Secular Trends in U.S. Consumption and Saving

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Abstract

The saving rate in the U.S. has been declining since the 1960s while the share of consumption in output has been increasing. We examine whether standard growth theory can explain the secular trends observed in 1960-2004. Using an infinite horizon, complete-markets growth model calibrated to U.S. data indicate this setup is able to generate saving rates and consumption that are resonably similar to the data during 1960-2004. The secular decrease in the population growth rate and the increase in the depreciation rate are significant in explaining the trends, where as the medium term fluctuations in the total factor productivity seem important in driving the year-to-year movements in macroeconomic aggregates.

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1 Introduction

Understanding the secular trends in consumption and saving in the U.S. has been an important part of academic research. It has also occupied center stage in policy discussions and media coverage. Figure 1 displays the changes in consumption and the saving rate in the U.S. between 1960-2004.[1]

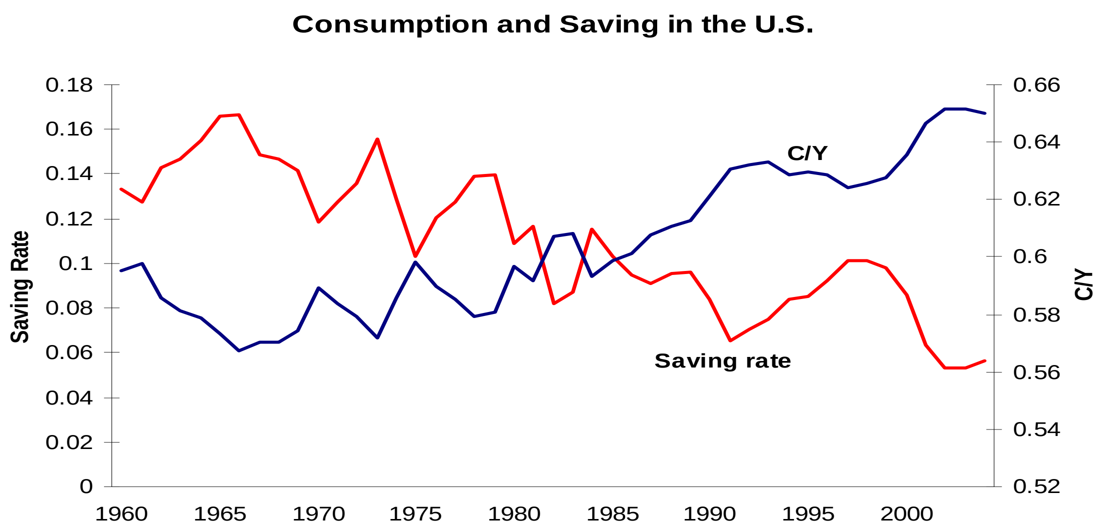


Figure 1: U.S. Data

Why has the national saving rate declined between 1960-2004, and why does the U.S. save less than other developed economies? Gokhale, Kotlikoff, and Sabelhaus (1996) attribute the decline in the net national saving rate to the redistribution of resources, though social security and medicare, from young consumers with low marginal propensities to consume to older generations with high marginal propensities to consume. Several papers explore whether particular cohorts are responsible for the low saving rate by examining personal saving rates in the U.S.[2] Attanasio (1998) argues that cohorts born between 1925 and 1939 may be to blame for the low personal saving rate. Summers and Caroll (1987) suggest that it is the reliance of the younger generations on social security that depresses saving in the U.S. Boskin and Lau (1988a,b) formulate a model based on longitudinal and cross-sectional microeconomic data together with aggregate time series and examine the importance of

[1] C/Y is the fraction of consumption in GNP, and the saving rate is net national saving as a percent of net national income. In the appendix we explain the adjustments that were made to the data to ensure consistency between the data and the model.

[2] See for example Summers, Carroll, and Blinder (1987) and Gale, Sabelhaus and Hall (1999).

various factors affecting aggregate consumption and saving in the U.S. Their results suggest that it is the decline in the saving of generations born after the great depression that may be responsible for the decline in the national saving rate.[3]

In this paper we revisit the implications of growth theory on the secular trends in the net national saving rate and the consumption output ratio in the U.S. between 1960 and 2004. Our approach is in line with the recent use of the one-sector growth model to explain 'Great Depressions'. In particular, we follow the methodology of Cole and Ohanian (1999) and Kehoe and Prescott (2002) in using an applied general equilibrium setup to account for the observed time path of the U.S. saving and consumption behavior.[4] We use the standard one-sector, neoclassical growth model with an infinitely-lived representative agent facing complete markets and calibrate the economy to the U.S. data for the 1960-2004 period. Our exogenous driving forces are the population growth rate, the tax rate on capital income, the share of government expenditures in output, the depreciation rate, and the actual time series data for the TFP growth rate. We conduct deterministic simulations, as in Hayashi and Prescott (2002), and perform an 'accounting exercise' to evaluate the impact of several factors that may explain the secular trends in the saving and consumption behavior the U.S. Our results suggest that the one sector growth model can generate the secular trends in the consumption and the saving behavior resonably well once the actual time paths of TFP growth rate, population growth rate, and the depreciation rate are taken into account.

The paper is organized as follows. Section 2 presents the growth model we use to evaluate U.S. consumption and saving behavior. Data and calibration issues are discussed in Section 3, and the quantitative findings are presented in Section 4. Concluding remarks are given in Section 5. Appendix A contains calibration details and data sources.

1.1 The Growth Model

There is a stand-in household with N_t working-age members at date t. The size of the household evolves over time exogenously at the rate $n_t = N_t/N_{t-1}$. In this framework a

[3] Another set of papers have focused on the possible relationship between the increase in stock prices and the boom in consumer spending. For example, see Parker (1999), Juster, Lupton, Smith, and Stafford (2000) who suggest that the significant capital gains in corporate equities experienced since 1984 is responsible for the decline in the personal saving rate. Backus, Henriksen, Lambert, and Chris Telmer{2005) argue that private saving rates are strongly and negatively correlated with the ratio of net worth to consumption. Also Poterba (2000) for a survey.

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

representative household solves

$$\max \sum_{t=0}^{\infty} \beta^t N_t (\log c_t + \alpha log(1 - h_t))$$

subject to

$$C_t + X_t \leq (1 - \tau_{h,t}) w_t H_t + r_t K_t - \tau_{k,t}(r_t - \delta_t) K_t + TR_t - \pi_t,$$

where $c_t = C_t/N_t$ is per member consumption, $h_t = H_t/N_t$ is the fraction of hours worked per member of the household, β is the subjective discount factor, α is the share of leisure in the utility function, H_t is total hours worked by all working-age members of the household, $\tau_{h,t}$ and $\tau_{k,t}$ are tax rates on labor and capital income, respectively, at time t, w_t is the real wage, TR_t is a government transfer, π_t is a lump sum tax, r_t is the rental rate of capital, and δ_t is the time-t depreciation rate. Households are assumed to own the capital, K_t, and rent it to businesses. The economy-wide resource constraint is given by.

$$C_t + X_t + G_t = Y_t,$$

where aggregate consumption, investment and government purchases add up to aggregate output. The law of motion for the capital stock is given by $K_{t+1} = (1 - \delta_t) K_t + X_t$.

The aggregate production function is given by

$$Y_t = A_t K_t^{\theta} (H_t)^{1-\theta},$$

where θ is the income share of capital and A_t is total factor productivity which grows exogenously at the rate $g_t^{1/(1-\theta)} = A_t / A_{t-1}$.

1.2 Government

There is a government that taxes income from labor and capital (net of depreciation) and uses the proceeds to finance exogenous streams of government purchases G_t and government transfers TR_t. A lump sum tax π_t is used to ensure that the government budget constraint is satisfied each period:

$$G_t + TR_t = \tau_{h,t} w H_t + \tau_{k,t}(r_t - \delta_t) K_t + \pi_t.$$

In other words, π_t is the primary government deficit in the model.

1.3 Competitive Equilibrium

Given a government policy $\{G_t, TR_t, \tau_{h,t}, \tau_{k,t}, \pi_t\}_{t=0}^{\infty}$, a competitive equilibrium consists of an allocation $\{C_t, X_t, H_t, K_{t+1}, Y_t\}_{t=0}^{\infty}$ and price system $\{w_t, r_t\}$ such that

- given policy and prices, the allocation solves the household's problem,
- given policy and prices, the allocation solves the firm's profit maximization problem with factor prices given by: $w_t = (1-\theta)A_t K_t^{\theta}(H_t)^{-\theta}$, and $r_t = \theta A_t K_t^{\theta-1}(H_t)^{1-\theta}$,
- the government budget is satisfied,
- and the goods market clears: $C_t + X_t + G_t = Y_t$.

1.4 Numerical Solution

Our numerical solution procedure borrows from Hayashi and Prescott (2002) by first calculating a final steady-state assumed for the U.S. economy in the sufficiently distant future. To obtain this steady-state, we write down the equilibrium conditions of the model, detrend variables to induce stationarity, and then impose steady-state conditions. Once the steady-state is obtained, we use a shooting algorithm toward this final steady state from given initial conditions in 1960. This solution method yields an equilibrium transition path from initial conditions toward a steady-state.

Equilibrium Conditions: The equilibrium conditions of this model can be described in two equations below:

$$\frac{C_{t+1}}{N_{t+1}} = \frac{C_t}{N_t}\beta\left\{1 + (1-\tau_{k,t+1})\left[\theta A_{t+1}K_{t+1}^{\theta-1}(H_{t+1})^{1-\theta} - \delta_{t+1}\right]\right\}, \tag{1}$$

$$K_{t+1} = (1-\delta_t)K_t + A_t K_t^{\theta}(H_t)^{1-\theta} - C_t - G_t. \tag{2}$$

Detrending: There are year-to-year fluctuations with secular growth in aggregate quantities and the wage rate. For an aggregate variable z_t, its detrended version is given by: $\widetilde{z}_t = z_t / \left[A_t^{\frac{1}{1-\theta}} N_t\right]$. Applying this change of variables, we obtain equations

$$\widetilde{c}_{t+1} = \frac{\widetilde{c}_t}{g_t}\beta\left\{1 + (1-\tau_{k,t+1})\left[\theta x_{t+1}^{\theta-1} - \delta_{t+1}\right]\right\},$$

$$\widetilde{k}_{t+1} = \frac{1}{g_t n_t}[(1-\delta_t) + (1-\psi_t)x_t^{\theta-1}]\widetilde{k}_t - \widetilde{c}_t,$$

where ψ_t is the ratio of government purchases to output, G_t/Y_t, and x_t is detrended capital-labor ratio, $(K_t/H_t)/A_t^{\frac{1}{1-\theta}}$.

Steady-state: Setting $\widetilde{z}_t = z$ for all t, we obtain the following steady-state for the model:

$$1 = \frac{1}{g}\beta\left\{1 + (1-\widetilde{\tau}_k)\left[\theta x^{\theta-1} - \widetilde{\delta}\right]\right\}$$

$$\widetilde{k} = \frac{1}{gn}[(1-\widetilde{\delta}) + (1-\widetilde{\psi})x^{\theta-1}]\widetilde{k} - \widetilde{c}.$$

These equations are solved for the steady-state values of detrended capital and consumption where $\widetilde{\delta}$ and $\widetilde{\tau}_k$ are the steady-state depreciation and capital income tax rates, respectively. The steady-state saving rate is given by

$$\widetilde{s} = \frac{(gn-1)\widetilde{k}}{\widetilde{y} - \widetilde{\delta}\widetilde{k}}. \quad (3)$$

Transition to the steady-state: Starting from a given value of the initial capital stock K_0, we guess a value for the endogenous variable C_0 and use equations (1) and (2) to obtain a path for the endogenous variables C_t and K_{t+1} towards the steady-state. If this path is not achieved, we iterate on the initial guess for C_0 using this 'shooting' algorithm until convergence to the steady-state is obtained. Equipped with the equilibrium path of C_t and K_{t+1}, we can then use other equilibrium conditions to construct time paths of all aggregate quantities and prices. In particular, we compute the saving rate using[5]

$$s_t = \frac{Y_t - G_t - C_t - \delta_t K_t}{Y_t - \delta_t K_t}.$$

2 Data and Calibration

We provide the details of our calibration exercise in the Appendix. In this section we provide a summary of the key parameter choices and the reasoning behind them. Our overall target for calibration is to make the model match certain aggregate averages over the 1960-2004 period. We use data from the National Income and Product Accounts (NIPA), Fixed Asset Tables (FAT), and Statistics of Income (SOI). The capital share parameter, θ is set to its average value of 0.4 over this period. The subjective discount factor, β is set to 0.972 so that the capital output ratio is 3.0 at the final steady state.

For the steady state calculations we set the values for the share of government purchases, G_t/Y_t, the depreciation rate δ_t, and the tax rates on capital and labor income, τ_k and τ_h, equal to their average values over 1960-2004. The resulting values for the steady state are $G/Y = 14.3\%$, $\delta = 4.4\%$, $\tau_k = 43\%$, and $\tau_h = 25.4\%$. We set share of leisure in the utility function to $\alpha = 1.45$ to match an average workweek of 35 hours. The growth rate of the TFP factor at the steady state is set to its 1960-2004 average value of 1.84%, the growth rate of the population to 1.01%. We assume that the steady state is reached in eighty years.[6]

[5]We treat the model as a closed economy where net national saving and invsetment are identical. Figure ?? in the Appendix displays the net national saving and investment rates for the U.S. economy in this time period. As expected, after the 1980s there is a divergence between the two series indicating the current accounts deficits in the U.S. Perhaps a two country model for that time period would be useful especially if the aim is to understand the current account deficits of that period. For the purposes of this model, the closed economy assumption seems sufficient.

[6]Between 2004 and the steady state, we assume that all exogenous variables except the population growth

Since our main question is to examine the secular trends in consumption and saving between 1960-2004, our simulations take the actual capital-output ratio in 1960 as the initial condition. We use the time series data for TFP growth rate, population growth rate, share of government spending in GNP, depreciation rate and the capital and labor income tax rates between 1960 and 2004.[7] To examine the contribution of each one of these factors to the secular trends in consumption and saving we conduct counterfactual experiments where we introduce each time series data one at a time.

Several of the exogenous variables we use in our simulations display significant changes in this time period. In the Appendix we display these data.

3 Results

We start by examining the net national saving rate and consumption output ratio that are generated by our model and perform counterfactual experiments to isolate the factors that impact the behavior of these variables in the U.S.

3.1 Main Findings

We start this section by comparing some of the key economic variables that are generated by the model versus the data. Figure 2 displays the observed and model-simulated net national saving rates. The model does well in terms of capturing the secular movements in the actual U.S. saving rate. However, between 1975 and 1990 the model generated saving rate is considerably smaller than the actual saving rates.

rate take their steady state values. For the population growth rate we use the 'middle' projections of the Bureau of the Census until 2060.

[7] The TFP is calculated as

$$A_t = Y_t / K_t^{\theta} (H_t)^{1-\theta},$$

where the capital share θ is set to 0.4, Y_t is GNP, K_t is nongovernmental capital stock inclusive of foreign capital, and H_t is aggregate hours worked. In this framework investment consists of domestic private investment and the current account surplus. Even though, we treat the model as a closed economy, we include the foreign capital in the definition of the capital stock to make sure that the TFP growth rates faced by the U.S. individuals can be accurately measured. However, it is important to note that this adjustment is quantitatively very small. None of the results are significantly altered by different measurements of TFP such as inclusion of government capital or the exclusion of foreign capital.

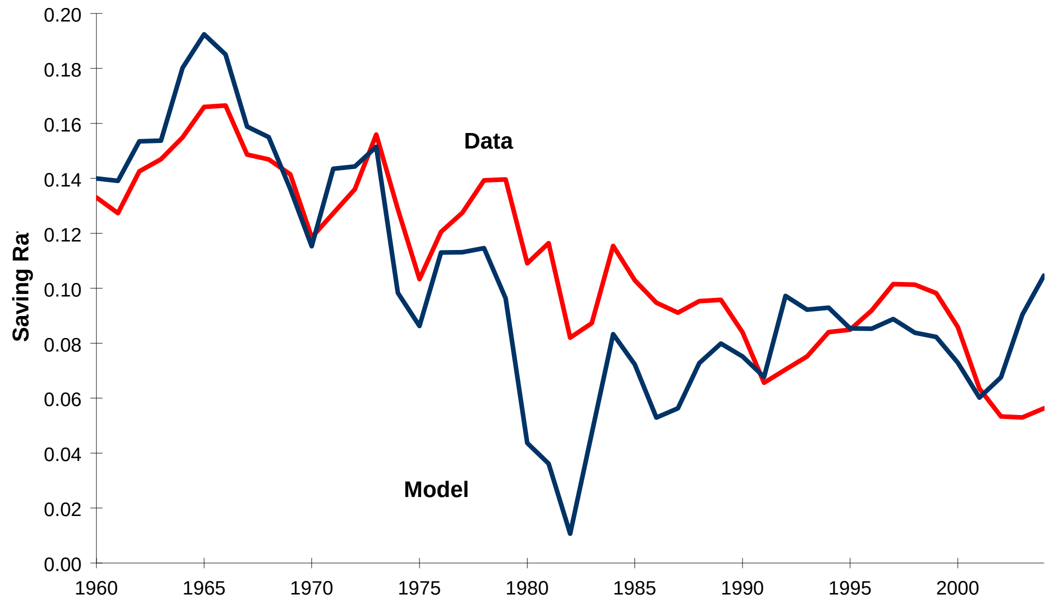


Figure 2: Net National Saving Rate

Figure 3 displays the actual and simulated consumption-output ratios which exhibit a similar fit. Although the secular movements are well characterized, certain time periods pose difficulty for the model.

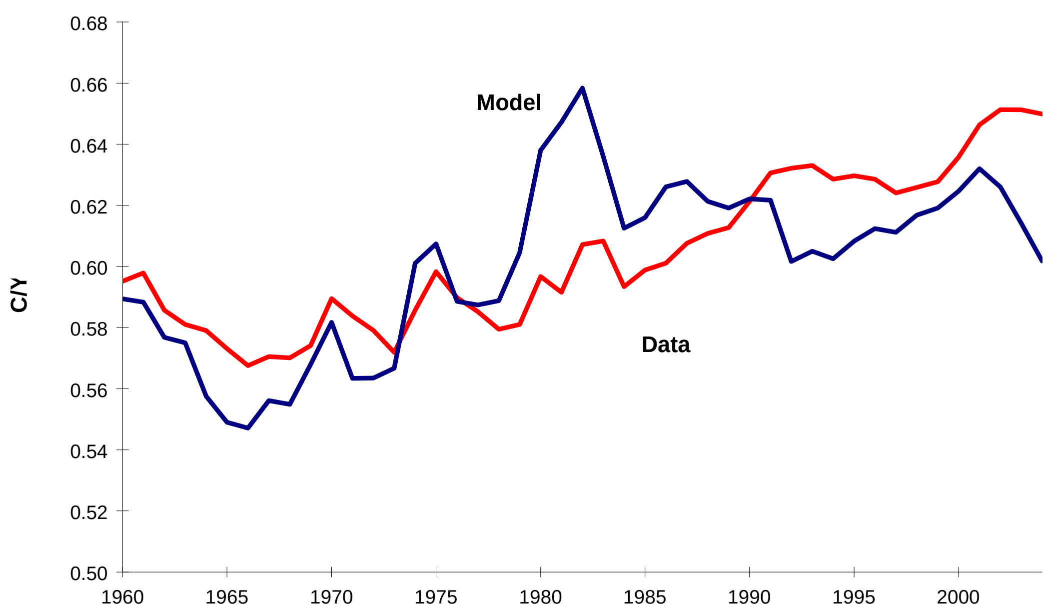
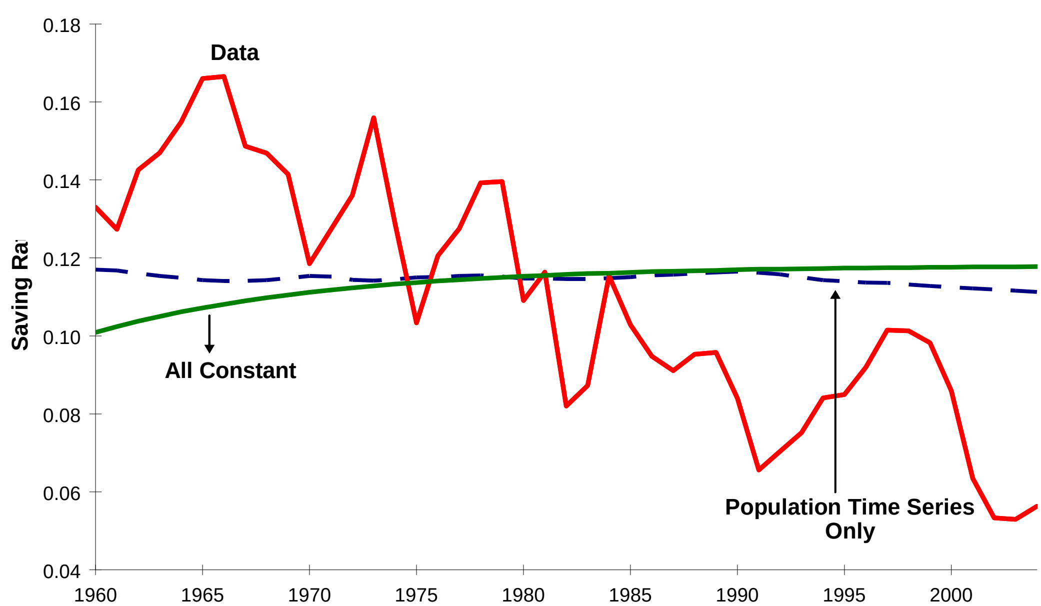


Figure 3: Consumption-Output Ratio

In order to understand the main factors behind the behavior of consumption and saving over this time period, we conduct several counterfactual experiments. In our benchmark economy, we have used time series data for the TFP growth rate, population growth rate, depreciation rate, capital and labor income tax rates, and fraction of government expenditures in GNP. There are particularly significant changes in the population growth rate which declines from 1.6% to 1.0%, and the depreciation rate which increases from 4.3% to 5.2% between 1960 and 2004[8]. In addition, capital income tax declines from 44% to 33% and the labor income tax increases from 23% to 27%. To isolate the impact of these changes one at a time we start with setting all the exogenous variables equal to their sample averages. Later we add the time series data for each exogenous variable one at a time.

Setting all exogenous variables equal to their sample averages generates the saving rate labeled 'All Constant' in Figure 4.[9] The series labeled 'Population Time Series Only' displays the saving rate that is generated by the model economy when the only time series data that is used in the simulations is the population growth rate. The rest of the exogenous variables, TFP growth rate, depreciation rate, capital and labor income tax rates, and G/Y are set to their long-run averages. A comparison between the two simulated series highlights the role of the population growth rate. The higher than average growth rate of the population in 1960s results in a saving rate that is higher than the 'average'. In the 90s, the decline in the population growth rate results in a saving rate that is lower than the sample average. The quantitative impact of the population growth rate in this time period, however, is fairly small, resulting in a 1% decline (from 12% in 1960 to 11% in 2004).



[8] Figures A2 and A3 in the appendix display the changes that took place in some of the exogenous variables over this time period.

[9] The slight increase that is displayed in this saving rate is due to the fact that the initial capital-output ratio is lower than the steady state capital-output ratio.

Figure 4: Role of Population Growth

In Figure 5 we conduct an experiment that quantifies the role of the population growth rate together with the depreciation rate. Our calibration has indicated a slight increase in the depreciation rate which alone would result in a decrease in the saving rate. The series labeled 'Time Series for population and depreciation' display the results of this experiment. The increase in the depreciation rate and the decrease in the population growth rate together result in a quantitatively significant decline in the saving rate between 1960 and 2004, about 3 percentage points.

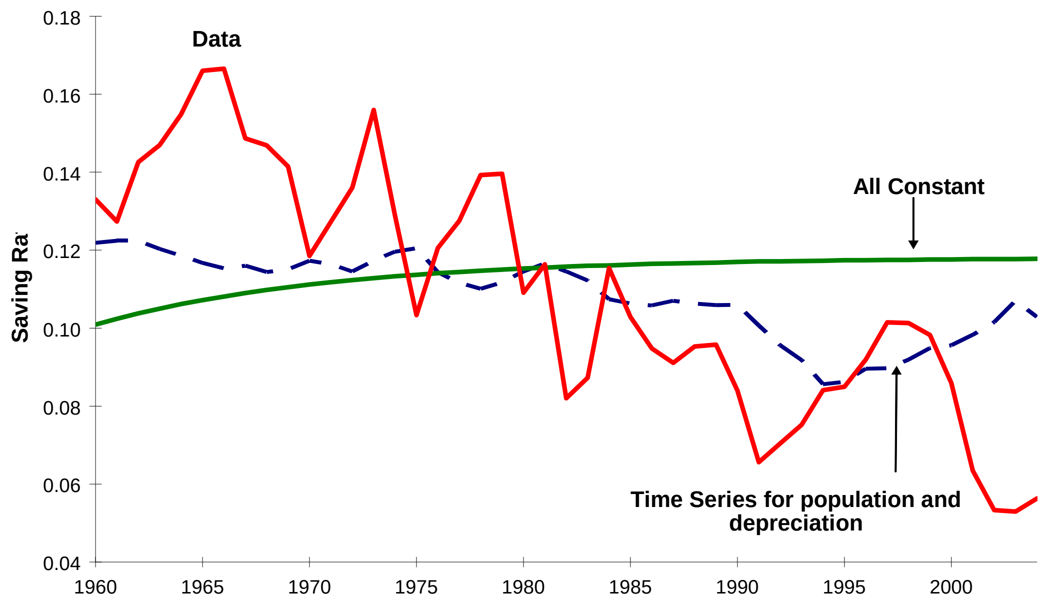


Figure 5: Role of the Population Growth and Depreciation

In Figure 6 we add the time series data on the capital and labor income taxes to our previous example. Thus in this environment, tax rates, population growth rate and the depreciation rate all take their time series values whereas the TFP growth rate is set to its long-run average. Notice that the resulting saving rate is able to capture the secular decline in the U.S. saving rate reasonably well. However, periods with significant fluctuations are not captured well.

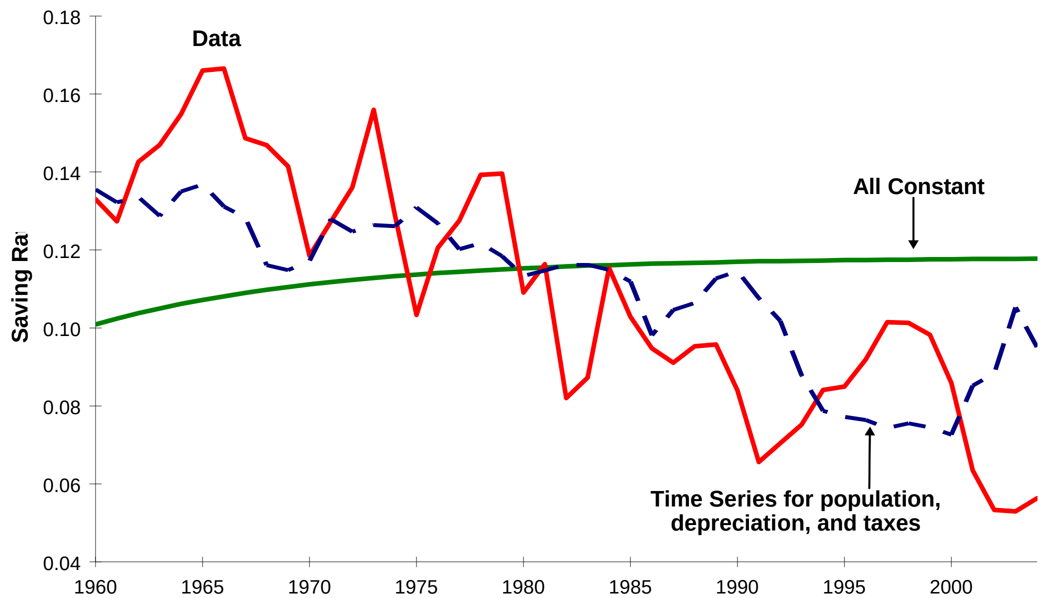


Figure 6: Taxes, Population Growth and Depreciation

Next, we examine the model generated saving rate when the only time series data that is included in the simulations is the TFP growth rate. We set all the other exogenous variables equal to their long-run averages. There are several interesting features of the model generated saving rate that is displayed in Figure 7. First, the model generated saving rate displays significant fluctuations that mimic the data rather well until 1975. There is a sharp decline in the model generated saving rate in the early 1980s and a sharp increase in the 1990s.

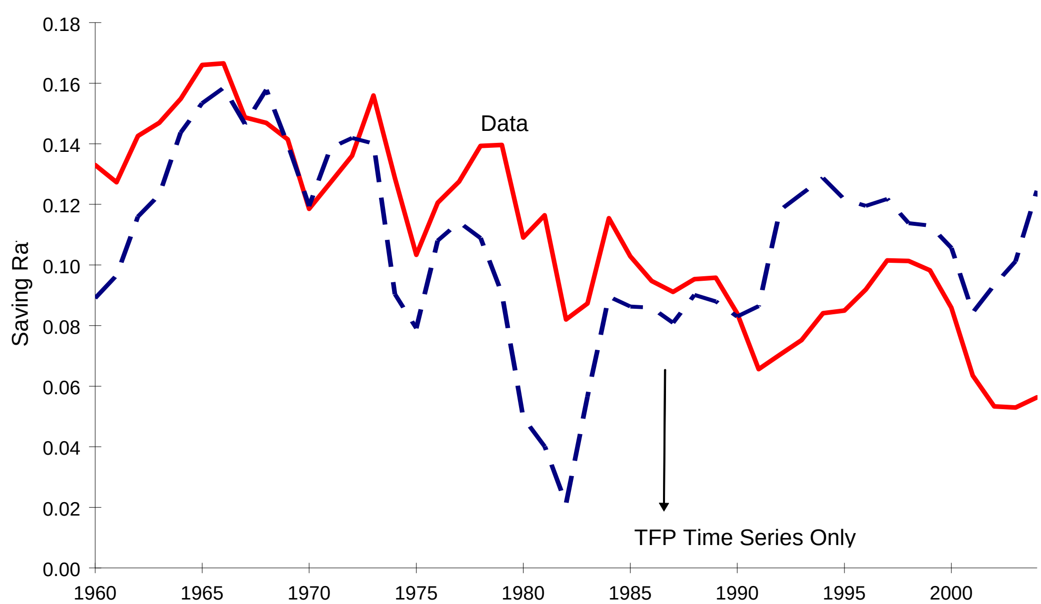


Figure 7: Role of TFP

To understand the relationship between TFP growth and the saving behavior better, we display these two series in Figure 8. Since we are conducting deterministic simulations, households know the entire path of the TFP growth rate and make decisions on how much to save based on this information. In general, periods with high TFP growth are associated with high return to capital and high saving rates. For example, the model generates a relatively high saving rate between 1990-1995 which is a period of relatively high TFP growth. The decline in the TFP growth rate in 2001 results in a sharp decline in the saving rate.

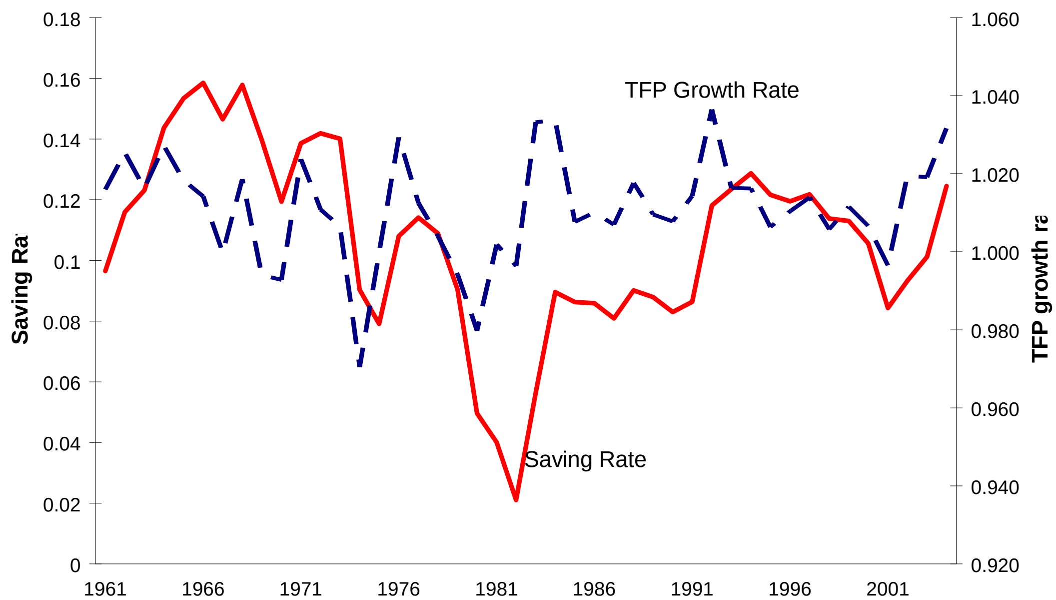


Figure 8: TFP Growth and the Saving Rate

Overall, our results suggest that *i*) the secular decline observed in the U.S. since 1960s is mostly due to the decline in the population growth rate and the increase in the depreciation rate, *ii*) observed TFP growth rates alone would have caused the saving rate to be much higher in the 1990-1995 period, and, *iii*) the decline in the TFP growth rate in 2001 had a significant negative impact on the saving rate.

3.2 Additional Properties and Sensitivity Analysis

In this section we examine the properties of the benchmark economy further by comparing the simulated series for labor, capital and the interest rate with their counterparts in the data. Our results indicate that the model economy works reasonably well in mimicking some aspects of the data but not all. In Figure 9 we display the time series path of the labor input and the after-tax return to capital (calculated from NIPA) that are generated by the model and compare them against the data. In the first panel, we display two different measure of the labor input in the data: hours worked per week and total hours.[10] Notice that while the simulated data display a decline in hours worked per week it is incapable of generating the increase in the employment rate which seems to be the reason why observed total hours did not decline.

In the second panel, we display the after-tax rate of return to capital in the data and the model economy. Although the fit from 1960 to 1990 appears tight, there is a major discrepancy between the two series in the 1990s.

[10] Total hours are equal to average hours per week times the employment rate. We have normalized the series to start at the same level as the average hours per week for expositional reasons.

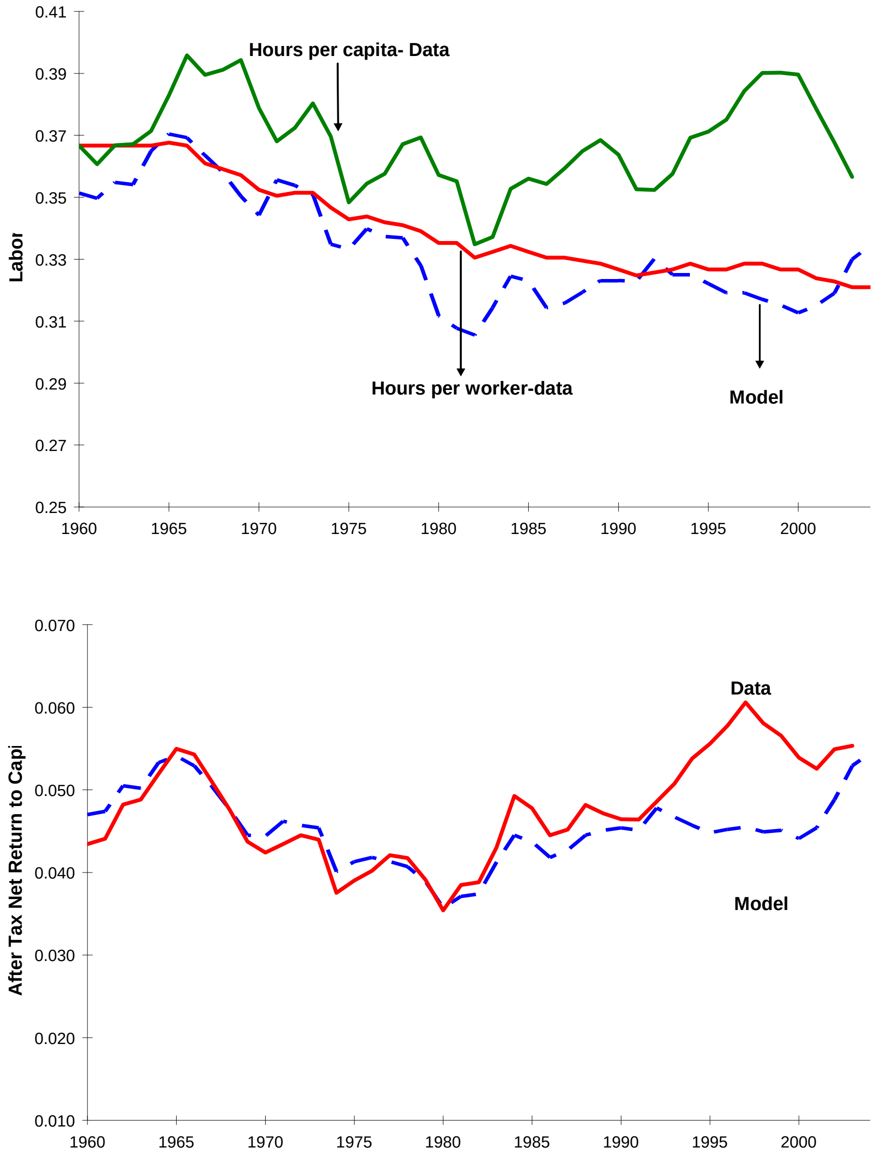


Figure 9: Additional Features

It is also possible to seperate the net national saving rate in this economy into its two components and examine the private and the government saving rates seperately. In Figure 10 we dispay the simulated series against their counterparts in the data.

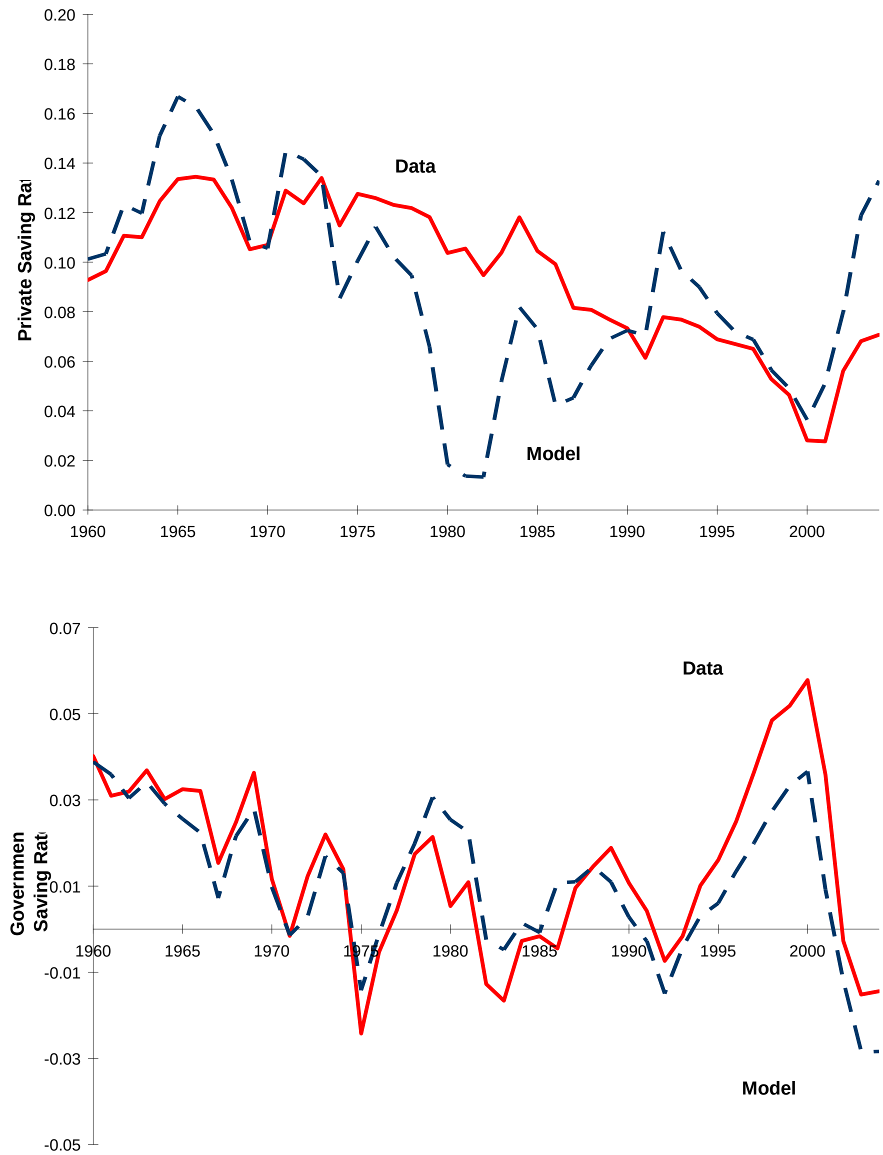


Figure 10: Private and Government Saving

Our procedure for assigning values for TFP growth rate between 2004 and the final steady-state is arbitrary. In our benchmark calculations we have set the TFP growth rate equal to its 1960-2004 average right after 2004. To check the sensitivity of our results to this assumption, we report simulations from a case where we assume the TFP growth rate to continue at its 2004 level which is higher than its steady state value. In Figure 11, the vertical line represents year 2004 beyond which the two simulations differ in terms of the TFP growth rate only. The two series are identical until 1990s. There are noticeable difference in the 1990-2004 period between the two series, however, both capture the increase in the saving rate and the decline in C/Y that takes place in this period. As one can see the implications of the TFP growth rate beyond 2004 significantly differ between the two simulations.

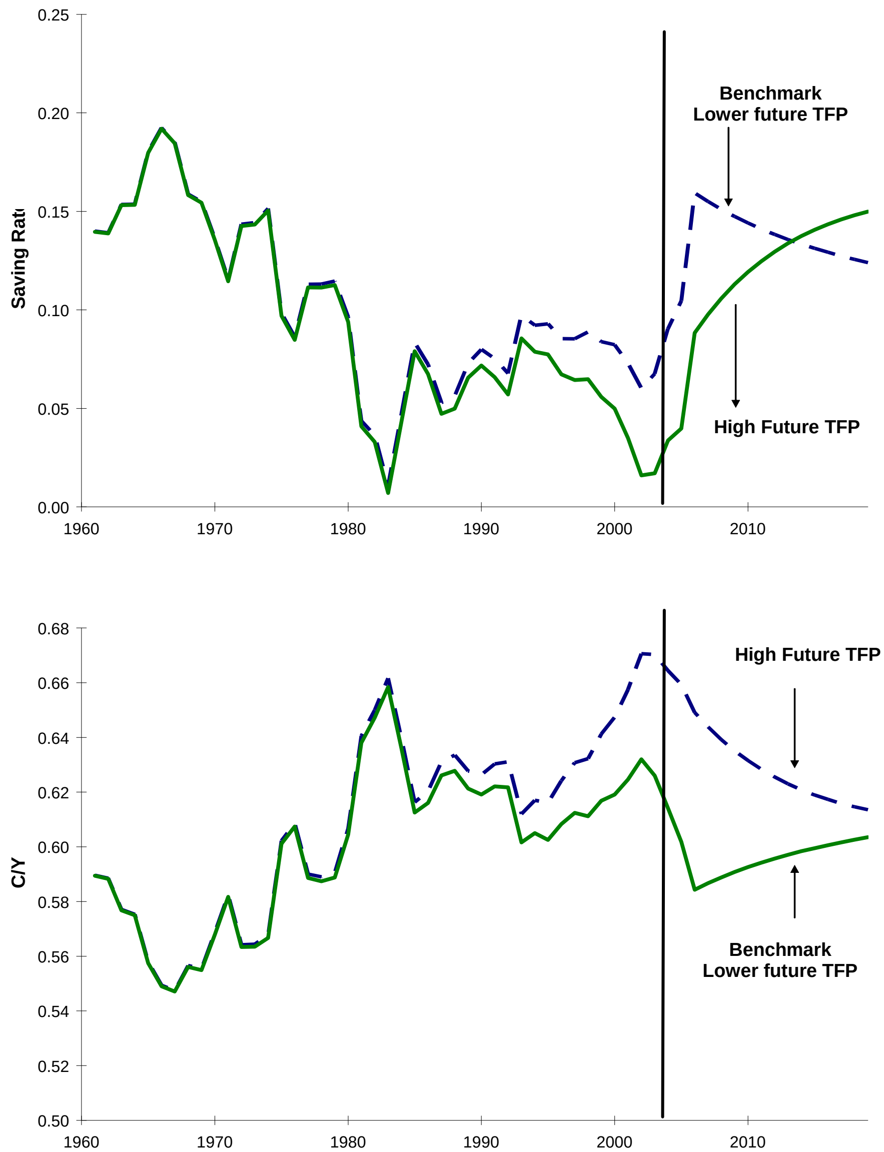


Figure 11: Role of the Future

4 Concluding Remarks

Why has the U.S. net national saving rate fallen from about 14 percent in 1960s to about 6 percent in early 2000s? A popular answer has been the decline in the private saving of the baby boom generation in response to an increase in the generosity of the social security program. In this paper, we abstract from life cycle features and social security, and employ a standard growth model calibrated to the U.S. economy. Our infinite horizon, complete markets setup captures the decline in the U.S. saving rate reasonably well. The important factors responsible for the secular decline between 1960 and 2004 are *i*) the decrease in the population growth rate, *ii*) the increse in the depreciation rate, and, *iii*) the increase in the labor income tax rate. The time path of observed TFP growth rates does not exhibit a trend but help explain the year-to-year fluctuations in the saving rate over this time period. Although the standard model performs well overall, during 1980s and early 1990s our model underpredicts the saving rate. We leave a more detailed analysis of this period for future research.

5 Appendix

5.1 Calibration of the Benchmark Economy

In this section, we provide the details of our calibration for the benchmark economy. We use data from the 2005 revision of National Income and Product Accounts (NIPA) and Fixed Asset Tables (FAT) of Bureau of Economic Analysis (BEA) for the years **1960-2004**. Our adjustments to measured macroeconomic aggregates follow Cooley and Prescott (1995).

Denote measured GNP as follows

$$(cs + cnd + icd) + g + i + nx + nfp = GNP = dep + NNP \tag{A-1}$$

where cs, cnd, icd denote service flow of consumer durables, consumption of nondurable and expenditure on consumer durable. g denotes the sum of government consumption, denoted as gc, and gross government investment, denoted as gi. i denotes gross private investment. nx denotes net export and nfp denotes net factor payments on foreign assets. dep denotes consumption of fixed capital.

First, we include government capital in the definition of the capital stock. Once we include the service flow from government capital, sg, A-1 becomes

$$(cs + cnd + icd + sg) + gc + (i + gi) + nx + nfp = GNP + sg = dep + (NNP + sg) \tag{A-2}$$

where dgi denotes depreciation of government fixed assets and $dep - dgi$ is depreciation of private fixed asset.

Second, we treat the stock of consumer durable as part of capital stock. Then A-2 becomes

$$\begin{aligned}(cs + cnd + csd + sg) + gc + (i + nicd + dcd + gi) \\ +nx + nfp &= GNP + sg + csd \\ &= (dep + dcd) + (NNP + sg + csd - dcd)\end{aligned} \tag{A-3}$$

where csd is service flow from consumer durable and dcd denote depreciation of consumer durable. Therefore, total private consumption becomes $(cs + cnd + csd + sg)$ and total investment investment becomes $(i + icd + gi)$ or $(i + nicd + dcd + gi)$, where $nicd$ is referred to as net investment in consumer durable and dcd denotes depreciation of consumer durable. Total depreciation becomes $(dep + dcd)$.

Third, we treat net foreign asset as part of capital stock. A-3 then becomes

$$\begin{aligned} &(cs + cnd + csd + sg) + gc && (4) \\ +(i + nicd + dcd + gi + nx + nfp) &= GNP + sg + csd && (5) \\ &= (dep + dcd) + (NNP + csd + sg - dcd) \end{aligned}$$

Now total investment becomes $(i + nicd + dcd + gi + nx + nfp)$.

In summary, we define capital K as the sum of the fixed assets, stock of consumer durables, inventory stock land, and net foreign assets. Output Y corresponds to $GNP + sg + csd$ and total depreciation corresponds to $dep + dcd$.

Following McGrattan and Prescott (2000), we assume that the rate of returns for consumer durable and government fixed assets are equal to the rate of return for non-corporate capital stock. Specifically, we have

$$\begin{aligned} i &= \frac{\text{(Accounting Returns + Imputed Returns)}}{\text{(Non-corporate capital +land+inventory+Capital of Foreign Subsidiary)}} \\ &= \frac{(0.0603 + 1.6803i)}{(2.976 + 0.0095/i)} \end{aligned}$$

where 0.0603 is non-corporate profit plus net interest less intermediate financial services, 1.6803 is the sum of the net stock of government capital, consumer durable, land and inventory; 2.976 is the sum of net stock of non-corporate business, government capital, consumer durable, land and inventory. 0.0095 is the net profit from foreign subsidiaries.

The above equation gives a value of i at 3.93% over the period between 1960 and 2000.

Y_{sd} and Y_{sg} denote the service flows from consumer durables and government capital, respectively, which are computed following Cooley and Prescott (1995).

$$\begin{aligned} Y_{sd} &= csd = (i + \delta_d) K_D \\ Y_{sg} &= iK_G \end{aligned}$$

Then the capital share in the output function α is computed as

$$\alpha = \frac{Y_{kp} + Y_{sd} + Y_{sg}}{GNP + Y_{sd} + Y_{sg}},$$

where Y_{kp} is the income from private fixed assets

$$\begin{aligned} Y_{kp} &= \text{Unambiguous capital income} + \theta_p \times \text{(proprietors' income} && \text{(A-5)} \\ &\quad + \text{indirect business tax)} + \text{depreciation} && (6) \\ &= \theta_p \times GNP \end{aligned}$$

This gives a value 0.32 for θ_p and a value of 0.41 for α.

Define the net national saving rate as

$$\begin{aligned} s &= \frac{Y - CON - GOV - DEPR}{Y - DEPR} \\ &= \frac{(GNP + sg + csd) - (cs + cnd + csd + sg) - gc - (dep + dcd)}{(GNP + sg + csd) - (dep + dcd)} \\ &= \frac{GNP - cs - cnd - gc - (dep + dcd)}{NNP + csd + sg - dcd} \end{aligned}$$

Since in our model government does not issue debt or lend to households, we define the primary government saving rate as

$$sgov = \frac{\text{Tax revenue} - (gc + tr) - \text{net interest payment on government liability}}{Y - DEPR}$$

Accordingly, the private saving rate is computed as

$$psav = s - sgov$$

TFP level is computed as

$$A = \frac{Y}{K^{\alpha} (hE)^{1-\alpha}}$$

Table A1. Model Economy Account

		Model Expression
1	Depreciation	δK
2	Labor income	wE
3	Capital income	rK
4	Total Income	Y
5	Private Consumption	C
6	Government Consumption	G
7	Investment	I
8	Total Product	Y

Table A2. National Accounts, Average 1960-2003 Relative to GNP	
Consumption of fixed capital	0.115
Compensation of employees	0.571
Unambiguous capital income[11]	0.154
Proprietors' Income with IVA and CCadj	0.074
Indirect Business Taxes[12]	0.086
Gross national income	1.000
Personal consumption expenditures	0.635
Durable goods	0.082
Nondurable goods and services	0.553
Gross private domestic investment	0.161
Government consumption expenditures and gross investment	0.206
Consumption expenditures	0.167
Gross investment	0.039
Net foreign investment[13]	-0.002
Gross national product	1.000
Addendum	
Consumption of fixed capital, durable goods	0.062
Consumption of government fixed assets	0.024
Net stock of government fixed assets	0.671
Net stock of consumer durable goods	0.301

[11] Unambiguous capital income = Rental Income of persons with CCAdj + Corporate Profits with IVA and CCadj + Net Interest and miscellaneous payments.

[12] Indirect business taxes are equal to the sum of tax on production and imports less subsidies, business transfer, current surplus of government enterprises and statistical discrepancy.

[13] Net foreign investment is equal to net export of goods and services plus net factor payment.

Table A3. Mapping From National Accounts to Model Accounts (Excluding Gov't Capital)

		Model	NIPA
1	Depreciation (δK)	0.153	
	Consumption of fixed capital		0.115
	Consumption of fixed capital, durable goods		0.062
	Less: Consumption of government fixed assets		-0.024
			0.153
2	Labor income (wE)	0.683	
	Compensation of employees		0.571
	0.7×(Proprietors' income + Indirect business taxes)		0.112
			0.683
3	Capital income (rK)	0.228	
	Unambiguous capital income		0.154
	0.3×(Proprietors' income + Indirect business taxes)		0.048
	Imputed capital services from durable goods		0.026
			0.228
4	Total income (Y)	1.064	1.064
	Table A3. Mapping From National Accounts to Model Accounts (Excluding Gov't Capital)		
5	Private consumption (C)	0.641	
	Personal consumption expenditure		0.635
	Less: Consumption expenditure, durable goods		-0.082
	Imputed capital ser. from durable goods[14]		0.026
	Consumption of fixed capital, durable goods		0.062
			0.641
6	Public consumption (G)	0.182	
	Government consumption exp. and gross investment		0.206
	Less: Consumption of fixed capital, gov. capital		-0.024
			0.182
7	Investment (I)	0.241	
	Gross domestic private investment		0.161
	Personal consumption expenditure, durable goods		0.082
	Net foreign investment		-0.002
			0.241
8	Total Product (Y)	1.064	1.064

[14] Imputed capital services from durable goods is equal to net stock of consumer durable goods times 8.69%.

Table A4. Mapping From National Accounts to Model Accounts (including gov't capital)

		Model	NIPA
1	Depreciation (δK)	0.177	
	Consumption of fixed capital		0.115
	Consumption of fixed capital, durable goods		0.062
			0.177
2	Labor income (wE)	0.683	
	Compensation of employees		0.571
	0.7× (Proprietors' income + Indirect business taxes)		0.112
			0.683
3	Capital income (rK)	0.286	
	Unambiguous capital income		0.154
	0.3× (Proprietors' income + Indirect business taxes)		0.048
	Imputed capital services from durable goods		0.026
	Imputed services from government fixed assets		0.058
			0.286
4	Total income (Y)	1.146	1.146
	Table A4 Mapping From National Accounts to Model Accounts (including gov't capital)		
5	Private consumption (C)	0.699	
	Personal consumption expenditure		0.635
	Less: Consumption expenditure, durable goods		-0.082
	Imputed capital services from durable goods		0.026
	Imputed services from government capital[15]		0.058
	Consumption of fixed capital, durable goods		0.062
			0.699
6	Public consumption (G)	0.167	
	Government consumption expenditure		0.167
7	Investment (I)	0.280	
	Gross domestic private investment		0.161
	Personal consumption expenditure, durable goods		0.082
	Net foreign investment		-0.002
	Gross government investment		0.039
			0.280
8	Total Product (Y)	1.146	1.146

[15] Imputed services from government fixed assets is equal to net stock of government fixed assets time 8.69%.

In Figure A1 we compare the data on the net national saving rate as a percent of GNP from the NIPAs with the one that results after all the adjustments discussed above are made to the data.

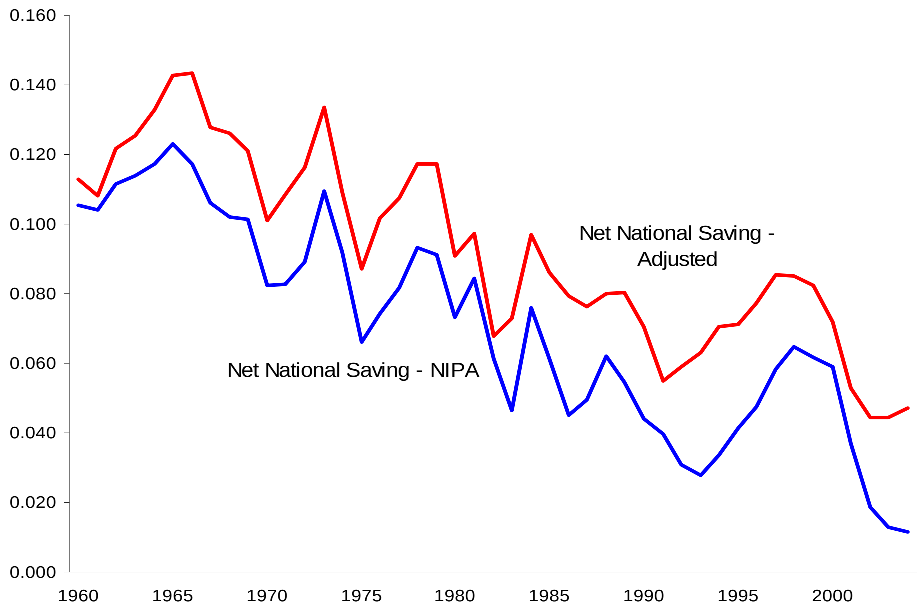


Figure A1: NIPA and the Adjusted Saving Rate

5.2 Computation of capital and labor income tax rates

This section briefly describes how we estimate the tax rates used in this paper. We use data from Statistics of Income (SOI), Individual Income Tax Returns (1947-2003) and Social Security Bulletin. The series of tax rates are constructed using the method of Joines (1981) and McGrattan (1994). The main difference between our approach and McGrattan (1994) is that we assume 32 percent of the proprietor's income is attributable to capital income and the remaining is attributable to labor income. This is consistent with our assumption in measuring the income of private fixed asset, Y_{kp}. In contrast, McGrattan (1994) assumes all proprietor's income belongs to labor income. As a result, our measurement of capital income tax rate is lower than its counterpart in McGrattan (1994).

5.3 Data

In Figure A2 we display the growth rate of the total resident population in the U.S. between 1960 and 2004. This data is obtained from the U.S. Bureau of the Census. Figure A2 also displays the value of the population growth rate at the steady state.

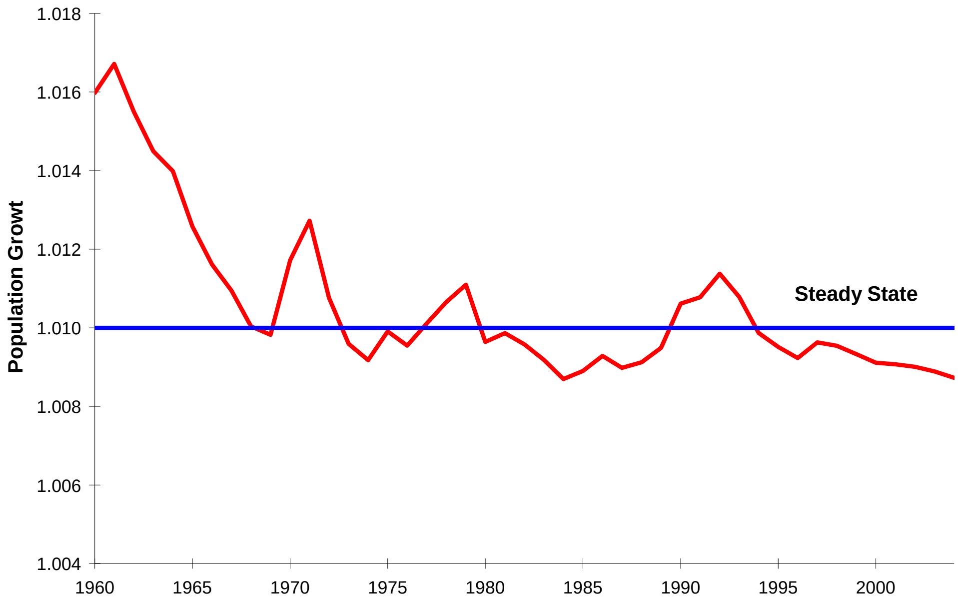
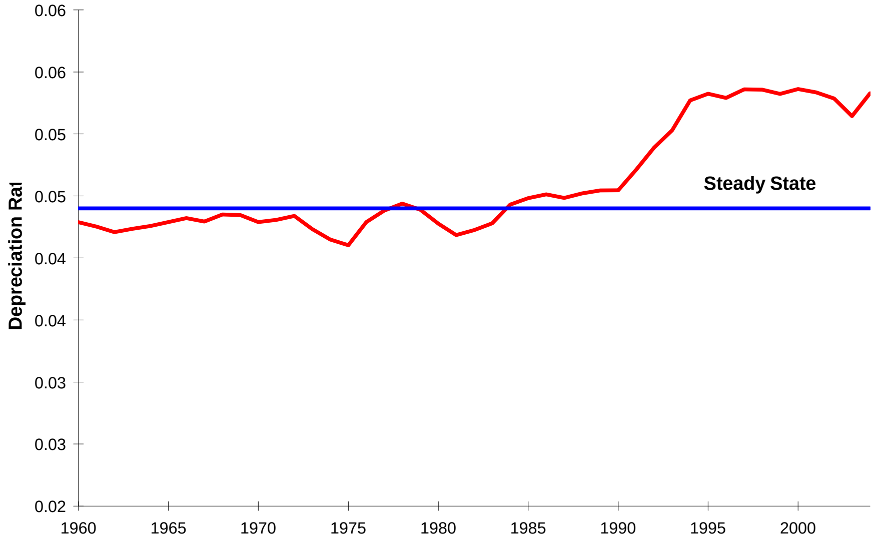


Figure A2: Population Growth Rate

Similarly, in Figure A2, we display the data for the depreciation rate, capital income tax rate, and labor income tax rate for the 1960-2004 period, as well as their steady state values.



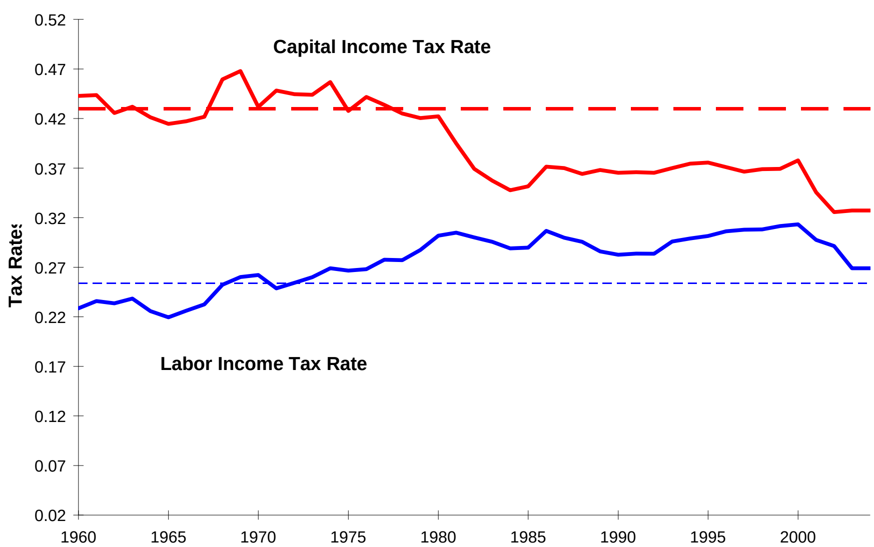


Figure A2: Data

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