Debt and the U.S. Economy

Kaiji Chen* Ayşe İmrohoroğlu**

This Version: October 2011

Abstract

Publicly held debt to GDP ratio in the U.S. is estimated to be 72% in 2011 and is expected to continue rising. Many proposals regarding the ways to curb the government deficit and the resulting debt are being discussed. In this paper, we use the standard neoclassical growth model to examine the implications of several policy proposals on the future path of employment, output, budget deficit, and debt in the U.S. economy.

* Department of Economics, Emory University, Atlanta, GA 30322-2240

**Department of Finance and Business Economics, Marshall School of Business, University of Southern California, 3670 Trousdale Parkway, Los Angeles, CA 90089-1427, USA

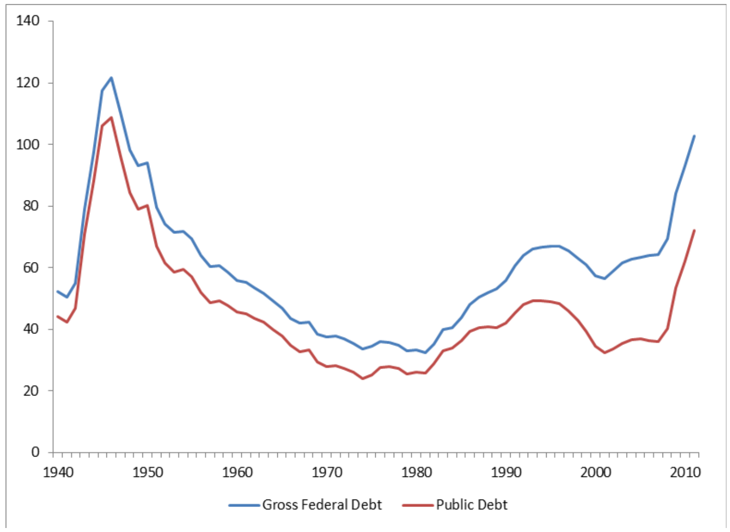

Figure 1: Federal Debt to GDP

1 Introduction

Publicly held debt to GDP ratio in the U.S. has risen from 36% in 2007 to 62% in 2010.[1] As can be observed from Figure 1 the current levels of debt/gdp is significantly higher than what has been experienced in the U.S. since World War II. This fiscal outlook is generating significant academic, public, and political debate in the U.S.

Currently many proposals regarding the ways to curb the government deficit and the resulting debt are being discussed. In this paper we use the standard growth model in order to study the effects of some of these proposals on the future path of the U.S. economy. The setup is an infinite horizon, complete markets framework that has been successfully used to address a variety of economic issues.[2] We calibrate the economy to the U.S. data for the 1960-2010 period and use this model to understand the impact of these fiscal policy actions on the future path of employment, output, deficits, and debt. While the model is highly stylized, it is able to capture the long run movements in many of the key variables we are interested in. In particular, model generated deficit and debt ratios relative to GDP mimic the data between 1960 and 2010 reasonably well.

Our benchmark results indicate a debt to GNP ratio of 150% by 2030. Many things affect this ratio and are easily investigated in this framework. Most of the experiments we

---

[1] Historical Tables, Office of Management and Budget, the White House. Table 7.1: Federal Debt at the End of Year: 1940-2016.

[2] Our model is similar to the ones used in Hayashi and Prescott (2002), and Chen, İmrohoroğlu, and İmrohoroğlu (2006 and 2009).

conduct however reveal how difficult it will be for the U.S. economy to reach debt to GNP ratios around 80% by 2030 as forecasted in the baseline CBO calculations. Unless there is a significant increase in the growth rate of GNP, debt to GNP ratios above 100% are more likely to continue into the future.

The main reason for the increase in the debt to GDP ratio in 2010 was the recession that started in the fourth quarter of 2007 and ended in June 2009. Real GDP declined by 0.3% in 2008 and 3.5% in 2009. Between December 2007 and May 2011 total non-farm employment declined by almost 7 million workers.[3] To combat the great recession U.S. enacted a $800 billion stimulus package in 2009. The increase in expenditures together with the decline in revenues resulted in significant increase in the government deficit which in 2010 and 2011 reached 8.9% of GDP. These deficits coupled with projected increases in future health care spending are resulting in large projected debt levels in the U.S. Intense negotiations took place recently as the U.S. debt reached its ceiling on May 2011. These negotiations involved various options to cut expenditures and raise taxes.

In this paper we examine the implications of different expenditure projections on the future debt to GDP ratio in the U.S. CBO has two scenarios on the possible path of the expenditures are revenues that reflect possible changes in the current law for various items. The National Commission on Fiscal Responsibility and Reform (Bowles-Simpson in short) has a proposal that involves cuts in expenditures beyond what the CBO projections consider.[4] There are vast difference across the projected debt to GDP ratios between the alternative projections provided by the CBO as well as the projections provided by the Bowles-Simpson commission. Under the first CBO scenario, publicly held debt to GDP ratio stabilizes around 80% while under the second scenario it reaches 187% by 2035. A major reason for this difference is the assumption about tax revenues. In the first scenario, marginal tax rates on labor income are assumed to increase from 29% in 2010 to 35% in 2025 and to 38% in 2035 leading to significant increases in tax revenues while in the second scenario tax revenues as a percent of GDP remain at their historical levels. The changes in tax rates under the first scenario, however, would likely have major consequences in the economy, mostly stemming from the reaction of the labor supply, which are not fully incorporated in the CBO projections. Consequently, tax revenues as a percent of GDP are projected to rise significantly resulting is smaller deficits and debt under this scenario. The Bowles-Simpson Commission proposes larger cuts in government spending and increases in the tax base that results in a debt to GDP ratio of 65.5% in 2020. In this paper we incorporate these different

[3] Bureau of Labor Statistics, Employment, Hours, and Earnings from the Current Employment Statistics survey.

[4] The National Commission on Fiscal Responsibility and Reform was created by president Obama in 2010 to identfy policies to improve the fiscal situation in the U.S. Alan Simpson and Erskine Bowles were the co-chairs of the commission.

policy proposals in a fully calibrated general equilibrium model. This framework allows us to model the reactions of labor and capital due to changes in policy which impact the projected debt to GDP ratios.

In Section 2 we summarize the model economy. Calibration is presented in Section 3 and the results in Section 4. Section 5 concludes.

2 The Standard Neoclassical Growth Model

In this model, a representative household makes consumption and saving decisions taking the factor prices and government policy as given. A stand-in firm maximizes its profits, setting factor prices equal to their marginal productivities. There is a government that finances exogenously given government purchases and transfer payments by taxing factor incomes and consumption, or by issuing new one-period bonds at an exogenously given interest rate. The engine of growth in the model is exogenously growing TFP. Agents in this perfect foresight environment maximize their objective functions taking into account future policy and prices.[5] Below, we present our model in detail.

2.1 Household's Problem

Time is discrete, starting from period 0. There is a representative household with N_t working-age members at date t, facing the following problem in a complete markets environment:

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

subject to

$$C_t + K_{t+1} \leq [1 + (1 - \tau_{k,t})(r_t - \delta_t)]K_t + (1 - \tau_{h,t})w_t H_t + TR_t + N_t \pi_t^p,$$

where $c_t = C_t/N_t$ is consumption per household member, $h_t = H_t/N_t$ is the fraction of hours worked per member of the household, β is the subjective discount factor, α is a parameter that indicates the relative weight of leisure in the utility functions, 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, w_t is the real wage, TR_t is aggregate government transfers, π_t^p is the per-member primary balance of the government, r_t is the rental rate of capital, and δ_t is the

[5] Chen, İmrohoroğlu, and İmrohoroğlu (2007) and Braun, Ikeda, and Joines (2009) develop overlapping generations models with incomplete markets to study the Japanese economy. By construction, these models deliver richer implications by disaggregating the economy into cohorts and different income and wealth groups. However, their aggregate predictions on the main macro variables seem to be consistent with those from the standard model with infinite horizon and complete markets.

time-t depreciation rate.[6] Beginning of period t assets are denoted by K_t. Population growth is given by the change in the size of the household, which evolves over time exogenously at the rate $n_t = N_t/N_{t-1}$. We assume that the representative household receives the interest earnings on the government debt I_t.

It is well know that the neoclassical growth model has difficulty in accounting for the hours boom in the 1990s. To accommodate the model to generate more reasonable results we feed in a labor wedge as in Chari, Kehoe and McGrattan (2007) or Ohanian, Raffo, and Rogerson (2006).

The labor wedge, Δ_t^H, is defined to satisfy the following equation when consumption, c_t, hours worked, h_t and output, y_t are all from the data.

$$\frac{-u_{h_t}\left(c_t, 1-h_t\right)}{u_{c_t}\left(c_t, 1-h_t\right)} = \Delta_t^H \left(1-\tau_{h,t}\right) MPL_t$$

where u_x ($x = c_t$ or h_t) is the partial derivative of period utility to x, MPL_t denotes the marginal product of labor. After computing the labor wedge we replace $(1-\tau_{h,t})$ in the first order condition for the consumption-leisure trade-off with $(1-\tau_{h,t})\Delta_t^H$. Since we already have taxes in this model, the labor wedge is interpreted as a proxy for changes in labor distortions other than taxes. Other interpretations of the changes in the labor wedge may be related to factors that caused increases in the labor force participation of women or the intangible capital explanation advanced by McGrattan and Prescott (2010) or the change in wage markups argued by Smets and Wouters (2007).

2.2 Firm's Problem

There is a stand-in firm with access to a constant returns to scale Cobb-Douglas production function 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 $\gamma_t = A_t/A_{t-1}$. Aggregate capital stock follows the law of motion

$$K_{t+1} = (1-\delta_t)K_t + X_t, \tag{1}$$

where X_t is gross investment at period t.

The representative firm maximizes its profits by choosing capital and labor, taking factor prices as given. This produces the usual equilibrium conditions that equate factor prices to their marginal productivities.

[6] Lower case letter will refer to per-capita items and upper case letters will be used to denote economy-wide aggregate quantities.

2.3 Government Budget

The government faces exogenously given streams of government purchases G_t, transfer payments TR_t, and interest payments to holders of its debt I_t. These can be financed by taxing consumption, income from labor, and capital, or by raising new debt. In this paper we do not explicitly model government debt. The main reason is that modeling debt requires a way of introducing rate-of-return dominance of private capital over government debt as we observe in the data over several decades and across many countries. Instead, we focus on the additions to existing debt by carefully modeling the government's flow budget constraint. Denoting the (per-capita) budget balance by π_t^b and the primary balance by π_t^p, we specify the government budgets as follows.

$$G_t + TR_t + I_t = \tau_{h,t} w_t H_t + \tau_{k,t}(r_t - \delta_t)K_t - N_t \pi_t^b, \tag{2}$$

$$G_t + TR_t = \tau_{h,t} w_t H_t + \tau_{k,t}(r_t - \delta_t)K_t - N_t \pi_t^p. \tag{3}$$

2.3.1 Constructing Debt-Output Ratio in the Model

Government debt is constructed to be consistent with the NIPA accounts. In nominal terms, the evolution of debt follows

$$\widehat{B}_{t+1}^g = \widehat{B}_t^g + \widehat{GB}_t, \tag{4}$$

where $\widehat{GB}_t$ is net borrowing. We describe the construction of $\widehat{GB}_t$ in Section 3.

All variables in our model are real and detrended, so we need to deflate and detrend the above law of motion for government debt. In real terms, equation 4 can be written as

$$B_{t+1}^g = \left(B_t^g + GB_t\right) P_t / P_{t+1}$$

where P_t/P_{t+1} is the inverse of the inflation rate. For every nominal variable $\widehat{x}_t$ $\left(\widehat{x}_t = \widehat{B}_t^g \text{ or } \widehat{GB}_t\right)$, we let x_t denote the corresponding real variable which is given as $\widehat{x}_t / P_t$.

Accordingly, law of motion of the debt to output ratio follows:

$$\frac{B_{t+1}^g}{Y_{t+1}} = \frac{\left(B_t^g + GB_t\right)}{Y_t} \frac{P_t}{P_{t+1}} \frac{Y_t}{Y_{t+1}} \tag{5}$$

The interest rate on government debt, denoted as i_t, is computed as I_t / B_t^g. In this paper we take the interest rate on government debt exogenously. As equation 5 implies, the relevant interest rate to compute debt is the nominal interest rate, once we explicit take the inflation into account.

It should be emphasized that we do not have a theory as to household's holding of government debt. There is no consensus in the literature on the optimal size of government debt primarily because there is no agreement on a theory of debt. For this reason, we concentrate on the effects of its financing on the economy as well as the effects of growth on the size of debt. In this sense, debt is endogenous in our model as we determine its level by accumulating budget deficits that are endogenously determined by the interaction of demographics, policy, and private sector behavior. Note that the projected increases in G_t and TR_t will proxy for the impact of the demographic transition in U.S. Government's fiscal policy will be represented with the assumed paths of the expenditure items and the tax rates. Finally, the private sector will optimally respond to changes in this environment by adjusting its consumption-saving behavior, and the general equilibrium effects will show up as the wage rate and rate of return to capital adjust accordingly.

2.4 Competitive Equilibrium

For a government fiscal policy $\{G_t, TR_t, i_t, \tau_{h,t}, \tau_{k,t}\}_{t=0}^{\infty}$, a competitive equilibrium consists of an allocation $\{C_t, X_t, H_t, K_{t+1}, Y_t\}_{t=0}^{\infty}$, a budget balance π_t^b, a primary balance π_t^p, and factor prices $\{w_t, r_t\}_{t=0}^{\infty}$ such that

- the allocation solves household's problem,
- 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,
- the goods market clears: $C_t + X_t + G_t = Y_t$.

2.5 Equilibrium Conditions

We can combine the equilibrium conditions of the model in three equations below:

$$\frac{\alpha C_t/N_t}{1-H_t/N_t} = (1-\tau_{h,t})\frac{(1-\theta)\,A_t K_t^{\theta} {H_t}^{1-\theta}}{H_t} \tag{6}$$

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

$$K_{t+1} = (1-\delta_t)K_t + A_t K_t^{\theta} {H_t}^{1-\theta} - C_t - G_t. \tag{8}$$

Our approach is to start from given initial conditions and then compute an equilibrium transition path towards a balanced growth path at which per capita aggregate variables grow at the rate $g_t = \gamma_t^{1/(1-\theta)}$. For a variable z_t, detrending is done by applying $\widetilde{z}_t = z_t/\left[A_t^{\frac{1}{1-\theta}} N_t\right]$.

Using this change of variables to (7) and (8), we obtain equations

$$\begin{aligned}
\frac{\alpha \widetilde{c}_t}{1-\widetilde{h}_t} &= (1-\tau_{h,t})(1-\theta)\, x_t^{\theta} \\
\widetilde{c}_{t+1} &= \frac{\widetilde{c}_t}{g_{t+1}}\beta \left\{1 + (1-\tau_{k,t+1})\left[\theta x_{t+1}^{\theta-1} - \delta_{t+1}\right]\right\}, \\
\widetilde{k}_{t+1} &= \frac{1}{g_{t+1}n_{t+1}}[(1-\delta_t) + (1-\psi_t)x_t^{\theta-1}]\widetilde{k}_t - \widetilde{c}_t,
\end{aligned}$$

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

The steady-state conditions are obtained by setting $\widetilde{z}_t = \widetilde{z}$ for all t :

$$\begin{aligned}
\frac{\alpha \widetilde{c}}{1-\widetilde{h}} &= (1-\tau_h)(1-\theta)\, x^{\theta} \\
1 &= \frac{1}{g}\beta \left\{1 + (1-\widetilde{\tau}_k)\left[\theta x^{\theta-1} - \widetilde{\delta}\right]\right\} \\
\widetilde{k} &= \frac{1}{gn}[(1-\widetilde{\delta}) + (1-\widetilde{\psi})x^{\theta-1}]\widetilde{k} - \widetilde{c}.
\end{aligned}$$

These two equations deliver the steady-state values of detrended capital and consumption where $\widetilde{\delta}$, $\widetilde{\tau}_h$, and $\widetilde{\tau}_k$ are the steady-state depreciation rate, labor income tax rate and capital income tax rate, respectively.

In our model, we can compute the labor wedge as

$$\Delta_t^H = \frac{\alpha c_t h_t}{(1-h_t)(1-\tau_{h,t})(1-\theta)\, y_t}.$$

Finally, the detrended law of motion for debt-output ratio is

$$\frac{\widetilde{B}_{t+1}^g}{\widetilde{Y}_{t+1}} = \frac{\left(\widetilde{B}_t^g + \widetilde{GB}_t\right)}{\widetilde{Y}_t} \frac{\widetilde{Y}_t A_t^{\frac{1}{1-\theta}} N_t}{\widetilde{Y}_{t+1} A_{t+1}^{\frac{1}{1-\theta}} N_{t+1}} \frac{P_t}{P_{t+1}}$$

3 Measurement and Calibration

In order for us to make predictions about the fiscal position of the U.S. in the near future, we want our model economy to generate aggregate behavior and fiscal outcomes that resemble their counterparts in the U.S. economy. First, we make adjustments to observed macroeconomic aggregates so that data accounts are in line with our model accounts. Second, we make adjustments to government accounts and bring them closer to what a government does in the standard growth model. Third, we calibrate our model economy to generate certain targets from the U.S. economy. Below, we will describe these calibration issues.

3.1 Adjustment to National Account

We use data from the 2011 revision of National Income and Product Accounts (NIPA) and Fixed Asset Tables (FAT) of Bureau of Economic Analysis (BEA) for the years 1960-2010. Our adjustments to measured macroeconomic aggregates follow Cooley and Prescott (1995). We define capital K as the sum of the fixed assets, stock of consumer durables, inventory stock and net foreign assets. Output Y corresponds to GNP plus the service flows from government capital and consumer durable, and capital depreciation is the sum of consumption of fixed capital and depreciation of consumer durables. For the rest of the analysis we thus use GNP as our measure of output.

3.2 Adjustment to Government Debt

This subsection describes how the General Government Accounts are arranged so that the government accounts in the data are in line with those in the model. In particular, government spending items will be categorized. The aim is to have primary and budget balances in the data and model to align conceptually. The ultimate goal of the paper is to quantify how close the standard growth theory comes in generating observed budget balance and debt figures and to use the model to deliver short run predictions on both the government accounts and national accounts.

The budget balance, $\tau_{h,t}w_tH_t + \tau_{k,t}(r_t - \delta_t)K_t - (G_t + TR_t + I_t)$, corresponds to net government saving in the NIPA data.

- The government tax revenue, $\tau_{h,t}w_tH_t + \tau_{k,t}(r_t - \delta_t)K_t$, is measured as current receipt in the data.[7]
- G_t is measured as government consumption.
- Transfer payments, TR_t, are calculated as

  Current Transfer Payment - Current Transfer Receipts

- Interest payment on government debt, I_t, is calculated as

  Interest Payment - Income Receipts on Asset

[7] Since our measured K_t includes consumer durable and government fixed capital, when we compute the capital income tax revenue, we tease out the share of consumer durable and government fixed capital, which are not taxed in reality.

Therefore, the net borrowing, GB_t is calculated in the data as

$$-\begin{pmatrix} \text{Current Receipts} \\ -\text{ Transfer Payment} \\ -\text{ Interest payment} \\ -\text{ Government Consumption} \\ -\text{ Gross Government Investment} \\ +\text{ Consumption of Fixed Capital} \end{pmatrix}$$

Note that GB_t includes both the budget deficit $N_t\pi_t^b$ and net government investment (denoted as GI_t), the latter of which is not explicitly modeled in this paper. To assess the model's prediction on net borrowing, we construct GB_t in the model as the sum of $N_t\pi_t^b$ and GI_t.

After we compute the net borrowing in the data, we construct government debt in each period between 1961 and 2010 following 4, taking 1959 value of the federal government debt held by the public as the initial debt level for 1960.

3.3 Calibration

The starting year for the analysis is 1960 and the last period for which we have data for all of the variables is 2010. The model takes the observations for the exogenous inputs as given for the 1960-2010 period, and makes certain assumption about their values for 2011 and beyond. A steady state is assumed to be reached far into the future so that we have a two-point boundary problem, starting with given initial conditions in 1960, and ending at a steady state. Following Hayashi and Prescott (2002), we use a shooting algorithm to calculate an equilibrium transition path that connects these two boundary points. We make sure that our assumptions about that steady state have minimal effects on the immediate future along the transition path.

The following three subsections present the calibration choices in detail summarizing the parameters that are constant throughout the analysis, the exogenous inputs for which we have direct observations, and the assumptions made for the values of these exogenous inputs for 2011 and beyond.

3.3.1 Constant Parameters and Steady State Calibration

There are three parameters that are time invariant throughout our analysis. The capital share parameter, θ, is set to 0.4. The subjective discount factor, β, is set to 0.969 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 in the U.S. The log utility function we use implies that the Frisch elasticity of leisure is equal to 1. We set the steady state depreciation rate, δ, at 0.055, its average value between 1990 and 2010. We use a TFP growth rate of 1.1% and population growth rate of 1% in the steady state. We set $\tau_k = 0.392$ and $\tau_h = 0.273$, the average of corresponding tax rates between 1960 and 2008. Government transfer to output ratio, TR/Y and consumption to output ratio, ψ, are set equal to 0.17 and 0.05 at the steady state, to be consistent with the projections for these variables. Since the steady state is assumed to be reached far into the future, the steady-state values do not affect our short-term predictions. These choices are summarized below.

Table 1: Parameter Values in the Steady State

θ	Capital Income Share	0.40
α	Utility Parameter for Leisure	1.45
β	Subjective Discount Factor	0.969
$g-1$	TFP Growth Rate	1.1%
$n-1$	Population Growth Rate	1.0%
ψ	Government Consumption to Output Ratio	0.05
δ	Depreciation Rate	0.055
TR/Y	Transfers to Output Ratio	0.17
τ_k	Capital Income Tax Rate	0.392
τ_n	Labor Income Tax Rate	0.273

3.3.2 Inputs for 1960-2010 and Beyond

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. In addition, the initial debt level in 1960 is set to target an initial debt to output ratio of 39.2%, which is the ratio of federal government debt held by the public to output at the beginning of 1960.

Calibration of the 1960-2010 period: In our benchmark simulation, we use the actual time series data for the U.S. between 1960-2010 for TFP growth rates, $g_t - 1$, population growth rates, $n_t - 1$, shares of government purchases in measured GNP, ψ_t, share of transfer payment in measured GNP, TR_t/Y_t, the depreciation rate, δ_t, and capital and labor income tax rates, $\tau_{k,t}, \tau_{h,t}$. The inflation rate, P_{t+1}/P_t, which we used to compute the law of motion for debt is taken as the growth rate of the GNP deflator. We compute the interest rate on government debt from the NIPA accounts as interest payments divided by the stock of gross federal debt from the previous period.

We use data from Statistics of Income (SOI), Individual Income Tax Returns (1960-2010), Social Security Bulletin and National Incomes and Product Accounts (1960-2010) and the method of Joines (1981) and McGrattan (1994) to construct the tax rates.[8]

[8] The main difference between our approach and McGrattan (1994) is that we assume 32 percent of the

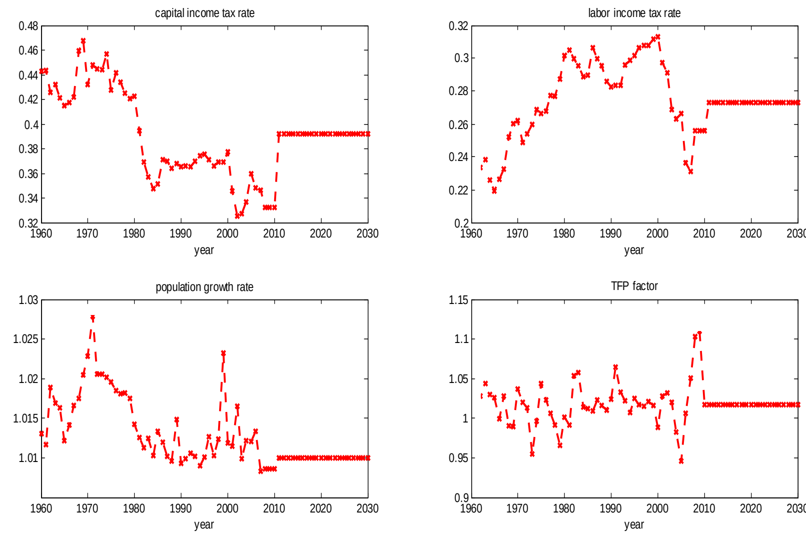

Figure 2: Data and Assumptions for the Future

Calibration of 2011 and beyond: We assume that the U.S. starts from given initial conditions in 1960 and eventually converge to a steady-state in 2070. We make certain assumptions about the future path of the exogenous variables and check the sensitivity of our results to these assumptions. For example, we assume that the capital and labor income tax rates as well as the TFP growth rate continue at their long run averages after 2010. We set the population growth rate equal to 1%, which is consistent with the projections of the Census Bureau, and the depreciation rate equal to 5.5%. Figure 2 summarizes the data and the assumptions for the future path of the capital and labor income tax rates, population growth rate, and the growth rate of the TFP factor.

We take the nominal interest rate on government bonds as exogenously given. There are several possible choices to use for this interest rate. Given that the U.S. government bonds are in many different maturities, we chose to compute the implicit interest rate as the ratio of interest payments by the government to the beginning of period stock of government debt. Figure 3 displays this imputed interest rate against the 3-month T-bill rate and the 10-year Treasury note rate between 1960 and 2010 as well as the projections used by the CBO for the T-bill and T-note rates until 2020. In our benchmark calculations we assume that the

proprietor's income is attributable to capital income and the remaining part goes 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.

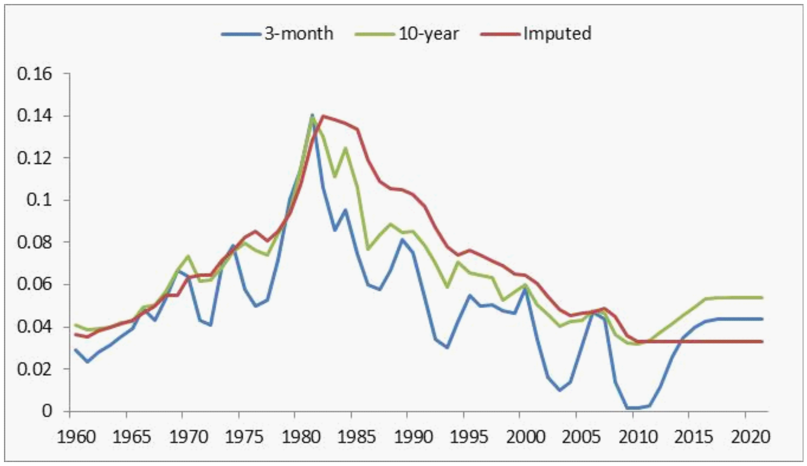

Figure 3: Nominal Rates

nominal interest rate on government bonds continue at their 2010 levels until 2030.

For the projections on government expenditures and transfer payments we use data from two sources. One from the Congressional Budget Office (CBO) and the other from the Bowles-Simpson Commission. Both provide projections on different categories of government spending for the federal government. In the CBO projection, TR_t is computed as the sum of social security, medicare, medicaid, CHIP, and Exchange Subsidies, while G_t, together with net government investment, constitutes the other noninterest spending. For the Bowles Simpson projections we combine their projections on social security and health care into TR_t and 'other mandatory spending' and 'discretionary spending' into G_t. Figure 4 summarizes the differences between the projections used in our experiments.[9]

4 Results

In the first part of this section we evaluate the impact of the future path of expenditures assumed in the CBO baseline versus the Bowles-Simpson plan on the future debt to GNP ratio in the U.S using our benchmark model. The calibration of the economy remains constant between these two cases except for the differences in the path of expenditures. Consequently, differences in the resulting debt to GNP ratio by 2030 only reflect the differences in the fu-

[9]Since Y_t is endogenous in our model, we actually use the projected growth rates of the level of G_t and TR_t from this data. To accomplish that we fisrt compute the model generated G_t and TR_t for 2010, as the product of Y_t and the corresponding spending shares in year 2010. Next, we project the level of G_t and TR_t starting from 2011 using the corresponding projected growth rate of the federal government spending and the initial levels at year 2010, which are computed in the first step. Lastly, we compute G_t/Y_t, and TR_t/Y_t using the model generated Y_t.

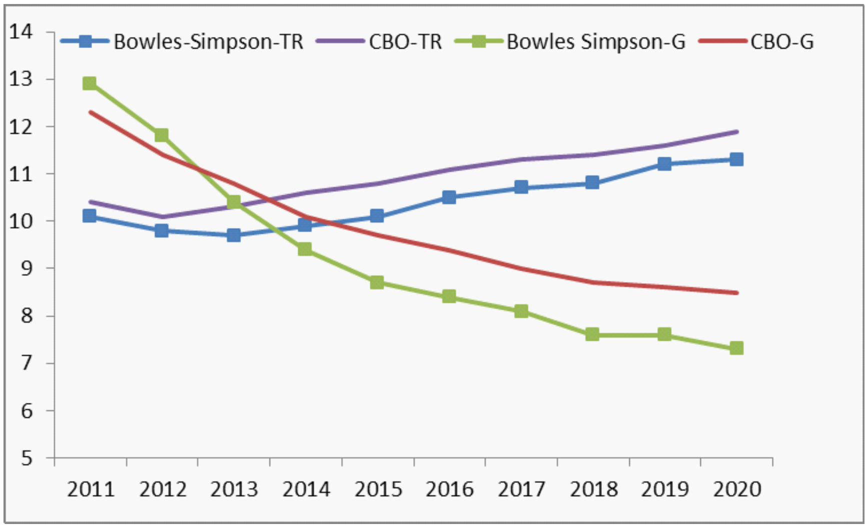

Figure 4: Expenditures as a percent of GDP

ture path of expenditures that are fed into the model and the endogenous response of the model economy to them. In the second section we conduct several experiments to asses the likely consequences of additional scenarios like an increase in the future inflation rate or the growth rate of TFP on the debt to GNP ratio by 2030.

4.1 Benchmark Calculations

We start this section by examining if the model generated economy can serve as a useful laboratory for studying the effects of different policies on the future debt to GNP ratios. In this benchmark we use the CBO projections for the future path of the expenditures. First two panels in Figure 5 summarize the GNP per person and hours per capita that is generated by the model as well as the data. Lower two panels summarize the results on the capital output ratio and the consumption output ratio. Notice that the model is not able to capture the continued increase in the consumption to output ratio that took place throughout the 1990s and 2000s. This is similar to the neoclassical model's inability to capture the hours boom in the 1990s.[10] In addition, model generated GNP per person and hours per capita are higher than their counterparts in the 1990s.

Figure 6 displays the overall government budget balance and debt to GNP ratios generated by the model economy as well as their counterparts in the data. The simulated series

[10]See McGrattan and Prescott (2010) for a discussion of this issue. Since we only feed in the labor wedge and not the other wedges, the model generated hours per capita is not identical to the data.

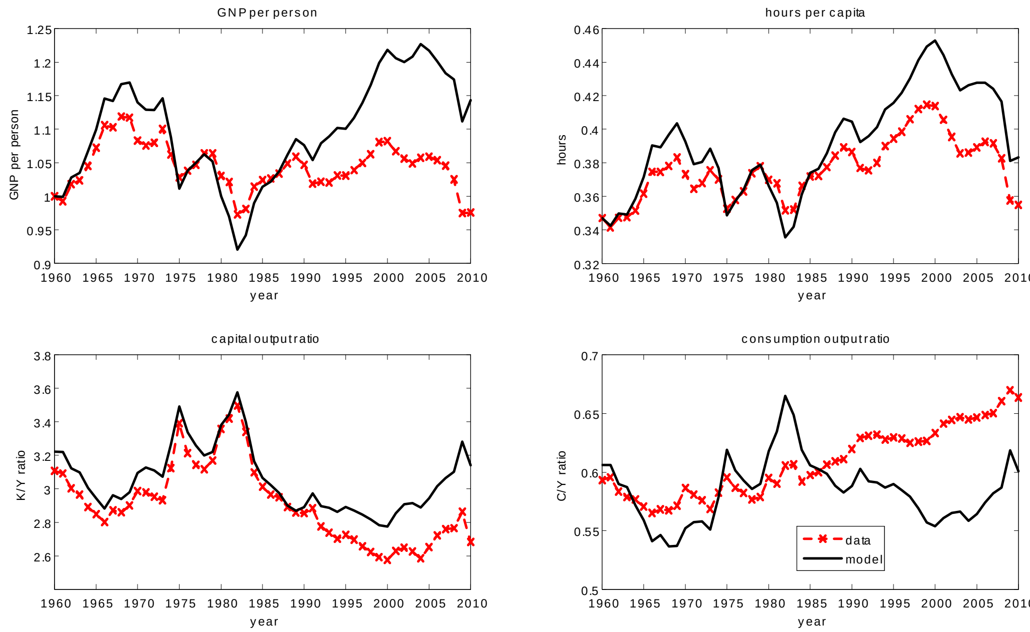

Figure 5: Benchmark Economy

which are generated through a mix of exogenously fed series such as government purchases and transfers and endogenous variables such as GNP and tax revenues captures the general increase in the government deficit and the debt to GNP ratio reasonably well. Model generated debt to GNP ratio in the 1990s is lower than the data due to lower deficits generated by the model in the 1990s. By 2010, however, both the budget balance and the debt ratio are close to their data counterparts.

While the model economy may not be able to capture all aspects of the U.S. economy precisley, it may be able to help us evaluate the implications of different expenditure projections on the future debt to GNP ratios. In the first experiment we use the expenditure projections given by the CBO under the extended baseline scenario. In the second one we use the proposed expenditure path by the Bowles-Simpson commission. We keep the tax rates set at their steady state values as described in the calibration section.

CBO Projections

In the first panel of Figure 7 we present the model generated budget balance up to 2030 and its data counterpart until 2010. The projections on expenditures and tax rates that are used in this calibration result in a initial improvement in the budget deficit which declines from about 9% in 2010 to around 7% until 2020 and deteriorates to 10% by 2030. The series labeled 'data' in the second panel of Figure 7 displays the actual debt to GNP ratio until 2010 and the CBO projections for it after 2010. CBO projections are the ones obtained

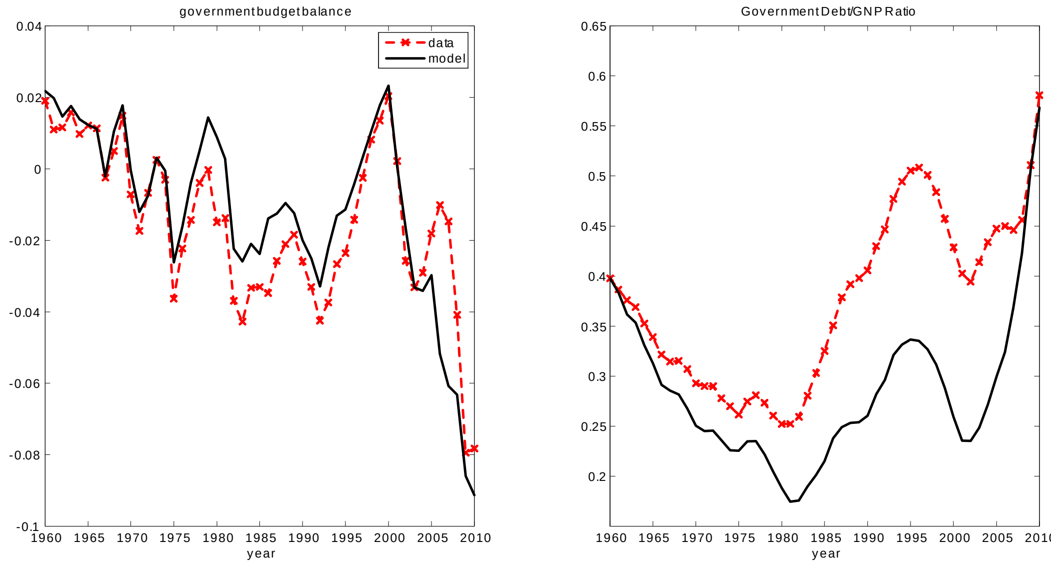

Figure 6: Government's Budget

under the extended baseline scenario where debt to GNP ratio reaches 80% by 2030. In contrast, the model generated debt to GNP ratio is 150% by 2030.

The main reason behind the high debt to output ratios obtained in the simulated model compared to the CBO projections is due to the differences in the projected revenues that can be seen in Figure 8. Projected increases in revenues in the CBO calculations (under the extended baseline scenario) arise due to the assumption that the provisions of current law remain in effect. In particular, they assume that the tax cuts that were enacted since 2001 are allowed to expire as scheduled in 2012 and the exemption amounts for the individual alternative minimum tax (AMT) revert to their 2001 levels in 2012. Both of these assumptions result in significantly higher tax collections after 2010 which result in their debt projections displayed earlier.[11] In their projections, however, CBO does not model the potential changes in labor supply that will result due to such significant changes in tax rates.

Higher Taxes with Endogenous Labor

In the next experiment, we increase the tax rate on labor income from about 25% in 2010 gradually to 35% in 2035, as assumed in the CBO projections. Figure 9 summarizes

[11] In the CBO's Extended-Baseline Scenario, marginal tax rates on labor increase from about 25% in 2011 to 35% in 2035. CBO projections only apply to federal government expenditures and tax revenues. In these calculations we extended their assumptions to include the state government expenditures and revenues as well. In our benchmark results we apply the CBO projections to the state and local governments as well. In the sensitivity analysis we investigate what might happen if the state and local government expenditures do not decline as projected by the CBO and rather stay at their historical levels.

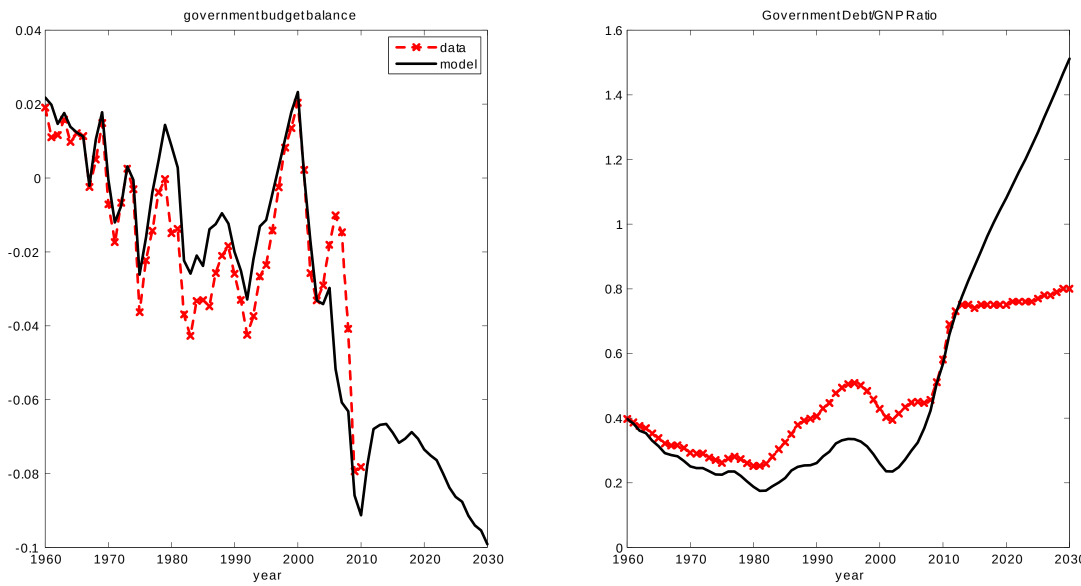

Figure 7: Using CBO Projections

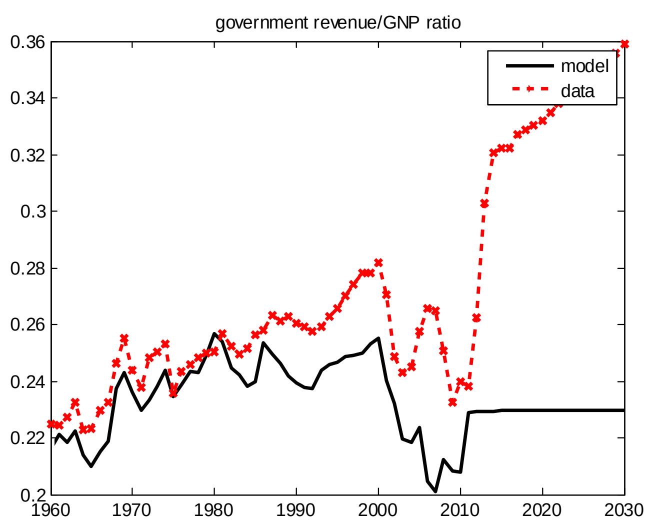

Figure 8: Revenues

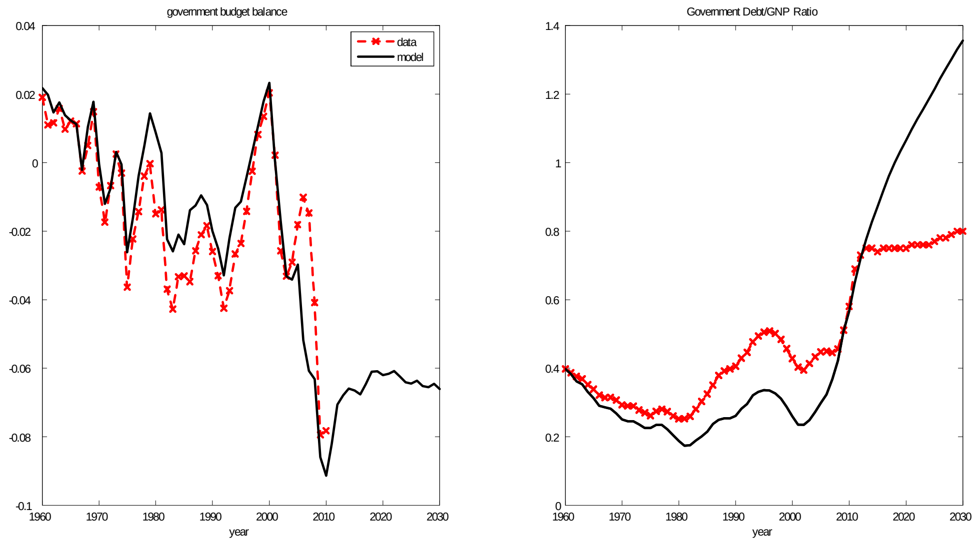

Figure 9: Budget with Higher Taxes

the resulting budget balance and debt to GNP ratios for this case. Notice that government budget balance improves in this case compared to the results presented in Figure 7. In particular the budget deficit remains around 6% until 2030 as opposed to reaching 10% if labor tax rates were to remain at 25%. The resulting debt to GNP ratio of 135% in 2030, is also slightly better than the benchmark case. However, 135%. is significantly higher than the CBO projection of 80%.

The impact of higher taxes on tax revenues can been observed in Figure 10 as well. Tax revenues rise from about 22% in 2010 to above 26% in 2030. However, this tax revenues is not close to matching what is projected by the CBO in order for the debt to GNP ratio to stabilize around 80%. In addition, higher tax rates result in a 2.8% lower GNP per capita by 2030.

Higer Taxes with Exogeneous Labor

As mentioned earlier, the CBO projections do not take into account the labor supply response to higher taxes. In the next experiment we keep the labor supply exogenous and repeat the exercise where the tax rate on labor income is increased from 25% in 2010 gradually to 35% in 2035. The debt to GNP ratio implied by the model in this case, shown in Figure 11 is 106% instead of 135% under the endogenous labor case. While there is significant discussion about the right elasticity of labor supply in the profession, this experiment demonstrates that the quantitative impact of labor supply responses can be very significant.

Bowles-Simpson Proposal for Expenditures:

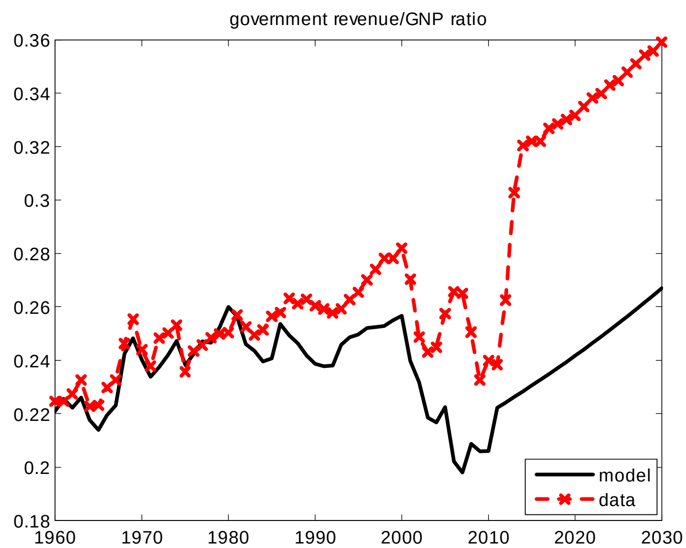

Figure 10: Revenue: CBO versus the Model

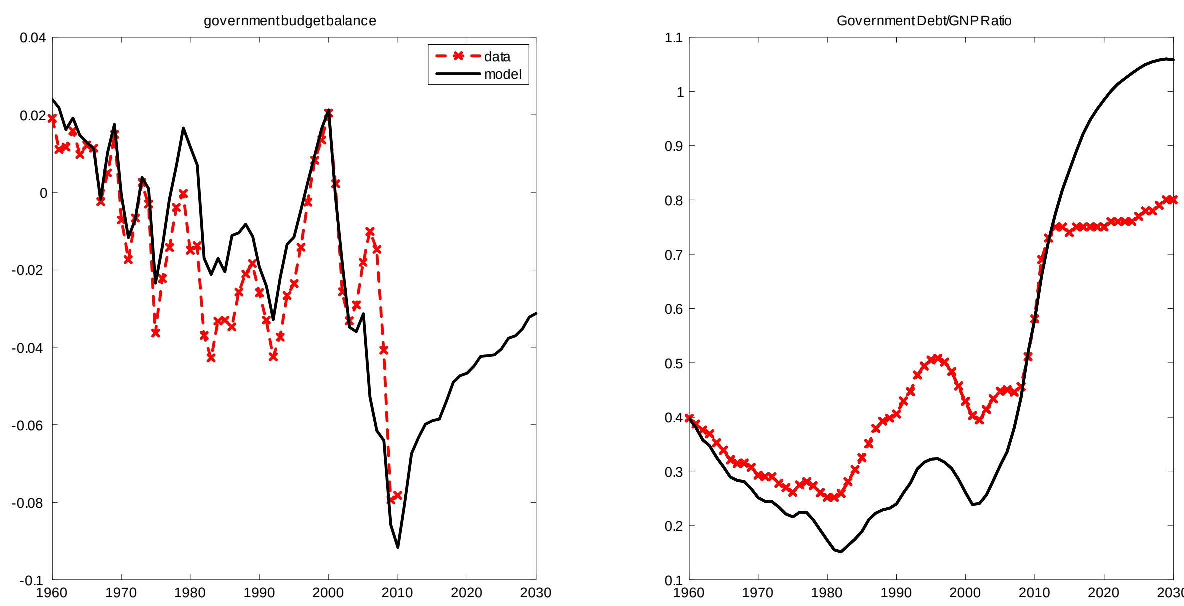

Figure 11: Budget with Exogeneous Labor

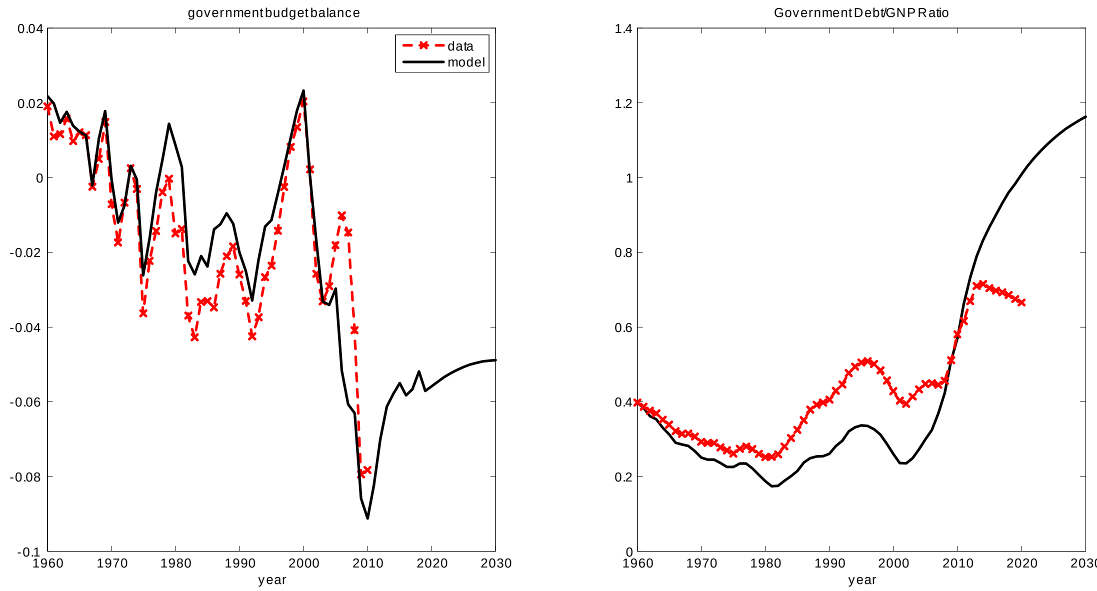

Figure 12: Bowles-Simpson Case

The National Commission on Fiscal Responsibility and Reform headed by Erskine Bowles and Alan Simpson has a proposal that involves larger cuts in both discretionary and mandatory spending categories such as social security and Medicare until 2020. They also make some recommendations on changes in the tax code. In this experiment we implement the path of expenditures in G_t and TR_t according to their proposal and examine the resulting debt to GNP ratio after 2010.

The main differences between the CBO projections and the Bowles-Simpson proposal can be summarized as follows. Total discretionary spending, which is the spending category G_t in the model economy, between 2012 and 2020 is set at \$9,724 billion in the Bowles-Simpson plan as opposed to \$11,666 billion in the CBO baseline. Expenditures on transfer payments (social security and health care) is also lower under the Bowles-Simpson plan.

Using the growth rate of the level of expenditures proposed by the Bowles-Simpson Commission results in government budget balance and debt to GNP ratios that are displayed in Figure 12. Compared with the results of the CBO baseline presented in Figure 7 Bowles-Simpson proposal results in smaller budget deficits as well as a smaller debt to GNP ratio by 2030 (116% versus 150%). The model is not rich enough to evaluate the changes in the tax code that is discussed in the Bowles-Simpson plan which focuses on increasing the tax base. A simple increase in the marginal tax rates as proposed in the CBO baseline, however, has a relatively small effect on the debt to GNP ratio in 2030.

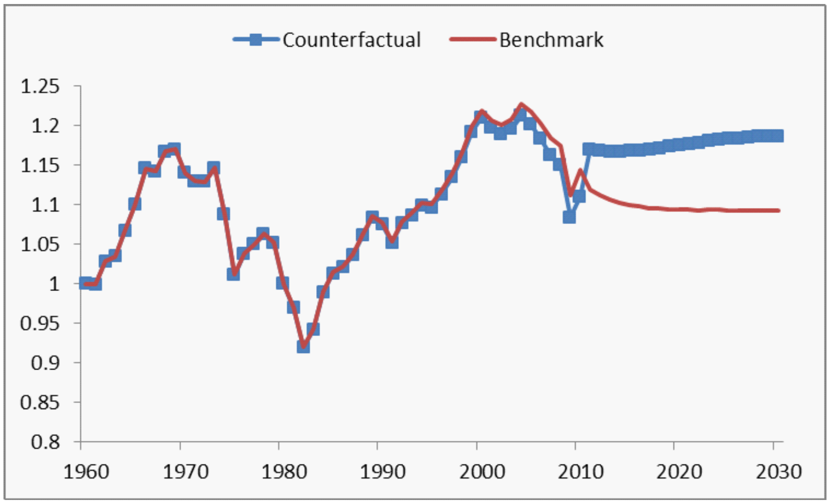

Figure 13: GDP per capita

4.2 Additional Experiments

In this section we conduct several additional experiments by making changes in the benchmark economy one at a time.

High Employment

There are many uncertainties about the future that make is difficult to provide forecasts. For example, in the benchmark results we assumed that the labor wedge will stay at its 2010 level which causes the average hours worked to be much lower than its peak in the 1990s. Consequently, GNP per person generated for the period after 2010 is also lower than its peak in 1990s. These features of the simulated data contribute to the high debt to GNP ratios generated for this benchmark. In the first counterfactual experiment we assume that the labor wedge after 2010 will go back to it's average level in the 1990s. If such a thing could happen, then GNP per person, displayed in Figure 13, is significantly higher after 2010 than what is implied by the benchmark model. This jump implies a high growth rate of GNP per capita between 2010 and 2011.

Under this fairly rosy scenario, debt to GNP ratio, displayed in Figure 14, reaches a relatively lower level of about 80% in 2030. This is due to the fact that the budget deficit shrinks immediately. A better fiscal outcome early on results in lower interest payments.

If hours worked increase more gradually instead of jumping to a higher level immediately, the resulting growth rate in GNP per capita after 2011 is lower and debt to GNP ratio in 2030 reaches 90%.

Federal versus State and Local Expenditures

In our benchmark results we assumed that both federal and state and local government

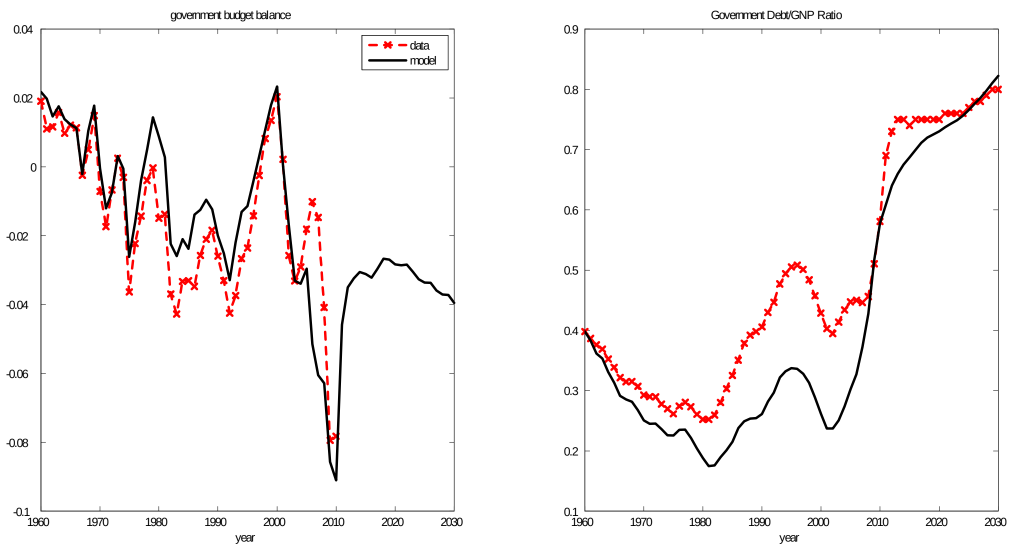

Figure 14: Debt with Higher Growth

purchases will decline after 2011 as projected by the CBO. However, CBO projections are primarily for the federal government which constitutes about 40% of government consumption and 33% of government investment. [12] In the next experiment we assume that state and local government expenditures as a percent of GNP stay constant after 2011 and only the federal expenditures decline as a percent of GNP as projected by the CBO. In this case, debt to output ratio, displayed on Figure 15 reach 200% in 2030.

Inflation

In the benchmark simulations we assumed the inflation rate in 2011 and beyond to continue at around 1%, it's level in 2010. In addition nominal interest rate on government debt is assumed to be 3.3% into the future. In the next set of counterfactual experiments we increase the inflation rate to 2%, 4%, and 6% without making any changes in the assumed nominal interest rate. Consequently, real interest rates are 1.3%, -0.7%, and -2.7%. We find that by 2030, debt to GNP ratio declines from 150% in the benchmark case to 132%, 102% and 82% for these three cases.

[12] In 2010, consumption expenditures of the federal government were 1,054 billion dollars while the total government consumption was 2,497 billion dollars. Gross government investment by the federal government was 168 billion dollars. The same year state and local government's spent 336 billion dollars on investment expenditures.

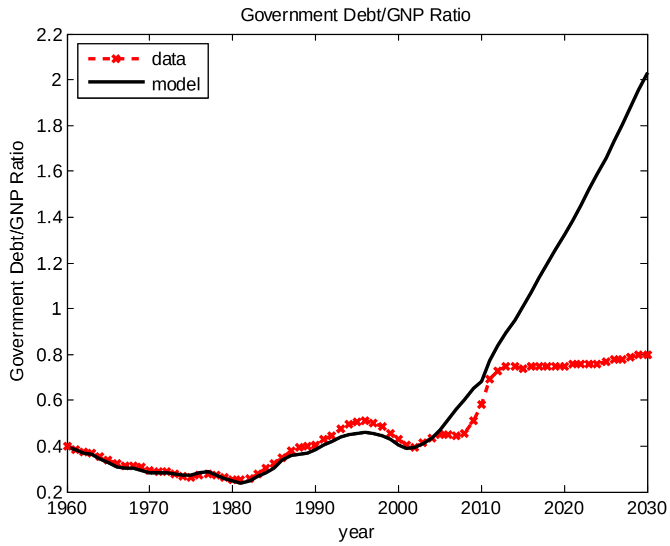

Figure 15: Different Assumptions on Expenditures

Summary

	Debt to GNP in 2030
CBO expenditures; historical tax; endogenous labor	150%
CBO expenditures; higher tax; endogenous labor	135%
CBO expenditures; higher tax; exogeneous labor	106%
CBO expenditures for federal gov only; historical tax	200%
Bowles Simpson expenditures; historical tax; endogenous labor	116%
Bowles Simpson expenditures; higher tax; endogenous labor	100%
Bowles Simpson expenditures; higher tax; exogenous labor	69%

5 Conclusions

In this paper we evaluate the likely consequences of the path of government expenditures foreseen by the CBO baseline and the Bowles-Simpson proposal in a fully calibrated general equilibrium model. While the framework is relatively simple, it incorporates the general equilibrium effects of policy that is often missing from the CBO projections. Our results suggest that it is fairly difficult for the U.S. economy to reach debt to GNP ratios around 80% by 2030 as forecasted in the baseline CBO calculations. Unless there is a significant increase in the growth rate of GNP, debt to GNP ratios above 100% are more likely to continue into the future.

References

[1] Braun, R. Anton and Etsuro Shioji (2007). "Investment Specific Technological Changes in Japan". Seoul Journal of Economics, 20, 165-199.

[2] Braun, R. A., D. Ikeda, and D. H. Joines (2009). "The Saving Rate In Japan: Why It Has Fallen And Why It Will Remain Low", *International Economic Review,* Vol. 50 (1), 291-321.

[3] Chari, V.V. , Kehoe P. J., and E. R. McGrattan, (2007). "Business Cycle Accounting", Econometrica, Vol. 75, No. 3, pp. 781-836.

[4] Chen, K., A. İmrohoroğlu and S. İmrohoroğlu (2006). "The Japanese Saving Rate". *American Economic Review* Vol. 96 (5), 1850-1858.

[5] Chen, K., A. İmrohoroğlu and S. İmrohoroğlu (2007). "The Japanese Saving Rate between 1960-2000: Productivity, Policy Changes, and Demographics". *Economic Theory* Vol. 32 (1), 87-104.

[6] Chen, K., A. İmrohoroğlu and S. İmrohoroğlu (2009). "A Quantitative Assessment of the Decline in the U.S. Current Account", *Journal of Monetary Economics,* Vol. 56 (8), 1135-1147.

[7] Congressional Budget Office (2011). CBO's 2011 Long-Term Budget Outlook (including Supplemental Data), June, http://www.cbo.gov/doc.cfm?index=12212.

[8] Hayashi, F. and E. C. Prescott (2002). "The 1990s in Japan: A Lost Decade". *Review of Economic Dynamics,* Vol. 5 (1), 206-235.

[9] Kehoe, T. and E. Prescott (2002). "Great Depressions of the 20th Century", *Review of Economic Dynamics,* Vol. 5, 1-18.

[10] McGrattan E., and E. C. Prescott (2010) "Unmeasured Investment and the Puzzling U.S. Boom in the 1990s", *American Economic Journal: Macroeconomics*, Vol. 2, No. 4, pp. 88-123.

[11] Ohanian, L., A. Raffo, and R. Rogerson, (2008). "Long-Term Changes in Labor Supply and Taxes: Evidence from OECD Countries, 1956-2004". *Journal of Monetary Economics.* Vol. 55 (8), 1353-1362.

[12] Smets, F, and R. Wouters (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach,"American Economic Review, 97(3): 586-606.

6 Appendix

6.1 Calibration of the Benchmark Economy

In this section, we provide the details of our calibration for the benchmark economy. We use data from the 2010 revision of National Income and Product Accounts (NIPA) and Fixed Asset Tables (FAT) of Bureau of Economic Analysis (BEA) for the years 1960-2010. Our adjustments to measured macroeconomic aggregates follow Cooley and Prescott (1995).

Denote measured GNP as follows

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

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

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

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

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

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

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

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

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

$$
\begin{aligned}
& (cs + cnd + csd + sg) + gc && (9) \\
+(i + nicd + dcd + gi + nx + nfp) &= GNP + sg + csd && (10) \\
&= (dep + dcd) + (NNP + csd + sg - dcd)
\end{aligned}
$$

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

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

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

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

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

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

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

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

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

$$
\begin{aligned}
Y_{kp} &= \text{Unambiguous capital income} + \theta_p \times (\text{proprietors' income} && \text{(A-5)} \\
&\quad +\text{indirect business tax}) + \text{depreciation} && (11) \\
&= \theta_p \times GNP
\end{aligned}
$$

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