Accounting for Consumption and Saving in the United States: 1960-2004

Kaiji Chen[†]   Ayşe İmrohoroğlu[‡]   Selahattin İmrohoroğlu[‡]

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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 the standard growth theory can explain the behavior observed between 1960-2004. We use an infinite horizon, complete-markets growth model calibrated to the U.S. data and show that the model generates saving rates and consumption-to-output ratios that are reasonably similar to the data during 1960-2004. The secular decline 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.

[*]Department of Economics, University of Oslo

[‡]Department of Finance and Business Economics, Marshall School of Business, University of Southern California, Los Angeles, CA 90089-1427.

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 to output ratio and the saving rate in the U.S. between 1960-2004.[1]
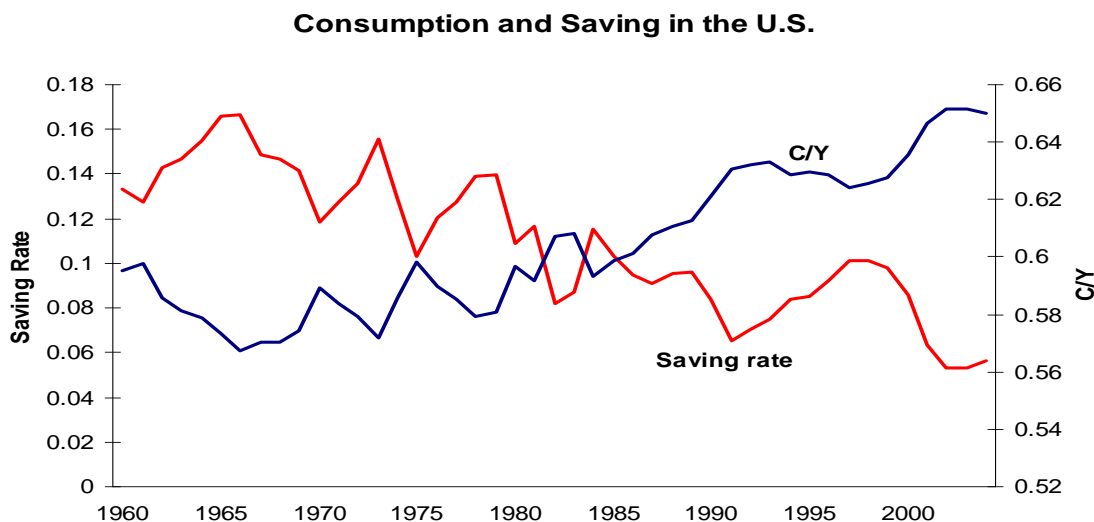
Consumption and Saving in the U.S.

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 Carroll (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

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[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).

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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 explore the quantitative 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 a 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 rates on capital and labor 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 reasonably 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

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[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 see 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 $g_t = A_t/A_{t-1}$.

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 follows Hayashi and Prescott (2002). After calibrating the model parameters and exogenous variables, we first compute a 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 these 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:

$$
\frac{\alpha h_t}{1 - h_t} = (1 - \tau_{h,t})(1 - \theta)\frac{y_t}{c_t}, \tag{1}
$$

$$
\frac{C_{t+1}}{N_{t+1}} = \frac{C_t}{N_t}\beta\left\{1 + (1 - \tau_{k,t+1})\left[\theta A_{t+1}K_{t+1}^{\theta-1}(H_{t+1})^{1-\theta} - \delta_{t+1}\right]\right\}, \tag{2}
$$

$$
K_{t+1} = (1 - \delta_t)K_t + A_t K_t^\theta (H_t)^{1-\theta} - C_t - G_t. \tag{3}
$$

Detrending: 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

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

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

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:

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

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

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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

$$\widetilde{s} = \frac{(g^{\frac{1}{1-\theta}} n - 1)\widetilde{k}}{\widetilde{y} - \widetilde{\delta}\widetilde{k}}. \tag{4}$$

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 (3) 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   Calibration

We calibrate the model economy using data from the 2005 revision of National Income and Product Accounts (NIPA), Fixed Asset Tables (FAT) of Bureau of Economic Analysis (BEA), Statistics of Income (SOI), Individual Income Tax Returns (1960-2003), and the Social Security Bulletin.

Constant Parameters: There are 3 parameters that are time invariant throughout our analysis. The capital share parameter, θ, is set to its average value of 0.4 over our sample period 1960-2004. The subjective discount factor, β, is set to 0.9702 so that the capital output ratio is 3.2 at the final steady state. The share of leisure in the utility function, α, is set to 1.45 to match an average workweek of 35 hours. These choices are summarized below.

Time-Invariant Parameters		
θ	0.4	1960-2004 average
β	0.9702	Target: $K/Y = 3.2$ in steady state
α	1.45	Target: Average workweek = 35 hours

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[5]We treat the model as a closed economy where net national saving and invsetment are identical. Figure 2 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.

Calibration of the Steady-State (2070 and Beyond) and 2005-2070: We assume that the U.S. economy starts from given conditions in 1960 and eventually converges to a steady-state in 2070.[6] In order to characterize this steady-state equilibrium, we use the following values for model variables, starting from year 2005:

Steady-State Values: 2005 and Beyond		
$g_t - 1$	TFP Growth Rate	0.0142
$n_t - 1$	Population Growth Rate	0.01
ψ_t	Government Purchases to GNP Ratio	0.14
δ_t	Depreciation Rate	0.05
TR_t/GNP	Transfers to GNP Ratio	0.10
$\tau_{k,t}$	Capital Income Tax Rate	0.40
$\tau_{h,t}$	Labor Income Tax Rate	0.276

In our benchmark model, we set the seven exogenous variables in the above list equal to their long-run averages.[7] Note that the population growth rate in the U.S. has been declining since the 1960s and according to the Census Bureau projections it will continue at very low rates in the future. Thus, we set the population growth rate after 2004 and at the steady state equal to 1% which is smaller than the average population growth rate of 1.5% between 1960-2004.[8] Similarly, the depreciation rate has been increasing in the U.S. For the periods after 2004 and at the steady state, we set the depreciation rate equal to 5% which is the average depreciation rate between 1990-2004.[9] We discuss the sensitivity of our results to the assumptions made for the periods beyond 2004 in the section on sensitivity analysis.

Calibration of the 1960-2004 period: In our benchmark simulation, we use the actual time series data between 1960-2004 for the following exogenous variables: TFP growth rate, population growth rate, depreciation rate, share of government purchases in GNP, share of government transfers in GNP, and capital and labor income tax rates. [10] Empirical tax

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[6] This is an approximation. Allowing for a longer transition period from 1960 for convergence to a steady-state has no quantitative impact on the 1960-2004 period we are investigating.

[7] With our assumed tax rates, the government budget will be in a surplus at the steady state.

[8] Population growth rates are obtained from the BLS and are the growth rates of civilian non-institutional population 16 years and over.

[9] Gomme and Rupert (2005) provide detailed calculations for the depreciation rate of different types of capital. Increasing depreciation rates are evident in computers and to some extent in market structures since 1960s.

[10] 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 plus service flow from stock of consumer durable and

rates are constructed using the methods of Joines (1981) and McGrattan (1994). The data used in the calibration are provided in the Appendix. We compute the initial capital-output ratio in 1960 as 3.5 and take it as a given initial condition.

1960-2004 Values: Benchmark Model with Time-Varying Exogenous Variables		
$g_t - 1$	TFP Growth Rate	Authors' Calculations
$n_t - 1$	Population Growth Rate	Authors' Calculations
ψ_t	Government Purchases to GNP Ratio	Authors' Calculations
δ_t	Depreciation Rate	Authors' Calculations
TR_t/GNP	Transfers to GNP Ratio	Authors' Calculations
$\tau_{k,t}$	Capital Income Tax Rate	Authors' Calculations
$\tau_{h,t}$	Labor Income Tax Rate	Authors' Calculations

3 Results

3.1 Main Findings

We start this section by a comparison of the key macroeconomic aggregates that are generated by the model against their empirical counterparts. Since we assume closed economy, there is no distinction between saving and investment in our model. In Figure 2 we display the data for net national saving rates and the ratio of net domestic investment to NNP, as well as the model generated saving rate. First, the observed saving and investment rates seem to display similar fluctuations in this time period. In two subperiods, late 1980s and late 1990s, the rate of investment is larger than the saving rate, highlighting the current account deficits in the U.S. for these periods. Since the focus of our paper is the saving rate, we will compare our model's simulated saving rate with the emprically calculated saving rate.

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government capital, K_t is capital stock inclusive of foreign capital, stock of consumer durable and government 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. Gomme and Rupert (2005) provide three different measures on the U.S. TFP growth rate based on very different assumptions on the capital stock. The TFP growth rates implied by their results as well as ours display very similar properties over this time period.
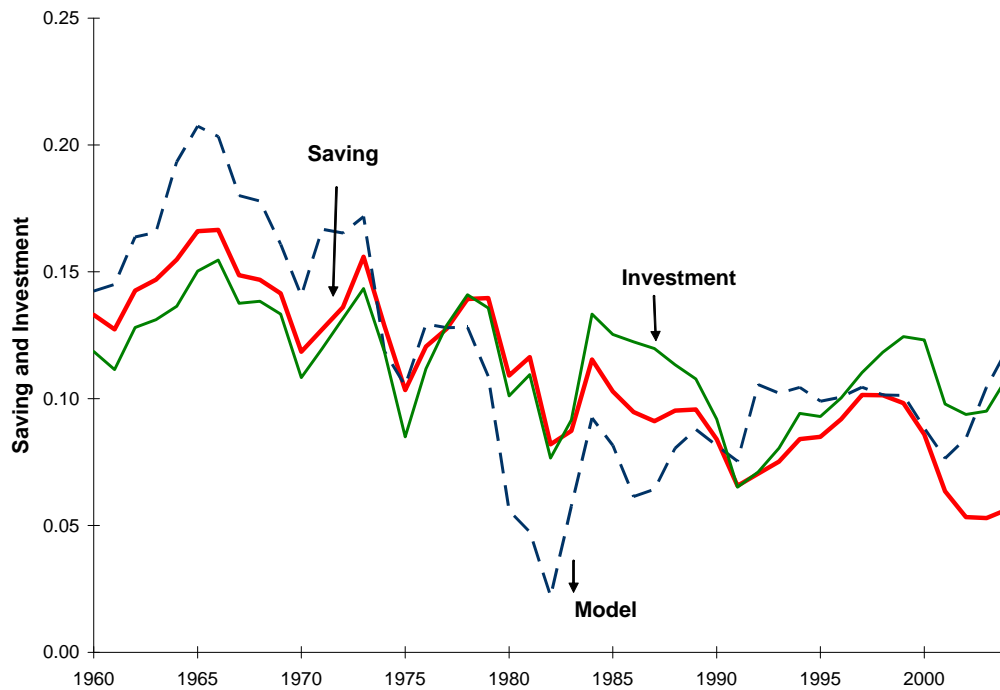
Figure 2: Data and the Model

The simulated saving rate is given in Figure 2 with the series labeled 'model'. The model does reasonably well in terms of capturing some of the movements in the actual U.S. data. However, the model generated saving rate is considerably larger than the data in the mid 1960s and smaller than the data between 1975 and 1990.

Figure 3 displays the actual and simulated consumption-output ratios which exhibit a similar fit. Although the secular movements seem to be reasonably characterized, the model has difficulty mimicking the observed behavior in certain subperiods.
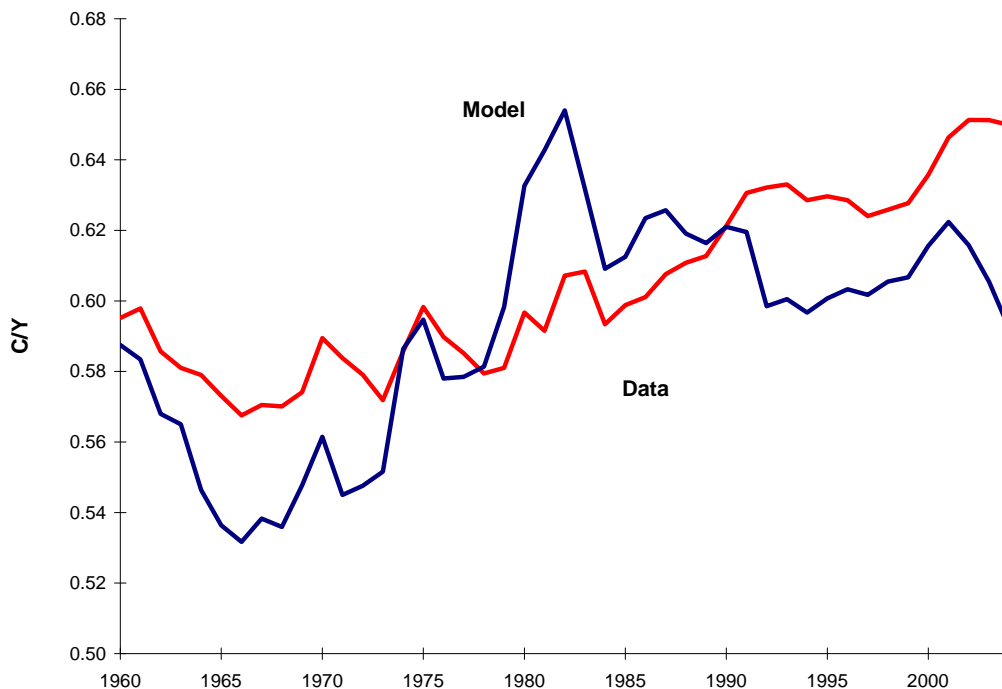
Figure 3: Consumption-Output Ratio

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[11]. 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.

Population Time Series Only: In our first counterfactual experiment we try to isolate the role of the declining population growth rate by simulating the saving rate in an economy where all the exogenous variables (TFP growth, G/Y, depreciation, tax rates, transfers) are set to their long-run averages except for the population growth rate. In Figure 4, we display the saving rate from the data labeled 'data'. The series labeled 'Population Time Series Only' displays the saving rate that is generated by the model economy where the only time series data that is used in the simulations is the population growth rate. The quantitative impact of the population growth rate in this time period seems fairly small, resulting in a

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

1% decline (from 12% in 1960 to 11% in 2004). The largest decline is from 14.3% in 1970 to 11.6% in 2004.
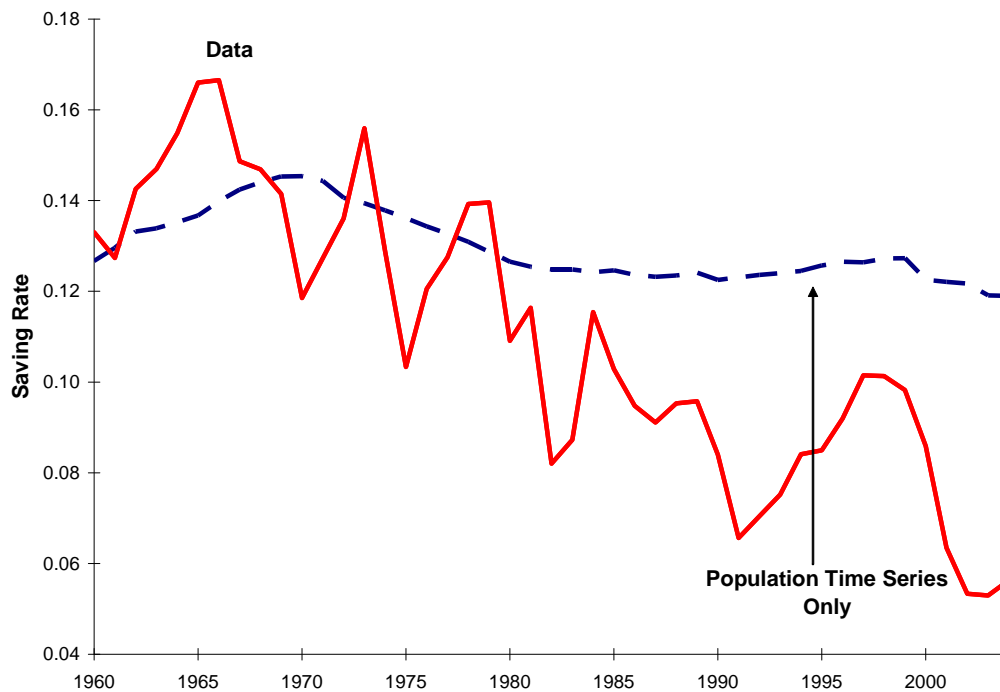

Figure 4: Role of Population Growth

Declining Population Growth Rate and Increasing Depreciation Rate: 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.
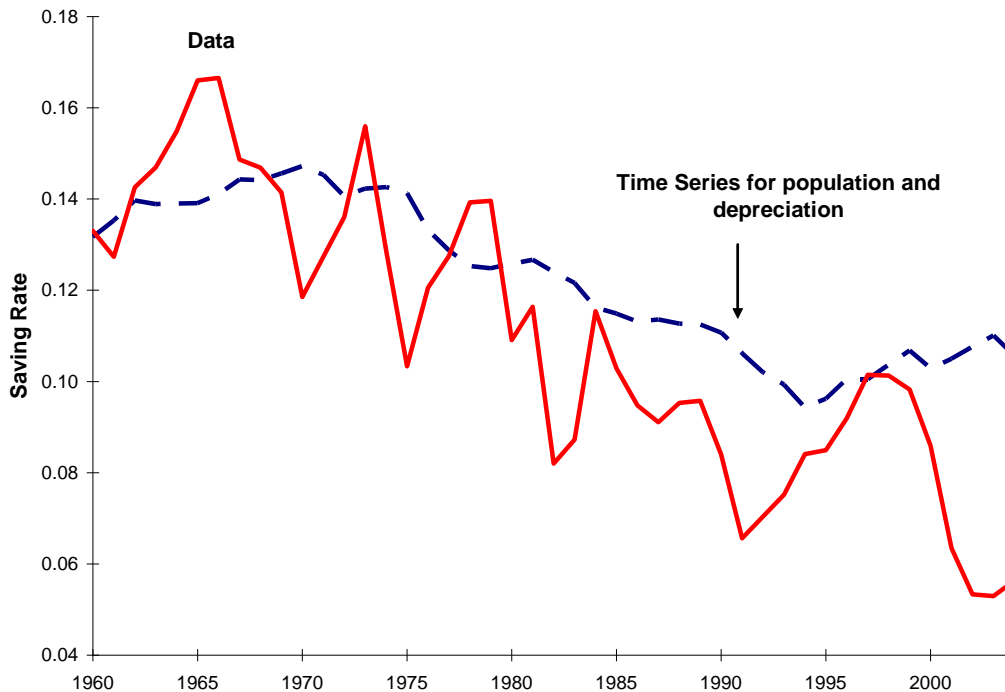
Figure 5: Role of the Population Growth and Depreciation

All Time-Varying Except TFP Growth Rate: In Figure 6 we generate the saving rate in an economy where time series values of all the exogenous variable except the TFP growth rate are used in the simulations. Thus in this environment, tax rates, transfers, 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 some of the secular decline in the saving rate. However, the simulated saving rate does **not** generate the decline observed in the data in late 1980s and late 1990s.
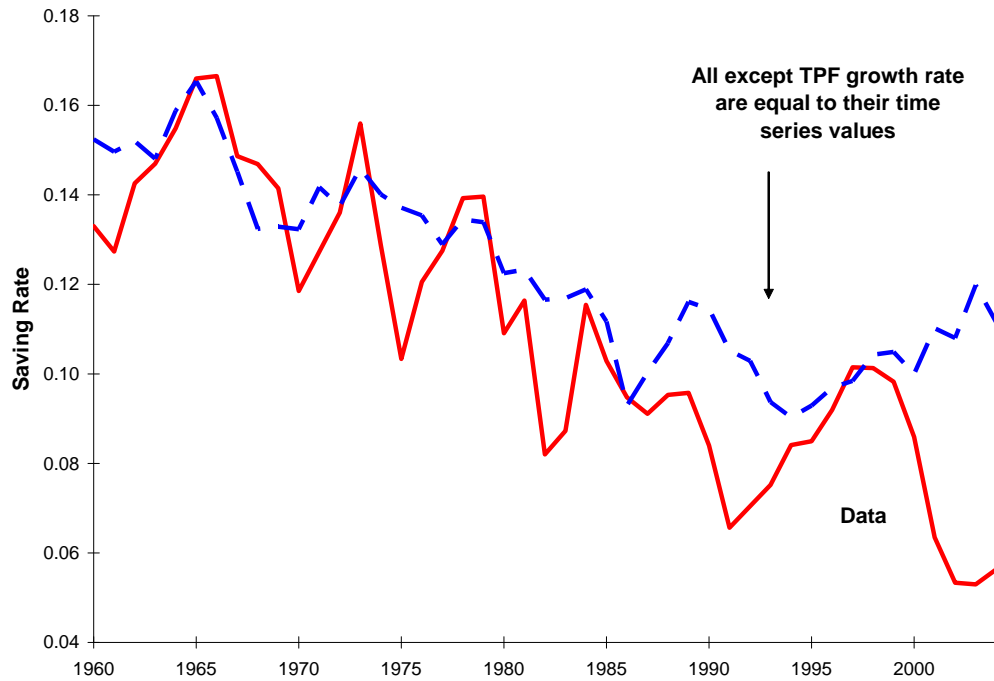
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Figure 6: All Except TFP

TFP Growth Rate Only: 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, it 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 late 1990s, and a sharp increase in the early 1990s.
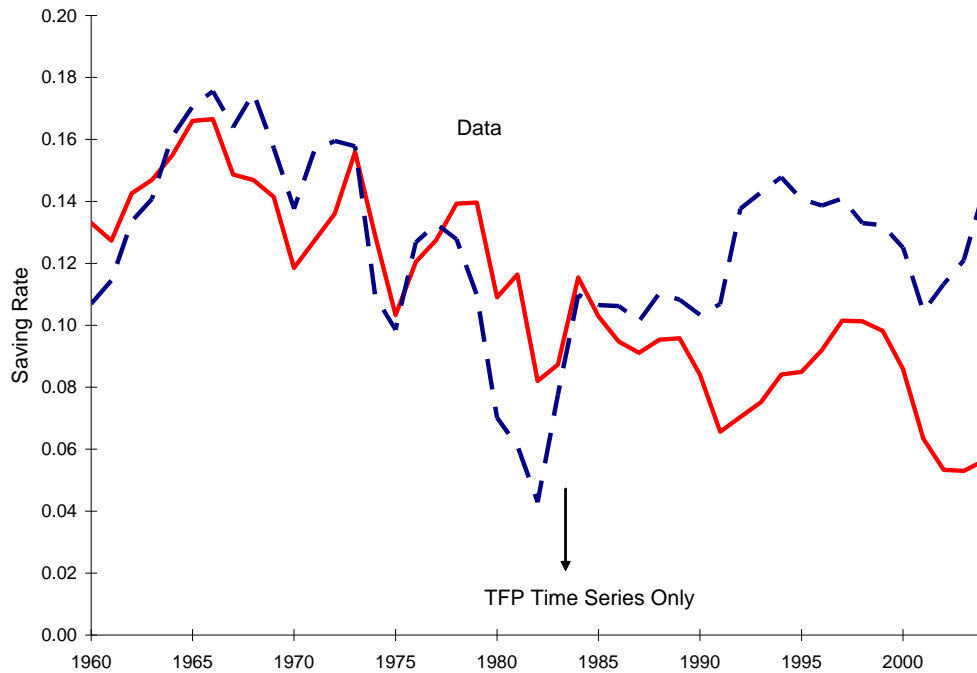
Figure 7: Role of TFP

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.
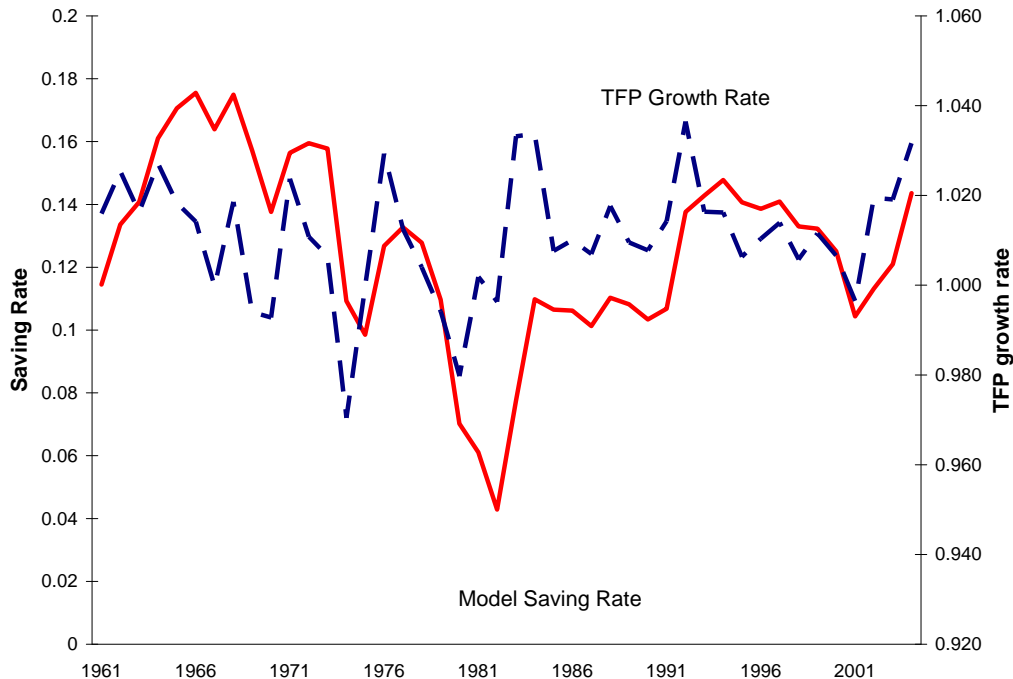
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Figure 8: TFP Growth and the Saving Rate

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

Labor Input and Return to Capital: In this section we examine additional properties of the benchmark economy 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 observed time series path of the labor input and the after-tax return to capital (calculated from NIPA) and compare them with those generated by our model. In the first panel, we display two different measures of the labor input in the data: hours worked per week and total hours per capita.[12] Notice that while the simulated series display a decline in hours worked per week it is incapable of generating the increase in the employment rate which seems to be

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[12]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.

the reason why observed total hours did not decline. In our simple model, the decrease in simulated hours is mainly driven by the fact that tax rates on labor increase steadily over the past forty years. Therefore, with perfect anticipation of this trend, the stand-in household tends to substitute hours in the early periods for hours in the late periods.

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. One potential reason for such a big discrepancy is that in the 1990s capital's share in total income increases a lot, while in our model it is constant due to the Cobb-Douglas production specification. Notice that the after-tax rate of return for capital in the data is positively correlated with capital share in total income and negatively correlated with the capital-output ratio, while in our model it is driven by capital-output ratio alone. Therefore, given that capital's share in total income increases during the 1990s, our model tends to underestimate the increase in the after-tax return to capital.
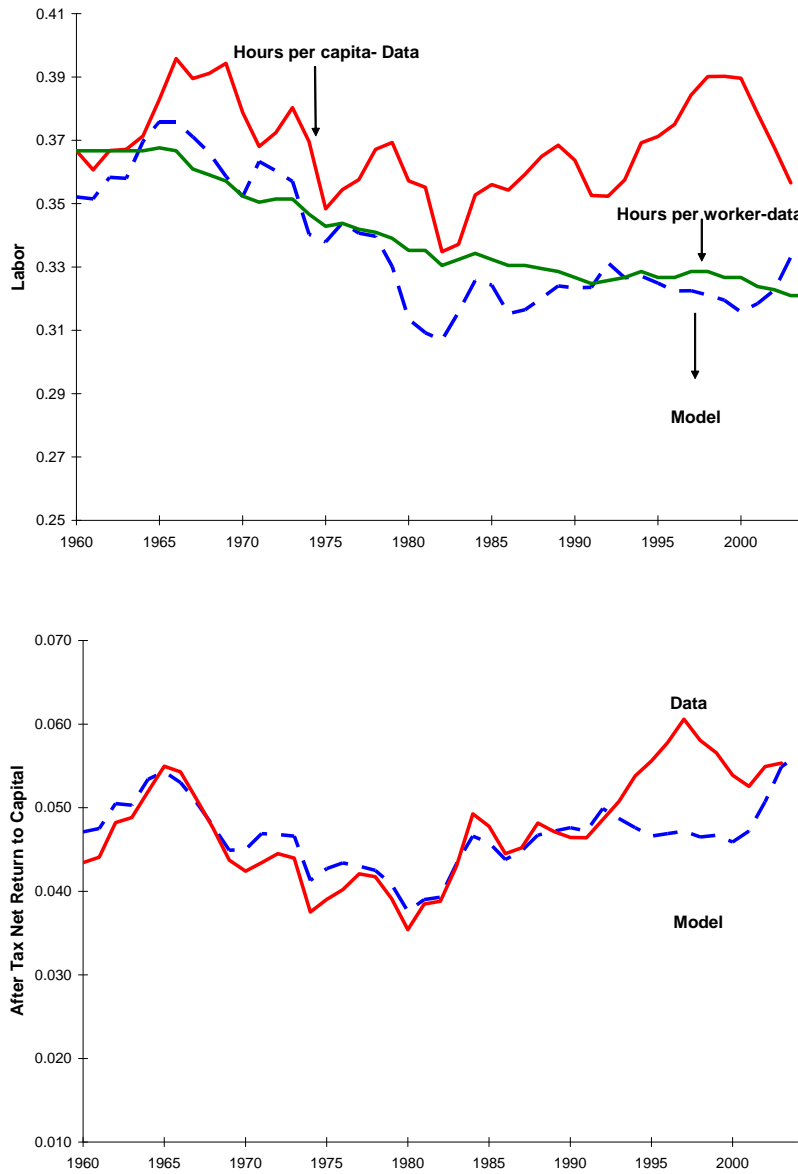
Figure 9: Additional Properties

Private and Public Saving Rates: It is also possible to separate the net national saving rate in this economy into its two components and examine the private and the government saving rates separately. In Figure 10 we display the simulated series against their counterparts in the data. Notice that while the simulations take the tax rates and the government consumption directly from the data, there is no guarantee that the simulated government saving rates should mimic the data well. To the extent that the model generated labor and capital series are "similar" to their counterparts in the data, the government revenues generated by the model will capture the data. As can be seen from the second panel

of Figure 10, the simulated government saving rates look reasonably close to data.[13] The private saving rate captures all the discrepancies that were present in the earlier results for the net national saving rate. The model generated saving rates are very low after 1975 and very high in 2004.

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[13]It is important to note that we have to make an adjustment to our definition of the capital stock, which includes durable goods and government capital, when we are calculating the tax revenues generated from capital income. In the NIPA data, these two components are not taxed at the capital income tax rate. Thus we take them out of the definition of capital when we are computing the tax revenues from capital income.
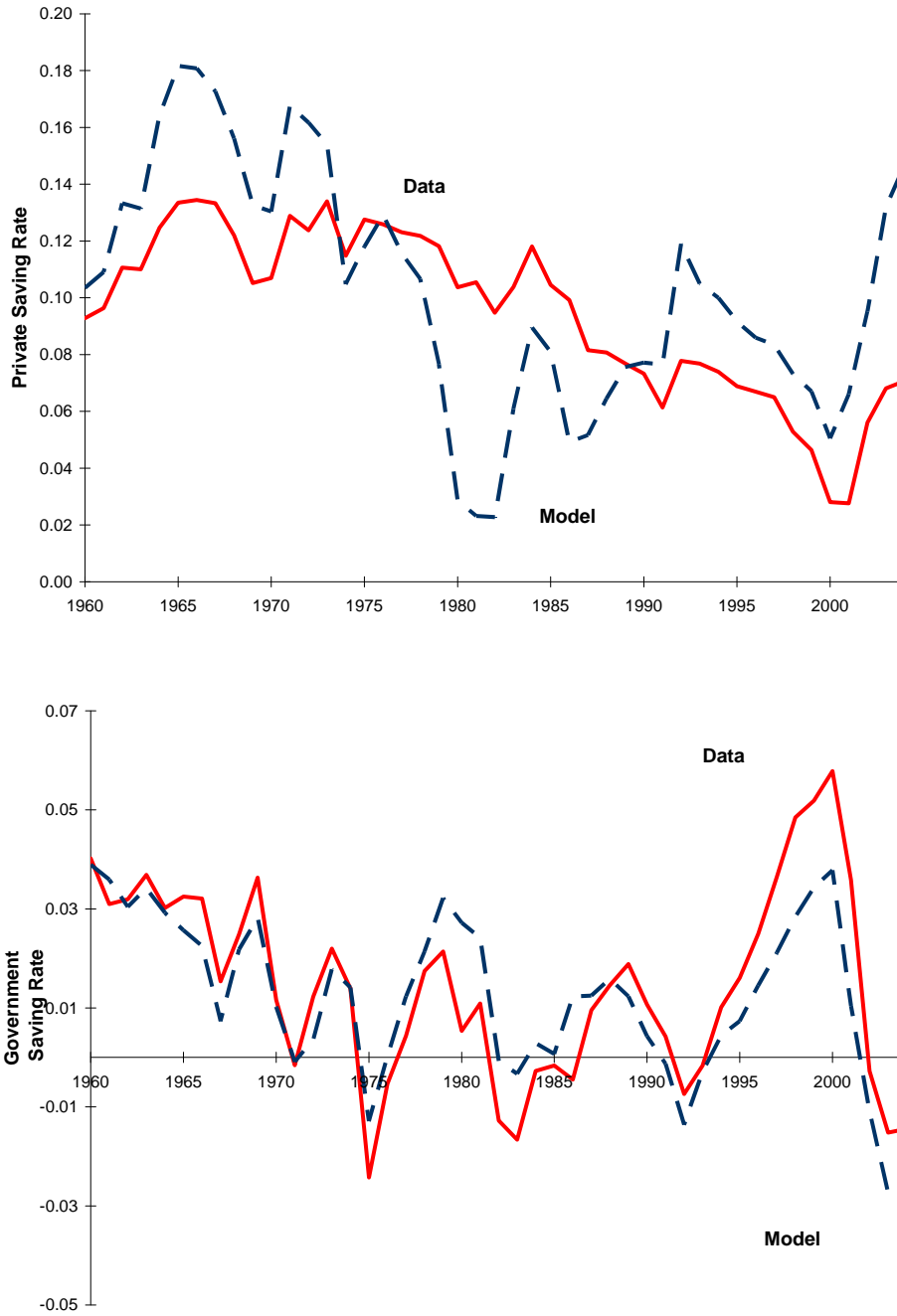
Figure 10: Private and Government Saving

Alternative Assumption on Values for 2005 and Beyond: Our procedure for assigning values to TFP growth rates between 2005 and the final steady-state is arbitrary. In our benchmark calculations we 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 the year 2004 beyond which the two simulated saving rates differ only because of the assumed values for the TFP growth rate for 2005 and beyond. The two series are virtually 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 Figure 11 shows, the implications of the TFP growth rate beyond 2004 significantly differ between the two simulations.
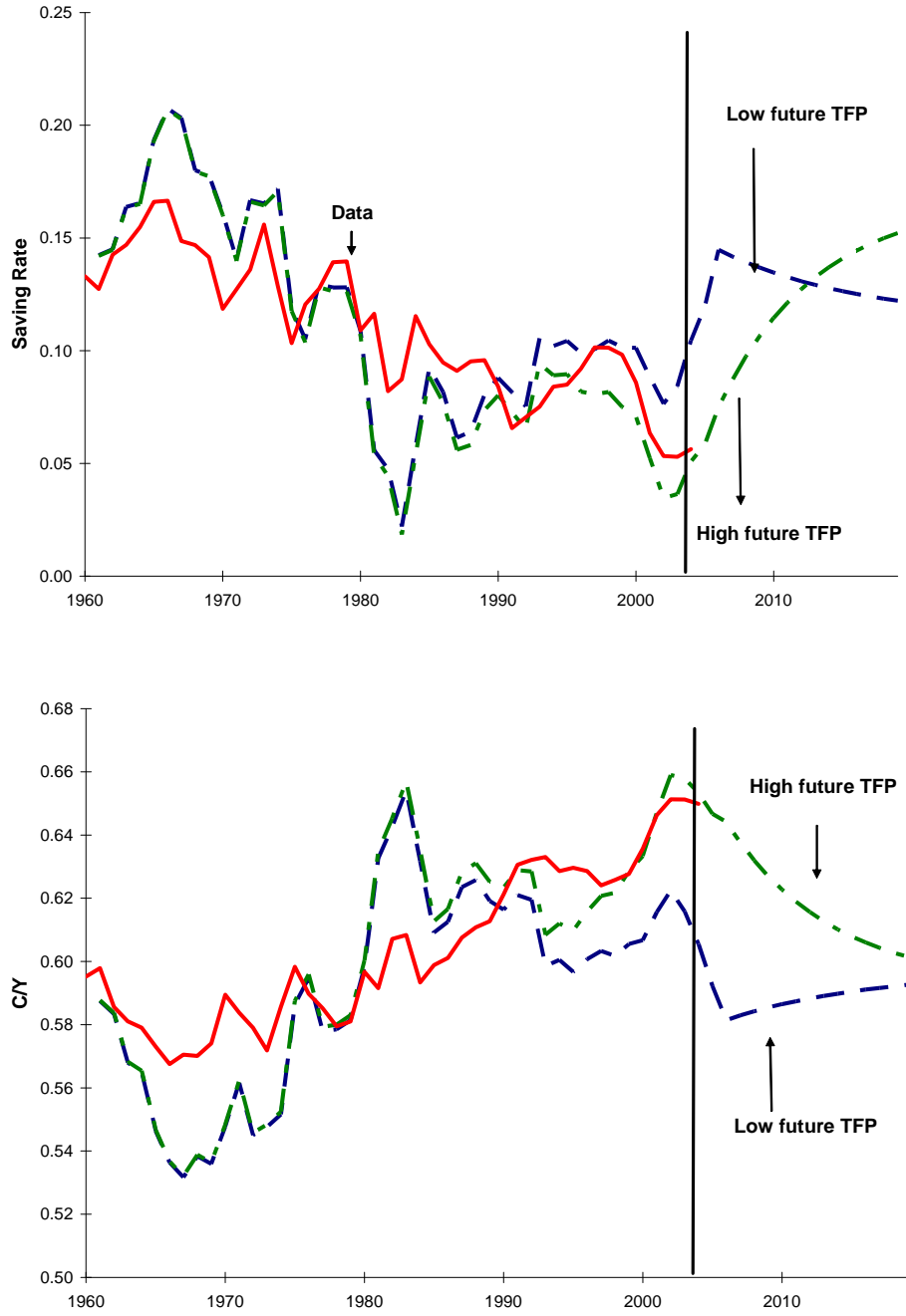
Figure 11: Role of the Future

3.3   No Perfect Foresight

So far we assume perfect foresight. Households know the entire time path of all exogenous variables. Hayashi and Prescott (2002) and Chen, İmrohoroğlu, and İmrohoroğlu (2006)

argue that this assumption plays a quantitatively minor role in the model's ability to generate empirically plausible aggregates. In this section, we will summarize our findings from two alternative assumptions on expectations for the TFP growth rate while we still feed in the time path of all the other exogenous variables deterministically.

Adaptive Expectations: Our first alternative expectations scheme is a simple adaptive framework where expectations of future TFP growth rates are formed according to

$$g_{t+1}^e = g_t^e + \lambda(g_t - g_t^e).$$

Here, the parameter $\lambda \in [0, 1]$ reflects the extent to which expectations will change as a result of past errors. A λ near zero indicates near-static expectations whereas a λ near unity suggests setting expectations equal to the most recently observed actual growth rate. In the latter case, the model's saving rate would essentially shift one period hence relative to our perfect foresight case.
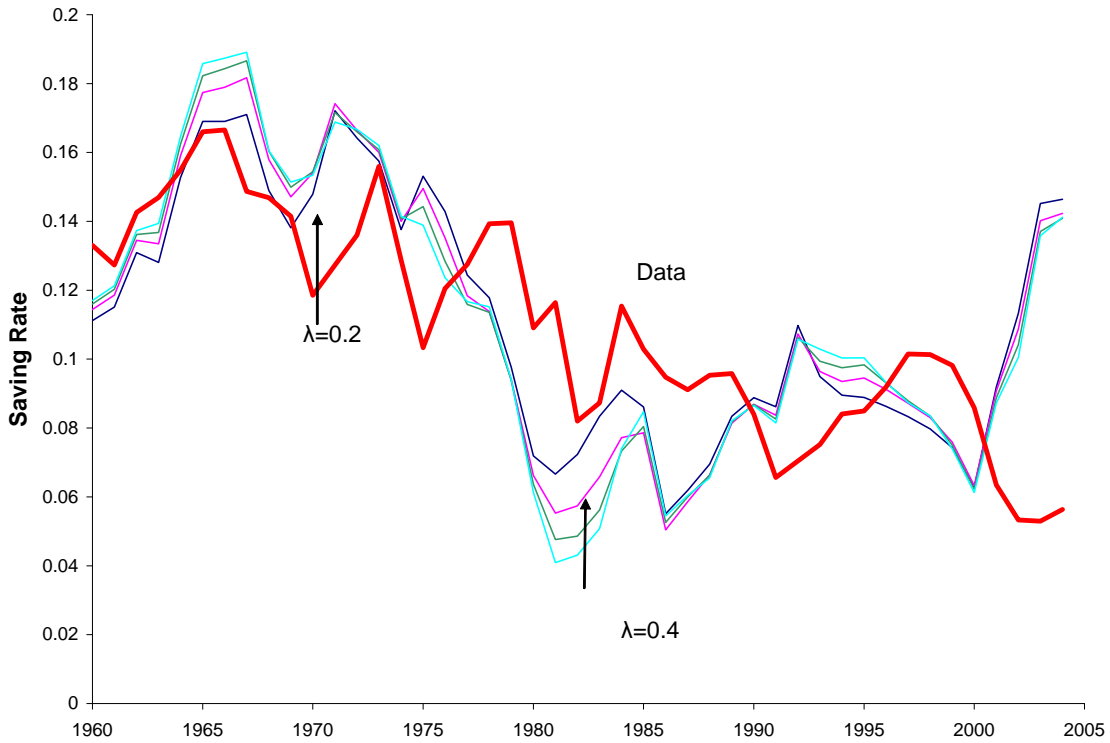
Figure 12: Saving Rate with Adaptive Expectations

Figure 12 displays observed saving rates and a collection of simulated saving rates indexed by a few values of λ. Even the near-static expectations cases with low values of λ generate saving rates with similar features compared to the deterministic case. The secular movements are reasonably well-represented, but the model does a poor job in the 1980s and early 2000s.

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Stochastic TFP Growth Rate: Another alternative formulation is to assume that TFP growth rate follows an *AR(1)* process.[14] Estimating this simple process yields a persistence coefficient of 0.33 (with an intercept term 0.69 and a standard error of regression 0.0224).
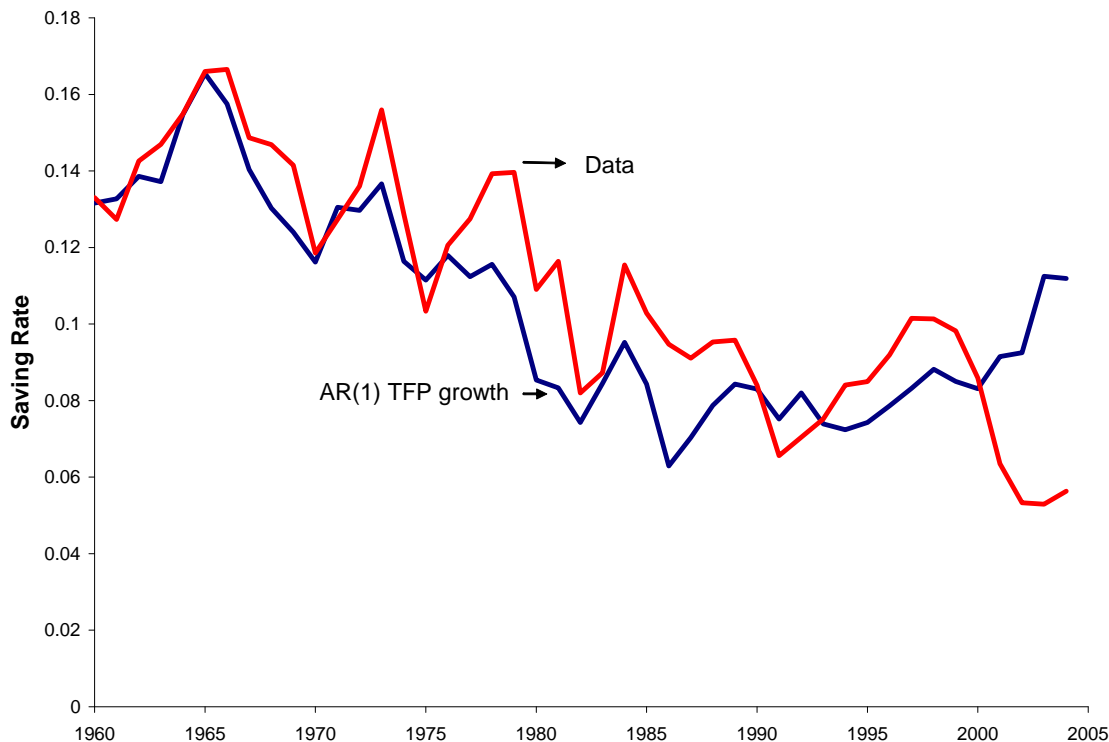

Figure 13: Saving Rate with AR(1)

Figure 13 depicts the actual saving rate and the model generated saving rate when households forecast future TFP growth rates using the estimated *AR(1)* process given above. The simulated saving rate is fairly close to the actual saving rate.. The AR1 assumption for the TFP growth rate produces smoother saving rates compared to the perfect foresight case. Households' intertemporal behavior is subdued due to the lack of perfect foresight of the real return to capital.

---

[14] We solve the decision rules in this model by using the finite element method following McGrattan (1996). We assume that agents have perfect foresight for all other exogenous variables by specifying a degenerated transition matrix with forty-six states. In this matrix, each state refers to a vector of exogenous series corresponding to a particular year and the transition probabilities from year j to $j+1$ ($j \leq 2004$) is one. We set the vector of of exogenous series corresponding to year 2005 as the steady state vector specified in the calibration section. Also, we set the last diagonal of this matrix to one which indicates that after 2005 the exogenous variables will stay at their 2005 values.

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 increase 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, the results for the periods after 1990 are sensitive to the assumptions made about the future. The model also abstracts from several features on the U.S. economy that seem to be important especially since the 1990s. For example, McGrattan and Prescott (2006) document the importance of intangible capital since 1990s that is absent in our calculations. In addition, the model we have used can not account for the large increase in household wealth and its possible impact on the saving consumption decision. These issues, and a more detailed study of the 1990s is left 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

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

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

$$(cs + cnd + csd + sg) + gc + (i + nicd + dcd + gi) \quad \text{(A-3)}$$
$$+nx + nfp = GNP + sg + csd$$
$$= (dep + dcd) + (NNP + sg + csd - dcd)$$

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

$$(cs + cnd + csd + sg) + gc \quad \text{(5)}$$
$$+(i + nicd + dcd + gi + nx + nfp) = GNP + sg + csd \quad \text{(6)}$$
$$= (dep + dcd) + (NNP + csd + sg - dcd)$$

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

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

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).

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

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

$$
\begin{aligned}
Y_{kp} &= \text{Unambiguous capital income} + \theta_p \times (\text{proprietors' income} \qquad \text{(A-5)} \\
&\quad + \text{indirect business tax}) + \text{depreciation} \qquad \text{(7)} \\
&= \theta_p \times GNP
\end{aligned}
$$

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

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

where tr is the net government transfer, computed as current transfer payment minus current transfer receipts. Accordingly, the private saving rate is computed as

$$
psav = s - sgov
$$

TFP level is computed as

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

Table A1. Model Economy Account

		Model Expression
1	Depreciation	δK
2	Labor income	wH
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[15]	0.154
Proprietors' Income with IVA and CCadj	0.074
Indirect Business Taxes[16]	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[17]	-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

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

[16] 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.

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

		Model	NIPA
Table A3. Mapping From National Accounts to Model Accounts (Excluding Gov't Capital)			
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
	$0.7\times$(Proprietors' income + Indirect business taxes)		0.112
			0.683
3	Capital income (rK)	0.228	
	Unambiguous capital income		0.154
	$0.3\times$(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)

		Model	NIPA
5	Private consumption (C)	0.641	
	Personal consumption expenditure		0.635
	Less: Consumption expenditure, durable goods		-0.082
	Imputed capital ser. from durable goods[18]		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

[18] 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 (wH)	0.683	
	Compensation of employees		0.571
	$0.7\times$ (Proprietors' income + Indirect business taxes)		0.112
			0.683
3	Capital income (rK)	0.286	
	Unambiguous capital income		0.154
	$0.3\times$ (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)

		Model	NIPA
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[19]		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

---

[19] 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.
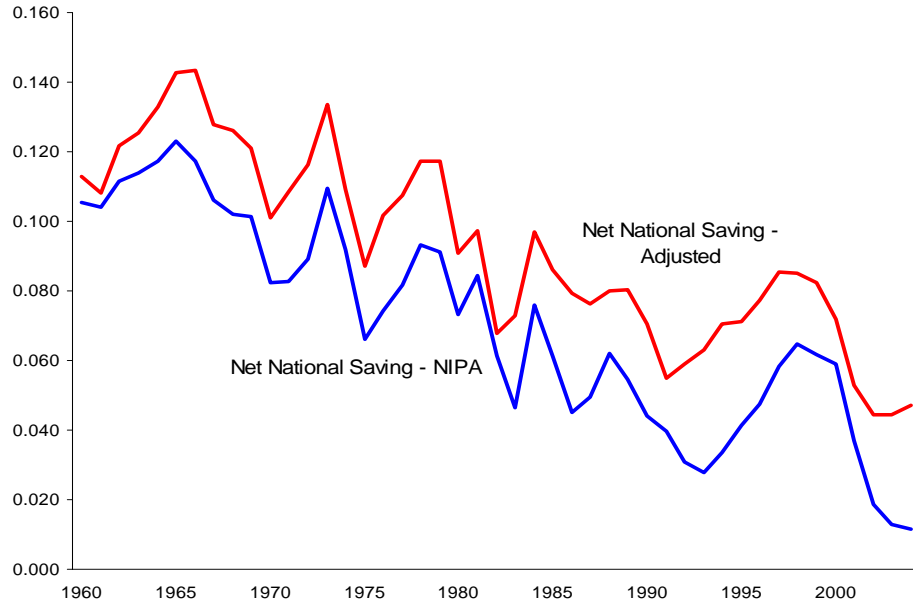

Figure A1: NIPA and the Adjusted Saving Rate

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 (1960-2003), Social Security Bulletin and National Incomes and Product Accounts (1960-2003). 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). In addition, we exclude net capital gain from income subject to the personal income tax.

5.3 Computation of After-Tax Rate of Return to Capital

We compute real after-tax capital income as

$$
\begin{aligned}
Y_{KAT} &= Y_{KBT} - \text{real capital income taxes} \\
&\quad where \\
Y_{KBT} &= (\text{net interest} + \text{corporate profits} + \text{rental income} \\
&\qquad + .32 \times \text{proprietor's income} + \text{state ibt property taxes}) \times A \\
A &= 1 + (\text{total ibt tax} - \text{state ibt property tax})/\text{national income}.
\end{aligned}
$$

Capital income tax is computed as proportional tax on capital income, denoted as TKP, plus the computed nonproportional tax on capital income and the proportional tax on both capital and labor income, denoted as TKN. Specifically

$$
\begin{aligned}
TKP &= \text{federal profit tax} + \text{state profit tax} \\
&\quad + \text{state property tax} + \text{state ibt property tax}
\end{aligned}
$$

and TKN is the product of Y_{KBT} and the sum of proportional tax rate on both capital and labor income and the computed tax rate on capital income that is part of the individual income.

Finally, real after tax return to capital is computed as

$$
R_{AT} = \frac{Y_{KAT}}{K - \text{stock of consumer durable and government capital}}
$$

where the measurement of K is the same as that in calibration of the benchmark economy.

5.4 Data

In Figure A2 we display the growth rate of the total resident population in the U.S. between 1960 and 2015. This data is obtained from the U.S. Bureau of the Census which has projections until 2099. The horizontal line in Figure A2 displays the average population growth rate in the 1960-2004 period. This value is used in the counter factual experiments where exogenous variables are set to their long-run averages.
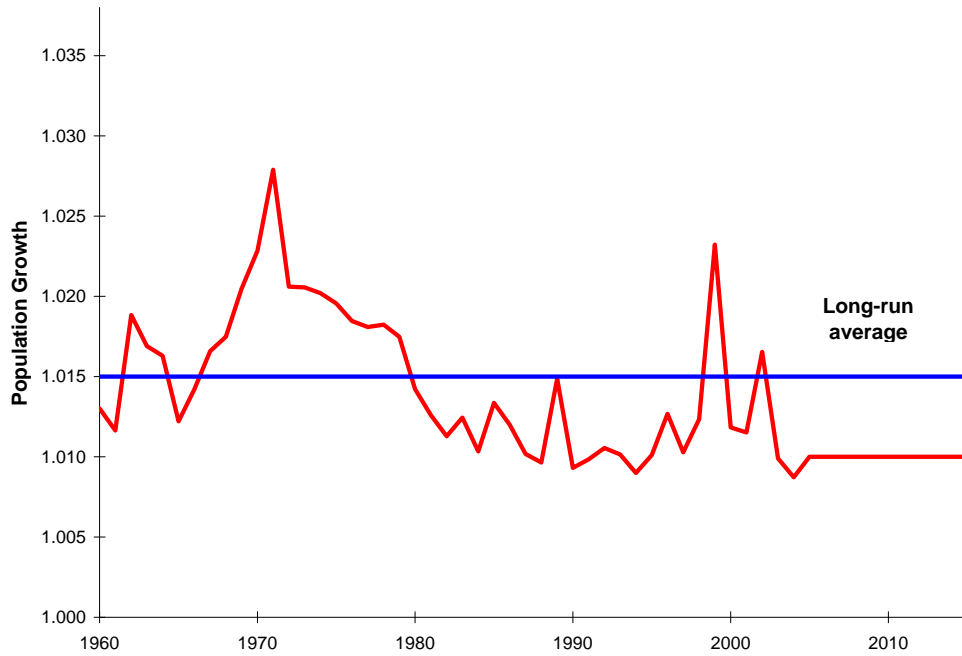
Figure A2: Population Growth Rate

Similarly, in Figure A3, we display the data for the depreciation rate, capital income tax rate, and labor income tax rate for the 1960-2015 period, as well as their average values for the counterfactual experiments. Notice that in the benchmark results we have assumed the values of these variables after 2004 to stay at their 2004 levels. .
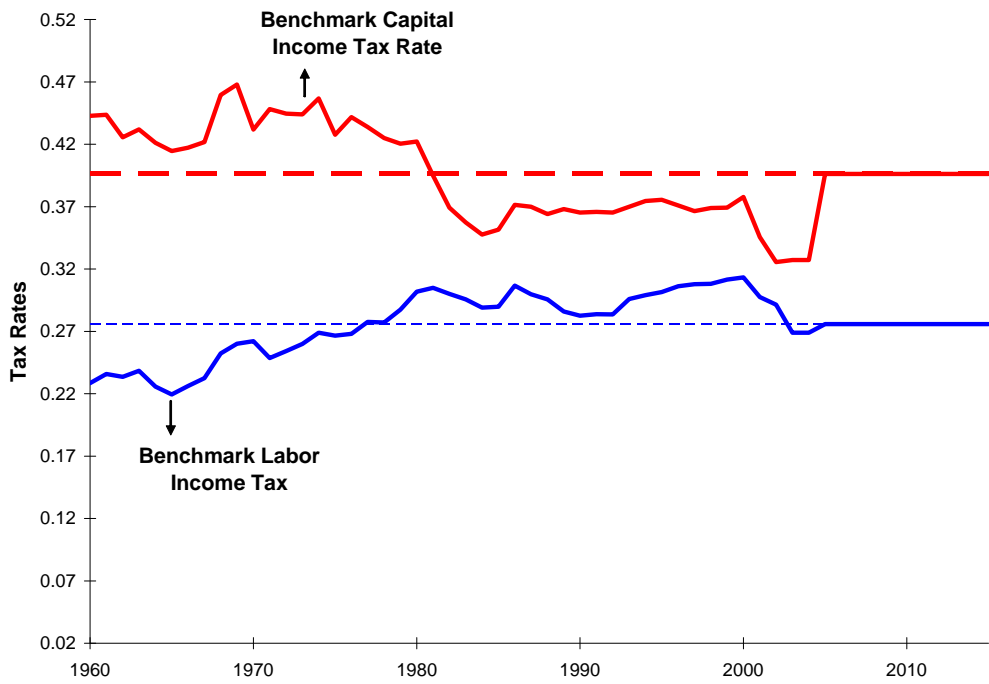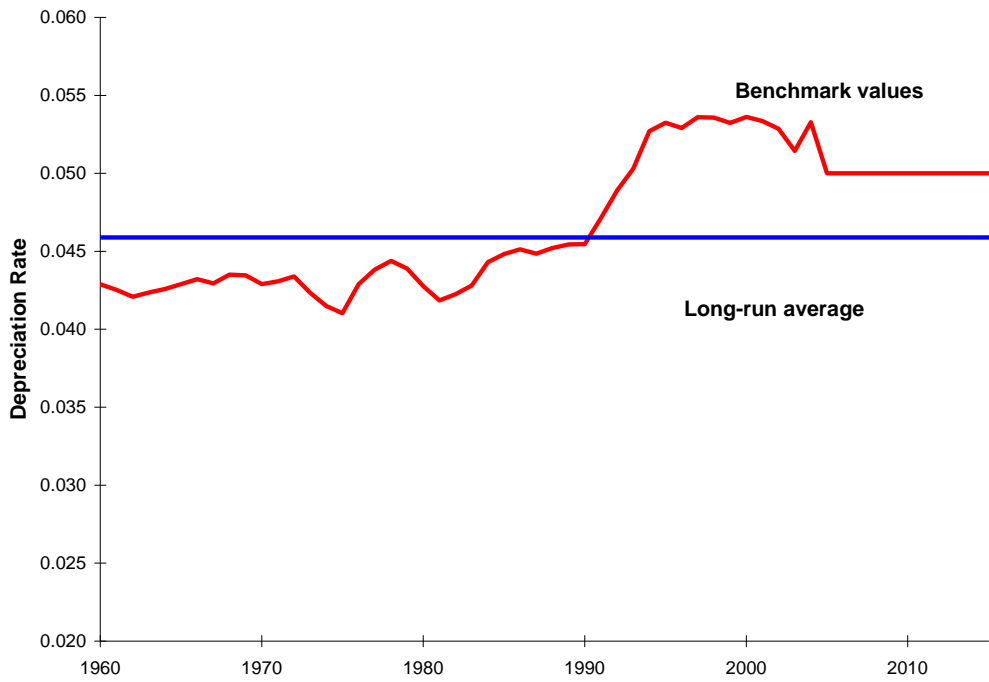
Figure A3: Data

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