A Quantitative Assessment of the Decline in the U.S. Saving Rate and the Current Account Balance*

Kaiji Chen† Ayşe Imrohoroğlu‡ Selahattin Imrohoroğlu‡

First Version October 2005; this Version April 2008

Abstract

We use the standard growth theory to evaluate the quantitative role of changes in the population growth rate, depreciation rate, tax rate on capital and labor income, and the TFP growth rate in explaining the decline in the saving rate and the current account balance in the U.S. Our findings suggest that the decline in the population growth rate and the increase in the depreciation rate play a significant role in explaining the secular trends in the U.S. saving rate up to early 1990s. We also find that the model is capable of capturing the current account deficit between the U.S. and the OECD countries, thus explaining one third of the overall U.S. current account deficit. Our results indicate that differences in the TFP growth rates between U.S. and its trading partners may have been responsible for the secular decline in the U.S. current account.

*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.

*We would like to thank the seminar participants at USC, University of California at Riverside, Federal Reserve Bank of Chicago, Conference on Economic Dynamics at the University of Tokyo, 2006 Annual Meetings of the Society for Economic Dynamics, CEMFI, Madrid, IIES, Stockholm University, Indiana University, Purdue University, CERGE-EI, Charles University in Prague and University of Iowa for helpful comments.
1 Introduction

The net national saving rate in the U.S., displayed in Figure 1, has declined from an average of 15\% in 1960s to 10\% in 1980s and 8.6\% in 1990s. This secular decline has occupied center stage in policy discussions and continues to attract media coverage. Understanding this decline as well as the differences in saving rates across countries have been an important part of academic research. Detailed analyses have been conducted to explore whether particular birth cohorts are responsible for the low saving rate by examining personal saving rates in the U.S. For example, Gokhale, Kotlikoff, and Sabelhaus (1996) attribute the decline in the saving rate to the redistribution of resources through social security and medicare, from young consumers with low marginal propensities to consume, to older generations with high marginal propensities to consume. 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 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.\footnote{Another set of papers have focused on the possible relationship between the increase in stock prices and the boom in consumer spending. For example, Parker (1999) and Juster, Lupton, Smith, and Stafford (2000) suggest that the significant capital gains in corporate equities experienced since 1984 are responsible for the more recent decline in the personal saving rate. Backus, Henriksen, Lambert, and 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.}

Another notable change between 1960 and 2004 has been the growing current account (CA) deficit in the U.S. Figure 2 displays the CA deficit between the U.S. and a set of its trading partners during this time period. The secular decline in the current account especially since the 1990s is evident in all the series.\footnote{Data on U.S. current account balance against various regions come from International Economic Accounts of Bureau of Economic. The data on the U.S. current account balance against our sample of OECD countries are the sum of the U.S. current account balances against Western Europe, Canada and Japan. After 1998 we use the U.S. current account balance against EU-15 to substitute for U.S. current account balance against Western Europe. Bilateral current account balance between U.S. and China is available since 1997.} Several authors have been analyzing the consequences of these large global imbalances. There seem to be two opposing views on this issue. On the one hand there is growing concern about the consequences of these global imbalances. For example, Obstfeld and Rogoff (2004) predict that the current account imbalances in the U.S. will result in a 30\% depreciation of the dollar. Roubini and Setser (2005) suggest that the U.S. is on an unsustainable and dangerous path. Summers (2004) cautions that the current account deficit in the U.S. has all the hallmarks of a particularly
serious situation. On the other hand, in a descriptive paper, Backus, Henriksen, Lambert and Telmer (2005) suggest that the current account deficit in the U.S. is mainly due to the weak economic conditions in several high-surplus countries relative to the U.S. and argue that “things are fine”. Several other explanations have been put forward to try to understand potential causes of the current account deficit. Fogli and Perri (2006) argue that the fall in the U.S. business cycle volatility has lead to lower precautionary savings resulting in lower current account balances. Mendoza, Quadrini and Rios-Rull (2007) argue that the U.S. has been accumulate foreign liabilities because the financial markets in the rest of the world are less well developed. Finally, Attanasio and Violante (2005), Domeij and Floden (2006), Henriksen (2005), and Krueger and Ludwig (2006) highlight the importance of demographic differences between regions leading to large and persistent current account imbalances.

Since 1960s there have been substantial changes in several macroeconomic indicators in the U.S. and the rest of the world that can have important consequences for the behavior of the national saving rates and the current account balances. For example, the average population growth rate and the depreciation rate between 1960 and 1980 in the U.S. were 1.8% and 4.3%, respectively. By 2000 the population growth rate had declined to about 0% while the depreciation rate had increased to 5.3%. While both of these changes would put a downward pressure on the saving rate in the U.S., there were other changes in the
economic environment, such as the decline in the capital income tax rate, that would have encouraged savings over this time period. Meanwhile some of these exogenous variables have been changing at different rates in the rest of the world. In particular, we later document that the rates of growth of total factor productivity (TFP) in a set of OECD countries relative to the U.S. have declined between 1960 and 2004.

In this paper we explore the quantitative implications of changes in TFP growth rates, factor income tax rates, population growth rates and depreciation rates in the U.S. relative to its trading partners on the secular trends in the net national saving rate and the current account balance using the standard growth theory. We start by studying the U.S. as a closed economy. We employ the neoclassical growth model with an infinitely-lived representative agent facing complete markets. We calibrate the economy to the U.S. data for the 1960-2004 period and use this model to isolate the quantitative impact of the domestic factors on the decline in the U.S. saving rate. First we show that the simple growth model is able to capture the consumption-saving trade-off reasonably well. Next, we conduct deter-

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3Our 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, 2002, 2004), Kehoe and Prescott (2002), and Chen, Imrohoroglu and Imrohoroglu (2006) in using an applied general equilibrium setup to account for the observed time path of the U.S. saving behavior and the current account balance.
ministic simulations, as in Hayashi and Prescott (2002), and perform an accounting exercise to evaluate the quantitative impact of the population growth rate, depreciation rate, TFP growth rate, and tax rates on the secular trends in the U.S. saving rate. Our results suggest that the secular decline in the population growth rate and the increase in the depreciation rate explain nearly half of the decline in the net national saving rate in the U.S. Changes in the TFP growth rate generate annual fluctuations in the saving rate that resemble the data reasonably well.

In order to address the decline in the U.S. saving rate and the CA balance simultaneously, we specify a two-country economy where differences between the U.S. and the rest of the world (ROW) with respect to the exogenous variables are introduced. For the ROW we restrict our attention to a subset of OECD countries for which we have consistent measurements. We calibrate their TFP growth rates, population growth rates, shares of government purchases in output, and tax rates on capital and labor income for the same period. Overall our results indicate that it is possible to generate realistic current account deficits for the U.S. in a carefully calibrated model. We conduct several counterfactual experiments to investigate the factors behind the secular decline in the U.S. current account. Our findings indicate that differences in the TFP growth rates play a significant role in the secular decline of the U.S. current account. We show that if the only difference between the U.S. and the ROW were their TFP growth rates, the model would still generate a declining current account balance for the U.S. When the TFP growth rates are relatively higher in the U.S., so are the returns to capital in the U.S. This drives up the demand for investment in the U.S. relative to its trading partners and its own domestic saving, generating the main reason for the secular increase in the current account deficit in the model economy.

Although the simple growth model is useful in explain some of the features of the U.S. saving rate and the current account balance, significant puzzles remain. In particular, the model misses the U.S. boom in hours in the 1990s. Consequently, the model generated NIPA accounts miss their empirical counterparts after 1990s as others have also demonstrated. Once a labor wedge, as in Chari, Kehoe and McGrattan (2004) or Ohanian, Raffo, and Rogerson (2006) is incorporated into the model the match improves significantly. Nevertheless, we argue that the model captures the consumption-saving trade-off reasonably well and can be a useful tool in understanding the main factors impacting the secular behavior of savings and current account balances.

The paper is organized as follows. Section 2 presents the growth model used in the paper and how it is calibrated to the U.S. economy. Our main quantitative findings are presented in Section 3. The results of the extension of the model to a two-country economy are given in Section 4. Section 5 conducts a sensitivity analysis and concluding remarks are given in Section 6. The Appendix contains calibration details and data sources.

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2 The Standard Growth Model

In this section we examine the properties of an closed economy. This allows us to isolate the quantitative impact of the domestic factors on the decline in the U.S. saving rate between 1960 and 2004. We show that the standard neoclassical model can be an effective tool in understanding the behavior of the saving rate until the early 1990s. In the next section we examine an open economy where differences between the U.S. and the ROW with respect to the exogenous variables are introduced. We investigate the role of these exogenous variables in impacting the secular movements in the U.S. current account.

2.1 The Environment

There is a stand-in household with $N_t$ working-age members at date $t$, that solves

$$\max_{c_t} \beta^t N_t(\log c_t + \alpha \log (1 - h_t))$$

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, $\beta$ is the subjective discount factor, $\alpha$ 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, $\pi_t$ is a lump sum tax, $r_t$ is the rental rate of capital, and $\delta_t$ is the time-$t$ depreciation rate. The size of the household evolves over time exogenously at the rate $n_t = N_t/N_{t-1}$. 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 $\theta$ is the income share of capital and $A_t$ is total factor productivity, which grows exogenously at the rate $g_t = A_t/A_{t-1}$.

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 $\pi_t$ 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, $\pi_t$ is the primary government deficit in the model.

The definition of the competitive equilibrium of this economy is standard and provided in the Appendix 7.1.

### 2.2 Measurement and Calibration

We measure the saving rate using

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

where in this closed economy $Y_t$ is measured using GNP.

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, $\theta$, is set to its average value of 0.4 over our sample period 1960-2004. The subjective discount factor, $\beta$, 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, $\alpha$, is set to 1.45 to match an average workweek of 35 hours.

**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, $g_t - 1$, population growth rate, $g_t - 1$, depreciation rate, share of government purchases in GNP, $\psi_t$, share of government transfers in GNP, $TR_t/GNP_t$, and capital and labor income tax rates, $\tau_{k,t}, \tau_{h,t}$.$^5$ Empirical marginal tax rates are constructed using the methods of Joines (1981) and McGrattan (1994). The data used in the calibration are provided in the

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$^5$TFP is calculated as

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

where the capital share $\theta$ is set to 0.4, $Y_t$ is GNP plus service flow from the stock of consumer durables and government capital, $K_t$ is capital stock inclusive of foreign capital, stock of consumer durables and government capital, and $H_t$ is aggregate hours worked. In this framework savings 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. Several TFP growth rates based on different definitions of capital are provided in the Appendix 7.6. Gomez and Rupert (2005) also provide
Appendix 7.2. We compute the initial capital-output ratio in 1960 as 3.5 and take it as a given initial condition.

**Calibration of 2005 and beyond:** We assume that the U.S. economy starts from given conditions in 1960 and eventually converges to a steady-state in 2070. In our benchmark model, we set the exogenous variables listed in table 1 equal to their steady state values starting in 2005. 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. Based on the ‘middle’ growth projections by the Census Bureau’s we set the population growth rate after 2004 and at the steady state equal to 1%. 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 depreciation rate in 2004. Our results are not sensitive to different assumptions about the calibration of most of the variables for the period 2005 and beyond. One variable that matters for the results is the growth rate of TFP. We discuss its impact in the sensitivity analysis.

<table>
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<tr>
<th>Table 1: Parameter Values for 2005 and Beyond, Closed Economy</th>
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<td>$g_t - 1$</td>
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three different measures of 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.

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 the growth rates of civilian non-institutional population 16 years and over reported by the BLS. Population projections are taken from U.S. Bureau of the Census (http://www.mnforsustain.org/united_states_population_growth_graph.htm)

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.
2.3 Numerical Solution

Our numerical solution procedure follows Hayashi and Prescott (2002). After calibrating the model parameters and exogenous variables, we first compute a final steady-state for the U.S. economy in a sufficiently distant future. To obtain this steady-state, we derive the equilibrium conditions of the model, detrend variables to induce stationarity, and then impose these steady-state conditions.\(^\text{10}\) Given this final steady-state, we use a shooting algorithm from given initial conditions in 1960 toward the final steady-state to compute the transition path. In particular, we start from a given value of the initial capital stock \(K_0\), guess a value for the endogenous variable \(C_0\) and use the Euler equation and resource constraint to obtain a path for the endogenous variables \(C_t\), \(H_t\) and \(K_{t+1}\) towards their steady-state values. If the path does not connect with the steady-state, 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 \(C_t\), \(H_t\) and \(K_{t+1}\), we can then use other equilibrium conditions to construct time paths of all aggregate quantities and prices.

3 Results for the Closed Economy

In this section we will first examine the general properties of the neoclassical growth model. Next, we will examine its implications for the U.S. saving rates.

3.1 General Properties

Figure 3 displays the model’s predictions for per capita GNP, hours, capital, labor productivity, capital output ratio and consumption output ratio together with their counterparts in the data. The model generated series and the data, except for hours per capita, are all detrended by \(1.018^t\).

The model generated per capita hours and GNP display large gaps from their data counterparts, as shown in Figure 3. In particular, simulated labor supply displays a decline while hours per capita in the data increase.\(^\text{11}\) As a result, we observe a divergence of our theory from data for both average labor productivity and capital-output ratio from early 1990s, although the discrepancy between the model and data is relatively small before then.

The reason for the hours boom in the U.S. is not well established. One possibility is the increase in the labor force participation of women. McGrattan and Rogerson (2004) show that the increase in hours per capita observed in the U.S. is mainly due to the increase in the labor force participation rate of females. In fact, between 1950 and 2000, employment to population ratio of women increases by 87% while that of men declines by 15.7%. Between

\(^{10}\) The details are provided in the Appendix 7.1.

\(^{11}\) These discrepancies were also noted by Uhlig (2003) and McGrattan and Prescott (2007b), among others.
Figure 3: Model Properties with Constant Labor Wedge
1980 and 2000 employment to population ratio of women increases by 17%. The simple framework used in this model is not capable of mimicking these trends.\footnote{Several papers investigate the rise of the female labor force participation such as Jones, Manuelli and McGrattan (2003), Olivetti (2001), Akbulut (2005), and Caucutt, Guner, and Knowles (2002).} It is also possible that the reason for the hours boom lies somewhere else such as the intangible capital explanation advanced by McGrattan and Prescott (2007a) or the change in wage markups argued by Smets and Wouters (2007).

In order to further understand the performance of the standard model, but without taking a stand on the main reasons behind the hours boom in the data, we introduce a labor wedge into the model. We would get a perfect match between the model and the data if we introduced a labor wedge and an investment wedge that would force equations 13 and 15 to hold. In the following experiment we introduce only the labor wedge to examine the role of labor in generating the results in Figure 3. Specifically we use the labor wedge calculated from
\[
L_{wt} = \frac{\alpha h_t C_t}{(1 - h_t)(1 - \tau_{h,t})(1 - \theta)Y_t}.
\]
After computing the labor wedge we replace \( (1 - \tau_{h,t}) \) in equation 13 with \( (1 - \tau_{h,t})L_{wt} \). Since we already have taxes in this model, the labor wedge would have to be a proxy for labor distortions other than taxes.

Figure 4 displays the results of this experiment with the labor wedge. Hours per capita do not match the data perfectly since we only have the labor wedge and do not have the investment wedge. The rest of the model-generated series resemble the U.S. data reasonably well. In particular, after we use labor wedges to generate an hours boom in the 1990s, the model accounts for both average labor productivity and capital-output ratio reasonably well. We conjecture that extensions of the standard model which can capture the hours boom may be successful in mimicking the other aspects of the U.S. economy well.\footnote{The labor wedge needed to generate these results is not non-negligible especially for the 1984-2004 period. It starts at the value of 1.0 in 1960 and grows to 1.12 at the end of 1984. However, the wedge that is needed to match the hours has to increase by 42% between 1984 and 2004. It is hard to explain the size of the wedge using labor distortions other than taxes especially for the later period. For the earlier period, it is possible that a model which incorporates the increases in labor force participation of women may explain the size of the wedge needed.}

### 3.2 Consumption-Output Ratio, Saving Rate and Interest Rate

We now turn our focus to the consumption-output ratio and the saving rate to evaluate the extent to which the model is able to mimic the real interest rate and the consumption-saving trade-off. In order to quantify this trade-off, it will be useful to re-write the Euler equation as
\[
\frac{C_{t+1}/Y_{t+1}}{C_t/Y_t} = \frac{Y_t}{Y_{t+1}} \beta \left[ 1 + (1 - \tau_{k,t+1}) (r_{t+1} - \delta_{t+1}) \right].
\]
Figure 4: Model Properties with Varying Labor Wedge
Figure 5: Investment Wedge

The left hand side of (1) is the growth rate of consumption-output ratio, which we can easily calculate from NIPA (after reorganizing the accounts so they match model accounts). We can also calculate the model-generated growth rate of consumption-output ratio using the right hand side of (1), taking $Y_t$ and $r_t$ from the data. We call the discrepancy between the two computations the “investment wedge”.

Figure (5) plots the rate of growth of consumption-output ratio from the data (the LHS of (1)) and the model’s prediction for the same growth rate after using the data on output and the real interest rate. We observe that the two measures for the growth rate of consumption-output ratio track each other very closely except the brief period in the mid- to late-1980s. This indicates that the standard theory is able to capture the consumption-saving trade off fairly well without the need to introduce additional frictions.

How well does the model perform in terms of the real interest rate? Figure (6) displays the after-tax rate of return to capital in the data and the model economy. We see that the model-generated after-tax rate of return to capital is fairly close to the data except for the mid- to late-1990s. Note that this divergence between the model and data in the 1990s is closely linked to the failure of our model to generate the hours boom in that period. In our model, hours are depressed in the 1990s while in the data they are booming. As a result,
the rate of return for capital decreases in our model while it increases quickly in the data.\footnote{In the version of the model with the labor wedge the gap between the data and the model generated rate of return to capital in the 1990s disappears.}

Next we examine our model’s performance with respect to the U.S. saving rate. In Figure (7) we display the data and the model generated net national saving rates with and without the labor wedge between 1960 and 2004. Saving rates generated by the two models are remarkably similar to each other until late 1980s. They both capture the secular decline from 1960 up to early 1990s, as well as the annual fluctuations in the actual U.S. data. However, both models generate higher saving rates than those in the data for the 1960s and lower rates for 1980s.\footnote{Later in sensitivity analysis, we show that some of the large fluctuations obtained in these graphs are due to the perfect foresight assumption. When the TFP growth rate is assumed to be stochastic, the simulated saving rates display smaller fluctuations compared to the perfect foresight case. Households’ intertemporal behavior is subdued due to the lack of perfect foresight of the real return to capital. Other features of the saving rate do not change significantly when the perfect foresight assumption is abandoned. This is consistent with the findings in McGrattan and Prescott (2007b).} After early 1990s the model with the labor wedge predicts higher saving rates than the model without the wedge. The differences in the saving rates between the two models grow in the 1990s. While the saving rate generated by the model without the labor wedge seems to mimic the data well for 1990s, we do not consider it a successful model since its performance along other dimensions as shown in Figure 1 is not satisfactory. Note that the major reason for our model’s unsatisfactory performance in the 1990s is not
that the standard model misses any important frictions that distort the consumption-saving trade-off. Rather, as our previous analysis shows, it is because the standard model is unable to generate the hours boom and thus the after-tax rate of return to capital. On the other hand, the finding that the saving rates generated by the two models are “similar” until the 1990s indicates that the model without the labor wedge is reasonably good in replicating the consumption-saving trade-off in the actual economy for that period even though it misses the consumption-leisure trade-off. Consequently, we will rely on the standard model to further examine the factors behind the secular decline in the saving rate until 1990s.\footnote{We also examined the private and the government saving rates separately in the benchmark economy. Our results indicate that the simulated government saving rates look reasonably close to its counterpart in the data while the private saving rate captures all the discrepancies that were present in the earlier results for the net national saving rate.}

3.2.1 Basic Intuition

In order to understand the main factors behind the behavior of saving over this time period, we conduct several counterfactual experiments. We use the model without the labor wedge to carry out these counterfactual experiments.\footnote{Notice that the model with the labor wedge is not truly suitable for running counterfactual experiments. For example, the wedge is calculated using the labor income taxes in the data. It would be impossible to run...} While we graph the results of the simulations...
and the data for the entire time period, our main focus is from 1960 to late 1980s where the
standard theory seems to perform reasonably well.

The intuition on how our model ingredients might affect the saving rate can be readily
seen from a back-of-envelope calculation of saving rates in the steady state

\[
\frac{S - \delta K}{Y} = \theta \frac{\gamma + n}{(\rho + \gamma) / (1 - \tau_k) + \delta}
\]

where \( \gamma = g^{1-\mu} \) denotes the growth rate of TFP factor. For simple analytical tractability, we
define the saving rate here as the ratio of net saving to gross output. From equation (2), a
decline in population growth rate, an increase in the depreciation rate, and a decline in the
growth rate of TFP all cause a decline in the saving rate. By contract, a decline in capital
income tax rate increases the steady-state saving rate. In particular, given our calibrated
parameter values, a decline in the population growth rate from 1.8% in the 1960s to 1.0%
afterswards and an increase in the depreciation rate from 4.3% before 1980 to 5% afterwards
would together cause a decline in saving rate by 3 percentage points, ceteris paribus.\(^{18}\)

3.2.2 Counterfactual Experiments

In our benchmark calibration, we 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. During 1960-2004 there was a significant decline in the population
growth rate and an increase in the depreciation rate. In addition, there was a decrease in
the capital income tax rate and an increase in the labor income tax rate.\(^{19}\) To isolate the
impact of these changes one at a time, we start with setting all exogenous variables equal to
their averages over 1960-2004. Later we add the time series data for each exogenous variable
one at a time.

Population and Depreciation: 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 to
GNP) are set to their long-run averages except for the population growth rate. In Figure 8,
the series labeled ’Time series for population 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 moderate, resulting in a 1-2% decline by early 1990s.

\(^{18}\)We thank Ellen McGrattan for suggesting these calculations.

\(^{19}\)Data are provided in the Appendix 7.6.
Next we generate a saving rate where both the population growth rate and the depreciation rate are set to their time series values. The rest of the exogenous variables are kept at their long-run averages. The results of this experiment are displayed by the saving rate labeled ‘Time series for population and depreciation’. The increase in the depreciation rate and the decrease in the population growth rate together account for 3-4 percentage point decline in the saving rate by early 1990s. The difference between the two simulated series also shows the impact of the depreciation rate alone in generating a decline in the saving rate especially in mid 1990s.

**TFP Growth Rate:** 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 9. First, it shows significant fluctuations that mimic the data rather well until 1975. Consistent with our intuition, a decline in the TFP growth rate between 1960s and 1980s causes a drop in the saving rate by about 2 percentage points. Between 1980s and 2004, however, the average TFP growth rate increases above its long-run trend. Accordingly, our

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20Figure A2 in the appendix displays the TFP growth rate for the U.S. under several different measures of the capital stock.
model predicts an increasing saving rate from mid-1980s. Our findings indicate that the model generated saving rates would have been much higher in the late 1990s if they were only due to the movements in the TFP growth rate.

Overall, our results suggest that i) the decline in the population growth rate and the increase in the depreciation rate alone account for a 3-4 percentage point decline in the saving rate, ii) the decline in the TFP growth rate before 1980s contributes to about 2% of the decline in the saving rate during this period, iii) observed TFP growth rates alone would have caused the saving rate to be much higher in the 1990-1995 period, and, iv) the decline in the TFP growth rate in 2001 had a significant negative impact on the saving rate.

4 Extension to A Two-Country Economy

In the previous section, we show that domestic factors alone play quantitative important roles in explaining the U.S. saving rate. In a closed economy, these factors, however, are also the driving forces for domestic investment. Therefore, the above setup is silent on the secular trend of current account balance. To explore the current account balance, we now open this economy up to introduce other factors that could potentially affect the U.S. domestic investment.
4.1 The Environment

Consider a perfect foresight two-country growth economy. For each country \( i = \{1, 2\} \), there is a stand-in household with \( N_i^t \) working-age members at date \( t \). Households are assumed to own the capital, \( K_i^t \), and rent it to businesses. The law of motion for the capital stock is given by equation 4. Both capital and labor are immobile across countries. We assume that there is a risk-free bond traded internationally each period. In this framework a representative household in country \( i \) maximizes

\[
\sum_{t=0}^{\infty} \beta^t N_i^t (\log c_i^t + \alpha \log (1 - h_i^t))
\]

subject to

\[
B_{i+1}^t + C_i^t + X_i^t + \phi K_i^t \left( \frac{X_i^t}{K_i^t} - \varphi^i \right)^2 
\leq B_i^t (1 + r_B^i) + (1 - \tau_{h,t}^i) w_i^t H_i^t + r_i^t K_i^t - \tau_{k,t}^i(r_i^t - \delta_i^t)K_i^t + TR_i^t - \pi_i^t \tag{3}
\]

\[
K_{t+1}^i = (1 - \delta_i^t) K_i^t + X_i^t 
\]

\[
B_0^i, K_0^i \text{ given,}
\]

where \( c_i^t = C_i^t / N_i^t \) is per member consumption, \( h_i^t = H_i^t / N_i^t \) is the fraction of hours worked per member of the household, \( \beta \) is the subjective discount factor, \( \alpha \) is the share of leisure in the utility function, \( H_i^t \) is total hours worked by all working-age members of the household, \( B_i^t \) is the beginning of period bond holdings by country \( i \), \( r_B^i \) is international interest rate, \( \tau_{h,t}^i \) and \( \tau_{k,t}^i \) are tax rates on labor and capital income, respectively, at time \( t \), \( w_i^t \) is the real wage, \( TR_i^t \) is a government transfer, \( \pi_i^t \) is a lump sum tax, \( r_i^t \) is the rental rate of capital, and \( \delta_i^t \) is the time-\( t \) depreciation rate in country \( i \). The size of the household evolves over time exogenously at the rate \( n_i^t = N_i^t / N_{i-1}^t \). Following the literature we have quadratic adjustment costs for each country’s capital accumulation represented by \( \phi K_i^t \left( \frac{X_i^t}{K_i^t} - \varphi^i \right)^2 \). In general, adjustment costs lead to smoother fluctuations in the current account. This allows us to concentrate on understanding the secular patterns in the current account.

The aggregate production function is given by

\[
Y_i^t = A_i^t (K_i^t)^\theta (H_i^t)^{1-\theta},
\]

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

\[\text{21} \]To make sure that the steady state in the economy with adjustment costs is the same as the one without, we set the parameter \( \varphi^i \) equal to the investment-capital ratio at the steady state, \( (g_i^t)^{1-n^i} n^i - 1 + \delta^i \), where the TFP growth rate \( g_i^t \), population growth rate \( n^i \) and the depreciation rate \( \delta^i \) denote the values of their counterparts on the balanced growth path.

\[\text{22} \]In section 5.2 we examine the sensitivity of our results to the adjustment cost parameter.
In each country $i$, 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 $G_i^t$ and government transfers $TR_i^t$. A lump sum tax $\pi_i^t$ is used to ensure that the government budget constraint is satisfied each period:

$$G_i^t + TR_i^t = \tau^l_i w_i^t H_i^t + \tau^k_i (r_i^t - \delta_i^t) K_i^t + \pi_i^t.$$ 

In other words, $\pi_i^t$ is the primary government deficit in the model.

National accounting identity is given by:

$$C_i^t + I_i^t + G_i^t + B_{i+1}^t = Y_i^t + B_i^t (1 + r_i^B).$$

or

$$C_i^t + I_i^t + G_i^t + CA_i^t = Y_i^t + B_i^t r_i^B = GNP_i^t,$$

where $CA_i^t = B_{i+1}^t - B_i^t$ is the current account balance for country $i$, $I_i^t = X_i^t + \phi K_i^t \left( \frac{X_i^t}{K_i^t} - \varphi \right)^2$.

In Appendix 7.5, we provide the definition of competitive equilibrium for this two-country model and the equilibrium conditions.

4.2 Measurement and Calibration

Our analysis is limited by the number of countries for which we can get consistent estimates of several exogenous variables, in particular the TFP growth rate. Consequently, we restrict our analysis to the CA balance between the U.S. and the following group of OECD countries: Austria, Canada, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom. For simplicity we refer to these OECD countries as the Rest of the World (ROW). We derive TFP growth rates for the U.S. and the ROW using data from Groningen Total Economy Database. For the ROW, we generate aggregate output, capital, and hours as the weighted sum of each individual country’s output, capital and hours, all weighted by each individual country’s output share.\(^{23}\)

Then we use the Solow decomposition to get aggregate TFP for the ROW. The TFP computed in this way differs very little from the TFP computed as the weighted average of TFP of individual countries, weighted by each country’s output share. We also compute the average population growth rate of the ROW using the same weighting method.

\(^{23}\) The data on the capital stock is not available from Groningen Total Economy Database. To compute the real capital stock that is consistent with real GDP in constant 1990 dollars (converted at Geary Khamis PPPs), we collect the data of real total capital stock as a percentage of real GDP between 1960 and 2001 from the Kiel Institute database on capital stock in the OECD countries. We then multiply this ratio with real GDP from Groningen Total Economy Database to obtain data of real capital stock for each country. We impute the real capital stock after 2001 by multiplying the real total capital stock as a percentage of real GDP at 2001 and the real GDP in each of the last three years.
We measure the saving rate using
\[ \text{savin}^i_t = \frac{Y^i_t - G^i_t - C^i_t - \delta^i_t K^i_t}{Y^i_t - \delta^i_t K^i_t}, \]
where \( Y^i_t \) is GDP in country \( i \) at time \( t \). Similarly, we compute the current account deficit as a percentage of GDP as
\[ \text{ca}^i_t = \frac{B^i_{t+1} - B^i_t}{Y^i_t}. \]

**Constant Parameters:** There are four parameters that are time and country invariant throughout our analysis. The capital share parameter, \( \theta \), is set to 0.4. The capital adjustment cost parameter, \( \phi \), is set to 1, which is well within the range of values used in the literature.\(^{24}\) The subjective discount factor, \( \beta \), is set to 0.9702 so that the capital output ratio is 3.2 at the final steady state in the U.S. The share of leisure in the utility function, \( \alpha \), is set to 1.45 to match an average workweek of 35 hours in the U.S.

**Calibration of the Initial Conditions:** We use the initial capital-output ratio for the U.S. in 1960, 3.5, to pin down the initial capital stock for the home country. We set the initial capital stock for the ROW to be 1.55 times that in the U.S., which is the actual ratio of capital stocks between ROW and the U.S. in 1960. The initial foreign asset holdings, \( \bar{b}^1_{1960} \) and \( \bar{b}^2_{1960} \) are both set to be zero.

A crucial parameter for the results is the size of the U.S. relative to the ROW in 1960. This relative size determines the importance of the U.S. in shaping the world prices relative to the ROW. If the ROW is too small to impact the world prices then the model converges to the closed economy case with a zero current account balance for the U.S. In our benchmark calibration, we have chosen the relative size such that the current account deficit generated by the model in 1960 is equal to its counterpart in the data.\(^{25}\) After the initial size is pinned down, the actual TFP and population growth rates determine the evolution of the relative size over time.\(^{26}\)

**Calibration of the 1960-2004 period:** In our benchmark simulation, we use the actual time series data for the U.S. and the ROW between 1960-2004 for the TFP growth rate, \( g_t - 1 \), population growth rate, \( n_t - 1 \), share of government purchases in GDP, \( \psi_t \), and capital and labor income tax rates, \( \tau_{k,t}, \tau_{h,t} \).\(^{27}\) The tax rate data for the U.S. and the ROW comes from updated calculations of Mendoza, Tesar and Razin (1994) up to 1996. For

\(^{24}\) See, for example, Baxter and Crucini (1993, 1995), Fogli and Perri (2006).

\(^{25}\) As we change the initial relative size and make the ROW matter more and more in 1960, model generated current account surplus for the U.S. in 1960s and the current account deficit in 2004 get implausibly large. In section 5.2 we present sensitivity analysis to this parameter.

\(^{26}\) An alternative is to introduce an openness index as in McGrattan and Prescott (2007c) that would impact the role of the U.S. in shaping the world prices.

\(^{27}\) The data on government purchases as a percent of GDP is calculated using the data of Government final
years after 1996 we set the tax rates equal to their 1996 values. For the ROW we set the
depreciation rates $\delta_t$, and the shares of government transfers in $GDP$, $TR_t/GDP_t$, equal to
the values in the U.S. All the data used in the paper are provided in the Appendix 7.6.

**Calibration of 2005 and beyond:** We assume that the U.S. and the ROW start
from given conditions in 1960 and eventually converge to a steady-state in 2070. In our
benchmark model, we set the seven exogenous variables in table 2 equal to their steady state
values starting in 2005. Similar to our closed economy, we set the U.S. population growth rate after 2004 and at the steady state equal to 1%. Since projections for the ROW are
not very different from the U.S. we set the steady state population growth in the ROW also
equal to 1%. Also, we set the U.S. depreciation rate equal to 5% for year 2005 and beyond,
similar to our closed economy. For the OECD countries we use the same depreciation rates
as the U.S. Again, our results are not sensitive to different assumptions about the calibration
of most of the variables for the period 2005 and beyond.

| Table 2: Parameter Values for 2005 and Beyond, Open Economy |
|------------------|------------------|
|                  | U.S. | ROW |
| $g_t - 1$       | TFP Growth Rate | 0.011 | 0.011 |
| $n_t - 1$       | Population Growth Rate | 0.01 | 0.01 |
| $\psi_t$       | Government Purchases to GDP Ratio | 0.16 | 0.18 |
| $\delta_t$     | Depreciation Rate | 0.05 | 0.05 |
| $TR_t/GDP$     | Transfers to GDP Ratio | 0.08 | 0.08 |
| $\tau_{k,t}$  | Capital Income Tax Rate | 0.42 | 0.34 |
| $\tau_{h,t}$  | Labor Income Tax Rate | 0.29 | 0.38 |

### 4.3 Numerical Solution

**Detrending:** For an aggregate variable of each country $i$, denoted as $z_t^i$, its detrended
version is given by: $\hat{z}_t^i = Z_t^i / \left[ (A_t^i)^{1-\xi} N_t^i \right]$. Note that for each country, an aggregate variable
is detrended by its own TFP factors and population size. The detrended international bond
consumption expenditures in national currency units for each country from OECD annual national accounts.
Data on transfer for the U.S. is obtained from National Income and Product Accounts. We use the same
data for the OECD countries. We obtain data on population from 15-64 years old from UN demographic year

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28 With our assumed tax rates, the government budget in the U.S. will be in a surplus at the steady state.

29 Population growth rates are the growth rates of civilian non-institutional population 16 years
and over reported by the BLS. Population projections are taken from U.S. Bureau of the Census
(http://www.mnforsustain.org/united_states_population_growth_graph.htm)
The market clearing equation is
\[ \tilde{b}_{t+1}^1 = -\tilde{b}_{t+1}^2 s_{t+1} \]  
(5)
where we follow McGrattan and Prescott (2007c) and denote \( s_{t+1} = \left( \frac{A_{t+1}^2}{A_{t+1}^1} \right)^{-1} \frac{N_{t+1}^2}{N_{t+1}^1} \) as the relative size of the two countries. Note that we can solve recursively for the entire sequence of \( s_{t+1} \) from \( s_{t+1} = g_1^{t+1} g_2^{t+1} \) given \( s_0 \) and the sequence of \( \{g_t^i, n_t^i\}_{t=0,1,\ldots,\infty} \).

Algorithm to compute the transition path and the steady-state: Given the steady state net foreign asset distribution \( \{\tilde{b}^1, \tilde{b}^2\} \), we can solve for other macro variables in the steady state. However, the steady state net foreign asset distribution depends critically on the transition path and the initial asset distribution. Therefore we need to solve for the transition path and the steady state simultaneously. Note that for equations (20) and (21) to hold for each country at the steady state, it must be \( g_1 = g_2 \) at the steady state. Similarly, for the relative size of the country to be stationary, we have \( n_1 = n_2 \).

We assume that the economy reaches steady state at some future date \( T \). Then starting from some initial asset distribution \( \{k_0^i, h_0^i, \tilde{b}_0^i\} \), we can solve for the entire path of \( \{c_t^i, c_t^2, r_t^B, k_{t+1}^i, k_{t+1}^2, b_{t+1}^i, b_{t+1}^2, h_{t+1}^i, h_{t+1}^2\} \) for \( t = 0 \) using the system of nonlinear equations (13), (20), (21), (23) and (5). To rule out Ponzi schemes, we require that at the steady state
\[ \tilde{b}_T^i \left( g_T^i \right)^{1-\theta} n_T^i - (1 + r_T^B) = (1 - \psi_T^i) \left( k_T^i \right)^{\theta} (h_T^i)^{\theta-1} - \tilde{c}_T^i - \tilde{x}_T^i \]
so that agents will not borrow infinitely. Note however, it is possible that at the steady state \( \tilde{b}^i \neq 0 \).

4.4 Results for the Open Economy

We start this section by showing the saving and investment rates obtained for the U.S. economy in the open economy setting without the labor wedge. A notable difference between the saving rate generated in this case as shown in Figure 10 and the earlier closed economy case in figure 7 is the lack of the sharp decline in the saving rate in 1980s that was present in the earlier case. This is due to the assumption of adjustment costs present in the open economy version.

We now present the model generated current account balances and the data. Figure 11 shows that our model generated CA balance captures quite well the overall secular decline in the observed CA balance since 1960s. In particular, both series start from a surplus of around 0.3% in 1960 and end up with a CA deficit about 2% in 2004. This result indicates that it is possible to generate realistic current account deficits for the U.S. in a carefully calibrated standard neoclassical growth model.

As Chattejee (1994) shows in a complete market economy there are infinite number of steady state wealth distributions.
Figure 10: U.S. Saving and Investment
4.4.1 Counterfactual Experiments

As in the closed economy case, we conduct several counterfactual experiments to understand the driving forces behind the CA deficits found in our framework. Figure 12 shows that the secular trends in the TFP growth rates between the U.S. and the ROW have been quite different. Notice that ROW display higher TFP growth in the 1960s relative to the U.S. The country that is mostly responsible for that measurement is Japan. In our framework where there is free trade, the model implies that capital should flow from the U.S. to the ROW in the 1960s. We also observe the trend TFP growth rates to reverse in the late 1990s where U.S. TFP growth exceeds that of the ROW indicating capital should flow to the U.S. This motivates us to investigate the role of the TFP growth rate versus the other exogenous variables which include the population growth rate, tax rates, and the share of government expenditures in GNP.

In our first counterfactual experiment we examine what would have happened to the CA balance of the U.S. if the ROW had the same TFP growth rates as the U.S. throughout this period. The only differences between the U.S. and the ROW in this case are due to the differences in the population growth rates, G/Y, and tax rates. The result of this

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31 Similar to the closed economy case, we use the economy without the wedge to run the counterfactual experiments.
experiment is depicted in figure 13. The line ‘Identical TFP growth’ shows the CA balance that would have resulted in the U.S. economy if the ROW had the same TFP growth rates as the U.S. In this experiment the model implied current account surpluses of the 1960s disappear. In addition, the CA deficit in 2004 declines from 2.2% in the benchmark case to 1%. More importantly, the current account balance implied in this case does not display a trend. Similar results are obtained when population growth rate, G/Y, and tax rates are introduced one at a time.32 Our findings cast doubt on the quantitative importance of the differential aging of populations in explaining the secular decline in the U.S. current account balance.

In the second counterfactual experiment, we shut down all the exogenous differences between the ROW and the U.S. except for the differences in TFP growth rates. We use the population growth rate, G/Y, and the tax rates that prevail in the U.S. for both the U.S. and the ROW. The only country specific exogenous variable we allow for is the TFP growth rate. Figure 14 displays the resulting CA balance labeled as “ROW same as U.S. except for TFP growth”. The secular decline in the U.S. CA balance clearly comes from the differences

32The relatively constant 1% CA deficit obtained in this counterfactual experiment comes mostly from the higher labor taxes in the U.S. and the differences in the level of capital stock that existed between the U.S. and the ROW in 1960. If we force the U.S. and the ROW to have the same initial levels of capital we get a flat current account deficit of 0.5%.
in TFP growth rates in this exercise. These differences drive up the U.S. investment demand relative to savings resulting in an increase in the U.S. current account deficit. These results are robust to alternative measures of TFP which are shown in figure A2 in the Appendix 7.2.

In summary, our findings suggest that the secular decline in the U.S. CA balance may be due to the differences in the TFP growth rates between the U.S. and the ROW. In other words, the standard growth model may be able to capture the secular movements in the current account against OECD countries reasonably well once differences in key exogenous variables, in particular the TFP growth rate across countries is incorporated into the analysis.

5 Sensitivity Analysis

In this section we will examine the sensitivity of our results to some of the modelling assumptions and parameter choices

5.1 Closed Economy

We start by examining the sensitivity of our closed economy results.
5.1.1 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 15, 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. There are noticeable difference in the 1990-2004 period between the two series. However, the two series are virtually identical until the 1990s which is one of the reasons why focus our results up to the 1990s.\textsuperscript{33}

5.1.2 No Perfect Foresight

So far we have assumed perfect foresight. Households know the entire time path of all exogenous variables. In this section, we will summarize our findings from two alternative

\textsuperscript{33}Among the exogenous variables for which we had to make assumptions about future values, TFP growth rate was the most important. Different assumptions about the values of the rest of the exogenous variables for 2005 and beyond had insignificant consequences in the results up to 2004.
Figure 15: Role of the Future 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 \( \lambda \) near zero indicates near-static expectations whereas a \( \lambda \) 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 16 displays observed saving rates and a collection of simulated saving rates indexed by a few values of \( \lambda \). Even the near-static expectations cases with low values of \( \lambda \) 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.

**Stochastic TFP Growth Rate:** Another alternative formulation is to assume that TFP growth rate follows an \( AR(1) \) process.\(^{34}\) Estimating this simple process yields a per-

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\(^{34}\)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 degenerate transition matrix with forty-six states. In this matrix, each state refers to a vector of exogenous series.
Figure 16: Saving Rate with Adaptive Expectations

Persistence coefficient of 0.33 (with an intercept term 0.69 and a standard error of regression 0.0224).

Figure 17 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.

5.2 Open Economy

There are two parameters that play an important role in the results regarding the model generated current account balances. These are the adjustment cost parameter, $\alpha$, and the size of the ROW, $N_2$. Both of these parameters have an impact on the size of the capital flows. For example, as the size of the ROW gets smaller the model gets closer to a closed 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 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.
economy model. As this parameter gets larger, the size of the capital flows increase. Figure 18 displays the current account balances generated by the model for different N2's. As the size of the ROW gets larger, the current account surpluses in the 1960s and the current account deficits in the later periods get larger.

Figure 19 displays the current account balances for different values of the adjustment cost parameter. As the adjustment costs decline the current account surpluses of the 1960s and the deficits in the later periods get larger.

The sensitivity analysis in this section reveals that the model economy generates current account deficits in the later periods under a large set of parameters.

6 Concluding Remarks

The U.S. national saving rate and the current account balance have experienced a secular decline since the 1960s. A popular answer for the decline in the national saving rate 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
Figure 18: Sensitivity to N2

Figure 19: Sensitivity to the Adjustment Cost
early 1990s are i) the decrease in the population growth rate, and ii) the increase in the depreciation 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. When we examine the role of these factors on the U.S. current account, we discover that differences in TFP growth rates between the U.S. and its trading partners play a significant role.

The remaining puzzle is the hours boom and the continuous decline in the saving rate since 1990s. Theories put forward would have to feature significant changes in an element missing from the standard model since the 1990s. It is possible that intangible capital as discussed by Corrado, Hulten, and Sichel (2006) and McGrattan and Prescott (2007a) might be the missing link. Direct calculations of intangible capital will be needed to modify the definition of savings in order to examine if it can be successful in mimicking the hours boom (as shown in McGrattan and Prescott (2007b)) and the change in savings since 1990s at the same time. These issues together with a more detailed study of the 1990s, and the implications of a life-cycle model as in Chen, İmrohoroğlu and İmrohoroğlu (2007) are left for future research.

7 Appendix

7.1 Competitive Equilibrium of the Closed Economy

Definition of 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: \( C_t + X_t + G_t = Y_t \).

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

\[
\frac{\alpha h_t}{1 - h_t} = (1 - \tau_{h,t})(1 - \theta) \frac{Y_t}{C_t}, \quad (6)
\]

\[
\frac{C_{t+1}}{N_{t+1}} = \frac{C_t}{N_t} \beta \left[ 1 + (1 - \tau_{k,t+1}) \left[ \theta A_{t+1} K_{t+1}^{\theta-1}(H_{t+1})^{1-\theta} - \delta_{t+1} \right] \right], \quad (7)
\]

\[
K_{t+1} = (1 - \delta_t) K_t + A_t K_t^{\theta}(H_t)^{1-\theta} - C_t - G_t. \quad (8)
\]
**Detrending:** For an aggregate variable \( z_t \), its detrended version is given by: 
\[
\tilde{z}_t = z_t/ \left[ A_t^{\frac{1}{\sigma}} N_t \right].
\]
Applying this change of variables to (7) and (8), we obtain equations
\[
\tilde{c}_{t+1} = \frac{\tilde{c}_t}{g_{t+1}^{\frac{1}{\sigma}}} \beta \left\{ 1 + (1 - \tau_{k,t+1}) \left[ \theta x_t^{\theta-1} - \delta_{t+1} \right] \right\},
\]
\[
\tilde{k}_{t+1} = \frac{1}{g_{t+1}^{\frac{1}{\sigma} n_{t+1}}} \left[ (1 - \delta_t) + (1 - \psi_t) x_t^{\theta-1} \right] k_t - \tilde{c}_t,
\]
where \( \psi_t \) is the ratio of government purchases to output, \( G_t/Y_t \), and \( x_t \) is detrended capital-labor ratio, \( (K_t/H_t)/A_t^{\frac{1}{\sigma}} \).

**Steady-state:** Setting \( \tilde{z}_t = \tilde{z} \) for all \( t \), we obtain the following steady-state for the model:
\[
\frac{\alpha h}{1 - h} = (1 - \bar{\tau}_h)(1 - \theta) \frac{\bar{y}}{\bar{c}}
\]
\[
1 = \frac{1}{g_{t+1}^{\frac{1}{\sigma}}} \beta \left\{ 1 + (1 - \bar{\tau}_k) \left[ \theta x_t^{\theta-1} - \bar{\delta} \right] \right\}
\]
\[
\bar{k} = \frac{1}{g_{t+1}^{\frac{1}{\sigma} n}} \left[ (1 - \bar{\delta}) + (1 - \bar{\psi}) x_t^{\theta-1} \right] k - \bar{c}.
\]

These equations are solved for the steady-state values of detrended capital, consumption and hours worked where \( \bar{\delta}, \bar{\tau}_h \), and \( \bar{\tau}_k \) are the steady-state depreciation, labor income tax rate and capital income tax rate, respectively. The steady-state saving rate is given by
\[
\bar{s} = \frac{(g_{t+1}^{\frac{1}{\sigma} n} - 1) \bar{k}}{\bar{y} - \bar{\delta} k}.
\] (9)

### 7.2 Details of the Calibration of the Closed Economy

In this section, we provide the details of our calibration for the closed 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.

Denote measured GNP as follows
\[
(cs + cnd + icd) + g + i + nx + nfp = GNP = dep + NNP,
\] (A-1)
where \( cs, cnd, icd \) denote real personal consumption expenditures on services, nondurables and durables, \( g \) denotes the sum of government consumption, denoted as \( gc \), and gross government investment, denoted as \( gi \), \( i \) denotes gross private domestic investment, \( nx \) denotes net export, \( nfp \) denotes net factor payments to the rest of the world, and \( dep \) denotes consumption of fixed capital.
Our adjustments to measured macroeconomic aggregates follow Cooley and Prescott (1995). First, we add government capital to measured capital stock. When we add the service flow from the government capital stock, \( sg \), to measured GNP, (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 assets.

Second, we add the stock of consumer durables to measured capital stock. Including the service flow from the stock of consumer durables, \( csd \), to measured GNP changes (A-2) to

\[
(cs + cnd + csd + sg) + gc + (i + nicd + dcd + gi) + nx + nfp = GNP + sg + csd
\]

\[
= (dep + dcd) + (NNP + sg + csd - dcd), \tag{A-3}
\]

where \( dcd \) denotes the depreciation of the stock of consumer durables. Therefore, total private consumption becomes \((cs + cnd + csd + sg)\) and total domestic investment becomes \((i + icd + gi)\) or \((i + nicd + dcd + gi)\), where \( nicd \) is referred to as net investment in the stock of consumer durables and \( dcd \) denotes the depreciation of the stock of consumer durables. Total depreciation becomes \((dep + dcd)\).

Third, we add net foreign assets to measured capital stock. The service flow from this stock is already measured as \( nfp \) in GNP. We reorganize (A-3) as

\[
(cs + cnd + csd + sg) + gc + (i + nicd + dcd + gi) + nx + nfp = GNP + sg + csd
\]

\[
= (dep + dcd) + (NNP + csd + sg - dcd), \tag{10}
\]

where total domestic investment is now defined as \((i + nicd + dcd + gi + nx + nfp)\).

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

\[
i = \frac{(\text{Accounting Returns} + \text{Imputed Returns})}{(\text{Non-corporate capital} + \text{Land} + \text{Inventory Stock} + \text{Capital of Foreign Subsidiaries})}
\]

\[
= \frac{(0.0603 + 1.6803i)}{(2.976 + 0.0095/i)},
\]

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, the stock of consumer durables, land and inventory stock, 2.976 is the sum of net stock of non-corporate business, government capital, stock of consumer durables, land and inventory stock, and 0.0095 is the net profit from foreign subsidiaries.
The above equation gives a value of 3.93% for \( i \) over the period between 1960 and 2000.

The service flows the stock of consumer durables and government capital, \( Y_{sd} \) and \( Y_{sg} \), respectively, are computed following Cooley and Prescott (1995):

\[
Y_{sd} = csd = (i + \delta_d) K_D, \\
Y_{sg} = (i + \delta_g) K_G.
\]

Then the capital share of output, \( \alpha \), is given by

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

where \( Y_{kp} \) is the income flow from private fixed assets,

\[
Y_{kp} = \text{Unambiguous Capital Income} + \theta_p \times (\text{Proprietors' Income} + \text{Indirect Business Taxes}) + \text{Depreciation} \quad (12)
\]

This gives a value of 0.32 for \( \theta_p \) and a value of 0.41 for \( \alpha \).

Define the net national saving rate as

\[
s = \frac{Y - CON - GOV - DEPR}{Y - DEPR} = \frac{(GNP + sg + csd) - (cs + cnd + csd + sg) - gc - (dep + dcd)}{(GNP + sg + csd) - (dep + dcd)} = \frac{GNP - cs - cnd - gc - (dep + dcd)}{NNP + csd + sg - dcd}.
\]

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

\[
sgov = \frac{\text{Tax Revenue} - (gc + tr) - \text{Net Interest Payment on Government Debt}}{Y - DEPR},
\]

where \( tr \) is net government transfers, computed as current transfer payments minus current transfer receipts. Accordingly, the private saving rate is computed as

\[
psav = s - sgov.
\]

In Figure A1 we compare the data on the net national saving rate (net national saving as a percent of NNP) from the NIPA with the net national saving rate that results after all the adjustments discussed above are made to the data.
In our benchmark economy we have defined capital to include the stock of consumer durables, government capital, and foreign capital. These adjustments to capital came with corresponding adjustments on the measurement of GNP as explained above. In Figure A2 we display four different TFP growth rate measures. One of these measures is the TFP growth rate used by Jorgenson (2003). The other three are growth rates obtained under different assumptions on the capital stock. In particular, we display TFP growth rates under the i) benchmark definition of the capital stock, ii) benchmark definition minus land, and, iii) benchmark definition minus the stock of consumer durables and government capital. This exercise demonstrates that measured TFP growth rates are not very sensitive to the definition of the capital stock.
Figure A2: Alternative TFP Growth Rate Measures

However, it is also important to note that using the definition of the capital stock that is consistent with the model is crucial in these exercises. Figure A3 displays two measures of the U.S. capital per person both detrended by \(1.018^t\). The first is the broad measure of the capital stock used in the benchmark exercise which includes land, foreign capital, stock of durables and government capital. The second measure is private capital only. As can be seen from the figure the two measures display significant differences. We use the broad definition of capital to align data accounts with model accounts.

Figure A3: Different Capital Measures
7.3 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 proprietors’ 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 proprietors’ 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.

7.4 Computation of After-Tax Rate of Return to Capital

We compute real after-tax capital income as

\[
Y_{KAT} = Y_{KBT} - \text{Real Capital Income Taxes,}
\]

where

\[
Y_{KBT} = (\text{Net Interest} + \text{Corporate Profits} + \text{Rental Income} + 0.32 \times \text{Proprietors’ Income} + \text{State IBT Property Taxes}) \times A
\]

\[
A = 1 + \frac{\text{Total IBT Tax} - \text{State IBT Property Tax}}{\text{National Income}}.
\]

Capital income tax is computed as a 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

\[
TKP = \text{Federal Profit Tax} + \text{State Profit Tax} + \text{State Property Tax} + \text{State IBT Property Tax},
\]

and \( TKN \) is the product of \( Y_{KBT} \) and the sum of proportional tax rates 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

\[
R_{AT} = \frac{Y_{KAT}}{K - \text{Stock of Consumer Durables and Government Capital}},
\]

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

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7.5 Competitive Equilibrium of the Open Economy

Definition of Competitive Equilibrium: Given a government policy \( \{G_t, TR_t, \tau_{h,t}, \tau_{k,t}, \pi_t\}_{t=0}^{\infty} \)
for \( i = 1, 2 \), a competitive equilibrium consists of allocations \( \{C_t, I_t, H_t, K_{t+1}, Y_t, B_t\}_{t=0}^{\infty} \) and prices \( \{w_t, r_t, r_B\} \) such that

- given policy and prices, the allocation solves the household’s problem in each \( i \),
- 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 budgets are satisfied,
- the goods market clears for each country: \( C_t + I_t + G_t + NX_t = Y_t \), where \( NX_t = CA_t - B_t r_B \) is net exports for country \( i \),
- \( r_{t+1} \) is such that the international bond market clears: \( B_{t+1} = B_{t+1}^2 \).

Equilibrium Conditions: For each country, the equilibrium conditions of this model can be described with the following equations below:

\[
\frac{\alpha h_t}{1 - h_t^i} = (1 - \tau_{h,t}^i(1 - \theta)Y_t^i C_t^i, \quad (13)
\]
\[
q_t^i = 1 + 2\phi \left( \frac{X_t^i}{K_t^i} - \varphi \right), \quad (14)
\]
\[
q_t^i C_{t+1}^i \frac{N_{t+1}^i}{N_t^i} = C_t^i \beta \left\{ q_{t+1}^i (1 - \delta_{t+1}^i) + (1 - \tau_{k,t+1}^i) \left( \theta A_{t+1}^i (K_{t+1}^i)^{\theta - 1} (H_t^{i+1})^{1 - \theta} - \delta_{t+1}^i \right) \right\}
\]
\[
+ \delta_{t+1}^i - \phi \left( \frac{X_{t+1}^i}{K_{t+1}^i} - \varphi \right)^2 + 2\phi \frac{X_{t+1}^i}{K_{t+1}^i} \left( \frac{X_{t+1}^i}{K_{t+1}^i} - \varphi \right) \quad (15)
\]
\[
C_{t+1}^i \frac{N_{t+1}^i}{N_t^i} = C_t^i \beta \left\{ 1 + r_{t+1}^B \right\}, \quad (16)
\]
\[
I_t^i = X_t^i + \phi K_t^i \left( \frac{X_t^i}{K_t^i} - \varphi \right)^2, \quad (17)
\]
\[
I_t^i = A_t(K_t)^{\theta}(H_t)^{1 - \theta} - C_t^i - G_t^i - (B_{t+1}^i - (1 + r_t^B) B_t^i), \quad (18)
\]
where $q_t$ is Tobin’s $q$. Applying ‘change of variables’ used in detrending to (13), (15) and (18), we obtain equations

$$q_t = 1 + 2\phi \left( \frac{x_{t+1}^i}{k_{t+1}^i} - \varphi^i \right),$$  \hspace{1cm} (19)

$$q_tC_{t+1}^i = \frac{-c_{t+1}^i}{(g_{t+1}^i)^{1-\theta}} \beta \left\{ q_{t+1} \left( 1 - \delta_{t+1}^i \right) + (1 - \tau_{k,t+1}^i) \left[ \theta \left( \frac{k_{t+1}^i}{h_t^i} \right)^{\theta-1} - \delta_{t+1}^i \right] \right\},$$  \hspace{1cm} (20)

$$c_{t+1}^i = \frac{-c_{t}^i}{(g_{t+1}^i)^{1-\theta}} \beta \left\{ 1 + r_{t+1}^B \right\},$$  \hspace{1cm} (21)

$$\tilde{v}_{t}^i = \tilde{x}_{t}^i + \phi \tilde{k}_{t+1}^i \left( \frac{x_{t+1}^i}{k_{t+1}^i} - \varphi^i \right)^2,$$  \hspace{1cm} (22)

$$\tilde{v}_{t}^i = (1 - \psi_t^i) \left( \frac{k_{t}^i}{h_t^i} \right)^{\theta} \left( \frac{h_{t+1}^i}{k_{t+1}^i} \right)^{\theta-1},$$  \hspace{1cm} (23)

$$-\tilde{c}_{t}^i - \left( \tilde{b}_{t+1}^i \left( g_{t+1}^i \right)^{1-\theta} n_{t+1}^i - (1 + r_{t+1}^B) \tilde{b}_{t}^i \right),$$  \hspace{1cm} (24)

where $\psi_t$ is the ratio of government purchases to output, $G_t^i/Y_t^i$.  

### 7.6 Data

In the following two tables we present the data used for the TFP factor growth rates, population growth rates, government expenditures as a percent of GDP, depreciation rates, capital and labor income taxes, transfers to GDP ratio and the labor wedge used in the calibration of the U.S. economy and the OECD countries.


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<th>k-tax</th>
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