Population Aging in Japan: Its Impact on Future Saving, Investment, and Budget Deficits

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I. Introduction.

Over the next several decades, Japan's population will be ageing rapidly. In 1955, only 5.5 percent of the population was 65 years or older; by 1998, 16.2 percent were elderly. Projections imply large increases in the elderly in the next 20 years; by 2015, 25 percent of the population will be 65 or above. The main reason for this aging is the fall in the total fertility rate (births per family). The total fertility rate was more than 4 before 1949, declining sharply to 2.1 in 1957. It has begun to fall again since 1974 and the current level of 1.4 was reached in 1997. There is still little sign that this has stabilized or returned to a higher level.

In this paper, we revisit the impact of demographic change on Japanese saving and investment, and government budget deficits. There is widespread belief that rapid aging will lead to major shifts in the Japanese saving and investment balance, and severely worsen Japan's fiscal situation. 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 government finances, as healthcare and social security spending soar. Unless 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.

Most of the earlier literature projecting the impact of demographic change on the Japanese saving-investment balance and government deficits dates back almost a decade. The data are correspondingly almost a decade old. The earlier literature assumed future population growth rates that are constant, and the economic projections relied on ad-hoc behavioral assumptions. We allow future population growth rates and support ratios (the ratio of the labor force to the population) to change every 5 years, and our projections are grounded in well-accepted microeconomic foundations.

Our 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 demographic 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 our simulations, we adopt the standard small-country, open capital market markets, Ramsey optimal growth model. 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. Section VI concludes.

II. Post-War 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.[1,2]

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

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[1]We 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).

[2]The 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.

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 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 or 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

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

[4]Horioka's results, however, must be interpreted with caution, since he includes variables with different orders of integration, I(.), 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.

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.

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 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

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[5]Kiyotaki 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.

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

[6]We 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.

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 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 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.

Fiscal Sustainability and Intergenerational Wealth Distribution.

The sharp increase in Japanese government debt in the 1990s has raised questions about the sustainability of this debt, and much policy work has been done in this area. Clearly, at current Japanese government fiscal deficit levels, the government debt will keep on growing. For given growth and interest rate assumptions, the fiscal surplus *exclusive of net debt interest payments*, or the *primary* fiscal surplus, necessary to stabilize the debt-GDP ratio is:

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

$$b = \frac{(r - gr) * d}{(1 + gr)},$$

where b is the primary surplus-GDP ratio, r is the long-run real interest rate, gr is the long-run real growth rate of GDP, and d is the debt-GDP ratio. For example, assume that r and gr are 0.06 and 0.012. To stabilize the debt-GDP ratio at the current net debt-GDP ratio of 0.85, the government will have to run a primary fiscal *surplus*-GDP ratio of almost 5 percent. Given the current cyclically-adjusted primary fiscal *deficit*-GDP ratio of about 4 percent, to keep the debt-GDP ratio at the current level, the required increase in the primary balance would be 9 percent of GDP. This required adjustment in the primary balance is somewhat higher (because of our higher long-run real interest rate assumption) than, but otherwise within the range (3-9 percent) reported in IMF (2000), and Jinno and Kaneko (2000).

It would be very difficult for the government to achieve this adjustment in the primary balance through fiscal reform in the near future. Thus, some analysts have argued that the government may attempt to lower the real value of the debt through inflation (Jinno and Kaneko, 2000; Miyao, 2001). Since Japanese government bonds pay a nominal coupon rate, inflation will lower the real return on bonds, and the real interest rate. From the equation above, we can see that the fall in the real interest rate will lower the required adjustment in the primary deficit.

In addition to debt-sustainability, many analysts have focused on the distributional effects of government debt (Sakurai, 1998; Jinno and Kaneko, 2000; Miyao, 2001). The benefits of current government spending largely fall on current generations, while the cost, in higher taxes or inflation, is borne by future generations. Thus, debt financed government spending entails a redistribution of resources from future generations to the current generation. These redistributional effects are particularly high for social security and healthcare expenditures, where the benefits fall almost entirely on the elderly, and the costs are borne by the young. Government spending that raises the future productive capacity of the economy–such as in education and physical infrastructure–will bestow benefits, as well as costs, on the young, and the redistributional effects are smaller.

Takayama and Kitamura (1999) identified large intergenerational imbalances in Japan, with future generations expected to pay about 3-4 times more in net taxes and social security contributions than the generation currently in retirement. Of course, these redistributional effects depend on Japanese households' being non-Ricardian. If the Japanese elderly raise their bequests to completely offset the costs to the young of the higher government debt, then government debt has no redistributive effects.

Recent Fiscal Reform Measures.

To restrain increases in the debt-GDP ratio, the government has proposed several fiscal reform measures in the 1990s. However, most of the measures were postponed or abandoned, as the government sought to stimulate demand, in light of the very weak domestic economy. Specifically, in 1997, the government enacted the Fiscal Structural Reform Law. The goal of the 1997 Law was to eliminate fiscal deficits by 2003.

The main instruments in the 1997 Law were cuts in government consumption and investment, rather than tax increases. Public investment spending was to be cut by 7 percent in 1998, with zero nominal growth until 2001; and energy, education, and overseas development assistance were to be cut by 10 percent in 1998, with annual reductions until 2001 (Ishi, 2000, p. 149). However, with the severe recession of 1997, fiscal consolidation was put on hold, and a wide-range of pump-priming measures were introduced. In particular, rather than declining, public investment for 1998 was increased by over 10 percent.

Areas where the 1997 Law made progress were in healthcare and social security reform, which are important, given the aging of the population. In 1997, the contribution rate and co-payments by patients for the government health insurance schemes were increased sharply (Ishi, 2000). In particular, patients aged 70 and above are required to pay a fixed proportion (10 percent) of their medical costs. The government also capped prescription drug prices, which are very high in Japan. In 2000, a pension reform bill based on the 1997 Law passed the legislature. The bill contained provisions to cut lifetime pension benefits by about 20 percent. Specifically, pension benefits for new retirees were cut by 5 percent; the age of pension eligibility will be gradually (from 2013) raised from 60 to 65; and pension benefits will be subject to an earnings test. Analysts have estimated that the 2000 pension reforms will reduce government unfunded social security liabilities from the current 60 percent of GDP to 30 percent of GDP (IMF, 2000).

Looking forward, the government is planning on implementing further budget cuts, once the economy fully recovers. Recently, a political commitment has been made to cap government deficit bond issues at 30 trillion (0.6 percent) of GDP in 2002. Although "deficit" bonds reflect only a portion of total government borrowing, this bond issuance ceiling should help lower future fiscal deficits.

As stipulated in the 1997 Law, public investment is due for further cuts. Criticism has been directed at the economic value of the public works projects, as well as contracting procedures. To address the efficiency issues, new cost-benefit guidelines for review of public works projects were announced. Contracting procedures have also been reformed. Public works projects in 2002 are scheduled to be cut by 10 percent, although whether the cuts will actually materialize is unclear. Moreover, the government intends to change the form of public works from the traditional type of construction projects to broader social infrastructure investment; for environment and energy-related projects, telecommunications networks, scientific research, nursing homes, and the like.

With regards to healthcare, contribution rates and co-payments, especially by the elderly, are planned to be increased further. The government's stated goal is to restrict the growth of medical costs of the elderly to no more than the rate of inflation. The age of eligibility for special elderly medical care will eventually be raised from 70 to 75. Further cuts are also planned in social security; for example, there are suggestions that average benefits should further be reduced by about 40 percent, to avoid large increases in future contribution rates (Sakurai, 1998).

IV. Aging and Support Ratios.

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

[8] The 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).

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 patters (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 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-

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

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 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, the Optimal Saving-Investment Balance, and Government Deficits.

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 Sali-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 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

[10]The 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.

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:

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

and thus private investment per capita is:

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

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, $\hat{j}_t$:

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

(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:

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

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:

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

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:

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

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

[11]We 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.

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 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:

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

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

[12]For 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.

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.

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

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

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.

(vi) Comparison with Earlier Projections of the Japanese Saving-Investment Balance and the Government Budget.

Many papers have projected the impact of demographic change on the Japanese saving-investment balance, although papers projecting future Japanese government budget balances are fewer. Despite the variety of methodologies and modeling assumptions, most earlier papers–like our paper--project declining saving and investment rates, with saving rates declining faster than investment rates, leading to current account deficits between 2025 and 2040. On the whole, the earlier papers predict deteriorating government budget balances, unless there is drastic fiscal reform. The proposed fiscal reforms in the earlier papers range from tax increases to cuts in social security benefits and in public investment. In our paper, we have focused on tax increases.

Most earlier papers projecting future saving and investment rates are based on ad hoc econometric specifications. Horioka (1991, 1992), using reduced-form time-series econometrics, estimates that Japanese private saving will become -15 per cent by 2020. Oishi and Yashiro (1997) develop a small (7 equations) simultaneous equation econometric model. They project that in 2025, the gross saving rate and the gross investment rate will reach 6 percent and 14 percent of GDP, respectively, leading to a net export deficit-GDP ratio of 8 percent. The Economic Planning Agency's (1997) large (270 equation) simultaneous equation model of the Japanese economy projects that by 2025, the gross saving and gross investment rates will be 23 percent and 25 percent, respectively. Their model projects that by 2050, the gross saving and gross investment rates will be 15 percent and 20 percent, respectively. Also using a large-scale macroeconometric model, the Japan Center of Economic Research (2000) estimates that in 2025, the private saving rate will be 3.7 percent.

Recently, researchers have made projections based on explicit utility maximizing frameworks. Auerbach *et. al.'s* (1989) overlapping-generations model--based on the life-cycle hypothesis where agents reduce their wealth in old age--finds that Japan's saving-investment balance will narrow until 2030, and become negative in 2035. Miles and Cerney's (2001) apply Auerbach *et. al.*'s model to the closed economy, and project that Japan's gross saving rate will be 18 percent by 2020, and 14 percent by 2040. McKibbin and Nguyen (2001) develop a multicountry model to simulate the economic effects of Japan's aging population. Since in their model, Japan is no longer "small", changes in Japan's saving and investment behavior can impact international real interest rates, unlike in our paper. In addition, the authors adopt the Blanchard (1985) saving function, where agents build up their financial wealth in their young years to maintain a target level of consumption in their elderly years. McKibbin and Nguyen project that by 2040, the gross saving and the gross investment rates will be 20 and 22 percent, respectively, leading to a current account deficit-GDP ratio of -2 percent.

With regards to the effect of aging on Japanese government budget balances, most earlier research portray falling tax revenues and rising pension benefits. Masson and Tryon (1990) find that between 2000 and 2025, the budget deficit-GDP ratio will deteriorate by 2.5 percentage points, owing to increasing pension burdens. The Japan Center of Economic Research (2000) estimates that the government saving-GDP ratio will decline from 2 percent in 2000 to -2.4 percent by 2025. The Economic Planning Agency's (1997) simultaneous equation model predicts a -0.5 percent government saving rate in 2025, and a 0.3 percent government saving rate in 2050. To achieve this budget turnaround, tax rates (total taxes+social security contributions)/GDP) are projected to gradually increase from the current 28 percent to 35 percent in 2025 and remain at that level thereafter. Muhleisen (2000) uses a simultaneous econometric equation model and projects steadily improving government finances. The fiscal balance (government saving minus public investment) deficit-GDP ratio improves from the current -7 percent to 1 percent in 2025 and 0 thereafter, mainly owing to an immediate reduction in the public investment rate from the current 8 percent to 4 percent.

VI. Conclusion.

The rapid aging of the population currently underway in Japan should lead to falling private saving and private investment rates over the next 25 to 40 years. Given current government debt levels and projected government spending and public investment, future taxes must be raised sharply for the government to remain solvent. Our model predicts that taxes as a percentage of GDP must increase from the current 28 percent to 45 percent by 2025, and 50 percent by 2040. Assuming that the government raises future taxes, the current government fiscal deficit will turn to surplus over the next 25 years, leading to a fall in the government debt thereafter. Alternatively, if taxes are not raised, the government must sharply cut social security spending and public investment. However, if public investment is necessary for production, as it is assumed in this paper, cutting public investment too sharply may be unwise.

Admittedly, the assumptions underlying our projections are somewhat special. We have assumed that Japanese households are dynastic, and do not follow life-cycle behavior. The implication of dynastic households is Ricardian equivalence, that government deficits do not affect the intergenerational distribution of wealth. Japanese citizens are mostly concerned about the unfairness of large unfunded liabilities in the Japanese social security system; the system transfers wealth from the current young to the current elderly. Because in our model we assume that the elderly offset their net benefits from social security by leaving larger bequests to the young, unfunded social security liabilities have no redistributional effects, although the liabilities certainly affect future tax rates and the division of total saving into private and government saving.

In life-cycle models, population aging causes aggregate private saving to fall by increasing the proportion of those who are bringing down their wealth (dissaving), and decreasing the proportion of those accumulating wealth (saving). In our dynastic model, population aging causes aggregate private saving to fall by rasing the consumption rate (consumption to GDP ratio). The consumption rate rises because while consumption per capita growth is reasonably constant (in open capital markets), output per capita growth is lower (owing to the decline in the number of workers relative to the population). However, given the empirical evidence in Japan against the life-cycle hypothesis (Horioka, 2001), we believe our assumption of dynastic households is as plausible as most alternatives about Japanese household behavior.

Another special assumption underlying our projections is that real interest rates are determined internationally, and are exogenous to Japan. However, since currently Japan is a large capital exporter, if Japanese saving increases, international real interest rates should fall. Endogenous international 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 (as in McKibbin and Nguyen, 2001).

In any event, most previous research–using a variety of assumptions and models–have predicted declining saving and investment rates as the Japanese population ages. Most previous research has also predicted worsening government budget deficits, unless there is fiscal reform. Thus, despite our special assumptions, the broad conclusions of our paper are in agreement with those of most previous research.

Appendix:

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,

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

where χ 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:

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

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:

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

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

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 $\gamma, h, \delta, r,$ 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:

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

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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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

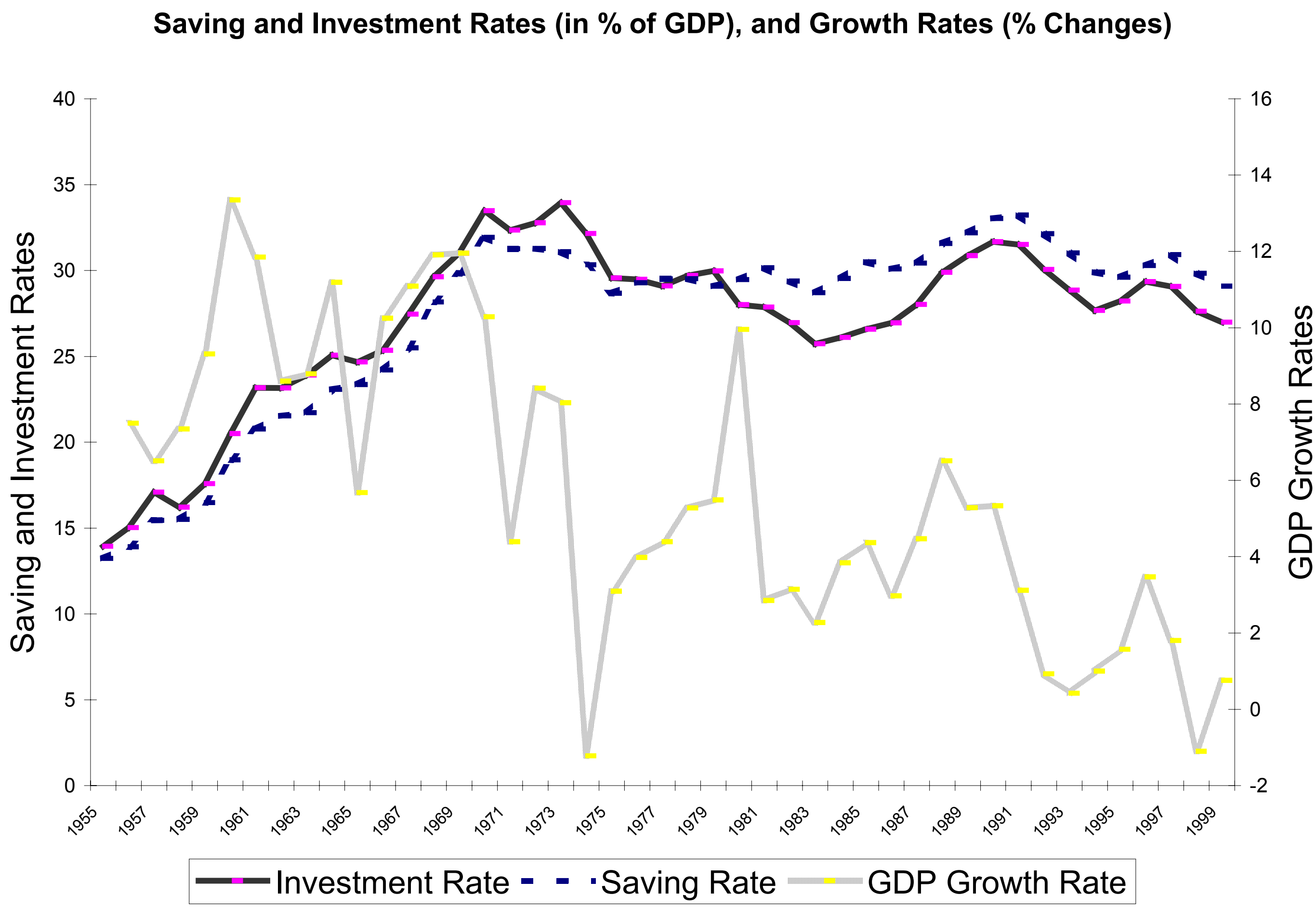
	Social Security	Health Care	Education	Social Security	Health Care	Education	Other	Total
	(in billions of 1995 yen)			(in percent of GDP)/1				
2000	57667	27271	16327	11	5.3	3.2	5.6	25.1
2005	65265	28471	15634	12	5.4	2.9	5.6	25.9
2010	74032	29462	15445	14	5.7	3.1	5.6	28.4
2015	78318	30550	15067	14	5.7	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



Saving and Investment Rates (in % of GDP), and Growth Rates (% Changes)
Saving and Investment Rates
GDP Growth Rates
0
5
10
15
20
25
30
35
40
-2
0
2
4
6
8
10
12
14
16
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
Investment Rate
Saving Rate
GDP Growth Rate

Figure 2: Government Saving (Surplus)/GDP

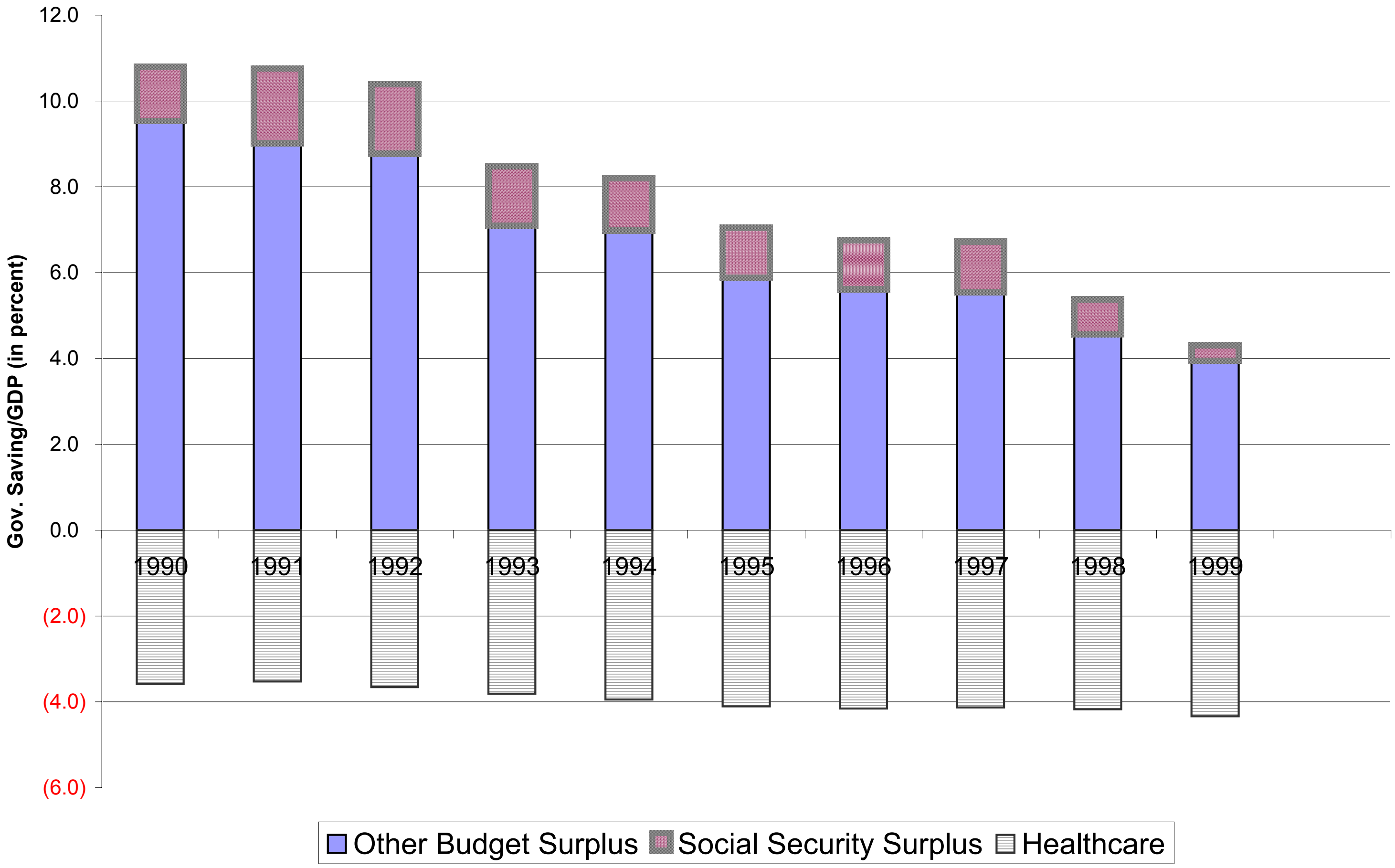


Figure 3: Population and Elderly Projections

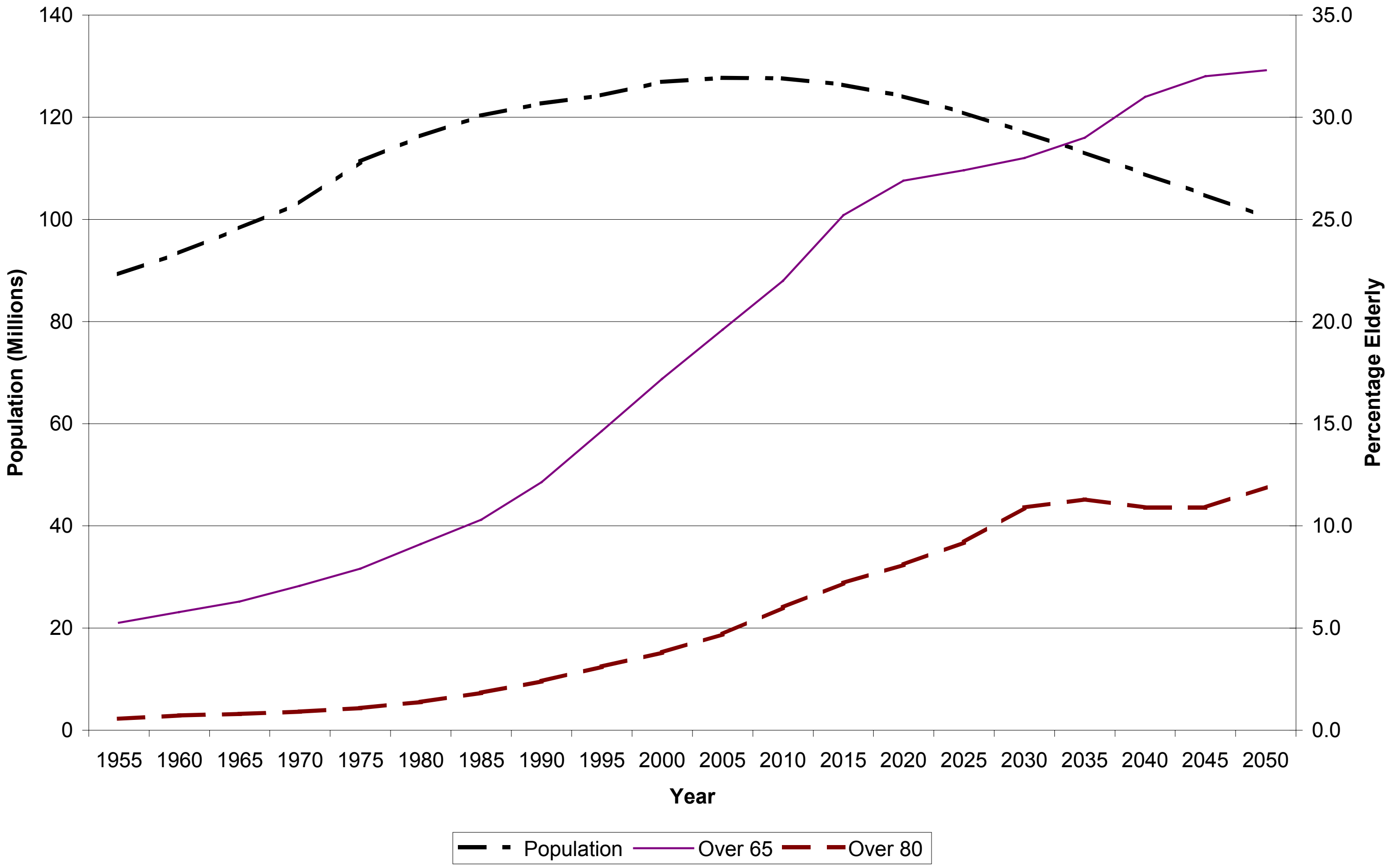


Figure 4: Support Ratios