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To Starve or Not to Starve the Beast?

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To Starve or Not to Starve the Beast?

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Abstract

While prominent voices have endorsed limiting the government's tax revenue in order to restrain spending for nearly 30 years, there has been little systematic analysis of the macroeconomic and welfare consequences of "starving the beast." This paper assesses the consequences of "starving the beast" using a large-scale multicountry general equilibrium model with a number of non-Ricardian elements. Overall, the analysis finds that the policy produces modest output and welfare gains in the United States, but this result depends on a number of assumptions and negative results can be obtained relatively easily.

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I. INTRODUCTION

For nearly 30 years, prominent voices have endorsed "starving the beast"—i.e., limiting government's tax revenue in order to restrain spending. Nobel Laureates Milton Friedman and Gary Becker have been among the proponents of this view, with Friedman (2003) offering the following summary:

> How can we ever cut government down to size? I believe there is one and only one way: the way parents control spendthrift children, cutting their allowance. For governments, this means cutting taxes. Resulting deficits will be an effective—I would go so far as to say, the only effective—restraint on the spending propensities of the executive branch and the legislature. The public reaction will make that restraint effective.

This philosophy has also been supported by a number of U.S. Presidents. For example, the Reagan tax cuts were aimed at stimulating aggregate supply and were based on the assumption that the tax cuts would induce spending restraint. In 1981, President Reagan said:

> There were always those who told us that taxes couldn't be cut until spending was reduced. Well, you know, we can lecture our children about extravagance until we run out of voice and breath. Or we can cure their extravagance by simply reducing their allowance.

The 2001 tax cuts were also consistent with the starve-the-beast approach. According to President Bush:

> So we have the tax relief plan, which is important for fiscal stimulus, coupled with Social Security being off limits except for—except for emergency. That now provides a new kind—a fiscal straightjacket for Congress. And that's good for the taxpayers, and it's incredibly positive news if you're worried about a federal government that has been growing at a dramatic pace over the past eight years and it has been.

At the same time, others have disputed the benefits of starving the beast. Krugman (2003), for instance, investigates whether the Reagan administration's 1981 tax cut, motivated by starve-the-beast considerations, led to faster growth. He concludes that:

> While the Reagan tax cuts didn't produce any visible supply-side gains, they did lead to large budget deficits. From the point of view of most economists, this was a bad thing. But for starve-the-beast tax-cutters, deficits are potentially a good thing, because they force the government to shrink.

There has been surprisingly little systematic analysis of the macroeconomic and welfare consequences of starving the beast.[1] Some earlier authors have suggested that revenue declines may not succeed in shrinking spending.[2] But even if they do—and even if spending is indeed as wasteful and taxes as distortionary as the strategy's proponents claim—the desirability of starving the beast merits a systematic assessment. This is because spending may adjust only with a lag, implying an increase in deficits and debt during the transition to the new low-tax/low-spending equilibrium. These transitional costs must be balanced against the benefits of the new equilibrium, and this is precisely what this paper attempts to do.

The analysis relies on experiments conducted in a large-scale multicountry general equilibrium model with a number of non-Ricardian elements. Ricardian equivalence does not hold because consumers have finite lifetimes and lifecycle income. The model, developed at the International Monetary Fund (IMF), is called the Global Integrated Monetary and Fiscal (GIMF) model (Kumhof and Laxton, 2007). GIMF reflects the latest advances in new open economy macroeconomic theory, and embodies a number of nominal and real rigidities, as well as a wide menu of fiscal and monetary policy tools, that allow it to yield empirically plausible short-term and long-run predictions.

The starve-the-beast approach is assessed in two ways. First, the paper examines whether the principal macroeconomic variables, such as GDP and consumption, respond positively to starving the beast. Second, the paper assesses social welfare effects, summarized using a compensating variation statistic. One of the paper's contributions is to investigate how the welfare assessment of starving the beast depends on the rate at which the utility of future generations is discounted. Also, given that the model contains two types of consumers, namely, wealthy consumers with access to financial markets, and less wealthy consumers without financial market access, the analysis also provides some insights on the distributional impact of starving the beast.

The remainder of the paper is structured as follows. Section A explains the design of the experiments, the analytical framework, and the approach to evaluating welfare effects. Section B reports the results, and Section C concludes.

[1] While the Congressional Budget Office (2003) does evaluate the potential macroeconomic effects of the Bush administration's overall 2004 budgetary proposals, it focuses on the combined effects of both spending increases and tax reductions.

[2] Krugman (2003), Niskanen (2006), Bayoumi and Goncalves (2007), and Romer and Romer (2007) suggest that, in the United States, tax cuts do not tend to be followed by government spending restraint. Other studies, such as Niepelt (2007), investigate the conditions, such as the presence of balanced budget rules, that could facilitate the implementation of a starve-the-beast approach.

II. METHODOLOGY

A. Experiments

The analysis is based on eight experiments—a baseline and seven variations. In the baseline experiment, an immediate and permanent cut in the payroll-tax-to-GDP ratio of 2 percentage points is followed by cuts in government transfers that offset the bulk of the tax cuts within 5 years. The reduction in lump-sum transfers is motivated by the notion that starve-the-beast advocates view government spending as unproductive, i.e., associated solely with aggregate demand, and not with long-run aggregate supply. The assumed 2 percentage point cut in the payroll tax-to-GDP ratio is also broadly consistent with the estimated size of the 2001–03 tax cuts implemented by the Bush administration.[3]

The seven variations on the baseline test the sensitivity of the results to key assumptions. The first variation reduces the speed at which government spending adjusts—if political conditions permit only a more gradual decline in spending, the net benefits of starving the beast may be smaller than in the baseline. The second variation addresses the productivity of government spending—with population aging driving transfers upward, starving the beast may result in cuts in public investment and other productive spending, which also would reduce the net benefits of the strategy. The third variation modifies the type of tax cut—the assessment of the strategy may also change if capital income taxes are cut rather than payroll taxes. The fourth variation changes the degree of international capital mobility—if this is imperfect, then the elasticity of U.S. interest rates to government debt would increase. This experiment investigates how a shock to the U.S. ease of access to foreign savings would affect the results. The fifth variation alters the degree of household myopia—this experiment demonstrates how the results change when the model is brought closer in line with the conventional infinite horizon paradigm.[4] The sixth variation investigates how the results depend on the assumed elasticity of labor supply—altering this parameter changes the output response to payroll tax cuts and thus fundamentally affects the assessment of the starve-the-beast strategy. The last variation relaxes the assumption that the reductions in taxes reduce future government spending, and simulates the effects of offsetting the initial tax cuts with subsequent tax changes in the opposite direction.

[3]See, for example, Ahearn (2004), who estimates that the three principal tax cuts implemented during 2001–03, namely, the Economic Growth and Tax Reform Reconciliation Act of 2001, the Job Creation and Worker Assistance Act of 2002, and the Jobs and Growth Tax Relief and Reconciliation Act of 2003 totaled two percent of net national product. Note that the results reported in this paper do not depend on the exact magnitude of the tax cut, as the same tax cut size is applied across all the simulations conducted.

[4]Examples of large-scale macroeconomic models that rely on the infinite horizon paradigm include the IMF's Global Economy Model (GEM), the Federal Reserve's SIGMA model (Erceg, Guerrieri, and Gust, 2006), and the European Central Bank's New Area-Wide Model (NAWM).

B. Analytical Framework

The Model The analysis uses GIMF, an open economy general equilibrium model developed at the International Monetary Fund (IMF) that is equipped for both monetary and fiscal policy analysis (Kumhof and Laxton, 2007). The model's nominal and real rigidities, monetary policy reaction function, multiple non-Ricardian features, and a fiscal policy reaction function, yield plausible macroeconomic responses to changes in fiscal and monetary policy.[5]

Ricardian equivalence is broken for four reasons. First, the model features overlapping generations agents (OLG) with finite lifetimes, i.e. a non-zero probability of death in each period. These agents are myopic in the sense that they perceive debt-financed tax cuts as an increase in their human wealth, and attach a low probability to having to pay for them in the future.[6] Second, workers have a life-cycle labor productivity pattern that implies a declining rate of productivity as workers age. This feature means that workers discount the effects of future payroll tax increase as they are likely to occur when they are older and less productive. Third, the model contains liquidity-constrained consumers (LIQ) who do not have access to financial markets to smooth consumption, and change their consumption one-for-one with changes in after-tax income.[7] Finally, the model includes payroll and capital income taxes that are distortionary because labor effort and private investment respond to relative price movements that result directly from variations in tax rates.

Importantly, GIMF relaxes the conventional assumption that all government spending is wasteful and does not contribute to aggregate supply. Instead, GIMF allows for productive public infrastructure spending that adds to the public capital stock, and enhances the productivity of private factors of production. Real rigidities embedded in the model include consumer habits that induce consumption persistence, investment adjustment costs that induce investment persistence, and import adjustment costs. Nominal rigidities include sticky prices and wages, and pricing to market. Further details on the model specification are provided in the technical Appendix.

Calibration Following Kumhof and Laxton (2007), the model is calibrated to contain two countries, the United States, and the rest of the world (RW). The fiscal parameters, such as the ratios to GDP of government transfers, purchases of goods and services, and public investment are calibrated based on data from national accounts. The productivity of public capital is calibrated following Ligthart and Suárez (2005) who present a meta analysis of large number of studies on the elasticity of aggregate output with respect to public capital, and estimate this elasticity at 0.14. Accordingly, the model is calibrated so

[5] I am grateful to Michael Kumhof and Douglas Laxton for sharing their model code with me.

[6] The model's overlapping generations structure with finitely-lived agents makes it particularly well suited to analyzing the implications of public sector deficits and debt both for the United States and for the rest of the world.

[7] These consumers do solve an intratemporal optimization problem for choosing consumption and leisure levels. However, without access to financial markets, they cannot smooth consumption in response to temporary changes in disposable income.

that a 10 percent increase in public investment is associated with a long-run increase in GDP of 1.4 percent. Given that public investment represents 3.3 percent of GDP, this elasticity of 0.14 implies an average annualized rate of return on public investment of about 3 percent over 50 years (net of depreciation).[8] The depreciation of public capital is set at 4 percent per year. The remaining parameters values are set following Kumhof and Laxton (2007), as described in the Appendix.

Welfare effects While the responses of macroeconomic variables provide a first approach to assessing the economic impact, this paper also quantifies welfare effects. In the model, a representative OLG household of age a at time t derives utility from consumption $c_{a,t}^{OLG}$ relatives to the consumption habit (proxied by lagged per capita consumption, $c_{a,t-1}^{OLG}$, leisure ($1-\, l_{a,t}^{OLG}$) (where 1 is the time endowment), and real money balances ($M_{a,t}/P_t^R$) (where P_t^R is the retail price index). The expected lifetime utility of a representative household of age a at time t has the form

$$\mathbf{E}_t \sum_{s=0}^{\infty} (\beta\theta)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{c_{a+s,t+s}^{OLG}}{\left(c_{a+s,t+s-1}^{OLG}\right)^{\nu}} \right)^{\eta^{OLG}} \left(1-\ell_{a+s,t+s}^{OLG}\right)^{1-\eta^{OLG}} \right)^{1-\gamma} + \frac{u^m}{1-\gamma} \left(\frac{M_{a+s,t+s}}{P_{t+s}^R} \right)^{1-\gamma} \right], \tag{1}$$

where $\beta < 1$ is the subjective discount factor (determined by the degree of consumer "impatience"), θ is the degree of myopia (determined by the probability of death), $\gamma > 0$ is the coefficient of relative risk aversion, ν represents the strength of habit formation, and $0 < \eta^{OLG} < 1$. $\mathbf{E}_t$ denotes the expectations operator conditional on information available in period t. Regarding utility derived for real money balances, the analysis only considers the cashless limit advocated by Woodford (2003), where $u^m \longrightarrow 0$. LIQ consumers have exactly the same preferences as OLG agents with $u^m = 0$. With $u^m = 0$, real balances do not enter into the calculation of utility for either groups of agents.

This paper assesses the utility of generations alive in any given period using the utility function, into which per capita consumption and leisure enter as arguments.[9] An important issue when there are overlapping generations is what weights to apply to different generations in assessing total welfare. Ganelli (2005) computes a weighted average of the utility of the current and of future generations, and explores how welfare results depend on the weights chosen. This paper follows the Ganelli (2005) approach by computing a weighted average of the utility of the current and future generations.[10] For

[8]The average annualized rate of return of 3 percent is obtained as follows. A 10 percent increase in public investment, i.e. an investment of 10 percent $\times$ 3.3 percentage points of GDP $=$ 0.33 percentage points of GDP, yields, after about 50 years, a 1.4 percent increase in GDP. The geometric average annual rate of return over the 50-year period is thus $\left(\frac{1.4}{0.33}\right)^{1/50} - 1 = 0.029$, i.e., about 3 percent.

[9]A complication in carrying out a welfare analysis in an overlapping generations model is the choice of the relevant criterion to measure total utility of current and future generations. This complication does not arise in infinite horizon models in which it is natural to take the utility function of the representative agent as the welfare criterion for society.

[10]Calvo and Obstfeld (1988) and Velculescu (2004) follow a similar welfare approach.

OLG agents, this weighted average is:

$$\mathbf{E}_t \sum_{s=0}^{\infty} (W)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{c_{t+s}^{OLG}}{\left(c_{t+s-1}^{OLG}\right)^{\nu}} \right)^{\eta^{OLG}} \left(1-\ell_{t+s}^{OLG}\right)^{1-\eta^{OLG}} \right)^{1-\gamma} \right], \tag{2}$$

where W denotes the weighting factor. A weighting factor of W = 1 would assign equal weights to current and future generations, i.e. a discount rate of zero.[11]

However, there are a number of reasons for not applying equal weights to current and future generations. As Marini and Scaramozzino (2000) explain, with positive technological change, not discounting the utility of future generations could result in present generations being treated unfairly. A positive discount rate could thus compensate for the bias in favor of future generations due to productivity growth.[12] Marini and Scaramozzino (2000) find that, under exogenous productivity growth, the optimal discount rate equals the sum of the rates of productivity and population growth. A plausible value for the discount rate based on such an approach could be 3 percent per year. This paper does not identify the optimal discount rate to apply to future generations. Rather, welfare results are reported for three alternative discount rates, 1 percent per year, 5 percent, and 10 percent.[13]

The compensating variation usefully summarizes results of the welfare analysis. Recall that the compensating variation indicates the increase in consumption that, with the original amount of leisure, yields the same change in welfare as the policy change does. For example, suppose that a policy change results in a 1 percent increase in consumption relative to the original steady state, but also increases the proportion of time spent working (reduces leisure). Because the decline in leisure has a negative effect on utility, the increase in consumption with the original level of leisure, required to change welfare by the same amount as the policy change would be less than 1 percent. A negative compensating variation implies that, after considering the changes in both consumption and leisure, consumers were better off before the policy change.

Computing the compensating variation involves equating the weighted average of utility in Equation (2) with the weighted average computed at the original level of leisure. The compensating variation, CV, enters the calculation as follows

$$\mathbf{E}_t \sum_{s=0}^{\infty} (W)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{(1+CV) \times c_{SS}^{OLG}}{\left(c_{SS}^{OLG}\right)^{\nu}} \right)^{\eta^{OLG}} \left(1-\ell_{SS}^{OLG}\right)^{1-\eta^{OLG}} \right)^{1-\gamma} \right], \tag{3}$$

[11] The weighted average for LIQ agents is analogous to Equation 2 with the superscript LIQ replacing the OLG superscript. The subscripts a no longer appear in the equation as the concern is now for the per-capita consumption and leisure of all agents alive in any given period.

[12] For example, with a steady state real growth rate of 1.5 percent per year, per capita income more than doubles in 50 years.

[13] These three discount rates provide a broad range of weights to apply to future generations. For example, while at the 1 percent discount rate, the utility of consumers alive 25 years from now has a weight $(W)^{25}$ that is 22 percent smaller than the weight attached to consumers alive today, that weight is 92 percent smaller than that of consumers alive today when the 10 percent discount rate is used.

where the subscript SS denotes the original steady state. The compensating variation is then found by searching for the value of CV that equates Equations (2) and (3).[14]

III. RESULTS

This section summarizes the main findings emerging from the seven experiments. In each case, the results are reported in deviation from control, i.e., the steady state that would occur if the starve-the-beast approach were not implemented.

A. Baseline Experiment

The baseline experiment suggest that starving the beast is beneficial to the U.S., but has negative spillover effects for RW. Figure 1 illustrates how the baseline experiment implements an immediate 2 percentage point cut in the payroll tax-to-GDP ratio. Next, reductions in government spending (lump-sum transfers) decline, offsetting the bulk of the tax cuts in 5 years. The fiscal deficits thus induced, as well as the increase in interest cots, raise the government debt-to-GDP ratio by, eventually 5 percentage points.

The payroll tax cut boosts consumption and aggregate demand and leads to a large near-term improvement in household utility (Figure 2). The increase in consumption is particularly strong for LIQ consumers who spend the full increase in disposable income. OLG consumers also increase consumption, notably because, with finite life-times, they discount the future reduction in transfers, and perceive the tax cuts as an improvement in their human wealth.[15] Monetary policy responds to the inflation pressure generated by the demand expansion by manipulating nominal interest rates to increase real interest rates, which has the effect of contracting investment, and contributing to a real U.S. dollar appreciation which in turn crowds in more imports. The resulting deterioration in net exports increases U.S. net foreign liabilities as the overall U.S. saving rate declines.[16]

[14]For the purposes of this paper, while the utility of households both in the United States and in the rest of the world is reported graphically, the compensating variation statistic is computed for U.S. households only.

[15]Note that, due to the presence of habit formation, the increase in consumption is gradual for OLG consumers.

[16]The negligible short-run response of GDP in the rest of the world to the short-run U.S. boom is, in part, due to the small size of U.S. imports as a share of rest-of-the-world GDP (3 percent of rest-of-the-world GDP). In addition, the short-run real appreciation of the U.S. exchange rate depresses consumption in the rest of the world.

Experiment	(1) Baseline	(2) Larger debt increase	(3) Public investment cut	(4) Capital tax cut	(5) Less access to foreign savings	(6) Less myopic agents	(7) Inelastic labor supply	(8) Undo tax cut
Real GDP								
In U.S.								
After 1 year	0.58	0.47	0.31	0.31	0.58	0.55	0.52	0.33
After 10 years	0.60	0.07	0.15	1.47	0.10	1.02	0.15	-0.56
After 100 years	0.66	-0.53	-1.00	2.31	-0.11	1.18	0.17	-0.73
In RW								
After 1 year	0.01	-0.01	-0.00	-0.01	0.02	0.01	0.01	0.00
After 10 years	-0.17	-0.27	-0.13	-0.45	-0.04	-0.02	-0.16	-0.10
After 100 years	-0.78	-2.32	-0.74	-1.29	-0.41	-0.03	-0.81	-0.75
Real consumption								
In U.S.								
After 1 year	1.38	1.66	1.34	0.97	1.25	1.04	1.40	0.98
After 10 years	1.45	1.98	1.27	1.04	1.08	1.51	0.96	0.08
After 100 years	0.88	-0.57	-0.66	1.51	0.37	1.41	0.28	-0.84
In RW								
After 1 year	-0.08	-0.20	-0.07	-0.19	-0.00	-0.02	-0.09	-0.09
After 10 years	-0.18	-0.44	-0.15	-0.35	-0.06	-0.02	-0.20	-0.20
After 100 years	-0.70	-2.18	-0.72	-1.09	-0.39	0.06	-0.75	-0.75

Table 1: Macroeconomic Effects: Real GDP and Consumption
(In percent deviation from initial steady state)

Over the medium term, the increase in U.S. net foreign liabilities raises global interest rates, crowding out private investment and output in the United States and abroad. At the same time, the U.S. real exchange rate depreciates to allow an increase in net exports sufficient to finance the larger interest obligations on the higher stock of net foreign liabilities. As Table 1 (column 1) reports, the spillover effects to RW are unambiguously negative. However, in the U.S., the negative effects due to higher interest rates are, in the long-run, more than offset by the output gains due to lower payroll taxes and the associated increase in hours worked. The elasticity of real interest rates to debt is, here, about 4 percent, meaning that the 5 percentage point increase in the debt-to-GDP ratio raises real interest rates by 20 basis points. This elasticity is in the lower range of estimates of Engen and Hubbard (2004), and Laubach (2003).

Overall, the baseline experiment raises welfare in the United States (Table 2, column 1). The welfare improvement is equivalent to an increase in steady state consumption of 0.63–1.1 percent, depending on the discount rate used. At a discount rate of 10 percent per year, the gain is 1.1 percent of steady state consumption, while at a discount rate of 1 percent per year, which gives greater weight to the long-run moderation in consumption, the gain is 0.63 percent of steady state consumption. In addition, the gains are distributed relatively evenly amongst OLG and LIQ consumers, with compensating variations of 0.64 and 0.61 percent of steady state consumption, respectively, evaluated using the 1 percent discount rate. The compensating variation, i.e., the welfare gain expressed in terms of steady state consumption, is smaller than the actual increase in consumption because of the disutility experienced by households spending a larger proportion of time working.

Experiment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline	Larger debt increase	Public investment cut	Capital tax cut	Less access to foreign savings	Less myopic agents	Inelastic labor supply	Undo tax cut
OLG Households								
10 % discount rate	0.99	1.29	0.74	1.50	0.66	0.86	0.60	0.18
5 % discount rate	0.91	0.85	0.37	1.78	0.49	0.97	0.44	-0.56
1 % discount rate	0.64	-0.31	-0.60	2.06	0.17	1.00	0.09	-0.56
LIQ Households								
10 % discount rate	1.30	1.63	1.16	0.10	0.88	1.48	0.97	0.36
5 % discount rate	1.01	0.89	0.59	0.20	0.45	1.34	0.59	-0.06
1 % discount rate	0.60	-0.55	-0.48	0.36	-0.07	1.17	0.10	-0.66
Total								
10 % discount rate	1.09	1.40	0.88	1.04	0.73	1.07	0.72	0.24
5 % discount rate	0.94	0.86	0.44	1.26	0.48	1.09	0.49	-0.39
1 % discount rate	0.63	-0.39	-0.56	1.50	0.09	1.05	0.09	-0.59

Table 2: Welfare Effects in the United States: Compensating Variation
(In percent of initial steady state consumption)

B. Alternative Scenarios

1. Speed of expenditure adjustment

The positive effects observed in the baseline experiment are sensitive to the speed at which government spending can respond to the cut in tax revenue. If, as in experiment 2, the decline in spending takes longer, with the bulk of the tax cuts being offset only after 10 years, rather than in 5 years as in the baseline, debt eventually increases by 15 percentage points of GDP, and the long-run effects on GDP are negative.[17] As Table 1 (column 2) and Figure 3 illustrate, the 50 basis-point long-run increase in real interest rates associated with the larger debt accumulation has a strong contractionary effect on U.S. investment and growth. The effects on GDP and consumption are particularly adverse in RW which experiences higher interest rates without the tax relief. The overall welfare effect is now negative in the U.S., and equivalent to a 0.55 percent decline in steady state consumption when evaluated at the 1 percent discount rate. However, the compensating variation remains positive when evaluated at the 5 and 10 percent discount rates, with the short-run benefits dominating the losses experienced by future generations.

2. Composition of expenditure adjustment

Similarly, the macroeconomic effects of starving the beast are negative when the government cuts productive spending. Accordingly, the adjustment in expenditure now also includes a permanent 10 percent reduction in public investment (corresponding to 0.3 percentage points of GDP, given that public investment initially comprises about 3 percent of GDP). As Figure 4 illustrates, cutting productive public investment has negative effects on output and consumption in the medium term. Consequently, the short-run positive effect on household utility associated with the tax cuts is offset by the medium term decline in consumption. Overall, the experiment yields a compensating variation of -0.56 percent of steady state consumption when evaluated at the 1 percent discount rate (Table 2, column 3). While the compensating variation also declines when evaluated at the 5 and 10 percent discount rates, it remains positive due to the short-run output boom. The spillover effects to RW associated with higher global interest rates remain substantial and negative (Figure 4).

3. Composition of tax cut

The next experiment provides the intuitive result that the long-run output gains associated with tax cuts are particularly strong if the tax cuts fall on capital income. When the 2 percentage-point cut in the tax-to-GDP ratio is implemented by cutting capital taxes, U.S.

[17] The increase in debt relative to the baseline experiment is greater than the increase in time taken for expenditure to offset the tax cuts because of the greater compounded interest costs associated with the fiscal deficits.

private savings increase by more than in the baseline experiment. In the long-run, the U.S. private investment gain is 5 percent despite the increase in interest rates in response to public debt accumulation. Consequently, the long-run expansion of U.S. output and consumption is larger than in the baseline experiment that relies solely on payroll tax cuts. After about 50 years, the U.S. output gain is about 2.3 percent (Figure 5), compared to an output gain of 0.66 percent in the baseline experiment. However, as Table 2 (column 4) reports, the distribution of the welfare gains is now highly unequal across OLG and LIQ consumers, with compensating variations of 2.1 and 0.36 percent of steady state consumption, respectively, when evaluated at the 1 percent discount rate.[18] Recall that the compensating variations are much more evenly distributed in the baseline experiment, with 0.64 and 0.61 percent of steady state consumption accruing to OLG and LIQ consumers, respectively.

4. Elasticity of U.S. interest rates to government debt

When U.S. access to foreign savings is restricted, and, consequently, the elasticity of U.S. interest rates to government debt increases, starving the beast is less beneficial. In particular, experiment five involves adding a country-specific premium to interest rates that increases with the current account deficit.[19] U.S. interest rates now respond more to the accumulation of public debt, and crowding out of private investment is more acute. While in the baseline experiment a permanent 1 percentage point rise in the government debt-to-GDP ratio increases U.S. real interest rates by about 4 basis points, that elasticity increases to more than 8 basis points when the U.S. ease of access to foreign savings is restricted.

While the economy still experiences a short-run demand boom, the long-run GDP effects are now negative, and welfare gains much smaller than in the baseline (Figure 6). At the 1 percent discount rate, the compensating variation is equivalent to only 0.09 percent of steady state consumption, compared to 0.63 percent in the baseline.[20] On the other hand, because interest rates in RW are now more isolated from the effects of higher U.S. government debt, the negative spillover effects to RW are smaller than in the baseline experiment. While a permanent one percentage point increase in the U.S. public debt-to-GDP ratio increases global interest rates by 4 basis points in the baseline experiment, this elasticity of global interest rates declines to less than 2 basis points in this limited financial integration scenario.

[18] The welfare gains are even more strongly skewed in favor of OLG consumers when the 5 percent and 10 percent discount rates are used.

[19] To emphasize how a reduction of ease of access to foreign savings affects the results, the interest rate, in this experiment, increases by 100 basis points for every 0.2 percentage point of GDP increase in the current account deficit.

[20] The compensating variation is also substantially lower than in the baseline at the 5 and 10 percent discount rates.

5. Degree of consumer myopia

If agents are less myopic, the negative effects of higher government debt for the United States are less severe, and the spillover effects to RW are negligible. In particular, the experiment involves lengthening households' planning horizons to 20 years from the baseline horizon of 10 years, and reducing the life-cycle decline in productivity from the baseline 5 percent per year to 2 percent per year. Consequently, with households acting in a more forward-looking manner, the tax cut has a smaller impact on aggregate demand in the short-run. With a more moderate demand expansion, a smaller monetary contraction is required, and the deterioration in net exports and the increase in net foreign liabilities is more modest, as is the corresponding long-run increase in interest rates (Figure 7). The smaller increase in global interest rates implies that the spillover effects to RW are negligible. Intuitively, the welfare gains associated with starving the beast are now unambiguously positive, with a compensating variation of 1.1 percent of steady state consumption under all three discount rates (Table 2, column 6).

6. Elasticity of labor supply

The next experiment suggests that, when labor supply is less elastic, payroll tax cuts have a less beneficial impact on long-run output. In particular, when the Frisch elasticity of substitution is reduced from the baseline value of 0.5 to 0.25, the long-run increase in GDP associated with starving the beast declines to 0.17 percent from 0.66 percent in the baseline experiment (Table 1, column 7, and Figure 8). The smaller increase in output restricts the increase in consumption, and results in a smaller welfare gain. The compensating variation is now only 0.09 percent compared to 0.63 percent under the baseline, when evaluated at the 1 percent discount rate. Because real interest rates still increase in response to the government debt accumulation as in the baseline, the spillover effects to RW remain negative.

7. Undoing the tax cuts

The last experiment suggests that, if the tax cuts do not succeed in inducing spending reductions, and the tax cut is eventually offset by tax changes in the opposite direction, the effects on output and welfare would be negative. The simulation assumes that the deficit created by the initial tax cut is closed over the same time horizon as it is in the baseline experiment, but using payroll tax increases instead of government transfer cuts (Figure 10). As in the baseline, the accumulation of deficits results in a permanent increase in the public debt-to-GDP ratio of 5 percentage points. In the short run, the economy still experiences an expansion as households perceive the initial tax cut as an increase in their human wealth. However, over time, the increase in public debt, and the higher taxes required to service the associated interest obligations crowd out output, resulting in lower consumption and welfare (Tables 1 and 2, column 8, and Figure 10). As in the baseline, the increase in global interest rates also implies negative spillovers to RW.

IV. CONCLUSION

Overall, the analysis in this paper suggests that the macroeconomic and welfare effects of starving the beast are uncertain. The baseline experiment suggests output and welfare gains in the United States, but this result depends on a number of assumptions and negative results can be obtained relatively easily. The policy can be particularly beneficial to the United States if it involves cutting capital income taxes (although this results in less even gains across the income distribution) and unproductive government spending, and if the elasticity of interest rates to public debt is low. On the other hand, if government spending adjusts more slowly to the tax cuts than assumed in the baseline, the resulting increase in public debt is likely to crowd out private activity, offsetting the welfare gains associated with the tax relief. Similarly, if the spending adjustment involves cutting not only unproductive spending but also productive spending, the welfare gains associated with tax relief are offset. Also, if the tax cuts fail to restrain spending, and are instead followed by tax increases, the effects on long-run output and welfare are negative.

In addition, the analysis suggests that the increase in global interest rates associated with the higher public debt involved in starving the beast implies negative spillover effects to RW. Moreover, these spillovers are likely to be particularly strong when countries are highly financially integrated, as a comparison of experiments 1 and 5 indicates.

The results also illustrate how welfare assessments depend crucially on the rate at which the utility of future generations is discounted. In particular, at discount rates of 5 percent or more, the gains associated with the near-term demand-led boom dominate losses experienced by future generations in the experiments conducted. This paper also addresses distributional effects only in a simple manner, by comparing the welfare effects for consumers with and without access to financial markets, who are less wealthy than OLG consumers. This is one of the many areas that future research could address in greater depth.

Appendix: Model Specification and Calibration

A. Specification

1. Households

Following Kumhof and Laxton (2007), the model consists of two countries, the United States, and RW, each populated by two types of households, namely, overlapping generations (OLG) and liquidity-constrained households (LIQ). All households consume final retailed output and supply labor to unions. OLG households comprise fraction ψ of all households, and solve the following optimization problem. The lifetime expected utility of a representative household of age a at time t is:

$$\mathbf{E}_t \sum_{s=0}^{\infty} (\beta\theta)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{c^{OLG}_{a+s,t+s}}{\left(c^{OLG}_{a+s,t+s-1}\right)^{\nu}} \right)^{\eta^{OLG}} \left(1-\ell^{OLG}_{a+s,t+s}\right)^{1-\eta^{OLG}} \right)^{1-\gamma} + \frac{u^m}{1-\gamma} \left(\frac{M_{a+s,t+s}}{P^R_{t+s}} \right)^{1-\gamma} \right], \tag{4}$$

where $\beta < 1$ is the subjective discount factor (determined by the degree of consumer "impatience"), θ is the probability of surviving from one period to the next (one minus the probability of death), $\gamma > 0$ is the coefficient of relative risk aversion, ν represents the strength of habit formation, and $0 < \eta^{OLG} < 1$. $\mathbf{E}_t$ denotes the expectations operator conditional on information available in period t. As utility derived for real money balances, the analysis only considers the cashless limit advocated by Woodford (2003), where $u^m \longrightarrow 0$. Consumption, $c^{OLG}_{a,t}$, is given by a CES aggregate over retailed consumption goods varieties, $c^{OLG}_{a,t}(i)$, with elasticity of substitution σ_R:

$$c^{OLG}_{a,t} = \left(\int_0^1 \left(c^{OLG}_{a,t}(i)\right)^{\frac{\sigma_R - 1}{\sigma_R}} di \right)^{\frac{\sigma_R}{\sigma_R - 1}}. \tag{5}$$

and demand for individual varieties is given by

$$c^{OLG}_{a,t}(i) = \left(\frac{P^R_t(i)}{P^R_t} \right)^{-\sigma_R} c^{OLG}_{a,t}, \tag{6}$$

where $P^R_t(i)$ is the retail price of variety i, and the aggregate retail price level P^R_t is given by

$$P^R_t = \left(\int_0^1 \left(P^R_t(i)\right)^{1-\sigma_R} di \right)^{\frac{1}{1-\sigma_R}}. \tag{7}$$

Each household can hold two types bonds, domestic government bonds, $B_{a,t}$, denominated in domestic currency, and foreign private bonds denominated in U.S. dollars. There is complete home bias in the ownership of government bonds. The nominal exchange rate vis-a-vis the United States is E_t, so that $E^*_t = 1$ for the United States [21]. Nominal holdings of net foreign assets in domestic currency are $E_t F_{a,t}$. The production based real exchange rate vis-a-vis the United States is $e_t = (E_t P^*_t)/P_t$, with $e^*_t = 1$. Gross nominal interest rates on U.S. and RW currency denominated assets are i^*_t and i_t. Financial assets from households that die are transferred to living households by insurance companies that pay a premium of $\frac{(1-\theta)}{\theta}$ on a household's financial wealth while it is alive and encash the family's assets when it dies.

Household sources of income consist of returns on financial assets, labor income, dividend income, and government lump-sum transfers. The labor productivity of an individual

[21] When the interaction between the United States and RW is discussed, U.S. variables are denoted by an asterisk. All nominal price level variables are written in upper case letters, and all relavtive price variables are written in lower case letters.

consumer declines with age, with the level of productivity at age a denoted by $\Phi_a = \kappa\chi^a$, where $\chi < 1$ determines the rate at which productivity declines with age, and the overall population's average labor productivity equals one. Household pre-tax wage income is $W_t\Phi_a l_{a,t}^{OLG}$, where W_t denotes the nominal wage. Labor income is taxed at payroll tax rate $\tau_{L,t}$, and consumption is taxed at rate $\tau_{c,t}$. The consumption tax is levied on the Lump-sum dividends are paid to OLG households from all firms in the nontradables (N) and tradables (T) manufacturing sectors; and the distribution (D), retail (R), and import agent (M) sectors, and from all unions (U) in the labor market, with after-tax nominal dividends from firm or union i denoted by $D_{a,t}^j(i), j = N, T, D, R, U, M$. The household's budget constraint is, in nominal terms

$$\begin{aligned} P_t^R c_{a,t}^{OLG} + P_t c_{a,t}^{OLG}\tau_{c,t} + B_{a,t} + E_t F_{a,t} &= \tfrac{1}{\theta}\left[i_{t-1}B_{a-1,t-1} + i_{t-1}^* E_t F_{a,-1,t-1}\right] \\ &+ W_t\kappa\chi^a l_{a,t}^{OLG}(1-\tau_{L,t}) + \sum_{j=N,T,D,R,U,M} \int_0^1 D_{a,t}^j(i)di \end{aligned} \tag{8}$$

where P_t is the aggregate final goods price level determined by distributors. The real wage is denoted by $w_t = W_t/P_t$, and the relative price, and gross inflation rate of any good x is denoted by $p_t^x = P_t^x/P_t$, and $\pi_t^x = P_t^x/P_{t-1}^x$.

The household maximizes lifetime expected utility (4) subject to (5) and (8). Aggregation of households takes account of the size of each age cohort a the time of birth, and of the remaining size of each generation. For OLG households, the aggregated consumption level is the following weighted average:

$$c_t^{OLG} = n(1-\psi)(1-\theta)\sum_{a=0}^{\infty}\theta^a c_{a,t}^{OLG}. \tag{9}$$

The first-order condition for the consumption-leisure choice is, after rescaling by technology[22], given by

$$\frac{\widetilde{c}_t^{OLG}}{n(1-\psi) - l_t^{OLG}} = \frac{\eta^{OLG}}{1-\eta^{OLG}}\widetilde{w}_t\frac{(1-\tau_{L,t})}{(p_t^R + \tau_{c,t})}. \tag{10}$$

The uncovered interest parity relation (arbitrage condition for foreign currency bonds) is

$$i_t = i_t^*\varepsilon_{t+1}. \tag{11}$$

The solution to the household's optimization problem also implies that the current level of consumption is a function of real financial, fw_t, and human wealth, hw_t, with the marginal propensity to consume out of total wealth given by $1/\Theta_t$, as reported in (**??**). Human wealth is in turn composed of hw_t^L, the expected present discounted value of future

[22]Given that the world economy grows at a growth rate of $g = T_t/T_{t-1}$ in steady state, where T_t is the level of labor augmenting world technology, it is necessary to express the model's real variables as ratios of T_t, such that a variable x_t is expressed as $\widetilde{x}_t = x_t/T_t$, and the steady state of $\widetilde{x}_t$ is $\overline{x}_t$. For the derivation of the first-order conditions for each generation, see Kumhof and Laxton (2007).

after-tax labor income, and hw_t^K, the expected present discounted value of capital, dividend income, and government transfers, Υ_t. Rescaling for technology yields the following

$$\widetilde{c}_t^{OLG} = \frac{1}{\Theta_t}\left[\widetilde{fw}_t + \widetilde{hw}_t\right] \tag{12}$$

where

$$\widetilde{fw}_t = \frac{1}{\pi_t g}\left[i_t\widetilde{b}_t + i_t^*\varepsilon_t\widetilde{f}_{t-1}e_{t-1}\right], \tag{13}$$

$$\widetilde{hw}_t = \widetilde{hw}_t^L + \widetilde{hw}_t^K, \tag{14}$$

$$\widetilde{hw}_t^L = (n(1-\psi)(\widetilde{w}_t(1-\tau_{L,t}))) + \frac{\theta\chi g}{r_t}\widetilde{hw}_{t+1}^L, \tag{15}$$

$$\widetilde{hw}_t^K = (\widetilde{d}_t^N + \widetilde{d}_t^T + \widetilde{d}_t^D + \widetilde{d}_t^R + \widetilde{d}_t^U + \widetilde{d}_t^M) + \widetilde{\Upsilon}_t + \frac{\theta\chi g}{r_t}\widetilde{hw}_{t+1}^L, \tag{16}$$

$$\Theta_t = \frac{p_t^R + \tau_{c,t}}{\eta^{OLG}} + \frac{\theta j_t}{r_t}\Theta_{t+1}, \tag{17}$$

$$j_t = \left(\beta\frac{i_t}{\pi_{t+1}}\right)^{\frac{1}{\gamma}}\left(\frac{p_t^R+\tau_{c,t}}{p_{t+1}^R+\tau_{c,t+1}}\right)^{\frac{1}{\gamma}}\left(\frac{\widetilde{w}_{t+1}g(1-\tau_{L,t+1})(p_t^R+\tau_{c,t})}{\widetilde{w}_t(1-\tau_{L,t})(p_{t+1}^R+\tau_{c,t+1})}\right)^{(1-\eta^{OLG})(1-\frac{1}{\gamma})} \left(\frac{c_t^{OLG}g}{c_{t-1}^{OLG}}\right)^{\nu\eta^{OLG}(1-\frac{1}{\gamma})}\chi^{(1-\eta^{OLG})(1-\frac{1}{\gamma})}. \tag{18}$$

Financial wealth, (13), is a sum of the domestic government's and foreign households' current liabilities. The discount factors in (15), (16),and (17) indicate that households discount future after-tax income, and, hence, future tax payments, at a rate of at least r_t/θ which is greater than the market rate, r_t The smaller is θ, i.e., the greater is the probability of death, the more heavily households discount future tax liabilities, and the more they perceive a decline in current taxes as an increase in their human wealth.

LIQ households have the same objective function as OLG households, but have a different budget constraint. In particular, LIQ households can consume at most their current income, which consists of their after tax wage income plus government transfers, $\widetilde{\Upsilon}_t$. The first-order conditions for LIQ households imply the following equations governing the consumption-leasure choice

$$\widetilde{c}_t^{LIQ} = \frac{1}{(p_t^R + \tau_{c,t})}\left[\widetilde{w}_t l_t^{LIQ}(1-\tau_{L,t}) + \widetilde{\Upsilon}_t\right], \tag{19}$$

$$\frac{\widetilde{c}_t^{LIQ}}{n\psi - l_t^{LIQ}} = \frac{\eta^{LIQ}}{(1-\eta^{LIQ})}\widetilde{w}_t \frac{(1-\tau_{L,t})}{(p_t^R + \tau_{c,t})}. \tag{20}$$

Equation (19) implies that LIQ households change their consumption one-for-one with a change in real after-tax labor income.

Aggregate consumption demand and labor supply is obtained by summing the respective quantities for OLG and LIQ households,i.e.

$$C_t = c_t^{OLG} + c_t^{LIQ}, \tag{21}$$

$$L_t = l_t^{OLG} + l_t^{LIQ}. \tag{22}$$

2. Firms and Unions

Manufacturers The two manufacturing sectors are indexed by $J \in [N,T]$. In each sector, there is a continuum of agents $i \in [0,1]$, that are perfectly competitive in their input markets and monopolistically competitive in their output markets. Manufacturers purchase labor from unions and capital from distributors. They sell goods to domestic distributors, to import agents abroad, and back to manufacturers. All of these agents demand a CES aggregate of manufactured varieties, with elasticity of substitution σ_J. Aggregate demand for variety i produced by sector J is derived by aggregating over all sources of demand, yielding

$$Z_t^J(i) = \left(\frac{P_t^J(i)}{P_t^J}\right)^{-\sigma_J} Z_t^J, \tag{23}$$

where $\widetilde{P}_t^J$ is defined similarly to (7), and where the demand quantities, $Z_t^J(i)$, and Z_t^J are determined by market clearing conditions. Technology is specified by way of CES production functions of capital $K_t^J(i)$, and labor, $U_t^J(i)$, with elasticity of substitution ξ_J, and labor-augmenting productivity, T_t, i.e.

$$Z_t^J(i) = F\left(K_t^J(i), U_t^J(i)\right) = \left((1-\alpha_J^U)^{\frac{1}{\xi_J}}(K_t^J(i))^{\frac{\xi_J-1}{\xi_J}} + (\alpha_J^U)^{\frac{1}{\xi_J}}(T_t U_t^J(i))^{\frac{\xi_J-1}{\xi_J}}\right)^{\frac{\xi_J}{\xi_J-1}}. \tag{24}$$

To help generate plausible inflation dynamics, manufacturing firms face quadratic inflation adjustment costs, .Quadratic adjustment costs also apply to capital accumulation, and are described by

$$G_{I,t}^J = \frac{\phi_I}{2}K_t^J(i)\left(\frac{I_t^J}{K^J} - \frac{I_{t-1}^J}{K_{t-1}^J}\right)^2 \tag{$G_{I,t}^T$}$$

Capital evolves according to

$$K_{t+1}^{J}(i) = (1-\delta)K_{t}^{J}(i) + I_{t}^{J}(i), \tag{25}$$

where δ represents the rate of capital depreciation. Dividends, $D_t^J(i)$, equal nominal revenue, $P_t^J(i)Z_t^J(i)$, minus nominal cash outflows, i.e., the wage bill $V_tU_t^J(i)$, where V_t is the aggregate nominal wage rate charge by unions, nominal investment $P_tI_t^J(i)$, nominal investment adjustment costs $P_tG_{I,t}(i)$, a fixed cost $P_t^JT_t\omega^J$ and price adjustment costs $P_t^JG_{P,t}^J(i)$.

The optimization problem of each manufacturing firm is

$$\underset{\left\{P_{t+s}^{J}(i),U_{t+s}^{J}(i),I_{t+s}^{J}(i),K_{t+s+1}^{J}(i)\right\}_{s=0}^{\infty}}{Max} \sum_{s=0}^{\infty} \widetilde{R}_{t,s} D_{t+s}^{J}(i), \tag{26}$$

where

$$\widetilde{R}_{t,s} = \prod_{l=1}^{s} \frac{\theta}{i_{t+l-1}} \text{ for } s > 0 \; (= 1 \text{ for } s = 0). \tag{27}$$

The first order conditions to this problem imply standard conditions for optimal choices of labor and investment, as well as a "sticky inflation" Phillips curve equation for sectorial inflation, π_t^J, with current inflation related to past inflation, future inflation, and real marginal cost in sector J, i.e.

$$\left[\frac{\sigma_J}{\sigma_J - 1}\frac{\lambda_t^J}{p_t^J} - 1\right] = \frac{\phi_{P^J}}{\sigma_J - 1}\left(\frac{\pi_t^J}{\pi_{t-1}^J}\right)\left(\frac{\pi_t^J}{\pi_{t-1}^J} - 1\right) \tag{28}$$

$$-\frac{\theta g}{r_t}\frac{\phi_{P^J}}{\sigma_J - 1}\frac{p_{t+1}^J}{p_t^J}\frac{\widetilde{Z}_{t+1}^J}{\widetilde{Z}_t^J}\left(\frac{\pi_{t+1}^J}{\pi_t^J}\right)\left(\frac{\pi_{t+1}^J}{\pi_t^J} - 1\right)$$

Unions Households sell labor to unions, who, in turn, sell it to manufacturers who demand a CES aggregate of labor varieties, with elasticity of substitution σ_U. Aggregate demand for labor variety i is

$$U_t(i) = \left(\frac{V_t(i)}{V_t}\right)^{-\sigma_U} U_t. \tag{29}$$

Nominal wage rigidities occur due to wage inflation adjustment costs, and the union's optimization problem involves maximizing the present discounted value of nominal wages paid by firms minus nominal wages paid out to workers, minus nominal wage inflation adjustment costs. The first-order condition is a wage inflation Phillips curve similar to (28).

Import Agents, Distributors, and Retailers Each country has two continua of import agents located in the other country, indexed by $J \in [T, D]$. Import agents in each sector buy final tradable goods from manufacturers in the other country and sell them to distributors in the home economy. The maximization problem of import agents consists of maximizing the present discounted value of nominal revenue minus nominal costs of inputs, minus nominal inflation adjustment costs, and the first order condition yields a Phillips curve for import price inflation similar to (28).

Distributors buy goods from manufacturers and import agents, use the stock of public infrastructure, and sell the final output to consumption goods retailers, manufacturing firms (in their role as investors), the government, final goods import agents in foreign countries, and to various other sectors for fixed costs and adjustment costs. Distributors produce final output following a four-stage procedure. First, distributors produce a tradables composite $Y_t^T(i)$ by combining foreign tradables $Y_t^{TF}(i)$ with domestic tradables $Y_t^{TH}(i)$, subject to an adjustment cost on changes in the share of foreign tradables, $G_{F,t}^T$. Second, distributors produce a tradables-nontradables composite $Y_t^A(i)$. Third, distributors combine this composite with public infrastructure K_t^G to produce Y_t^{DH}. Fourth, distributors combine the private-public composite with foreign final output, subject to an import adjustment cost, $G_{F,t}^D$, to produce domestic final output, Y_t. The following four equations describe the four-stage procedure.[23]

$$Y_t^T(i) = \left((\alpha_{TH})^{\frac{1}{\xi_D}} \left(Y_t^{TH}\right)^{\frac{\xi_T - 1}{\xi_T}} + (1-\alpha_{TH})^{\frac{1}{\xi_T}} \left(Y_t^{TF}(1-G_{F,t}^T)\right)^{\frac{\xi_T - 1}{\xi_T}} \right)^{\frac{\xi_T}{\xi_T - 1}} \tag{30}$$

$$Y_t^A = \left((1-\alpha_N)^{\frac{1}{\xi_A}} \left(Y_t^T(i)\right)^{\frac{\xi_A - 1}{\xi_A}} + (\alpha_N)^{\frac{1}{\xi_A}} \left(Y_t^N(i)\right)^{\frac{\xi_A - 1}{\xi_A}} \right)^{\frac{\xi_A}{\xi_A - 1}} \tag{31}$$

$$Y_t^{DH} = Y_t^A \left(K_t^G\right)^{\alpha_G} \mathfrak{s} \tag{32}$$

$$Y_t = \left((\alpha_{DH})^{\frac{1}{\xi_D}} \left(Y_t^{DH}\right)^{\frac{\xi_D - 1}{\xi_D}} + (1-\alpha_{DH})^{\frac{1}{\xi_D}} \left(Y_t^{DF}(1-G_{F,t}^D)\right)^{\frac{\xi_D - 1}{\xi_D}} \right)^{\frac{\xi_D}{\xi_D - 1}} \tag{33}$$

Retailers buy final output from distributors and sell it to consumers. The optimization problem of retailers consists of maximizing the present discounted value of nominal revenue $P_t^R(i)C_t(i)$ minus nominal costs of inputs $P_tC_t(i)$, minus nominal quantity adjustment costs $P_tG_{Y,t}^R(i)$.

[23]The coefficient $\mathfrak{s}$ is a technology scale factor used to nomalize the relative size of each economy to correspond to its relative population size.

3. Government

Fiscal Policy The government determines payroll, consumption, and capital income taxes, as well as the levels of government consumption G_t^{cons}, government investment G_t^{inv}, and government transfers Υ_t. Government consumption is exogenous and unproductive. Government investment contributes to the stock of public infrastructure capital K_t^G used, as (32) describes, to produce final output, which evolves according to

$$K_t^G = (1 - \delta_G) K_{t-1}^G + G_t^{inv}. \tag{34}$$

where δ_G is the public capital depreciation rate. The government issues one-period debt B_t at the gross nominal interest rate i_t, and has the following budget constraint

$$b_t = \frac{i_{t-1}}{\pi_t g} b_{t-1} + G_t^{cons} + G_t^{inv} + \Upsilon_t - \tau_t \tag{35}$$

where tax revenue τ_t consists of payroll taxes, consumption taxes, and capital income taxes.

$$\begin{aligned} \tau_t \quad = \quad & \tau_{L,t} w_t L_t + \tau_{c,t} C_t \\ & + \tau_{k,t} \left[r_{k,t}^N - \delta q_t^N \right] K_t^N \\ & + \tau_{k,t} \left[r_{k,t}^T - \delta q_t^T \right] K_t^T \end{aligned} \tag{36}$$

Debt stabilization is ensured by adjusting taxes or spending via a fiscal rule in which the primary surplus responds to deviations of the debt-to-GDP ratio from a desired level. The fiscal policy adjustments are determined by the following equation

$$\frac{b_t}{gdp_t} = (1 - \mu_b) \bar{b}_t + \mu_b \frac{b_{t-1}}{gdp_{t-1}} - \mu_{bgr} \frac{b_t - b_{t-1}}{gdp_t} \tag{37}$$

where μ_b determines the speed at which the actual debt-to-GDP ratio adjusts towards the exogenous desired level $\bar{b}_t$. The term μ_{bgr} prevents excessive cycling in the primary surplus and the real economy.

Monetary Policy The central bank adjusts nominal interest rates gradually to stabilize inflation and output growth in line with the rules suggested by Orphanides (2003). The term r_t^{smooth} is a weighted average of past, current, and future real interest rates, and represent's the central bank's estimate of the time-varying steady-state real interest rate.

$$\begin{aligned} i_t \quad = \quad & (i_{t-1})^{\mu_i} \left(r_t^{smooth} \pi_{t+1} \right)^{1-\mu_i} \left(\frac{\pi_{t+1}}{\bar{\pi}} \right)^{(1-\mu_i)\mu_\pi} \\ & \left[\left(\frac{gdp_{t+1}}{gdp_t} \right) \right]^{(1-\mu_i)\mu_{ygr}} \end{aligned} \tag{38}$$

$$r_t^{smooth} = \mathbf{E}_t \left(r_{t-1} r_t r_{t+1} \right)^{\frac{1}{3}} \tag{39}$$

4. Equilibrium

A perfect foresight solution for the model is obtained that consists of a price system and government policies such that households maximize lifetime utility, and firms and unions maximize the present discounted value of their cash flows. The model is solved using the TROLL software based on a Newton stacked-time algorithm that involves stacking the time-dependent equations of the model such that each endogenous variable is represented by an independent equation. The stacked structure is then solved simultaneously using a Newton procedure.[24]

B. Calibration

The model is calibrated to comprise two countries, the United States and RW, and so that each period represents one year. The structural parameters are calibrated following Kumhoff and Laxton (2007), and are in the range of available empirical estimates, or, when such estimates are not available, equal to conventional values. For the steady-state ratios to GDP, the calibration is consistent with recent data from national accounts.

Regarding the parameters that are different across the two countries, the United States is calibrated to comprise 25 percent of world GDP, and have steady state government debt and net foreign liabilities ratios of 60 and 55 percent, respectively. RW has net foreign assets of 18.3 percent of GDP, and a government debt-to-GDP ratio of 30 percent. The share of liquidity constrained consumers is 33 percent in the United States, and 50 percent in RW. The trade share parameters α_{TH} and α_{DH} are chosen to produce U.S. ratios to GDP of intermediate and final goods imports and of intermediate goods exports of 6 percent, and to normalize the initial steady state real exchange rate to 1.

The remaining structural parameters and macroeconomic ratios are the same in the two countries. The steady state growth and inflation rates are calibrated at 1.5 and 2 percent, respectively, and the initial global real interest rate is set to equal 2 percent using the discount factor β. The parameters θ and χ that are important for breaking Ricardian equivalence are calibrated at 0.9 and 0.95 implying a probability of death of 10 percent per year, and an average remaining working life of 20 years. The degree of habit strength ν is 0.4 per year, the Frisch elasticity of substitution depends on the parameters η^{OLG} and η^{LIQ} and is set to equal 0.5 in each country. The elasticities of substitution between capital and labor in both tradables and nontradables are assume to equal 1. The elasticities of substitution between domestic and foreign intermediates and final goods are assumed to equal 1.5, and the elasticity of substitution between tradables and nontradables is set to 0.5. Investment adjustment costs ϕ_I equal 10, and trade and consumption adjustment costs equal 5.

Regarding price setting, the markup of price over marginal cost equals 20 percent in the manufacturing and labor market sectors. In the distribution and retail sectors, the

[24] See Armstrong, Black, Laxton, and Rose (1998).

markups are 5 percent, and import agents have markups of 2.5 percent. The inflation adjustment cost in all sectors equals 10, except in the RW import sector, where it equals zero. The manufacturing labor income share parameters α_T^U and α_T^U are chosen to set labor income shares of 64 percent in each sector. The nontradables parameter is chosen to ensure that the nontradables share in GDP is 50 percent.

Regarding macroeconomic ratios, private consumption and investment spending equal 66 and 16 percent, respectively, in the initial steady state. The ratios to GDP of government consumption, government investment, and government transfers are set equal to 15.8, 3.3, and 8 percent of GDP, respectively. Private capital is assumed to depreciate at a rate of 10 percent per year. The calibration of the productivity of public capital is discussed in Section II.

Regarding the policy rule parameters, the monetary policy rule features a response of $\mu_i = 0.25$ per year to the lagged interest rate, the response to the inflation forecast gap is $\mu_\pi = 1.6$, and the response to output growth is set to $\mu_{ygr} = 0.25$. The fiscal rule coefficient values are $\mu_g = 0.7$ and $\mu_{bgr} = 0.25$.

Armstrong, J., R. Black, Douglas Laxton, and D. Rose, "A Robust Method for Simulating Forward-Looking Models," *Journal of Economic Dynamics and Control*, 22 (April 1998), 489-501.

Bayoumi, Tamim, and Fernando M. Goncalves, 2007, "Beauty or the Beast?" forthcoming IMF Working Paper (Washington: International Monetary Fund).

Bush, George W., 2001, Remarks by President Bush and Secretary Rumsfeld in Announcement of Chairman and Vice-Chairman of the Joint Chiefs of Staff, The White House, http://www.whitehouse.gov/news/releases/2001/08/20010824.html.

Calvo, Guillermo, and Maurice Obstfeld, 1998, "Optimal Time-Consistent Fiscal Policy With Finite Lifetimes," *Econometrica*, Vol. 56, No. 2 (March), pp. 411–32.

Congressional Budget Office, 2003, "An Analysis of the President's Budgetary Proposals for Fiscal Year 2004," Congressional Budget Office, http://www.cbo.gov/ftpdoc.cfm?index=4129&type=0&sequence=0#pt5.

Engen, Eric M., and Hubbard, R. Glenn, 2004, "Federal Government Debt and Interest Rates," NBER Macroeconomics Annual, Vol. 19, pp. 83–138.

Erceg, Christopher J., Luca Guerrieri, and Christopher Gust, 2006, "SIGMA: a new open economy model for policy analysis," International Journal of Central Banking, Vol. 2 (March), Issue 1.

Friedman, Milton, 2003, "What Every American Wants," Wall Street Journal (7 October), as quoted by William A. Niskanen, 2006, "Limiting Government: the Failure of "Starve the Beast,"" Cato Journal, Vol. 26, No. 3 (Fall 2006).

Ganelli, Giovanni, 2005, “The New Open Economy Macroeconomics of Government Debt,” Journal of International Economics 65 (1), January 2005, pp. 167–84.

Krugman, Paul, 2003, “The Tax-Cut Con,” published in The New York Times (September 14, 2003).

Kumhof, Michael, and Douglas Laxton, 2007, “A Party Without a Hangover? On the Effects of U.S. Government Deficits,” IMF Working Paper No. 07/202 (Washington: International Monetary Fund).

Laubach, Thomas, 2003, “New Evidence on the Interest Rate Effects of Budget Deficits and Debt,” Finance and Economics Discussion Series 2003–12, Board of Governors of the Federal Reserve System.

Ligthart, Jenny E., and Rosa M. Martin Suarez, 2005, “The Productivity of Public Capital: A Meta Analysis,” manuscript, University of Groningen, and Tilburg University.

Marini, Giancarlo, and Pasquale Scaramozzino, 2000, “Social Time Preference,” Journal of Population Economics (2000) 13, pp. 639–45.

Niepelt, Dirk, 2007, “Starving the Beast? Intra-generational Conflict and Balanced Budget Rules,” European Economic Review 51 (2007), pp. 145–59.

Orphanides, Athanasios, 2003, “Historical Monetary Policy Analysis and the Taylor Rule,” *Journal of Monetary Economics*, 50, 983-1022.

Reagan, Ronald, 1981, Address to the Nation on the Economy (5 February), as quoted by Jerry H. Tempelman, 2006, “Does ‘Starve the Beast’ Work?” *Cato Journal*, Vol. 26, No. 3 (Fall 2006).

Romer, Christina D., and David H. Romer, 2007, “Starve the Beast or Explode the Deficit? The Effects of Tax Cuts on Government Spending,” manuscript, University of California, Berkeley.

Velculescu, Delia, 2004, “Intergenerational Habits, Fiscal Policy, and Welfare,” *Topics in Macroeconomics*, Volume 4, No. 1.

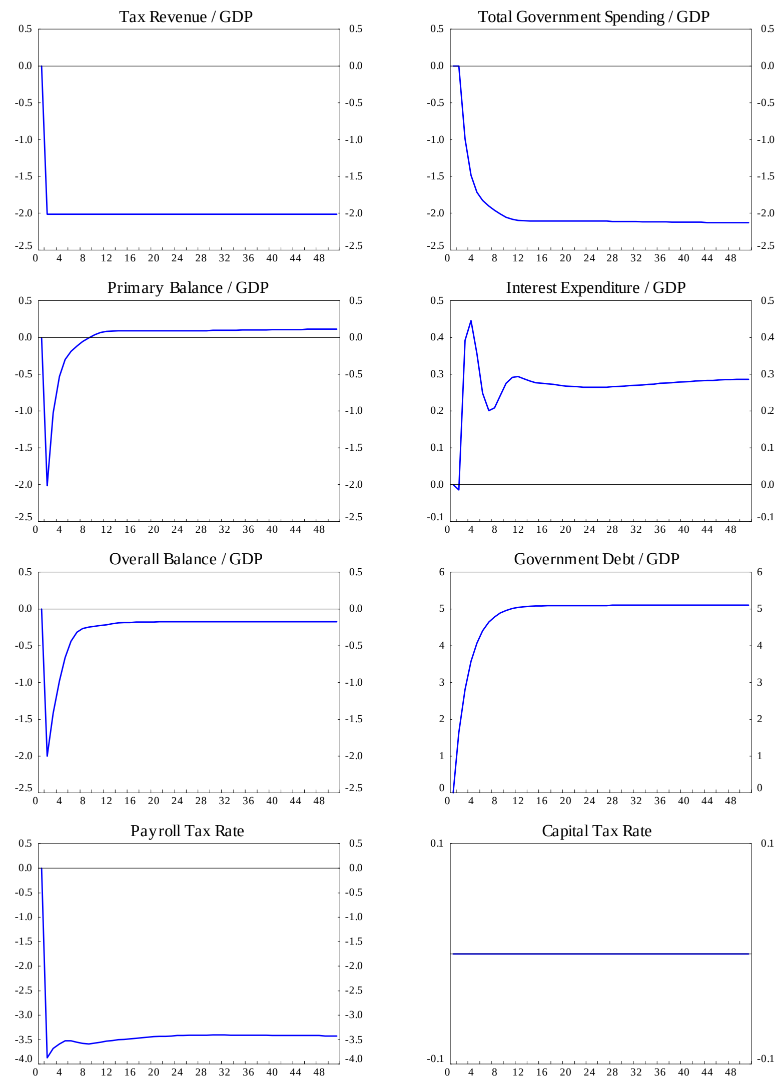

Figure 1: Baseline: Fiscal Variables

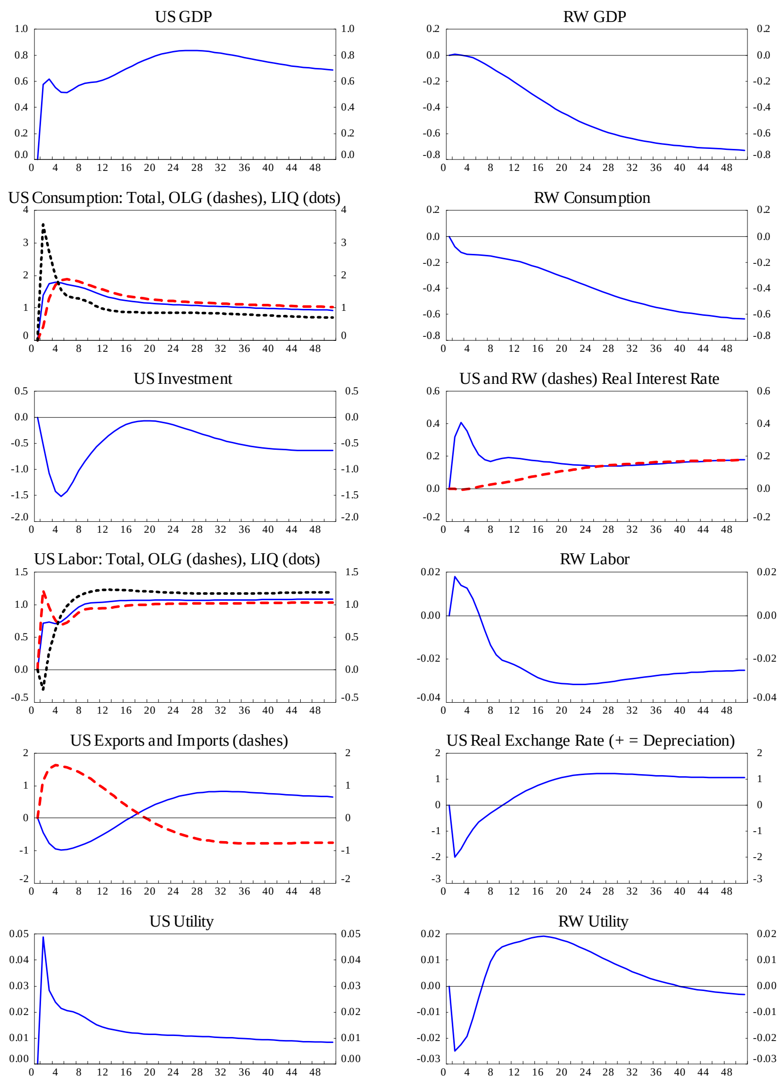

Figure 2: Baseline: Macroeconomic Variables

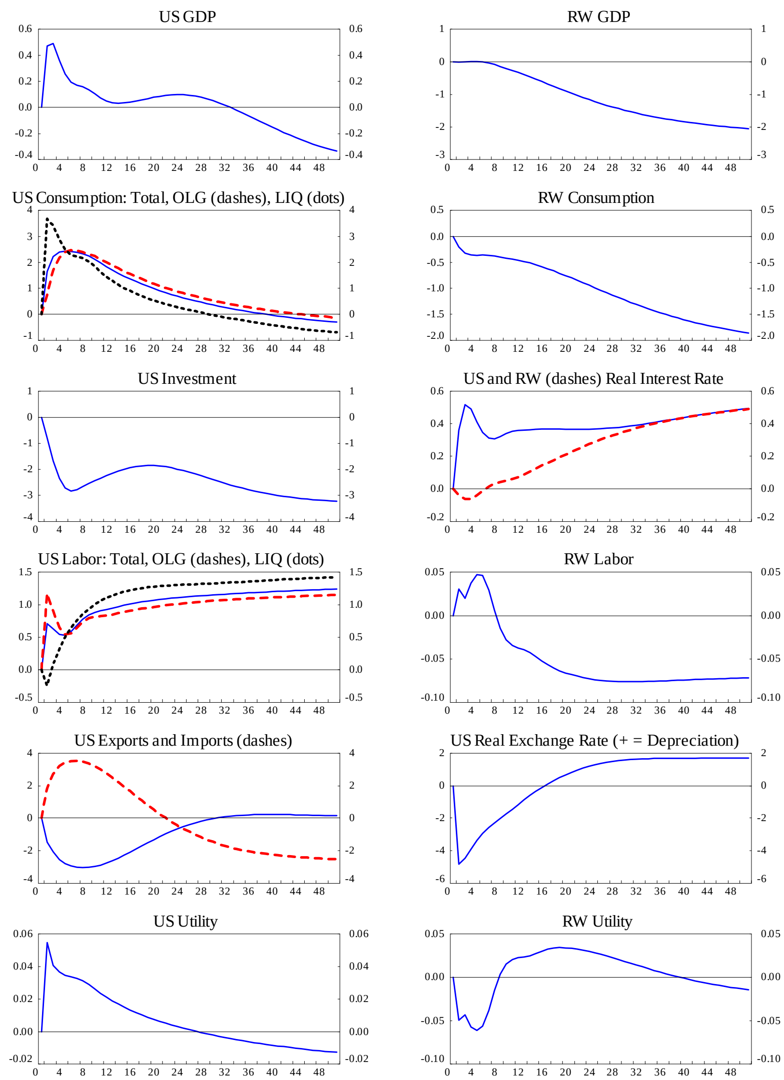

Figure 3: Larger Debt Increase

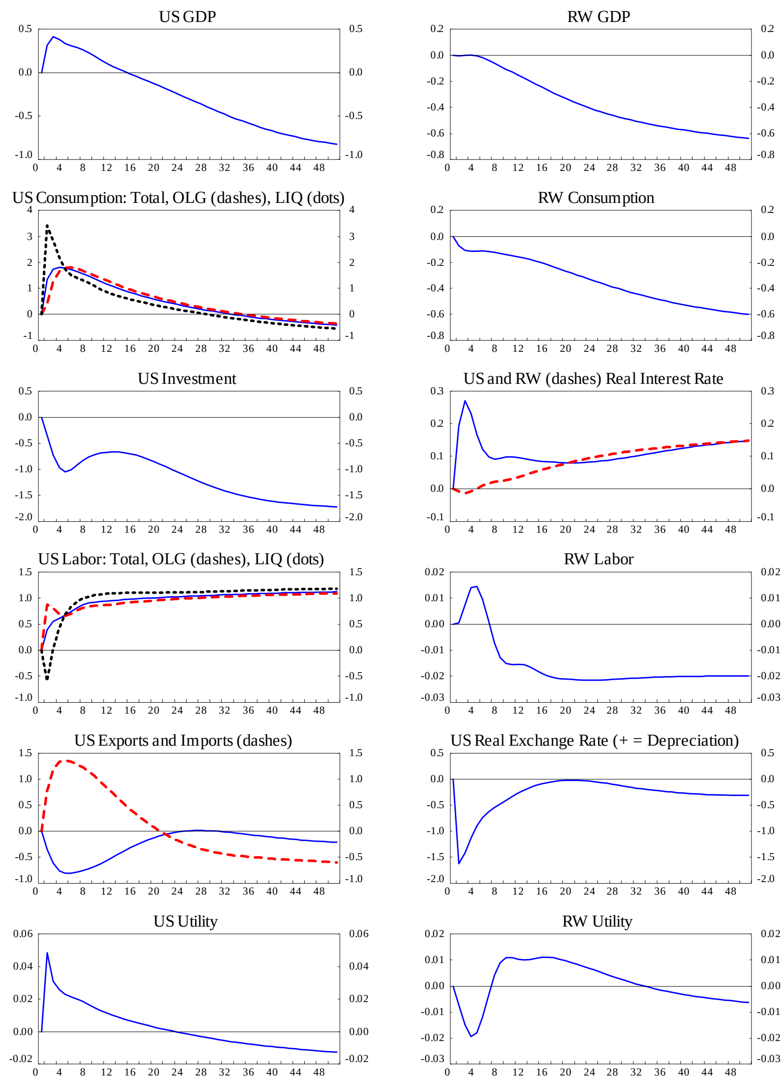

Figure 4: Public Investment Cut

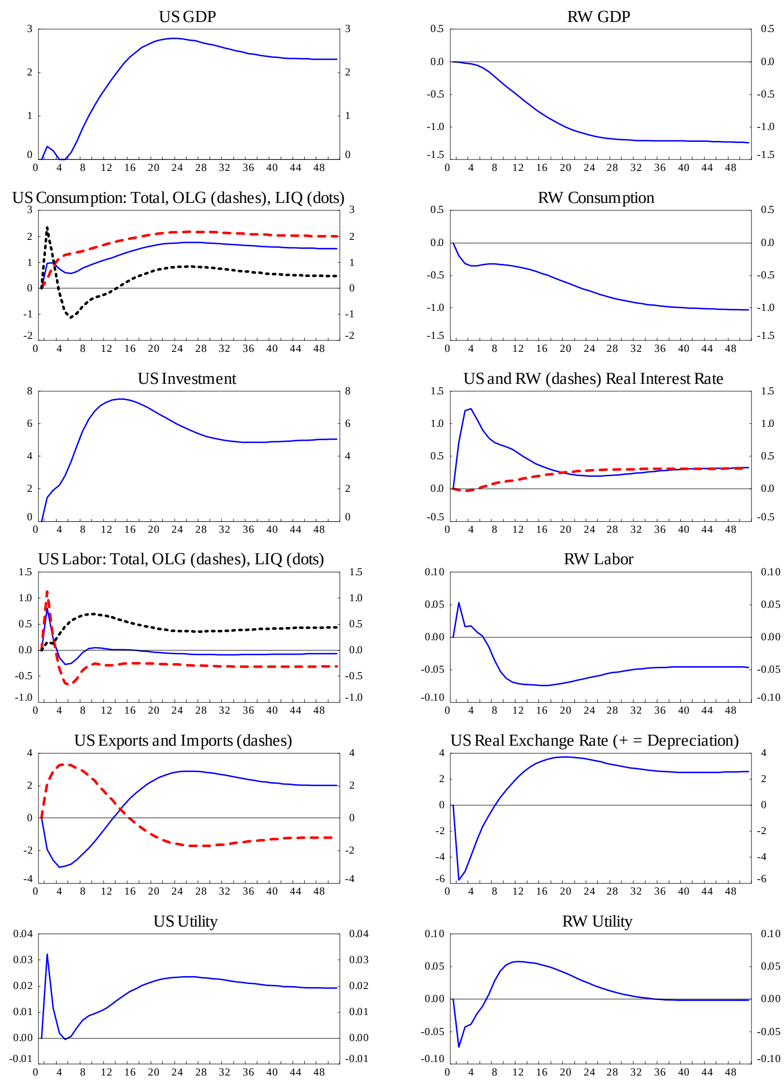

Figure 5: Capital Tax Cut

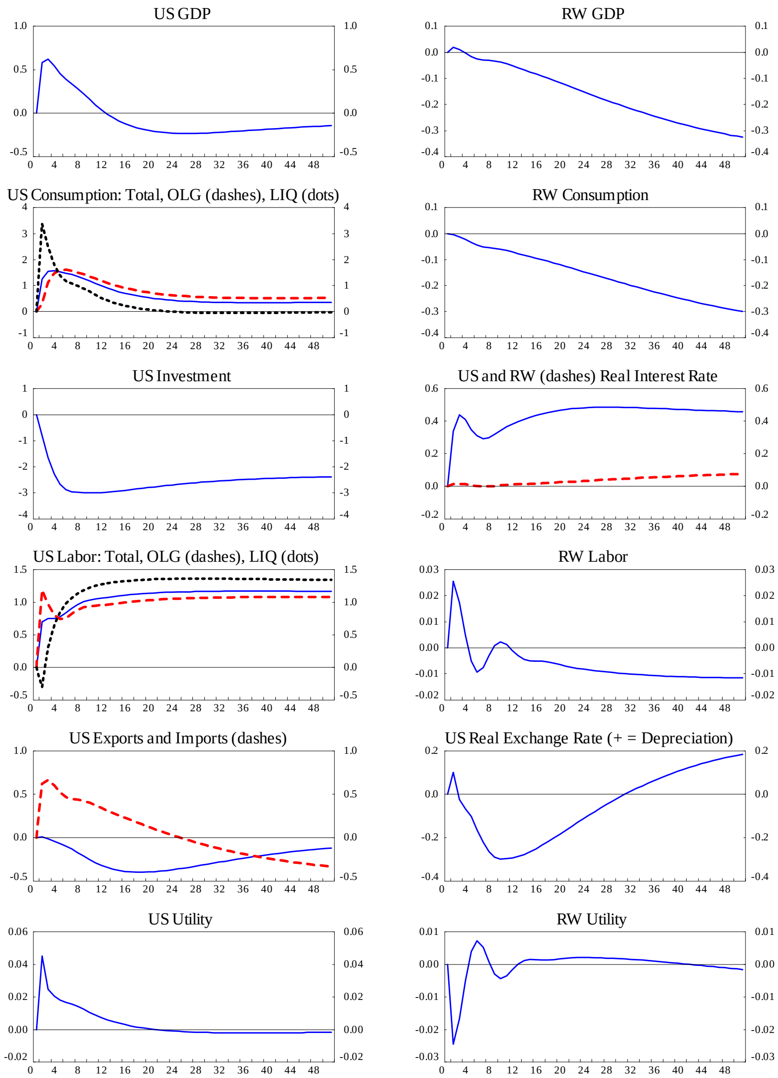

Figure 6: Less Access to Foreign Savings

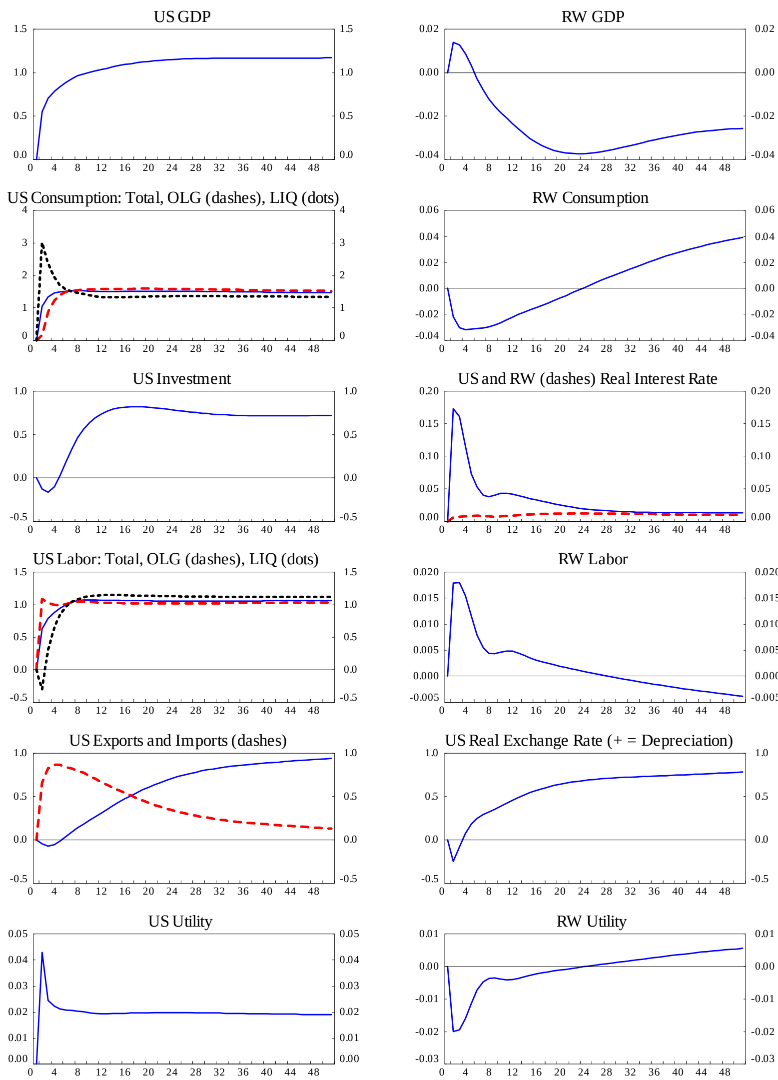

Figure 7: Less Myopic Agents

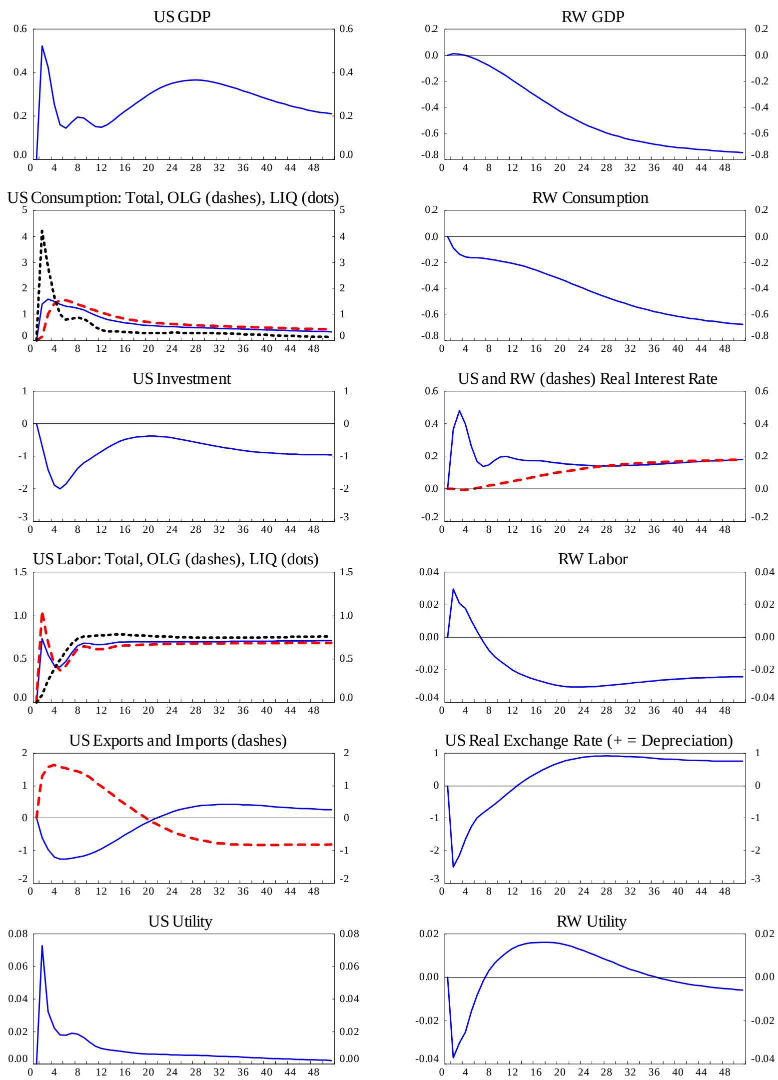

Figure 8: Inelastic Labor Supply

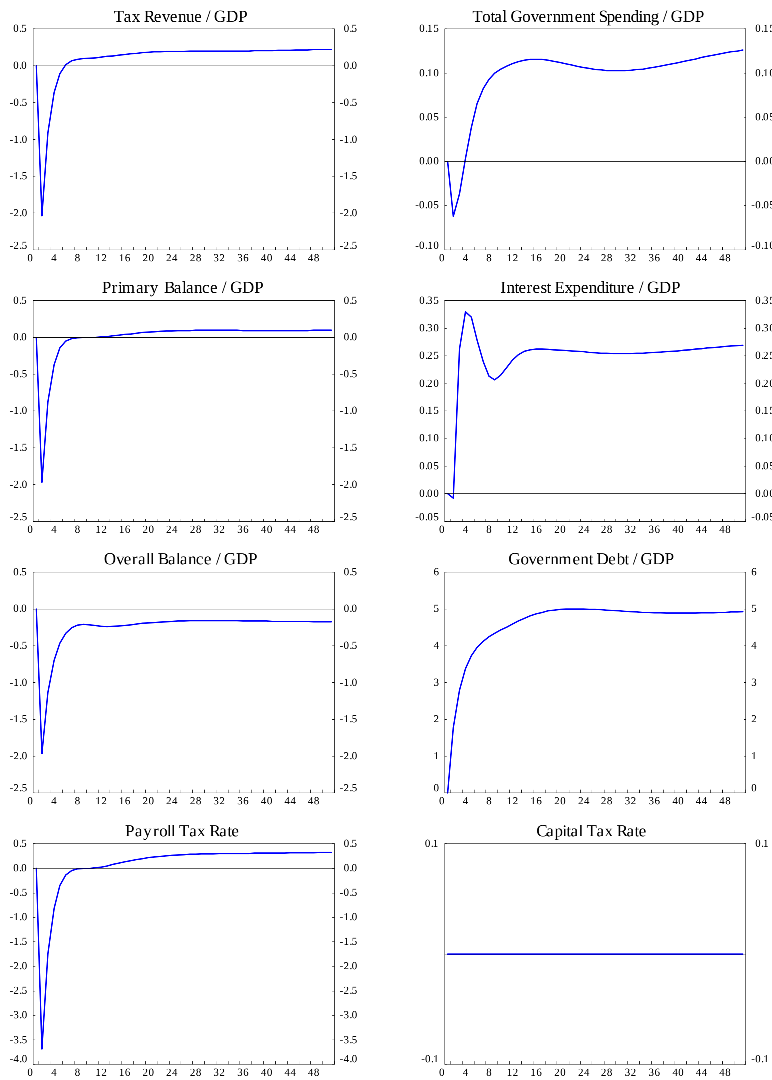

Figure 9: Undoing the Tax Cut: Fiscal Variables

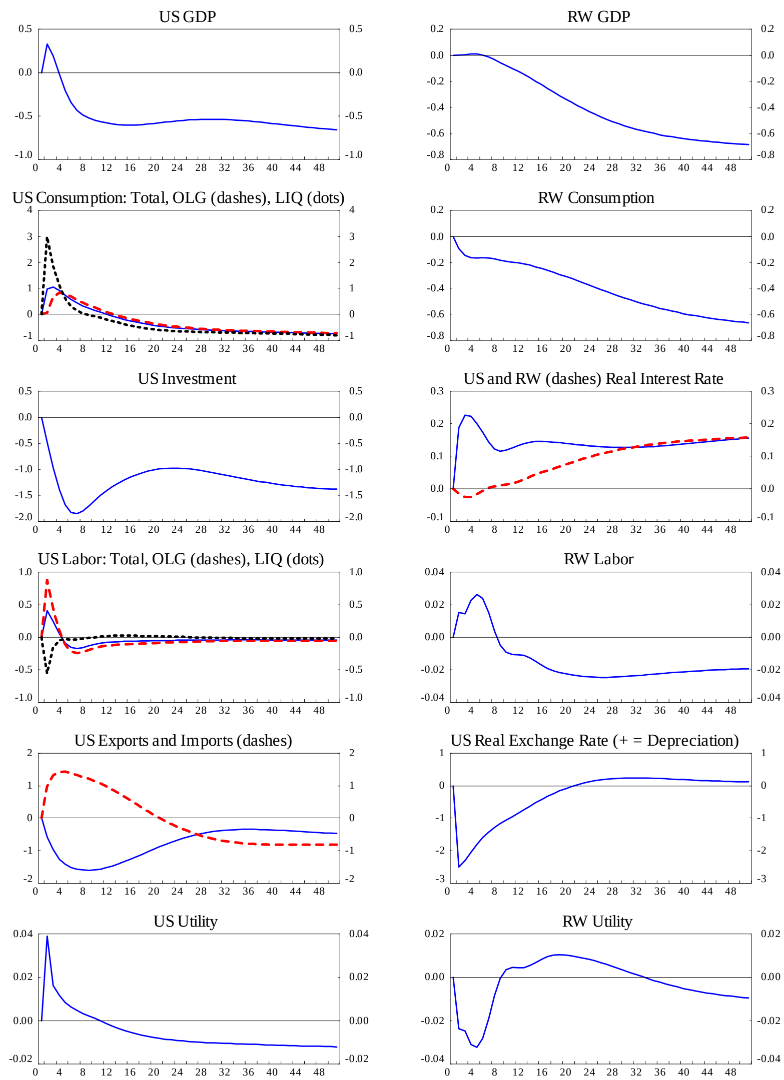

Figure 10: Undoing the Tax Cut: Macroeconomic Variables