Japanese Saving Rate[*]

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Abstract

In this paper, we use a standard overlapping generations model to study the time-series behavior of the saving rate in Japan between 1961-1998. The model economy is able to generate saving rates that are remarkably similar to the data during this period. We conduct counterfactual experiments to isolate the impact of several factors such as the social security system, fiscal policy, and total factor productivity growth on saving behavior. Our results identify changes in the TFP growth rate and the low initial capital stock as the main factors behind the time series behavior of saving rates in Japan.

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1 Introduction

There have been substantial differences between the saving rates of Japan and U.S. in the last forty years that have motivated an extensive research in this area. Figure 1 presents net national saving rates for the two countries between 1961 and1998 [1]

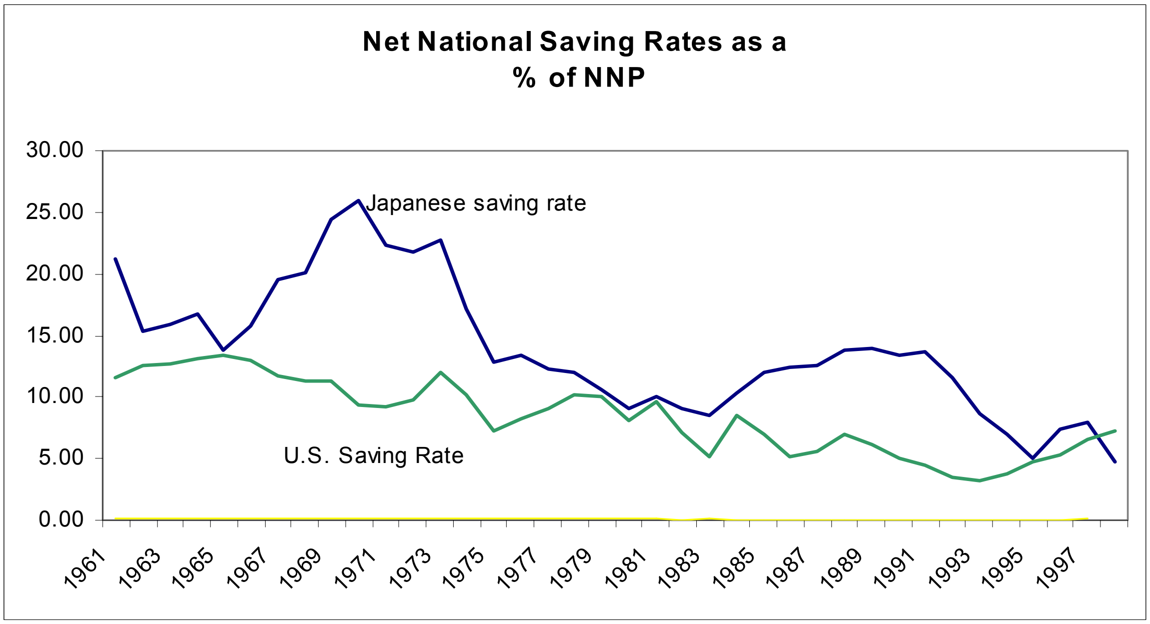

Figure 1: Saving Rates

Attempts to explain the relatively high saving rate in Japan have focused on many factors. Discussions ranged from economic factors to preferences peculiar to Japan as well as the relevance of life-cycle versus dynastic models. Ando, Yamashita, and Murayama (1986) mention that one of the reasons for the high saving rate in Japan during 1970s is the high growth rate during those years. Hayashi (1986) argues that low initial capital stock is the main reason behind the high saving rate in the late 1960s and the early 1970s. Christiano (1989) examines if the low initial capital stock can lead to the observed behavior of the

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[1] The data are obtained from Hayashi (1989) who provides a comprehensive data set that corrects for differences in accounting and measurement standards between the two countries. There are two major differences between the accounting standards of the two countries. Japanese National Income and Product accounts report depreciation based on historical cost as opposed to the replacement cost as in the U.S. In addition, in Japan government investment is explicitly accounted for while in the U.S. all government expenditures were classified as government consumption. While Dekle and Summers (1991) argue that the implied depreciation rates in Japan are implausibly high with these adjustments, Hayashi (1991) argues that they are justified due to the high depreciation rate for owner-occupied housing and the treatment of equipment capital.

saving rate in a one-sector, infinite horizon, representative agent model. He assumes that the Japanese capital-output ratio was at 12% of its steady-state level and computes the transition path to a steady-state which coincides with that of the U.S. economy. His idea is to see how fast the capital-output ratio will converge to this steady-state. The answer is quite fast, but this (simple) standard model cannot generate anything close to the actual time path of the saving rate.[2] Dekle (1986), Hayashi (1986), and Hayashi, Ito, and Slemrod (1987) emphasize the importance of a bequest motive in understanding Japanese savings. Hayashi, Ito, and Slemrod (1987) presents a life-cycle simulation analysis which includes housing purchase decisions. Their results indicate that the contribution of the down payment requirement seems to be too small to explain the large differential in the saving rates of the two countries. They are able to generate high saving rates only when they introduce a bequest motive. They also show the tax deductibility of mortgage interest payments and the tax exempt status of interest income to have a small impact on the aggregate saving rate. Horioka, Yamashita, Nishikawa, and Iwamoto (2002) argue that bequest motives are weak in Japan both absolutely and relative to the U.S. and suggest that the life-cycle model is the dominant model of household behavior in Japan.

Many other papers examine the reasons behind the high saving rate in Japan focusing on factors ranging from the bonus system, high housing prices, high educational costs, low level of social security benefits, especially until late 1970s, bequests, and transfers.[3] There does not appear to be a consensus on the importance of many of these factors.

In this paper, we use a calibrated general equilibrium model to explore the year-to-year fluctuations in the Japanese saving rate and capital-output ratio. Our approach is more in line with the recent use of the one-sector growth model to explain 'big shocks'. In particular, we follow Ohanian (1997) and Kehoe and Prescott (2002) in bringing an applied general equilibrium setup to bear on the question posed above and to conduct counterfactual experiments to account for the actual time path of Japanese saving behavior.[4] We use an overlapping generations setup with potentially important public institutions such as social security that can address the aging of the population and the change in the size of the retirement benefits over time, as well as incorporate the time path of total factor productivity (TFP) and government fiscal policy parameters. The question we ask is: 'what features of

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[2] Christiano then introduces a subsistence level of consumption in the period utility function that makes the marginal utility of the distance between consumption and its subsistence level very small as consumption falls (and saving rises rapidly in the first few years of convergence) and therefore dampens the desire to save. The resulting (smooth) path of 'slow convergence' does better in terms of mimicking the Japanese saving rate.

[3] See Horioka (1990) for a survey.

[4] Related work that uses general equilibrium models to address short run issues are Cooley and Ohanian (1997), Cole and Ohanian (2002, 2004), and all the papers in the 2002 special issue of *Reivew of Economic Dynamics,* entitled 'Great Depressions of the 20th Century'.

the Japanese economy are critical in generating the observed saving behavior between 1961-1998?'.

Our model consists of overlapping generations of 80 period lived individuals facing mortality risk and borrowing constraints. Private annuity markets and credit markets are closed by assumption. Until the mandatory retirement age, agents in this economy work an exogenously given number of hours and accumulate assets to provide for old age. After retirement agents receive social security benefits that are financed by a payroll tax. The return on asset holdings and the wage rate are determined by the profit maximizing behavior of a firm with a constant returns to scale technology. We specify the optimization problem of the individual as a finite state, finite horizon dynamic program and use numerical methods to compute stationary equilibria.

We calibrate the model to Japanese data for the 1961-1998 period. We use the average tax rates on capital, labor and consumption, observed social security replacement rate, average population growth rate and survival probabilities that prevailed in that time period. The simulations from year 1961 takes the actual capital stock in 1960 as the initial condition and uses the actual time path of TFP. We conduct deterministic simulations, as in Hayashi and Prescott (2003), and argue that this framework allows us to identify between several factors that may explain the differences in saving rates between Japan and U.S. in a relatively simple manner. This framework allows us to quantify the effect of several factors on the saving rate including the social security system, growth rate of population, tax rates, growth rate of TFP, and low initial physical capital stock.

Our results indicate that two factors alone can account for most of the differences between the saving rates in Japan and U.S. in the 1961-1998 time period. These are the TFP growth rate and the low level of the initial capital stock in 1960. We show that if Japan were to be faced with the U.S. TFP during the 1961-1998 period as well as a high initial capital stock, the time path of the saving rate in Japan would have looked very similar to that of U.S. These findings suggest that the impact of factors such as the social security system or the aging of the population on the Japanese saving rate in this time period may be of second order importance.

2 A Standard OG Model

2.1 The Environment and Demographics

The question we want to study requires the computation of a transition path to a steady state, very much like Hayashi and Prescott (2003). It is easier to start the description of the model with a stationary overlapping generations setup similar to that in Auerbach and Kotlikoff (1987) but with a different market structure.

At each date s, a new generation of individuals is born. We denote the population growth rate by $\eta\%$. Individuals face long but random lives, work until the mandatory retirement age of j_R, and might live through maximum possible age J. Life-span uncertainty is described by ψ_j, the conditional survival probability from age j to $j+1$. We assume a stationary population by making the survival probabilities $\{\psi_j\}_{j=1}^{J}$ and the population growth rate η time-invariant. We also assume $\psi_J = 0$. The cohort shares, $\{\mu_j\}_{j=1}^{J}$, are given by

$$\mu_j = \frac{\psi_{j-1}}{(1+\eta)}\mu_{j-1}, \text{ where } \sum_{j=1}^{J}\mu_j = 1. \tag{1}$$

Although the notation above assumes a stationary population, it is easy to allow the conditional survival probabilities and the population growth rate to vary over time. This would allow us to capture the impact of the aging of the population along the transition path to the eventual balanced growth path. For the time being, though, we abstract from demographic dynamics.[5]

2.2 Technology

There is a representative firm with access to a constant returns to scale Cobb-Douglas production function with deterministic total factor productivity A_s:

$$Y_s = A_s K_s^{\theta} {H_s}^{1-\theta}, \tag{2}$$

where K_s and H_s are aggregate capital and labor inputs, respectively, θ is capital's output share, and TFP grows at the rate ${g_s}^{1/(1-\theta)} > 0$. We assume that $H_s = \bar{h}N_s$, and N_s grows at the rate η.

The aggregate capital stock evolves according to the law of motion:

$$K_{s+1} = (1-\delta_s)K_s + X_s,$$

where X_s is aggregate gross investment and δ_s is the rate of depreciation of capital at time s.

The stand-in firm rents capital and labor from the households in competitive spot markets at the rates r_s and w_s, respectively, and maximizes its profits. Factor prices equal their marginal productivities:

$$\begin{aligned} r_s &= \theta A_s \left(\frac{K_s}{H_s}\right)^{\theta-1}, \qquad (3) \\ w_s &= (1-\theta)A_s\left(\frac{K_s}{H_s}\right)^{\theta}. \end{aligned}$$

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[5] Braun, Ikeda, and Joines (2004) study the impact of the aging of the population on the Japanese saving rate in the 1990s and beyond.

2.3 Households

A household who is i years old at time t solves the following problem:

$$\max \sum_{j=i}^{J} \beta^{j-i} \left[\prod_{k=i}^{j} \psi_k \right] u(c_{j,s})$$

subject to a sequence of budget constraints over the remaining lifetime:

$$(1+\tau_c)c_{j,s} + a_{j+1,s+1} = R_s a_{j,s} + (1-\tau_{h,s}-\tau_{n,s})w_s\varepsilon_j h + b_{j,s} + \ell_s, \tag{4}$$

where β is the subjective discount factor, $c_{j,s}$ is consumption of an age-j individual at time $s = t+i-j$. Asset holdings at the beginning of age j at time s are given by $a_{j,s}$. They earn the gross interest rate (net of taxes and depreciation) $R_s = [1 + (1-\tau_{a,s})(r_s - \delta_s)]$. The tax rates on consumption, capital income, and labor income are denoted by τ_c, $\tau_{a,s}$, and $\tau_{h,s}$, respectively. $b_{j,s}$ denotes social security benefits received by an age-j individual at time s, to be described later, and $\tau_{n,s}$ is the payroll tax for social security at time s. Benefits $b_{j,s}$ are a fraction $rrate_s$ of average lifetime earnings. Each individual receives a lump-sum amount ℓ_s which is the sum of a government transfer (to clear its budget) and the redistribution of accidental bequests. Note that we allow for some of the tax rates and the rate of depreciation δ_s to vary over time. We also assume that there is no borrowing:

$$a_{j,s} \geq 0, \quad \text{all} \quad j, s, \tag{5}$$

with $a_{1,s} = a_{J,s} = 0$ for all s. Note that we have a representative individual for each cohort. However, we do not allow any borrowing. Furthermore, we do not allow for annuity markets.[6]

The above notation allows for some transitional generations that will have to re-solve their remaining lifetime optimization problem in response to an unanticipated change in their environment, starting from an initial balanced growth path or given initial conditions. For a newborn at time t, the objective function simplifies to

$$\sum_{j=1}^{J} \beta^{j-1} \left[\prod_{k=1}^{j} \psi_k \right] u(c_{j,s}), \tag{6}$$

and $s = t+j-1$.

We use recursive tools to solve the individual's perfect foresight decision problem. Let $V_{j,s}(a_{j,s})$ denote the value function of an age-j individual at time $s = t+j-1$. We compute

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[6] This seems important in generating a hump-shape in the age-consumption profile over the life cycle. Since we are interested in analyzing the Japanese saving rate and other aggregate behavior in the 1960s through 1990s, our first attempt is to see the extent to which this OLG framework can replicate behavior. If not, departures from this setup in other directions such as more incomplete markets, other frictions, changes in demographics, and monetary issues would be warranted

the value functions for $j = 1, 2, \cdots, J$, and all s, using

$$V_{j,s}(a_{j,s}) = \max_{\{c_{j,s}, a_{j+1,s+1}\}} \left\{ u(c_{j,s}) + \beta\psi_j V_{j+1,s+1}(a_{j+1,s+1}) \right\} \tag{7}$$

subject to (4) and (5). Following İmrohoroğlu, İmrohoroğlu, and Joines (1999), we discretize the state space and numerically obtain the value functions and the accompanying decision rules.

2.4 Social Security

Social security benefits are given by

$$b_{j,s} = \begin{cases} 0 & \text{for } j = 1, 2, \cdots, j_R - 1, \\ b_{j_R, t+j_R-j} & \text{for } j = j_R, j_R + 1, \cdots, J. \end{cases}$$

where the pension received by a new retiree at time $t + j_R - i$ is given by

$$b_{j_R, t+j_R-i} = rrate_s \frac{1}{j_R - 1} \sum_{j=1}^{j_R-1} w_{t+j-i} h \varepsilon_j (1+g)^{j_R - j}.$$

Note that the retirement benefits received by an individual are constant throughout the individual's lifetime, although successive cohorts receive successively larger benefits at the rate of TFP growth.

We assume that the system is unfunded so that the payroll tax is selected to equate the total benefits to total taxes collected for each time period. Total benefits paid at time $t+j_R-i$ are equal to $\sum_{j=j_R}^{J} \mu_j b_{j,t+j_R-i} = b_{j_R,t+j_R-i} \sum_{j=j_R}^{J} \mu_j (1+g)^{j_R-j}$. Total taxes are therefore equal to:

$$\tau_{n,s} = \frac{b_{j_R,t+j_R-i} \sum_{j=j_R}^{J} \mu_j (1+g)^{j_R-j}}{w_{t+j_R-i} h \sum_{j=1}^{j_R-1} \mu_j \varepsilon_j}. \tag{8}$$

2.5 Government

In addition to the unfunded social security system, the government needs to finance its per capita purchases G_s by taxing consumption, labor and capital income, and confiscating unintended bequests. We require period-by-period budget balance which necessitates a (per capita) lump-sum transfer ℓ_s.

$$\tau_c \sum_{j=1}^{J} \mu_j c_{j,s} + \tau_{h,s} \sum_{j=1}^{J} \mu_j w_s \varepsilon_j h + \tau_{a,s} \sum_{j=1}^{J} \mu_j (r_s - \delta_s) a_{j,s} + \sum_{j=1}^{J-1} (1-\psi_j) a_{j+1,s} \mu_j / (1+\eta) = G_s + \ell_s. \tag{9}$$

2.6 Aggregation

Aggregate variables are computed in the usual way by obtaining the weighted average of different cohorts' decision rules, using the population weights determined by our demographic assumptions. For example, (per capita) aggregate capital and labor inputs are given by:

$$\begin{aligned} K_s/N_s &= \sum_{j=1}^{J} \mu_j a_{j,s}. \\ H_s/N_s &= \sum_{j=1}^{J} \mu_j \varepsilon_j h. \end{aligned}$$

2.7 Recursive Competitive Equilibrium

A *government policy* consists of $\{G_s, \tau_c, \tau_{a,s}, \tau_{h,s}, \tau_{n,s}, rrate_s, \ell_s\}_{s=s_1}^{s2}$, where s_1 and s_2 are some initial and final dates. An *allocation* is given by a sequence of decision rules $\{A_{j+1,s+1}(a), C_{j,s}(a)\}_{j=1}^{J}$ over $[s_1, s_2]$. A *price system* is a sequence of pairs $\{w_s, r_s\}_{s=s_1}^{s2}$. For a given government policy, a *Recursive Competitive Equilibrium* is an *allocation* and *price system* such that

- the allocation solves the dynamic program (7) for all individuals, given the price system and government policy,
- the allocation maximizes firms' profit by satisfying (3),
- the allocation and government policy satisfy the government's budget constraint (9) given the price system,
- the social security system is unfunded, that is (8) satisfied, and,
- the commodity market clears

$$C_s + X_s + G_s = Y_s.$$

3 Data and Calibration

We calibrate the model to the 1961-1998 Japanese economy using data provided by Hayashi and Prescott (2003). The capital share parameter, θ is set to its average value over 1961-1998. The subjective discount factor and the risk aversion parameter are set so that the capital output ratio is 2 at the final steady state. This results in $\beta = 0.999$ and $\sigma = 1.5$ where the period utility function is taken as:

$$u(c_{j,s}) = \frac{c_{j,s}^{1-\sigma} - 1}{1-\sigma}.$$

For the steady state calculations we set the values for the share of government purchases, G_s/Y_s, the depreciation rate δ_s, tax rates on capital income, $\tau_{a,s}$, labor income, $\tau_{h,s}$, and consumption, τ_c, equal to their average values over 1961-1998. We take the TFP factor as 0.087 at the final steady state assumed to be achieved in 1999. The growth rate of TFP is set to its 1961-1998 average value of 1.95%, the growth rate of the population is taken as 1.23%. We take the age-specific survival probabilities from the Japanese Life Tables for 1970.[7]

Since our main question is to examine the determinants of the saving rate in Japan between 1961-1998, our simulations take the actual capital output ratio in 1960 as the initial condition. More precisely, we set the initial level of capital to 32% of its level in 1990. We use the data for actual TFP, A_s, during this time period. In our benchmark experiment we use the average value for the depreciation rate, δ_s, share of government purchases, G_s/Y_s, and the tax rate on capital income, $\tau_{a,s}$ which are the same as the steady state values mentioned above. Since these variables display significant changes over this time period we check the sensitivity of our results by conducting additional experiments where the actual time series values for these variables are used in the simulations. The data for these variables are provided in Appendix B. We set the consumption tax rate and the labor income tax rate to their average values of 5.6% and 10% for all the experiments.[8] We also set h equal to 40. This parameter is set so that the average labor input in the model matches the labor input used in growth accounting to generate the level of TFP for Japan. We approximate the replacement rate for social security from Oshio and Yashiro (1997) who indicate that it was equal to 17% for 1961-1976 and 40% afterwards.

To summarize, our benchmark experiment uses the actual time series values for A_s for the period 1961-1998 and assume long-run averages for all the exogenous variables for the periods after 1998.

Table 1 summarizes the steady state calibration:

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[7] "Abridged Life Tables For Japan 2002", Statistics and Information Department, Ministry of Health,Labour and Welfare.

[8] The labor income tax rate in the model does not include the payroll tax for social security since that tax rate is computed endogenously to clear the social security balance for the government.

Table 1: Steady State

θ	capital share	0.363
β	discount factor	0.999
σ	risk aversion	1.5
η	growth rate of pop.	0.0123
g	TFP growth rate	0.0195
G_s/Y_s	share of government	0.15
τ_a	capital income tax rate	0.35
τ_c	consumption tax rate	0.056
τ_h	labor income tax rate	0.10

In the first part of Table 1 in Appendix B, we present the time series data that are used in the transitional analysis. The second part of the table includes data on the capital output ratio, net national saving and the after tax interest rate in Japan. This information will be used to examine if the saving rate, capital output ratio and the interest rate generated by the model mimic the data.

4 Results

In examining the time series behavior of the saving rate in Japan, we follow Hayashi and Prescott (2003) and conduct deterministic simulations. We do not argue that the entire path of TFP during 1961-1998 could be forecasted by agents even though we treat it as if it were. We start by examining some of the properties of saving rates generated by the model and then compare our benchmark saving rate with the data. Next, we perform counterfactual experiments to isolate the factors that impact the behavior of the saving rate in Japan.

4.0.1 Properties of the Model

Our measure of saving rate is net national saving as a percent of Net National Product (NNP). While we conduct extensive sensitivity analysis later on, there is one factor that has an important impact on the saving rate that we discuss up-front. The capital output ratio in 1960 has important implications for the saving rate in the first few periods following 1960. Hayashi and Prescott (2003) provide a measure of the capital output ratio for Japan where they estimate the size of the foreign capital based on the current account. For 1990, the capital output ratio inclusive of foreign capital is equal to 0.77. If foreign capital is excluded that ratio is increased to 1.06, since early 1960s show Japan as borrowing from abroad. In Figure 2, we present model-generated saving rate paths for Japan based on these two different measures of the initial capital output ratio.

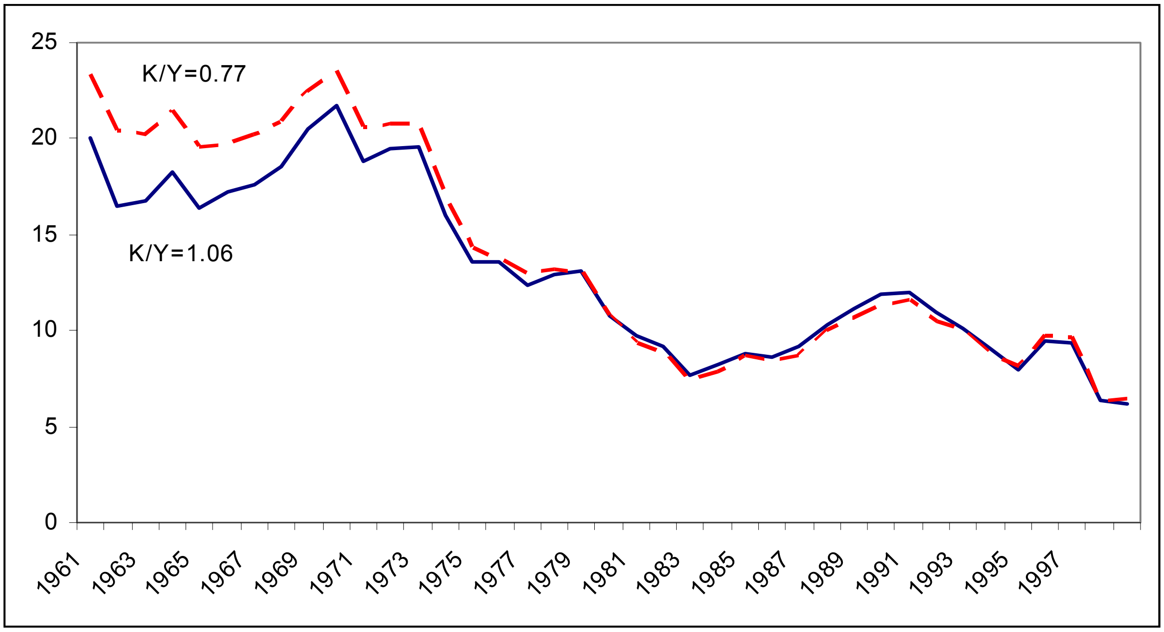

Figure 2: Saving Rate

Notice that the impact of the initial capital output ratio disappears by mid 1970s. This is expected since there is faster 'catching-up' when the economy starts further below the eventual steady-state capital output ratio. In our benchmark economy, we are going to be using the higher capital output ratio as our starting point.

In the next figure we present the actual net national saving as a percent of NNP in Japan and the simulated data from the benchmark economy where the time series sequence on TFP is the only exogenous time series information that is included in the simulations. The rest of the exogenous variables are set to their long term averages, except for the social security replacement rate which is allowed to change during this time period as explained in the calibration section. The average saving rate for the period is 13.62 in the data and 13.08 in the model.

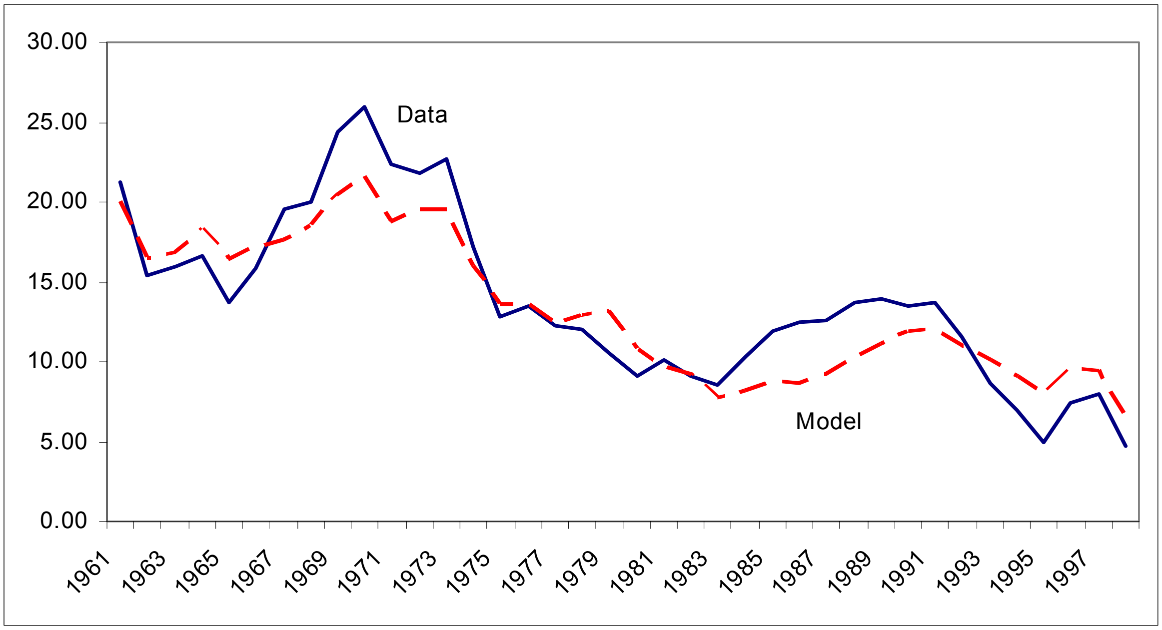

Figure 3: Saving Rate: Data and the Model

As can be observed from the figure, the model economy generates fluctuations in the saving rate that resemble the data remarkably well for most of the periods. The main discrepancies are in the late 1960s and early 19780s, and mid 1980s where the saving rate generated by the model is smaller than the data, and the late 1990s where the saving rate generated by the model is greater than the saving rate in the data.

In the next experiment, we include time series data for the capital income tax, depreciation rate and the government's share in GNP into the model. As can be seen from Figure 4, the deprecation rate and the capital income tax rate have changed significantly in this time period with the deprecation rate declining and the capital income tax rate increasing.

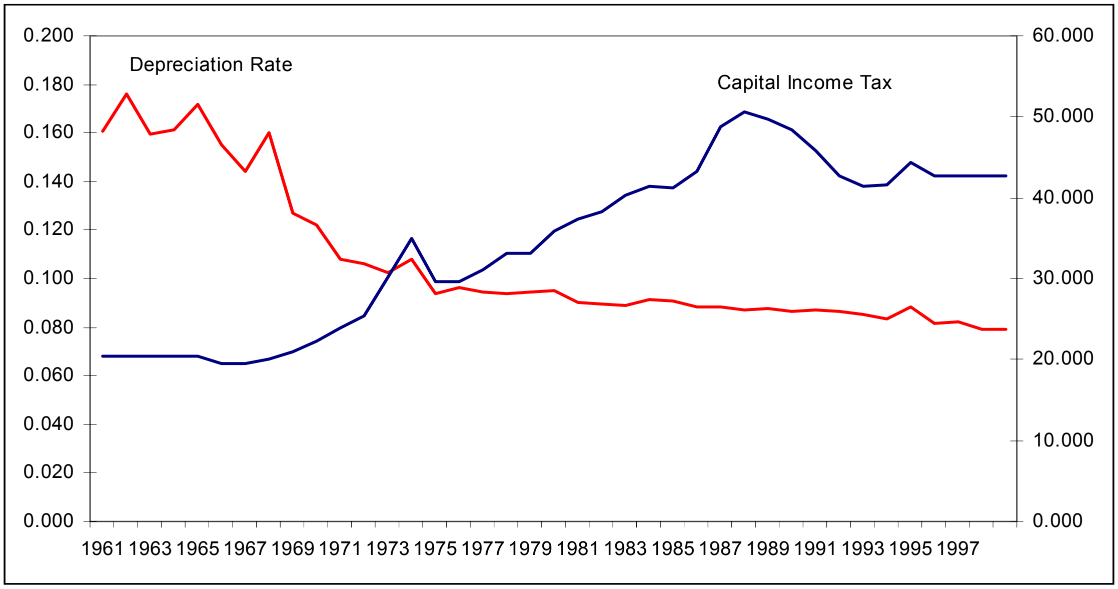

Figure 4: Data

As can be seen from Figure 5, this experiment moves the two series closer to each other in the mid 1960s and early 1970s. In order to understand the impact of these factors better we will conduct counterfactual experiments where we change one time series data at a time. However, before moving into the counterfactual experiments, we present data on few other features of this economy.

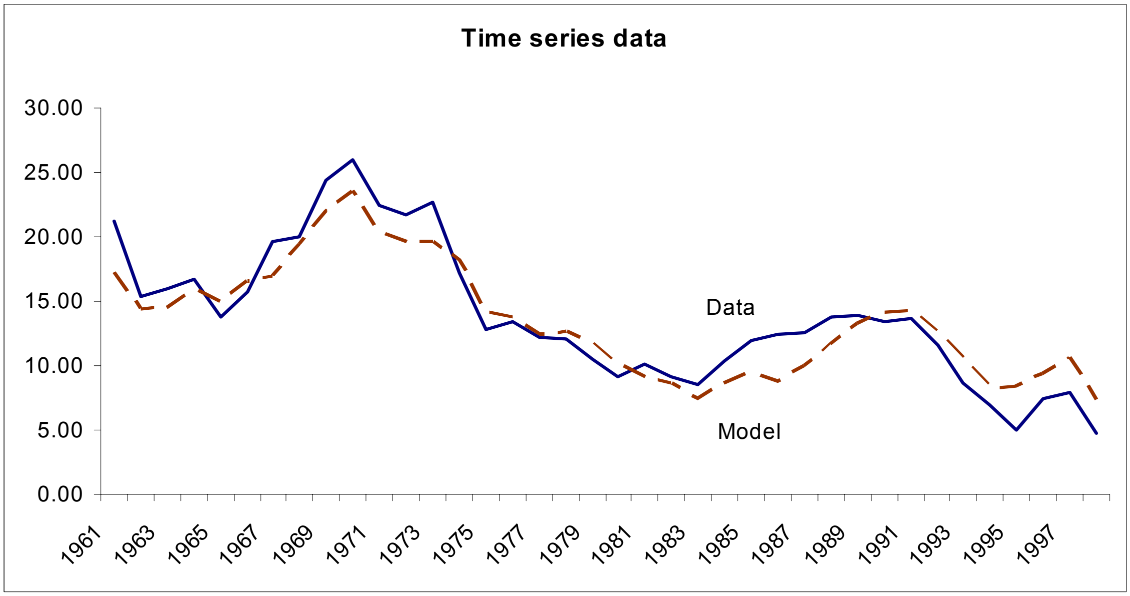

Figure 5: Saving Rate

In the next figure we display the capital output ratio and the after tax return on capital for this economy. The model economy is able to generate movements in the capital output ratio and the interest rate that mimic the data

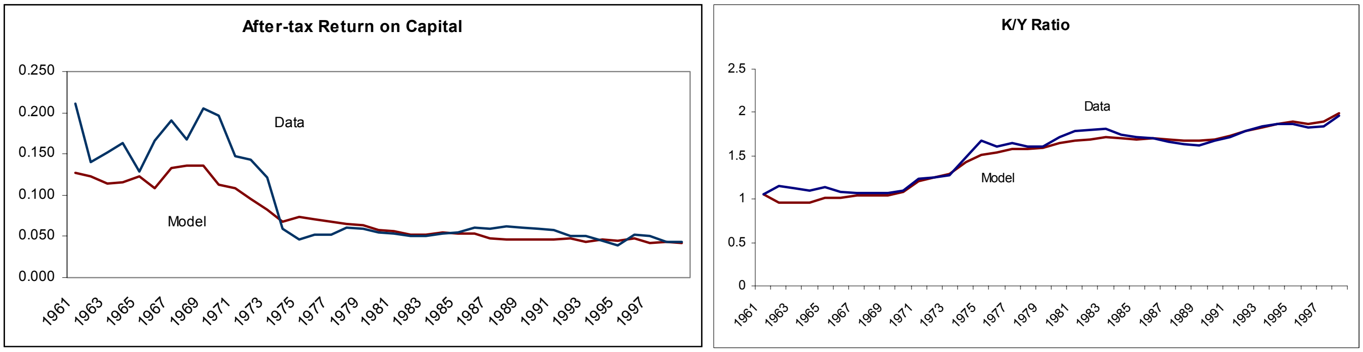

Figure 6: Properties of the economy with time series data.

4.0.2 Counterfactual Experiments

This framework allows us to conduct counterfactual experiments to assess the role of different factors that may have a role in the determination of saving rates in Japan. We start this section by assessing the role of the depreciation rate, δ, and the capital income tax rate, τ_a. As our benchmark, we take the economy where δ and τ_a are set to their long-term averages of 10% and 35% respectively. Then we change one feature at a time and examine its impact on the saving rate.

Table 2: Counterfactual 1

	Data		**Saving Rates**		
Year	$\boldsymbol{\tau_a}$	$\boldsymbol{\delta}$	**Benchmark**	τ_a **time series**	δ **time series**
1962-1967	20.14	16.14	17.13	20.27	12.92
1968-1978	27.39	11.01	17.01	16.10	18.19
1979-1989	41.82	9.02	9.70	7.15	12.35
1990-1998	43.57	8.46	9.71	9.57	11.67

We can make several observation from Table 2. For example, if the capital income tax rate were to stay at its long term average of 35% instead of increasing to 41.82% between 1979-1989; the saving rate would have been higher by 2.55 percentage points. If the depreciation rate were equal to its long-term average of 10% instead of the 16.14% in the 1962-1967 period, the saving rate in that period would have been higher by 4.21 percentage points.

In the next set of counterfactual experiments, we examine the role of the TFP growth rate and the initial capital output ratio in determining the saving rate in Japan. While there are several ways we could carry out such a counterfactual experiment, we do it by asking the following questions: If the Japanese TFP and the initial capital output ratio were the same as the U.S. TFP and the initial capital output ratio during this time period, what would the Japanese saving rate look like? In order to answer this question we need a measure of the U.S. TFP which we take from Jorgenson (2003).[9] The noteworthy differences between the time series behavior of U.S. versus Japanese TFP's are summarized in Table 3.

Table 3: TFP Growth Rates

Years	**Japan**	**U.S.**
1962-1967	3.32	1.88
1968-1978	1.72	0.72
1979-1989	1.46	1.29
1990-1998	0.27	0.77

According to Table 3, the TFP growth rate in Japan is significantly higher than that of U.S. in the 1961-1968 period. There is also a large decline in the U.S. TFP in period 1968-1978.

In the fourth column of Table 4 we summarize the results of the counterfactual experiment where U.S. TFP is used for the Japanese economy. As one can observe from these results, the relationship between the TFP growth rate and saving rate is a nonlinear one. Saving rate in a given period is affected by the growth rate of current and future TFP. When we use the U.S. TFP for Japan together with the low initial capital stock that was faced by the Japanese, we actually obtain a higher saving rate for the period 1962-1967.. Notice also that TFP growth rate declines more dramatically in the 1968-1978 period in U.S. than in Japan.

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[9] The data includes TFP measures for Japan and U.S. In the following tables we use the Hayashi Prescott (2003) measure of TFP for Japan and Jorgenson (2003) measure of TFP for U.S. Since this data set ends in 1995, we have included author's calculations for the 1995-1998 period for the U.S. In the sensitivity analysis we examine the Japanese saving rate based on the TFP measure provided in Jorgenson (2003) as well.

Table 4: Counterfactual 2

		Saving Rates		
Year	**Data**	**Benchmark**	**U.S. TFP**	**Initial Cond.**
1962-1967	16.20	17.13	19.95	8.78
1968-1978	18.62	17.01	13.43	12.88
1979-1989	11.12	9.70	7.45	8.76
1990-1998	8.83	9.71	7.74	12.89
1962-1998	13.62	13.08	11.33	10.99

Next we examine the importance of the initial conditions for Japan. In particular, we change the initial level of capital from 32% of its detrended level in 1990 to 77% of its level in 1990. The second panel of Table 4 displays the results for this case. This change causes a dramatic decrease in the saving rate between 1962-1967. In other words, the high saving rate that was observed in Japan during 1962-1967 may very well be due to the fact that Japan was "catching-up".

In Figure 7, we graph the saving rate for Japan that would have happened if the two features examined above were present at the same time. That is, in this case, both the initial conditions and the TFP levels for Japan are similar to conditions that existed for the U.S. In addition, we show the U.S. saving rate in the graph. As can be observed, the model economy, with these two counterfactual features, generates a saving rate for Japan that looks very similar to the U.S. saving rate. The average saving rate for the 1962-1998 period for this case is equal to 9.40%. The average saving rate for the U.S. in the same time period was 8.36%.

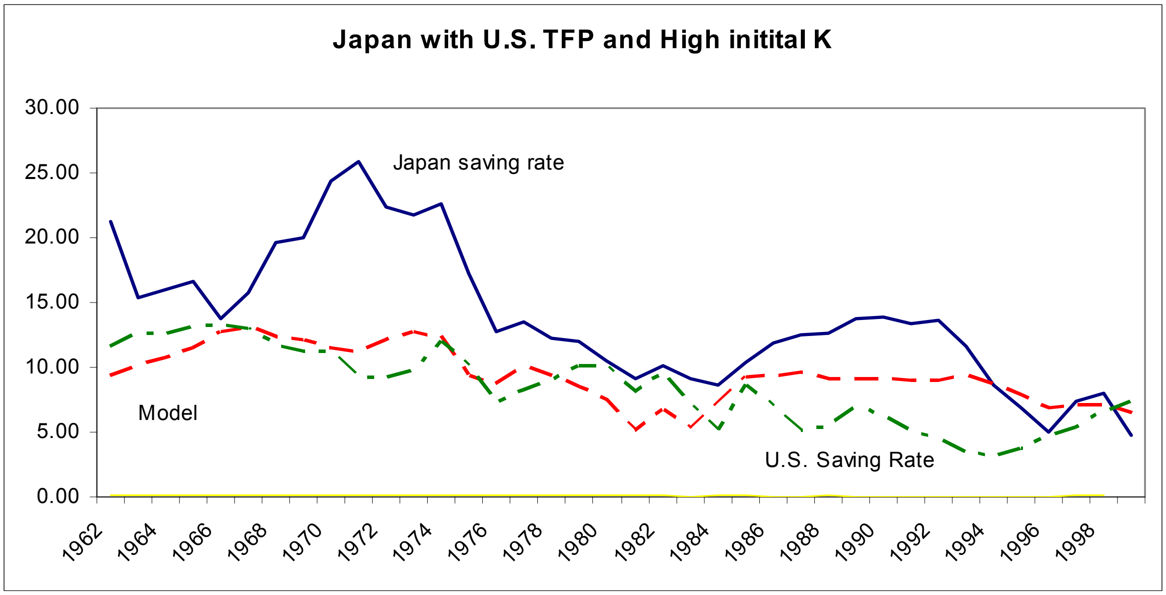

Figure 7: Saving Rates

The above results indicate that the time series behavior of the saving rate in Japan was mainly influenced by the TFP growth rate and low level of initial capital in this time period. Given this finding it is unlikely that many of the factors that were discussed in the literature, such as the social security system, mortgage arrangements, family structure, monetary policy, equity price bubble, or the aging of the population in Japan would play a significant role in explaining the differences in saving rates between Japan and the U.S. Nevertheless our framework allows us to examine some of these factors.

In this paper we do not investigate the role of the changes in the population growth rate over time. However, we can examine the quantitative impact of such a change in the overall saving rate by changing the growth rate of the population that was used in our experiments. So far we had assumed the growth rate of population to be equal to its long-term average of 1.23%. Instead, if we assume the population growth rate to be 0.9%, its average in the 1980-1998 period, the overall saving rate declines by 1%. In general, a decrease in the population growth rate has a similar effect to a decrease in the TFP growth rate, causing the saving rate to decline.

We can also analyze the role of social security by experimenting with different social security replacement rates at the steady state and along the transition. Basically, a one percent increase in the payroll tax rate to finance an unfunded social security system causes a 0.4% decline in the saving rate. If the economy were to move from no social security to a social security system with a 40% replacement rate, this would indicate a 4% drop in the saving rate. While these changes are not insignificant, they are not in the order of magnitude that would help resolve the difference between U.S. and Japanese saving rates, especially since in the beginning of the 1960s there was an unfunded social security system even if it was a modest one.

Overall, our results indicate that the major factors behind the behavior of the saving rate in Japan were the TFP growth rate and the initial low level of the capital output ratio.

4.0.3 Sensitivity Analysis

In this section we conduct two types of sensitivity analyses. First we examine the impact of certain parameters and exogenous variables on the saving rate in the model. In the second part, we examine the role of the overlapping generations framework that is used in this paper by comparing our results on the saving rate to those generated from an infinite horizon model.

In our benchmark economy, we used the TFP measure provided by Hayashi and Prescott (2003). In the following experiment we use the data given in Jorgenson (2003) to examine the sensitivity of our results to the differences in TFP measures provided by these two sources which are displayed in Table 5.[10]

Table 5: TFP Growth and Saving Rates

	TFP Data		**Saving Rate**	
Years	**Japan (HP)**	**Japan (Jorgenson)**	**Japan(HP)**	**Japan(Jorgenson)**
1962-1967	3.32	5.85	17.13	14.60
1968-1978	1.72	2.35	17.01	19.45
1979-1989	1.46	0.76	9.70	11.71
1990-1995	0.23	-0.19	9.71	8.68

The last two columns display the saving rates implied by these two measure of TFP. Initial capital output ratio in both cases is set to 1.06. There are some visible differences between the two saving rates. However, both measures are able to capture some of the major fluctuations that took place in the Japanese saving rate between 1961-1998. Figure 8 repeats the information in Figure 3 with the TFP for Japan data taken from Jorgenson (2003).

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[10] The TFP data for both countries are displayed in the Appendix.

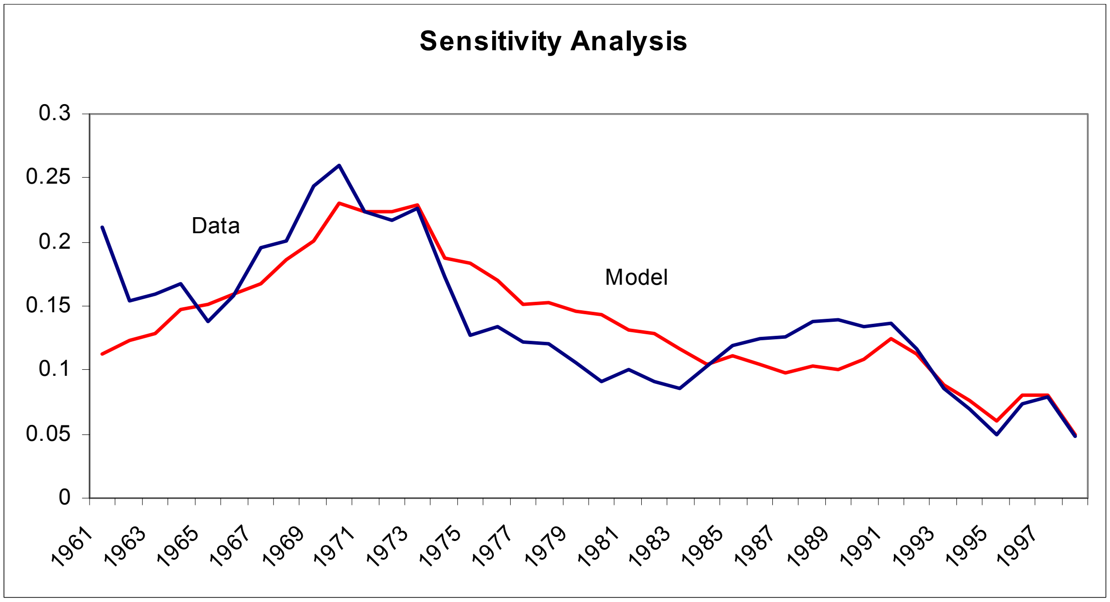

Figure 8: Saving Rates

In our initial calculations we had set the tax rate on capital income to be 35% which was taken from data provided in Mendoza, Razin, and Tesar (1994). However, Hayashi and Prescott (2003) estimate the tax rate on capital income to be 45% for a similar time period. Thus, we repeat our experiment for a constant tax rate of 0.45 for the entire period. Our results indicate that the average capital output ratio for the 1961-1998 period goes down by approximately 3.5% for all time periods with this higher tax rate. Average saving rate in the initial ten periods declines from an average of 17.5% to 14.2%.

Our benchmark economy also has taxes on labor income and consumption. In the next experiment, we examine the saving rate when these tax rates are set to zero. This change causes an increase of about 1% in the average saving rate.

In the second part of the sensitivity analysis, we examine the role of the OLG framework on the saving rate generated by the model economy. In order to accomplish that we solve a standard neoclassical growth model with infinitely lived individuals. In particular, we use an exogenous labor version of the model used in Hayashi and Prescott (2003) which we briefly describe below.

In this framework households solve

$$\max \sum_{t=0}^{\infty} \beta^t \log c_t$$

subject to

$$C_t + X_t \leq w_t E_t + r_t K_t - \tau(r_t - \delta) K_t - \pi_t,$$

where c_t is consumption and β is the subjective discount factor, E_t is the measure of labor input, τ is the tax rate on capital income, w_t is the real wage, π_t is a lump sum tax and

r_t is the rental rate of capital. Households are assumed to own the capital and rent it to businesses. Aggregate output is divided between consumption, C_t, government purchases of goods and services, G_t, and investment X_t. The law of motion for the capital stock is given by $K_{t+1} = (1 - \delta)K_t + X_t$.

In order to compare our findings with the results in Christiano(1989) we initially calibrate this economy to the 1946-1998 period. We set the parameters in the model such that the resulting steady state values for K/Y are identical between our benchmark OG model and the infinite horizon model. In this calibration, the share of capital and the depreciation rate are same as before, $\theta = 0.363$; $\delta = 0.10$. We choose the discount factor for the infinite horizon case to be 0.964 so that the two model economies generate similar steady-state capital output ratios. We start with a capital income tax rate of zero as in Christiano (1989) and also examine the results with $\tau = 0.35$. Total labor input is set to the average number of hours worked in a week times the measure of individuals working, which is the same measure used in the calibration of the benchmark model. We start both economies at 12% of the steady state capital stock, and assume a constant growth rate of per capita output of 3%.

In Figures 9 and 10 we display the results for the saving rate and the capital output ratio for the two models. Figure 9 shows that the main difference between the two models occurs in the initial year where the saving rate is 44% for the infinite horizon case and 38% in the overlapping generations economy. This difference must be due to the fact that in an OG model, age plays an important role in the saving decisions of the individuals. In particular, the retirees and young workers are not inclined to save in the OG model, thus resulting in a smaller saving rate at the beginning of the simulations.

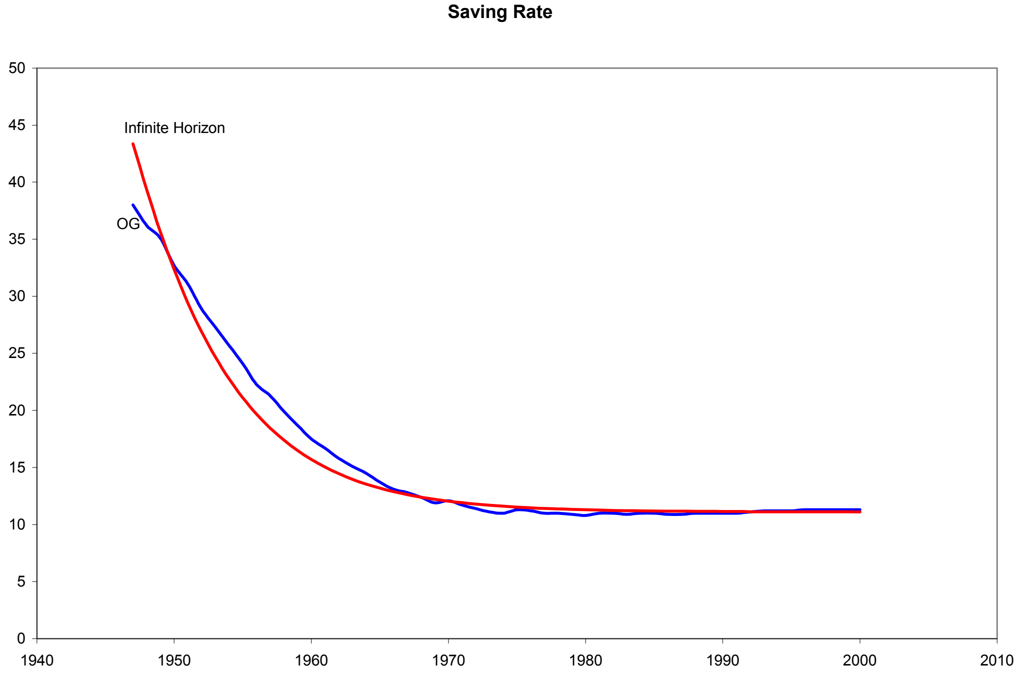

Figure 9: Saving Rates in OG versus Infinite Horizon

We can also see from Figure 9 that the hump shape in the Japanese saving rate can not be generated by either of the models under the assumption of a constant TFP growth. The small differences in the K/Y ratio between the two models are displayed in Figure 10.

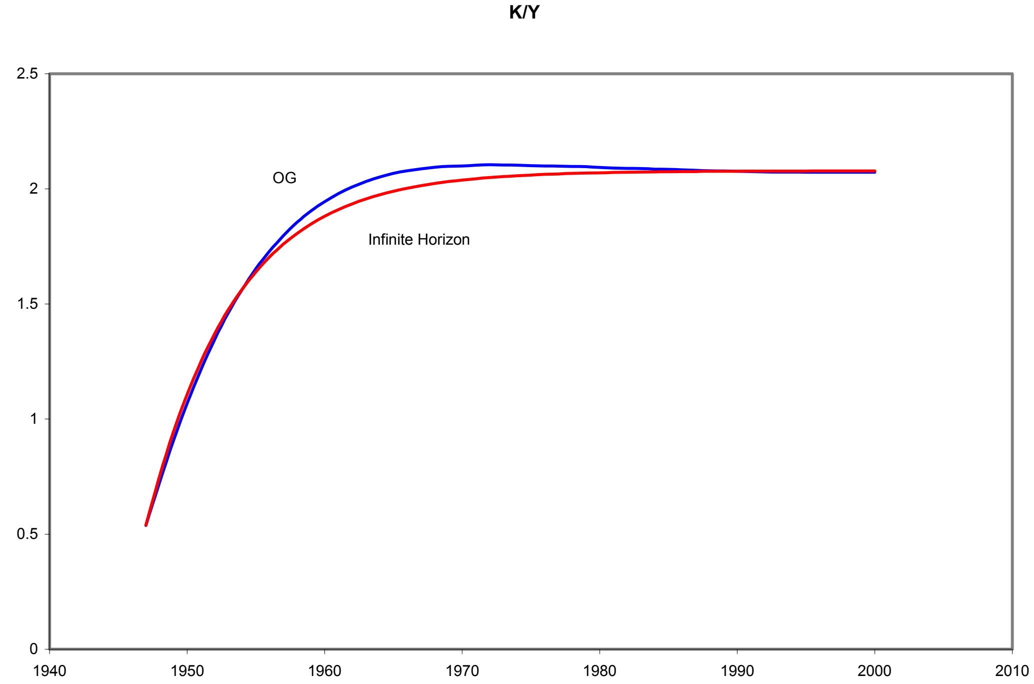

Figure 10: Capital-Output Ratio

When we repeat the same exercise with a 35% tax rate on the capital income, the saving rate is reduced in both economies for all time periods. In 1946, the saving rate becomes 33% in the infinite horizon case and 29% in the overlapping generations economy.

In the next figure we repeat the results for the saving rate in our benchmark economy together with the saving rate that would have been generated under a constant growth rate assumption.[11] The hump shaped saving rate in Japan appears to be a product of the changing TFP during this time period. Moreover, the infinite horizon model calibrated to generate the same steady state saving rate also delivers a similar saving rate, except again for the initial few years where the saving rate generated by the infinite horizon model is greater than that of the OG model.

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[11] Since the TFP data starts from 1960, we are not able to do this exercise for the 1946-1998 period.

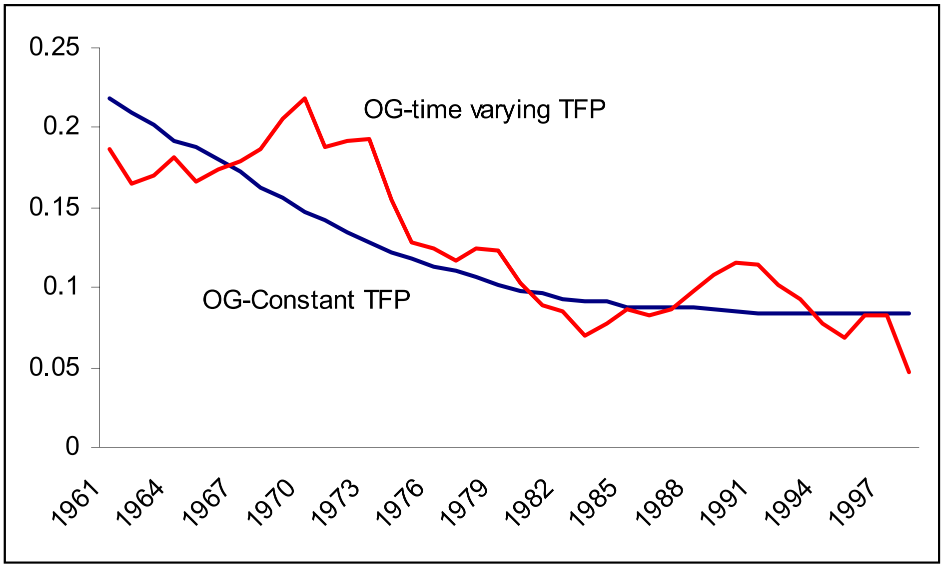

Figure 11: Saving Rate

5 Conclusions

In this paper, we use a 80 period overlapping generations model to explore the year-to-year fluctuations in the Japanese saving rate and capital-output ratio between 1961 and 1998. The individuals in our model face mortality risk and borrowing constraints. Private annuity markets and credit markets are closed by assumption. Until the mandatory retirement age, agents in this economy work an exogenously given number of hours and accumulate assets to provide for old age. After retirement agents receive social security benefits that are financed by a payroll tax . The return on asset holdings and the wage rate are determined endogenously by the profit maximizing behavior of a firm with. We specify the optimization problem of the individual as a finite state, finite horizon dynamic program and use numerical methods to compute stationary equilibria

We calibrate the model to Japanese data for the 1961-1998 period. We use the average tax rates on capital, labor and consumption, observed social security replacement rate, average population growth rate and survival probabilities that prevailed in that time period. The simulations from year 1961 takes the actual capital stock in 1960 as the initial condition and uses the actual time path of TFP. We conduct deterministic simulations and argue that this framework allows us to identify between several factors that may explain the differences in saving rates between Japan and U.S. in a relatively simple manner.

Our results indicate that two factors alone can account for most of the differences between the saving rates in Japan and U.S. in the 1961-1998 time period. These are the TFP growth rate and the low level of the initial capital stock in 1960. We show that if Japan were to be faced with the U.S. TFP during the 1961-1998 period as well as a high initial capital stock, the time path of the saving rate in Japan would have looked very similar to that of U.S.

6 Appendix A: Data

Japanese data are obtained from the following sources. Data on TFP, A_t, depreciation rate, δ_t, government share in output, G_t/Y_t, and the capital output ratio, K_t/Y_t, are taken from Hayashi and Prescott (2003). Net national saving rate and the after-tax return on capital are obtained from Hayashi (1989). Tax rates on consumption, and capital and labor income are obtained from Mendoza, Razin, and Tesar (1994).

Table 1: Time Series Data

year	A_t	δ_t	G_t/Y_t	τa	k_t/y_t	Net national Saving	After-tax return on capital
1961	0.043	0.160	0.113	20.430	**1.06**	**21.22**	0.211
1962	0.043	0.176	0.122	20.430	1.15	15.39	0.141
1963	0.045	0.160	0.124	20.430	1.13	15.98	0.152
1964	0.048	0.161	0.121	20.430	1.10	16.68	0.163
1965	0.049	0.172	0.123	20.430	1.14	13.76	0.129
1966	0.051	0.155	0.123	19.500	1.09	15.79	0.166
1967	0.054	0.144	0.115	19.590	1.08	19.59	0.191
1968	0.057	0.160	0.113	20.000	1.07	20.05	0.168
1969	0.061	0.127	0.112	20.940	1.07	24.37	0.205
1970	0.064	0.122	0.115	22.310	1.09	25.92	0.196
1971	0.063	0.108	0.126	23.990	1.23	22.38	0.147
1972	0.066	0.106	0.132	25.340	1.24	21.74	0.143
1973	0.067	0.102	0.136	30.230	1.27	22.69	0.121
1974	0.065	0.108	0.140	34.940	1.48	17.22	0.059
1975	0.064	0.094	0.150	29.640	1.67	12.78	0.047
1976	0.066	0.096	0.146	29.600	1.61	13.46	0.053
1977	0.067	0.094	0.150	31.150	1.64	12.23	0.052
1978	0.069	0.094	0.153	33.200	1.61	12.03	0.061
1979	0.070	0.095	0.156	33.100	1.60	10.54	0.060
1980	0.070	0.095	0.154	35.980	1.72	9.09	0.055
1981	0.070	0.090	0.155	37.300	1.78	10.07	0.053
1982	0.071	0.090	0.151	38.250	1.80	9.09	0.051
1983	0.071	0.089	0.148	40.290	1.81	8.57	0.051
1984	0.073	0.092	0.142	41.450	1.74	10.32	0.053
1985	0.075	0.091	0.137	41.250	1.71	11.94	0.055
1986	0.076	0.088	0.138	43.260	1.70	12.48	0.061
1987	0.078	0.088	0.138	48.750	1.66	12.60	0.060
1988	0.080	0.087	0.136	50.700	1.64	13.76	0.063
1989	0.082	0.088	0.134	49.670	1.63	13.89	0.060
1990	0.084	0.087	0.135	48.470	1.67	13.44	0.060
1991	0.086	0.087	0.135	45.910	1.71	13.68	0.058
1992	0.085	0.087	0.142	42.650	1.78	11.62	0.051
1993	0.086	0.085	0.153	41.450	1.84	8.62	0.050
1994	0.085	0.084	0.154	41.510	1.87	6.92	0.044
1995	0.085	0.088	0.155	44.300	1.87	4.99	0.039
1996	0.088	0.082	0.156	42.610	1.82	7.43	0.052
1997	0.089	0.082	0.147	42.610	1.84	7.97	0.051
1998	0.086	0.079	0.151	42.610	1.96	4.77	0.043
1999	0.087	0.079	0.155	42.610	1.95		0.043
2000	0.087	0.077	0.146	42.610	1.98		0.039

Figure A1 displays the TFP data used for Japan and the U.S. As mentioned in the text, Japanese TFP data is taken from Hayashi and Prescott (2003). U.S. TFP is calculated by using the differences in TFP levels between the two countries implied in Jorgenson (2003).

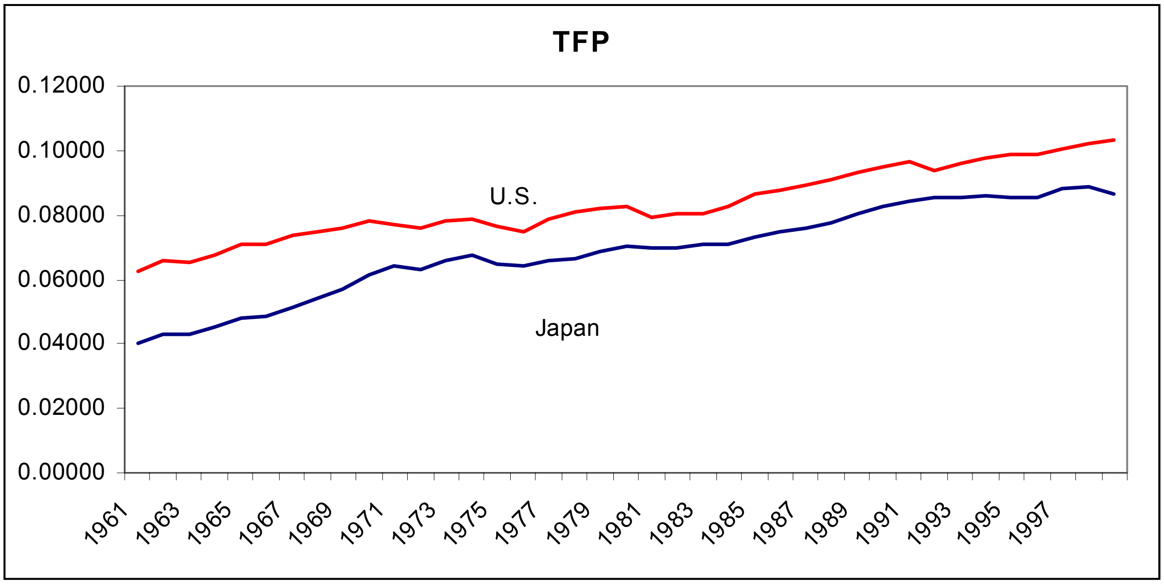

Figure A1: U.S. and Japan- TFP levels

7 Appendix B: Computational Details:

In this paper, we follow Hayashi and Prescott (2003) in computing a transition path towards the final steady state, starting from a given set of initial conditions, taking as given the sequence of exogenous variables $\{A_s, \delta_s, G_s/Y_s, N_s, rrate_s, \tau_{a,s}, \tau_{h,s}\}_{s=s_1}^{s_2}$.

Our steps are as follows:

1. Compute the final steady state following the algorithm in İmrohoroğlu et. al (1999). This step requires the detrending of aggregate variables by $A_s^{1/(1-\theta)} N_s$ so that we obtain a balanced growth path, after specializing the definition of recursive competitive equilibrium and numerically solving the two-dimensional fixed point problem. In particular, we iterate on an initial guess for the interest rate and the lump-sum transfer to the individuals (r, ℓ) until convergence. Note that the individuals can solve their optimization problems when we feed them the two factor prices and all policy parameters which is accomplished with our initial guesses and other calibrated parameters. Following Hayashi and Prescott (2002) we assume that the Japanese economy reaches the final steady state in 2002.

2. Use the actual 1960 and 1961 Japanese data as given initial conditions; in particular use the actual capital output ratio in Japan, and assume a uniform distribution of assets holdings (except for age 1 individuals who are born with zero assets) at the initial state.

3. Guess a time path for the vector $\{(r_s, \ell_s)\}_{s=1962}^{1998}$ of endogenous variables. Together with the sequence of exogenous variables $\{A_s, \delta_s, G_s/Y_s, N_s, rrate_s, \tau_{a,s}, \tau_{h,s}\}_{s=1962}^{1998}$, all individuals can now solve their optimization problems as they have complete knowledge of the time paths of policy and prices.

4. Compute the transition path taking the initial conditions as given.

   (a) Starting from $S-1=1999$ and working backward, obtain the decision rules of all cohorts through backward recursions.

   (b) Using the given initial asset distribution Φ_2 over the initial cohorts in 1961, and the collection of decision rules just computed, calculate the new $\{\Phi_s\}_{s=3}^{S-1}$ and $\{(r_s, \ell_s\}_{s=3}^{S-1}$.

   (c) Compare the first sequence of $\{(r_s, \ell_s)\}$ to the latest and iterate on it until convergence.

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