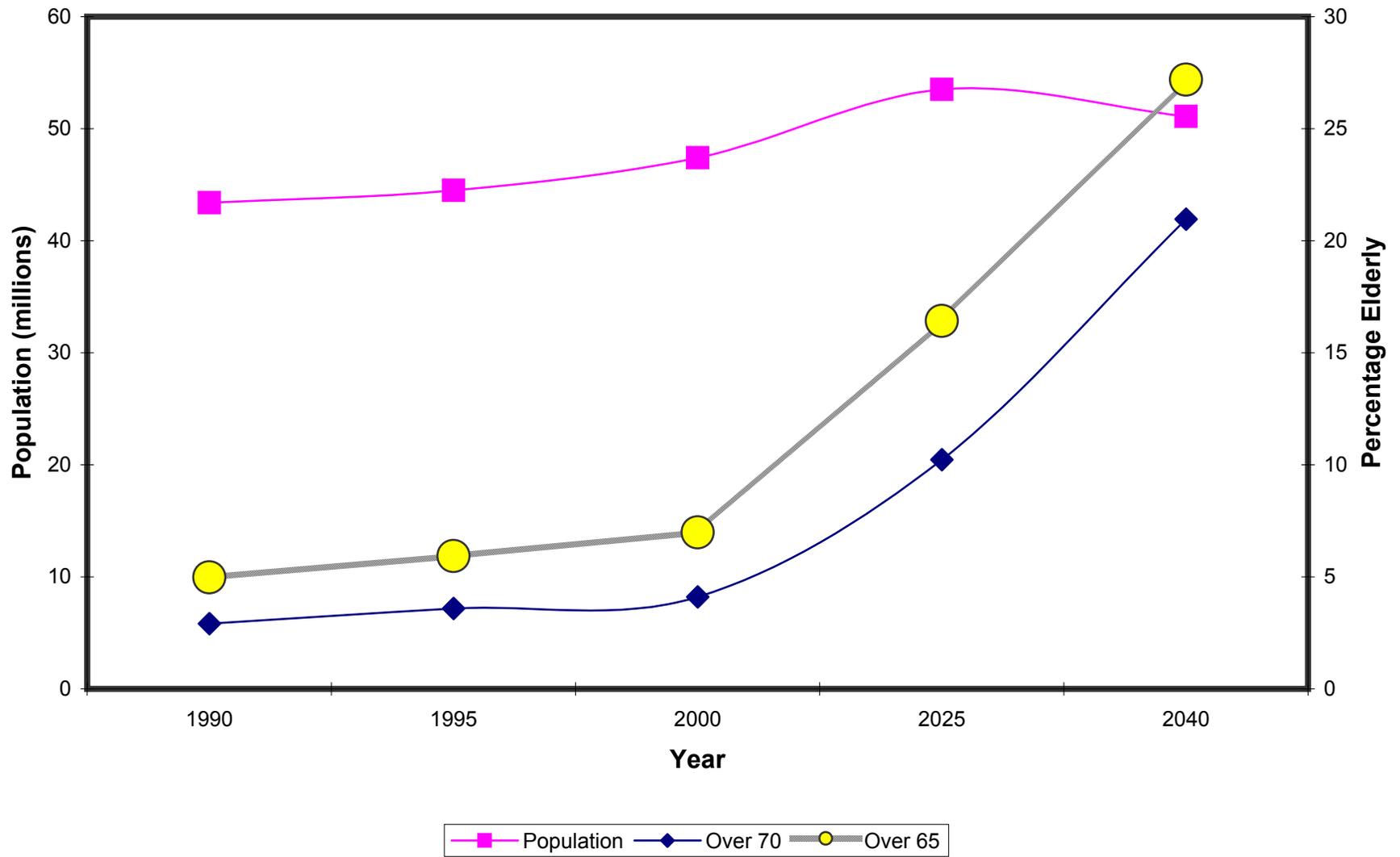


Table 1
Japanese Private and Government Saving, Investment, and Net Exports
(in percent of GDP)

	Private saving	Government saving	Private Investment	Public Investment	Net export surplus
1955-73	14	10	17	7	-2
1974-79	26	3	21	9	-1
1980-90	26	5	21	7	2
1991-95	26	5	22	8	2
1996-99	28	2	20	8	2

Note: Government Saving includes net social security surplus; Private Investment includes plant and equipment, housing, and inventory investment.

Source: Economic and Social Research Institute, *Annual Report on the National Accounts, 1999 and 2001 editions*.

Table 2
Fiscal Balances and Government Debt
(in percent of GDP)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fiscal Balance/GDP 1/	2	2	1	-2	-3	-4	-5	-4	-11	-7
Gross Debt/GDP	65	65	68	73	78	85	92	97	109	121
Net Debt/GDP	7	6	12	10	12	17	22	28	38	44
Net Debt/GDP, excluding Social Security	35	35	43	43	47	53	58	65	76	85

Note: 1/Gross Public Investment minus Gross Government Saving plus Net Land Purchases and Net Gift and Inheritance Taxes.

Source: Economic and Social Research Institute, Annual Report on the National Accounts, 2001 edition.

Table 3: Projected Government Consumption, 2000-2050

	Social Security (in billions of 1995 yen)	Health Care	Education	Social Security (in percent of GDP) ¹	Health Care (in percent of GDP) ¹	Education	Other	Total
2000	57667	27271	16327	11	5.3	3.2	5.6	25.1
2005	65265	28471	15634	12	5.4	2.9	5.6	25.9
2010	74032	29462	15445	14	5.7	3.1	5.6	28.4
2015	78318	30550	15067	14	5.7	2.8	5.6	28.1
2020	78903	30659	14689	13	5.1	2.4	5.6	26.1
2025	79098	30089	13680	14	5.2	2.3	5.6	27.1
2030	79683	29392	12923	14	5.2	2.3	5.6	27.1
2035	81630	28764	12167	18	6.3	2.7	5.6	32.6
2040	81046	28407	11915	16	5.7	2.4	5.6	29.7

^{1/} GDP projections are from the simulation model in the text.

Table 4: Projection of Saving and Investment Rates, Government Debt, Current Account

(in percent of GDP)

	Private Saving	Tax Rate	Government Saving	Private Investment	Public Investment	Net Gov. Debt/GDP	Curr. Acc./GDP
2000	28	28	1	20	8	45	2
2005	28	31	0	20	8	88	0
2010	26	38	2	19	7	128	2
2015	18	43	6	18	7	153	-1
2020	15	45	10	18	7	155	-1
2025	13	45	9	17	6	140	-1
2030	11	46	10	17	6	122	-1
2035	12	47	7	16	6	102	-3
2040	6	49	13	16	6	89	-3

Table 5
Korean Saving and Investment and Net Exports
(in percent of GDP)

	Private saving	Government saving	Investment	Net Export Surplus
1970-80	19	4	27	-5
1981-85	24	5	29	0
1986-90	33	5	31	6
1991-95	32	4	37	-1
1996-00	31	5	37	-1

Source: Bank of Korea, *National Accounts*.

Table 6

Korea: Projections of Investment and Saving Rates, Current Account, and Net External Assets
(as percent of GDP)

	Support Ratio	Investment Rate	Saving Rate	Current Account	Net Foreign Assets
2000	0.63	37%	36%	0%	8%
2025	0.62	35%	36%	2%	23%
2040	0.53	30%	27%	1%	69%