

Fiscal Sentiment and the Weak Recovery from the Great Recession: A Quantitative Exploration

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Abstract

The US economy hasn't recovered from the Great Recession as strongly as predicted by the neoclassical growth model, even after incorporating a variety of frictions to it. The paper explores quantitatively the hypothesis that the counterfactual predictions are mostly the result of ignoring the expectations of higher taxes prompted by the unprecedented fiscal challenges faced by that country in peacetime. The main finding is that this fiscal sentiment hypothesis can account for a substantial fraction of the decline in investment and labor input in the aftermath of the Great Recession, provided the perceived higher taxes fall almost exclusively on capital income.

Keywords: US economy, Great Recession, neoclassical growth model, tax regime switch, transitional dynamics.

JEL classification: E01, E13, E17, E62, E65.

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1. Introduction

Even six years after the trough of the Great Recession, the US economic recovery continued to disappoint. It should have been considerably stronger by the standards of prior recessions of significant depth. The fact that it hasn't has led some to question the abstraction of reality proposed by well-established economic models that lend support to that prediction.

The inability to account for the anemic recovery from the Great Recession is particularly noticeable in models that introduce a variety of real (as opposed to nominal) frictions and shocks in the basic analytical framework of the neoclassical growth model. As is well-known, built into that class of models is a "rubber band" effect, by virtue of which the further output falls below its steady-state level, the stronger is the subsequent rebound to it, unless particular realizations of shocks to the economy prevent that from happening. It hasn't proved easy, however, to identify shocks with such a "delaying effect" in the recovery, even in versions of the neoclassical growth model that introduce financial frictions in the analysis, such as the one considered by Jermann and Quadrini (2012). Their indicator of financial market conditions successfully accounts for a large fraction of the sharp economic contraction observed during the Great Recession, but the almost immediate subsequent improvement of that same indicator also implies a counterfactually strong recovery.

The failed attempts, so far, to account for the weak recovery from the Great Recession as the outcome of the unique Walrasian competitive equilibrium implied by the canonical neoclassical growth model seems to have convinced prominent members of the economics profession that radical departures from that analytical framework are needed to account for the phenomenon under study.¹ Other equally prominent scholars have argued, however, that the ability of that analytical framework to account for the anemic post-Great Recession recovery should not be dismissed before properly incorporating into it unprecedented devel-

¹Eggertsson and Mehrotra (2014) is fairly representative of this view.

opments on the fiscal front that, at least in the US, accompanied that downturn: record high fiscal deficits and levels of public debt during peacetime, along with projections of a significant structural rise in that country's government transfers in coming decades.

Such is the conjecture offered by Lucas (2011) in his concise and eloquent interpretation of the lack of dynamism that characterized the US economy in the wake of the Great Recession:

A healthy economy that falls into recession has higher than average growth for a while and gets back to the old trend line. We haven't done that. I have plenty of suspicions but little evidence. I think people are concerned about high tax rates... But none of this has happened yet. You can't look at evidence. The taxes haven't really been raised yet."

It is fairly obvious that the hypothesis advanced by Lucas must refer to higher *distortionary* taxes, as higher lump-sum taxes wouldn't have any effect on allocations and couldn't be responsible, therefore, for inducing any deviation of the economy from its previous trend. As reflected in its title, the paper refers to this specific conjecture about the role of higher prospect distortionary taxes in the allegedly slow US economic recovery from the Great Recession as the "fiscal sentiment hypothesis," to differentiate it from "consumer sentiment" or self-fulfilling beliefs (sunspots) interpretations of the same phenomenon, such as that proposed by Farmer (2012).

The motivation for exploring the *quantitative* relevance of the fiscal sentiment hypothesis pursued in this paper came, however, from the observation that it is not quite true that it is not possible to look at the evidence to validate or dismiss the hypothesis before the taxes have been actually raised. Lucas himself has pioneered techniques designed to do precisely that. Specifically, those techniques can be used to produce rather stark predictions about the economic outcomes that should be observed during the recovery from the Great Recession if economic agents indeed started to make their consumption, employment, and investment decisions near the trough of that episode as if convinced that a higher-taxes regime would

be in place soon. The comparison of those predictions with the evidence can be used in principle to assess the quantitative plausibility of the fiscal sentiment hypothesis.

That is precisely what the paper sets out to do, equipped with a properly adapted version of the neoclassical growth model, arguably the analytical framework that Lucas had in mind in his brief characterization of the fiscal sentiment hypothesis.

The model predictions-data comparison proposed above would have been problematic with an off-the-shelf neoclassical growth model, however, because the typical closed economy version of that model will unavoidably underestimate the level of consumption and/of investment, which do contain an additional "net import" component in the actual economy. The paper addresses this lack of correspondence between variables in the model and their empirical counterparts by 1) adding to an otherwise rather conventional neoclassical growth model an external-like sector in the manner proposed by Trabandt and Uhlig (2011), and 2) implementing an updated version of the "private sector output" approach to measuring the actual economy pioneered by Gomme and Rupert (2007), who argue that it delivers a better correspondence between the data and models that assume that observed aggregates reflect the optimizing behavior of households and firms. In addition, quantitative discipline is imposed in the analysis by 1) calibrating the model to long-run features of the economy prior to the Great Recession, and 2) restricting the perceived forthcoming higher-taxes regime that could be plausibly considered to those that capture the Congressional Budget Office's assessment of that country's fiscal situation at the early stages of the recovery from that episode.

Overall, the findings of the paper offer enough reasons to keep the prospect of higher taxes in the list of suspects potentially responsible for slowing down the economic recovery from the Great Recession, provided the higher taxes fall on capital income. The anticipation that the higher taxes will fall on labor income produces counterfactual predictions, as theory would have suggested.

More precisely, in a benchmark higher-capital-income-tax scenario considered by the paper, the fiscal sentiment hypothesis accounts approximately for between two-thirds and all of the decline of gross private domestic investment during the recovery from the Great Recession, relative to what should have been its normal level by the criterion established in this paper. The hypothesis under exploration can also account approximately for between one-third and two-thirds of the analogous decline in the labor input absorbed by private sector firms. The corresponding figures for an alternative higher-capital-income taxes scenario are lower, but still sizable.

Although the performance of the model along the labor market dimension appears to be less satisfactory, it is worth emphasizing, as discussed in section 3., that this might reflect the methodological discipline of not letting the rather low values of labor input observed during the recovery influence the identification of its underlying trend. The model also predicts above-trend consumption, as in the data, with some overshooting at the beginning that probably reflects the fact just mentioned that labor input, and therefore output, don't fall as much in the model as in the data.

The observation that aggregate consumption has been above trend in the US during the rebound from the Great Recession may come as a surprise given the widespread perception to the contrary. It is the result, however, of two features of the US economy typically ignored in popular accounts of the phenomenon under study. First, consumption has been propped up for many years by unusually large trade deficits that only after the Great Recession started to show signs of slowly reverting to their historical mean. Second, the paper points out that many estimates of the potential output have grossly overestimated historical trends by ignoring that transitional dynamic effects present in that country's labor markets have lifted US growth rates for many decades above those sustainable in the long run. Thus, there is an important measurement dimension to this paper as well, as it shows that correction of the resulting upward bias in the growth rates of labor input and, consequently, of output,

brings the deviations of the main macroeconomic variables from their trends down to a range that the fiscal sentiment hypothesis has better chances to account for without appealing to implausibly high tax rates on the "wrong" side of the Laffer curve.

From a broader perspective, as hinted at previously, the quantitative exploration of the fiscal sentiment hypothesis pursued in this paper contributes to advancing an active research agenda exploring alternative channels through which current or prospect fiscal policy developments could slow down rebounds from recessions. Recent efforts in that direction include those by Born and Pfeifer (2014) and Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015). While the present paper explores the quantitative impact of the virtual certainty of the future-tax-increases channel, those two papers study that of the increased *uncertainty* about future fiscal policy. The extent to which the latter studies capture the evidence for the disappointing economic recovery from the Great Recession is unclear, though, because they do not specifically study that episode.

In any case, both of those papers conjecture that asymmetric changes in the level of uncertainty, that is, developments that tilt the distribution of fiscal policy outcomes in a particular direction, may have larger quantitative effects than factors that induce symmetric changes in the distribution of policy risks. That speculation is entirely consistent with the more general message of this paper: recoveries may fail to be as strong as they should be if the economic and political environment leads households and businesses to expect that the fiscal imbalances created or aggravated by preceding severe downturns will be resolved with significant tax-rate hikes on capital income, rather than by more symmetric changes in all fiscal policy instruments. One possible reason for that to be the case, suggested by the historical evidence on financial and fiscal crises extensively documented by Reinhart and Rogoff (2009), is that, under the stress associated with pronounced economic contractions, societies are more likely to succumb to the time-inconsistency temptation of collecting the then particularly needed fiscal revenues by taxing capital and/or its returns at higher rates

than previously foreseen.

The paper is organized as follows. Section 2 outlines the model. Section 3 discusses some measurement issues relevant for the accuracy of the quantitative results documented later. Section 4 provides details about the parameterization of the model. Section 5 describes the numerical experiments and reports the findings of the paper. Section 6 concludes.

2. The Model Economy

As argued in the introduction, the fiscal sentiment hypothesis seems to have been inspired by well-known properties of the closed-economy neoclassical growth model. Even more appropriate for the quantitative exploration of that hypothesis is the private-sector economy version of that model augmented with an external-like sector described below.

2.1. Households

Preferences The model economy is populated by identical atomistic households who derive satisfaction from consuming goods and non-market activities. Their preferences are summarized by the following utility function:

$$E \sum_{t=0}^{\infty} [\beta(1+\eta)(1+\gamma)^{\alpha(1-\sigma)}]^t \frac{[c_t^\alpha l_t^{1-\alpha}]^{1-\sigma} - 1}{1-\sigma} \quad (1)$$

where $\beta > 0$, $\sigma > 0$, $0 < \alpha < 1$, η is the net annual growth rate of population 16 years of age and older, γ the net annual total factor productivity (TFP) growth rate induced by labor augmenting technological progress, c_t is detrended consumption per member of the population 16 years of age and older, and l_t the fraction of available time that the population in that age group allocates to non-market activities.

Following the standard procedure to transform an economy displaying secular deterministic growth into a detrended one that doesn't, the discount factor β has been adjusted by the factor $(1+\gamma)^{\alpha(1-\sigma)}$, and all variables subject to secular balanced growth detrended by the factor $(1+\gamma)(1+\eta)$.

Allocation of available time The household faces the following restriction on the allocation of time:

$$1 = l_t + h_t = l_t + h_t^{pr} + h_t^{pu}, \quad (2)$$

where h_t denotes the fraction of available time, normalized to one, that the households are actually at work, and h_t^{pr} and h_t^{pu} the fraction of that time absorbed by private sector firms and government agencies, respectively.

Capital accumulation For consistency with the National Income and Product Accounts (NIPA) methodology, households in the model economy are assumed to control the level of capital stock they rent to private firms. They cannot influence, however, the public sector capital stock. The private sector capital stock evolves over time according to the usual law of motion for a detrended economy that preserves nevertheless the transitional dynamics of one with a trend:

$$(1 + \eta)(1 + \gamma)k_{t+1} = x_t + (1 - \delta)k_t. \quad (3)$$

where k_t is the *private sector* capital stock available for production at the beginning of a given period t , x_t the private sector gross domestic investment during that same period, both measured in terms of units of the consumption good, and δ the economic depreciation rate of the private sector capital stock.

Budget constraint In this private sector output economy, households rent their labor to the public and private sector and their capital stock only to the latter. Accordingly, their budget constraint is given by:

$$c_t + x_t = (1 - \tau_t^h)w_t h_t + [r_t - \tau_t^k(r_t - \delta)]k_t + ck_t^{ge} + \tau_t + ni_t \quad (4)$$

where τ_t^h is the tax rate on labor income, w_t the wage rate in terms of consumption per unit of the available time the stand-in household devotes to work, τ_t^k the tax rate on capital

income, r_t the rental rate of private sector capital, τ_t lump-sum transfers (taxes if negative), ni_t an exogenously given endowment, and ck_t^{ge} captures the imputation of the compensation for the services of the capital stock controlled by government enterprises, treated in the NIPA as income for households, the ultimate owners of that stock.²

The variable ni_t , which stands for "net imports," introduces in the rudimentary manner proposed by Trabandt and Uhlig (2011) the open economy feature that prevents the model from underestimating aggregate spending relative to that observed in the actual economy. The empirical counterpart of this variable is the negative of the trade balance, that is, the negative of the item "Net exports of goods and service" in NIPA. To be consistent with balanced growth, these exogenous payments must grow on average at the same rate as output. Accordingly, the quantitative implementation of the model will assume that the dynamics of the ratio of net imports to private sector firms output, niy_t , is dictated by the following AR(1) process:

$$niy_t = (1 - \rho_{niy})niy + \rho_{niy}niy_{t-1} + \varepsilon_{niy,t}, \quad (5)$$

where $0 < \rho_{niy} < 1$, niy a constant that will be calibrated to features of the US economy, and $\varepsilon_{niy,t}$ an identically and independently distributed random variable, with mean zero and variance σ_{niy}^2 .

2.2. Private Sector Firms

There are two kinds of firms that produce output in the stationary economy without growth and without a government final good: private firms and government enterprises. As discussed in online appendix B, the NIPA methodology treats the investment activities and net operating surpluses (or deficits) of government enterprises differently from the corre-

²As explained in the online Appendix B, the NIPA methodology implicitly assumes that this source of income is not under households' control, because it is the government that decides the government enterprises investment expenses and, therefore, the level of those enterprises' capital stock. Accordingly, in the private sector model economy setting of this paper, this source of income will be treated as a lump-sum transfer, independent of the households' behavior.

sponding variables of private firms, presumably because the business decisions of the former are not driven by the objective of maximizing profits. Accordingly, the behavior of these firms in labor and capital markets will be modelled parametrically below.

Non-profit-maximizing government enterprises aside, the model economy is populated by a large number of identical private firms that transform labor and capital inputs into output with a constant returns to scale technology that satisfies the balanced growth requirement that investment-specific technological progress can be represented as being of the labor-augmenting type. Detrended aggregate output therefore can be thought of as generated by a single representative firm endowed with a Cobb-Douglas production function:

$$y_t^{pr} = Ae^{(1-\theta)z_t} k_t^\theta (h_t^{pr})^{1-\theta}, \quad (6)$$

where y_t^{pr} is the output per working age person produced by private sector firms and z_t is a stochastic technology level whose statistical properties are represented by an AR(1) process:

$$z_t = \rho z_{t-1} + \varepsilon_t, \quad (7)$$

where $\rho < 1$, and ε_t is an identically and independently distributed random variable, with mean zero and variance σ_z^2 .

2.3. *Public Sector Policies*

For consistency with the behavioral assumptions implicit in the NIPA methodology discussed in online appendix B, the motivations behind the economic decisions of government agencies will not be modeled explicitly. The variables under their control, therefore, are determined exogenously.

Government budget constraint Recall that the ultimate goal of the paper is to establish the extent to which the perceptions of a switch to a higher-taxes regime can account quantitatively for the weakness of the recovery observed in the aftermath of the Great Recession. The historically high fiscal deficits observed and projected after that episode are one

reason for expecting higher future taxes, but the change of regime could take place even if the government budget is balanced every period, as assumed for simplicity for the purposes of this paper.³

Thus, in this private sector economy, the government absorption of private sector output, denoted ga_t , must equal government revenues from all sources, as indicated by the following government budget constraint:

$$ga_t = \tau_t^h w_t (h_t^{pr} + h_t^{pu}) + \tau_t^k (r_t - \delta) k_t + s_t^{ge} - \tau_t - w_t h_t^{gc}, \quad (8)$$

where s_t^{ge} stands for government enterprises surpluses, h_t^{gc} for the fraction of time the stand-in household spends working for government agencies other than enterprises, and $h_t^{pu} \equiv h_t^{gc} + h_t^{ge}$, where h_t^{ge} denotes the fraction of time the stand-in household works for government enterprises.

The empirical counterpart of the variable ga_t is obtained by subtracting from the "Government consumption expenditures and gross investment" component of GDP the value added by the general government in the process of producing non-market goods and services, both as reported in NIPA.⁴

Public Sector Labor Demand The general government and government enterprises' demand for labor services is assumed to be constant, except for the additive transient fluctuations induced by an identically and independently distributed random variable, as formally captured by the following simple stochastic processes:

$$\ln h_t^{pu} = \ln h^{pu} + \varepsilon_t^{hpu} \quad (9)$$

³As explained later, lump-sum transfers will adjust endogenously to balance the budget in response to changes in revenues originated in distortionary taxes.

⁴This variable captures the intermediate inputs produced by the private sector that the government uses up in the process of providing public goods. Those inputs don't yield utility, however, until transformed by the labor and capital services managed by the government. The Gomme-Rupert procedure, therefore, cannot be applied to economies in which households derive utility from the goods and services provided by the government, but not from the intermediate inputs used to produce those goods.

where ε_t^{hpu} is an identically and independently distributed random variable with mean zero and variance σ_{hpu}^2 .

General Government Absorption of Private Sector Output The amount of private sector output absorbed by the general government, ga_t , and the value added by government enterprises, va_t^{ge} , as defined in online appendix B, should grow at the same rate as private output along a balanced growth path. Therefore, it is natural to postulate that the evolution of those variables over time will be characterized by the following stochastic processes:

$$\ln \frac{ga_t}{y_t^{pr}} = \ln gy + \varepsilon_t^{gc}, \quad (10)$$

$$\ln \frac{va_t^{ge}}{y_t^{pr}} = \ln vy + \varepsilon_t^{ge}, \quad (11)$$

where gy is the steady-state ratio of government purchases, ga_t , to output produced by private sector firms, vy the analogous ratio for va_t^{ge} , and ε_t^{gc} and ε_t^{ge} are identically and independently distributed random variables with mean zero and variance σ_{gc}^2 and σ_{ge}^2 , respectively.⁵

Tax Policy Given the purpose of the paper, it seemed reasonable to require that tax policies be modelled in a way that captures the essence of the fiscal sentiment hypothesis and at the same time is computationally tractable. Those two conditions are satisfied by the assumption that the tax policies in the model economy are characterized by a deterministic sequence of labor and capital income tax rates with the following generic configuration:

$$\left\{ \left\{ \tau_{t+i}^h, \tau_{t+i}^k \right\}_{i=0}^j, \left\{ \tau_{t+j+n}^h, \tau_{t+j+n}^k \right\}_{n=1}^\infty \right\}_{t=s}; \tau_{t+j+n}^h > \tau_{t+i}^h \text{ and/or } \tau_{t+j+n}^k > \tau_{t+i}^k, \quad (12)$$

⁵It is worth mentioning that the government enterprises policy (11) doesn't determine separately the components of the value added by these firms. This indeterminacy doesn't affect the equilibrium allocation, however, because any change in one of the government enterprises' value added components, say compensation for labor services, will have to be offset by a change of the same size but opposite sign in the other component, say capital services. Since the government enterprises surpluses are in the end rebated back to households (see discussion in Appendix B), the stand-in household budget constraint is unchanged.

for all $i \geq 0$, $j \geq i$, and $n \geq 1$.

Notice that this representation of the fiscal sentiment hypothesis assumes that it is only at a certain period s that households and businesses start making their consumption and investment decisions taking for granted a switch to a higher-taxes regime $j + 1$ periods later. In the empirical implementation of the model, for the arguments given in subsection 4.1., the period s will correspond to the year 2009, right after the trough of the Great Recession in the US. The implicit assumption is that prior to that contraction, households attached a zero or near-zero probability event to such a regime change.

2.4. Walrasian equilibrium allocation

In the abstraction of the model, the equilibrium allocations are the outcome of market clearing prices that arbitrage the decisions that households and private sector firms make to maximize some objective function.

Accordingly, the household that stands in for the large number of those who inhabit the actual economy chooses state-contingent levels of the variables under its control, consumption, leisure, and investment, to maximize its expected lifetime utility (1), subject to the time-use constraint (2), the law of motion of the private capital stock (3), and the budget constraint (4), taking prices and government policies as given. The representative private sector firm that stands for the large number of those making decisions in the actual economy hires capital and labor services to maximize profits every period, that is, the function $Ae^{z_t} k_t^\theta (h_t^{pr})^{1-\theta} - w_t h_t^{pr} - r_t k_t$, taking prices and the technology (6) as given.

The Walrasian equilibrium allocation of the model, which is unique in the economic environment of the model, must satisfy the following three equations:

$$c_t = \frac{\alpha}{1-\alpha} (1 - h_t^{pu} - h_t^{pr}) (1 - \tau_t^h) (1 - \theta) A e^{z_t} \left(\frac{k_t}{h_t^{pr}} \right)^\theta, \quad (13)$$

$$E_t (1 - \tau_t^k) \left[\theta A e^{z_{t+1}} \left(\frac{h_{t+1}^{pr}}{k_{t+1}} \right)^{1-\theta} - \delta \right] + 1 = \frac{(1 + \gamma)}{\beta(1 + \gamma)^{\alpha(1-\sigma)}} E_t \left[\frac{c_{t+1}}{c_t} \left[\left(\frac{c_{t+1}}{c_t} \right)^\alpha \left(\frac{1 - h_{t+1}^{pu} - h_{t+1}^{pr}}{1 - h_t^{pu} - h_t^{pr}} \right)^{1-\alpha} \right]^{\sigma-1} \right], \quad (14)$$

$$c_t + x_t = (1 + v y_t + n i y_t - g y_t) A e^{(1-\theta)z_t} k_t^\theta (h_t^{pr})^{1-\theta}. \quad (15)$$

Equations (13) and (14) are the intratemporal and intertemporal equilibrium first-order necessary conditions implied by the solution to the household and firm's maximization problems described above. Equation (15) is the resource constraint, obtained from consolidating the private sector budget constraint (4) with the government budget constraint (8).⁶

3. Model steady-state and actual economy long-run trend

The main challenge that this paper faced for calibrating the model economy is summarized by the full line in Figure 1, which plots the observed balanced-growth-consistent labor input measure, that is, the fraction of available time that the population in working age (16 years of age and older) have devoted on average actually to work in the US.

<insert Figure 1 around here>

As is apparent from the figure, around the mid-1970s labor input started to rise steadily for several decades, under the influence of temporary factors, such as the incorporation to the labor force of women and of the unusually large cohort of so-called baby boomers. Many projections of the output trend produced when the Great Recession was unfolding implicitly assumed that labor input would keep growing faster than working-age population, as Figure 1 shows it did until approximately the beginning of the 21st century. As pointed out in an earlier version of this paper (Kydland and Zarazaga, 2012), by ignoring the transient nature of the factors described above, those projections overestimated the trend growth of output in the US and, therefore, the magnitude of the decline of output from its trend during the recovery from the Great Recession.

⁶Further details about the consistency of this resource constraint with the private sector and government budget constraints are provided in online Appendix B. Notice that equation (13) is the same intratemporal condition that would obtain in an economy in which the demand for labor services by the public sector is zero. The larger the size of the public sector, the more likely that a version of the system of equations (13) to (15) that doesn't make the distinction between primary inputs allocated to the private sector on one hand, and the public sector on the other, will severely misrepresent the equilibrium allocations predicted by the model relative to those observed in reality.

The fiscal sentiment hypothesis couldn't possibly account for those large negative deviations of output from trend without appealing to implausibly high tax rates on the "wrong" side of the Laffer curve. The quantitative inquiry of this paper and its choice of analytical framework made it imperative, therefore, to correct the overestimation of those gaps in a manner consistent with the neoclassical growth model, which predicts that along a balanced growth path, labor input should behave as a stationary variable. That is, because the model is formulated in terms of detrended variables, a fair comparison of its predictions with the data required removing from labor input the transitional dynamic effects apparently present in US labor markets until not long before the Great Recession.

Unfortunately, theory doesn't offer much guidance on how to accomplish that, because studies such as those by Cociuba and Ueberfeldt (2010), Kaygusuz (2010) and other authors cited therein suggest that it is hard formally to model the transitional trend underlying the upward drift in labor input as the exclusive consequence of economic factors. An admittedly ad-hoc approach was used, therefore, to infer that transitional trend by combining a Hodrick-Prescott filter for the period 1977-1993 with a regression analysis from 1994 to 2007, exploiting the more detailed information about time at work for each age group in the population available since that year. A description of the exact sequence of steps involved is rather tedious and given, therefore, in the online appendix C.

The result of the procedure outlined above is the transitional trend identified by the dotted line in Figure 1. Given that this trend, denoted $h(tr)_t$ in what follows, seemed to be converging to 0.24, this was assumed to be the stationary value for labor input in the model economy, denoted h_{ss} .⁷

It is worth noting at this point that the labor input trend obtained as explained above has been moving along a flat line from the mid-1990s onwards. There are three main reasons why it is not showing instead the pronounced decline since then that ought to be expected

⁷Notice that this value is not far from the equivalent figure of 0.25 proposed by Prescott (2004).

from the results documented in many studies that have looked at labor market trends. First, those other studies don't measure the empirical counterpart of labor input in the neoclassical growth model, but indicators of its extensive margin component. Second, many of the studies with the implication just mentioned for the labor input trend in this paper, such as those by Stock and Watson (2012), let the particularly dire economic conditions prevailing during the Great Recession influence the estimation of related labor market trends. As indicated in the introduction, the procedure in this paper does not, mindful of the calibration approach principle that parameter values and steady-state relationships of the model economy should not be "fit" to the phenomenon under study. In fact, the trend for the related concept of potential labor force participation falls rather slowly over the last two decades in the projections that the Congressional Budget Office (2007) prepared right before the Great Recession, taking into account the effects of an on average aging population. That demographic factor, however, may be at least partially undone by an effect ignored by that study, as well as many others: a seemingly consistent changing pattern in the time that different age groups have been allocating to work. For example, as the unusually large generation of so-called baby boomers has been approaching retirement age, the employment ratio of population 65 years of age and older has been steadily rising from around 12% in 1995 to approximately 18% in 2013. The labor input trend in Figure 1 captures the net effect of the two opposing forces just described.⁸

The non-stationary effects that that trend had on labor input were removed from the component of that input in the private sector with the following formula, under the assumption that over the period 1977-2013 this factor of production would have displayed in the model economy the same deviations from its stationary value, $h_{ss}^{pr} = h_{ss} - h^{pu}$, as it actually

⁸So does the paper by Fallick and Pingle (2007), whose projection for 2013 of what could be regarded as a proxy of the employment/population ratio component of the labor input trend proper was, reassuringly, only 2.5% below its value by the time it started to show signs of a rather gentle decline, in 2005.

did from the estimated transitional trend, $h^{pr}(tr)_t = h(tr)_t - h^{pu}$:

$$\widehat{h}_t^{pr} = \frac{h_t^{pr}}{h^{pr}(tr)_t} h_{ss}^{pr}, \quad (16)$$

where h_t^{pr} is the observed labor input absorbed by the private sector in period t and \widehat{h}_t^{pr} the resulting detrended value.

As mentioned earlier, the transitional growth effects in labor input just removed are transmitted to output and need to be subtracted from that variable as well. The adjustment can be easily performed by multiplying both sides of the "intensive" version of (6) by the factor $\frac{h_t^{pr}}{h^{pr}(tr)_t}$. For the calibrated values documented in the next section, this procedure produces the time series for detrended output, \widehat{y}_t^{pr} , and for technology shocks measured with Solow residuals shown in Figure 2.

<insert Figure 2 around here>

It is important to point out that, according to the figure, output never fell from its trend during the period under study by the large magnitudes that, for the reasons given above, would have severely impaired the ability of the fiscal sentiment hypothesis to account for the weak recovery from the Great Recession. The 4% decline of output from trend during that episode and its aftermath documented in Figure 2 is not unusually big by past historical experiences, and it is certainly less than half the size of alternative estimates of the "output gap" initially reported by different sources as the Great Recession was unfolding. It is reassuring, however, that those larger estimates have been progressively revised down to the orders of magnitude estimated in this paper.⁹

⁹For example, the December 9, 2009 issue of the Federal Reserve's Greenbook forecast estimated the so-called output gap to have been as large as 8% on average that year. The January 2007 estimates of potential output by the Congressional Budget Office implied that its difference with actual output in 2012 was as large as 9.8%. Seven years later, that agency's downward revisions to potential output had cut that same gap nearly in half (CBO, 2014), in line with the estimate in Fernald (2014) and in this paper.

4. Model Calibration

The remaining parameters values and steady-state relationships of the model economy were calibrated using data from the sources listed in online appendix A for the period 1977-2007. The initial year of this period was determined by the fact that the NIPA accounts don't report before then the series necessary to implement the updated version of the Gomme-Rupert approach to measure private sector output documented in detail in online appendix B. The information after 2007 was excluded, as mentioned above, to respect the discipline advocated by the calibration methodology.

Table 1 summarizes the parameter values that were used in the computational experiments reported in section 5. and briefly indicates if they were inferred from the data, implied by model relationships, or inferred by procedures documented in online appendix C, which provides additional details relevant for the calibration of the model, but omitted here.

<insert Table 1 around here>

The configuration of the higher-taxes regimes to consider in the quantitative evaluation of the fiscal sentiment hypothesis required special treatment and is discussed in detail, therefore, in the next subsection.

4.1. Restrictions on Higher-Taxes Regimes

A natural restriction is that the tax increases shouldn't result in additional revenues larger than necessary to correct the fiscal imbalances eventually responsible for the "fiscal sentiment" of an imminent switch to a higher-taxes regime. Coming up with a specific figure is not particularly easy, however, because it depends on a variety of assumptions about growth rates, changes to entitlement programs such as Social Security and Medicaid, etc.

It is also tempting to impose the further restriction that the quantitative exploration of the fiscal sentiment hypothesis should be limited to optimal tax structures. It is doubtful,

however, that such a constraint will do justice to the spirit of the fiscal sentiment hypothesis, that the weak recovery from the Great Recession can be traced to perceptions that the structural budget problems that the US economy faced in the aftermath of that event would not be addressed with anything resembling an optimal tax structure. Such perceptions wouldn't be unjustified. From the theoretical point of view, there are good reasons to believe, as anticipated in the introduction, that it is precisely after the political and economic upheaval often times associated with severe downturns that societies may fall into the time-inconsistency trap of replacing a tax structure that no longer appears to be optimal with one that does have that appearance, but it's not. From an empirical point of view, it is possible to see evidence that societies have indeed fallen into that trap in the historical developments surrounding the severe crises reviewed by Cole and Ohanian (2004), Reinhart and Rogoff (2009), and McGrattan (2010).

In the case of the US, looming fiscal imbalances predated the Great Recession, but that downturn may have dented the hopes that they would be "naturally" resolved by high output growth rates. A reasonable way to capture those scenarios is to postulate that, as the level of economic activity was approaching its bottom in 2009, households and businesses reassessed the fiscal situation and reached conclusions similar to those of non-partisan official agencies, such as the Congressional Budget Office (CBO hereafter). In particular, the director of this agency, Douglas Elmendorf (2011), suggested in public testimony to Congress that fiscal deficits should be reduced between \$3.8 trillion and \$6.2 trillion over the next decade. Distributed over that time span, those figures implied government spending cuts or additional revenues equivalent to between 2.5% and 4.1% of GDP during ten years. Just to err on the side of caution, though, the lowest of those two figures was adopted as the "benchmark scenario" for the purposes of calibrating the higher-taxes regime in the model economy.

4.2. *Options to fix fiscal imbalances other than with higher taxes not obvious*

It is important to reiterate that, in its crude assessment of the fiscal challenges faced by the US, the CBO stayed away from proposing higher taxes as the only way to address them. But in practice it seems difficult to maintain that, in the aftermath of the Great Recession, households and firms were attaching any significant probability to the prospects that fiscal adjustments of the size estimated by that agency could be achieved by other means. The alternative assumption that economic agents expected that much could be done on the spending side seems unrealistic, given that the required drastic reduction in government expenditures was out of line with historical experience and that several government programs launched during the Great Recession instead *increased* those expenditures.¹⁰

Other theoretically possible options, such as a government debt default, either outright or by inflating it away, didn't seem plausible. It is hard to detect any fears of an open default in the pace and historically high prices at which world capital markets gobbled up US government debt during and after the Great Recession, a manifestation of the "flight-to-quality" triggered by that episode. There were also grounds to be skeptical that higher-than-anticipated inflation could deliver any significant reduction in the burden of that debt given that, as pointed out by Hilscher, Raviv, and Reis (2014), the share of it held by the public was concentrated on relatively short maturities.

The preceding arguments have hopefully established that it is not unreasonable to conjecture that, by the end of the Great Recession, households and firms had become convinced that the US would address the fiscal challenges aggravated by that episode by mostly raising distortionary taxes.

¹⁰The emergency measures included the Troubled Asset Relief Program (TARP), a financial aid package for the auto industry, the extension of unemployment benefits, and food-stamp expansions, among others. Complemented with the introduction of a universal health care system in the U.S., these programs may have reinforced the impression that there was not enough political will to cut Social Security benefits either.

4.3. Calibration of benchmark and alternative higher-taxes scenarios

For the purpose of establishing the quantitative relevance of that hypothesis, the initial period considered for the necessary computations, identified as period s in the generic characterization of the tax policy (12), will coincide chronologically with the year 2009, which marked the trough of the Great Recession. As mentioned before, it is not unreasonable to postulate that it was at that time that households and businesses woke up to the fiscal challenges faced by the US and started to make decisions as if taking for granted that the tax regime prevailing until then would last only until 2012 (period j in the convention of the model) and be replaced in 2013 (period $j + 1$ in the model) for the following ten years, including 2022, by a regime with the higher tax rates required to generate additional annual revenues equivalent to 2.5 % of GDP on average over that period. On the assumption that the temporarily higher taxes of this benchmark scenario succeed in stabilizing the debt/GDP ratio, as envisioned by the CBO's evaluation of the fiscal situation briefly described above, the tax rates are lowered again starting in 2023, although not to the level of the initial low taxes regime, but 3.8 percentage points higher than that in the case of the capital income tax rate, to take into account the permanent surcharge on investment income—a form of capital income taxation—introduced by the Health Care and Education Reconciliation Act of 2010 (commonly referred to as "Obamacare").

Incidentally, notice that the government budget constraint (8), along with (9), (10), and (11), implies, as mentioned in subsection 2.3, that the additional revenues generated by the higher taxes are rebated to households as lump-sum transfers. This is a realistic assumption, given that, according to most budget projections, the expenses originated in the expansion of several mandatory programs will be the main source of a structural rise in government spending in coming decades. Not equally realistic, perhaps, is the assumption that tax rates after 2022 revert back to their steady-state values, except for the permanent 3.8% surcharge on investment income, with the implication that the resulting reduction in revenues will be

accompanied by lower lump-sum transfers. It is important to emphasize, however, that this assumption is not particularly favorable to the fiscal sentiment hypothesis, as it would have eventually been possible to find a combination of distortionary taxes from 2023 onwards that replicates better the overall dynamics of the weak recovery that inspired that hypothesis. The appeal of such an exercise would be limited, however, because it would lack the discipline imposed by CBO recommendations for fiscal deficit reductions targets, typically not as clear cut beyond ten-year horizons as those just invoked to calibrate the higher-taxes regimes over the decade spanned by the years 2013 to 2022.

In any case, as a way to establish the sensitivity of the results to the assumptions above, an "alternative scenario" was also considered, for which the higher taxes are required to generate additional revenues equivalent to only 2.0% of GDP on average over the ten-year period just mentioned. This lower revenue requirement might be a way to capture the possibility that, as early as 2009, economic agents anticipated the activation of the across-the-board cuts in government consumption that were prescribed in legislation introduced two years later (the 2011 Budget Control Act) and effectively triggered only in late 2013. These so-called "budget sequestration" cuts would in principle reduce US fiscal deficits by about 0.5% of GDP, roughly over the same decade spanned by the higher-taxes regime considered in this paper, providing an argument to reduce the additional revenue needs from 2.5% of GDP in the benchmark scenario to 2.0% in this alternative scenario. To keep the analysis of the two scenarios symmetric, however, the paper retains the assumption that the lower revenues are matched by reductions in transfers, even if in reality the cuts fell almost exclusively on government consumption.¹¹

¹¹Reductions of government consumption are typically considered recessionary, so introducing them in the model could help the fiscal sentiment hypothesis to account for the weakness of labor markets and output during the recovery from the Great Recession. That standard result, however, relies on the assumption that government consumption cuts are accompanied by reductions in non-distortionary lump-sum taxes. The lower government consumption might stimulate the level of economic activity if accompanied as well by lower distortionary taxes. The net outcome of that particular policy combination is thus ambiguous and a subject of potential interest for future research.

The initial year for the decade-long tax rate increases in both the benchmark and alternative scenarios was assumed to be 2013 for two reasons. First, that was the year in which the temporary tax cuts introduced in 2001 and 2003 were supposed to expire, creating the window of opportunity typically needed to make changes to the tax code. Second, the additional tax rate of 3.8% in investment income just mentioned became effective that year.

5. Numerical experiments

This section outlines the computational method used to simulate the trajectory of macroeconomic variables in numerical experiments specifically designed to shed light on the quantitative question addressed by this paper and documents in detail the resulting findings.

5.1. *Computational method*

The model was computed by approximating the three-difference-equations system in subsection 2.4. with a second order perturbation around the logarithm of the steady-state values of the variables under the permanently higher capital income tax rate that captures the surcharge on investment income that, as mentioned earlier, became effective in 2013. The second, rather than the usual first order perturbation approximation, seemed a natural choice, given that what will matter for the comparison of the predictions of the model and the data is the level of the variables of interest, rather than their moments.

Notice that the equations underlying the computations correspond to an environment characterized by a mixture of stochastic variables and a perfect foresight tax regime change. The unconventional feature of the second order perturbation method adopted for this paper is, therefore, that the state variables that appear in the decision rules include, in addition to those that are exogenous or predetermined, the anticipated future tax rates, when different from their steady-state values.

5.2. Findings

As anticipated in the introduction, the quantitative ability of the fiscal sentiment hypothesis to account for the lackluster recovery of the US economy from the Great Recession depends critically on whether the higher future taxes envisioned by the hypothesis fall mostly on capital or labor income. Following Christiano, Eichenbaum, and Rebelo (2011), the paper explores the performance of the model by increasing these two different type of taxes one at a time, with the details provided below. Of course, both extreme regimes had to satisfy the institutional and revenue restrictions established in subsection 4.1.

5.2.1. Tax regime with higher capital income taxes only

A search algorithm over a grid of progressively increasing tax rates established that the higher-taxes regime restrictions just mentioned were satisfied, for the case of the capital income tax, by the following configuration in the benchmark scenario, that is, in the scenario that delivers additional annual revenues of 2.5% of GDP on average over the decade spanned by the years 2013 to 2022:

$$\begin{aligned}
 \tau_{2009+i}^h &= 0.23; \tau_{2009+i}^k = 0.35 \text{ for } 0 \leq i \leq 3, \\
 \tau_{2013+i}^h &= 0.23; \tau_{2013+i}^k = 0.55 \text{ for } 0 \leq i \leq 9, \\
 \tau_{2023+i}^h &= 0.23; \tau_{2023+i}^k = 0.388 \text{ for all } i > 0.
 \end{aligned} \tag{17}$$

The capital income tax rate that generates additional annual revenues equivalent to just 2.0% of GDP on average over the period 2013-2022 in the alternative scenario was determined to be 0.51.

Notice that in these high capital income tax rates configurations, the initial labor income and capital tax rates are set at the levels implied by the calibration of the model to the period 1977-2007. The terminal value for the capital tax rate simply increases the initial one

by the 3.8% surcharge on investment income mentioned earlier.

The fifteen to twenty percentage points increase in the capital income tax rate implied by the benchmark and alternative scenarios between 2013 and 2022 may appear implausibly high. However, in late 2012 tax rates were scheduled to rise as much as ten percentage points the following year on same categories of capital income. Moreover, the budget for the 2016 fiscal year that the Executive Branch of the US government submitted to Congress on February 2, 2015, included the proposal of raising the tax rate on overseas earnings made by US companies from 0% to 19%, well in line with the higher capital income tax configuration considered in this section.¹²

In any case, many significant fiscal developments took place in 2013, including modifications to the provisions of the tax code that were supposed to become effective at the expiration of allegedly temporary tax cuts and the somewhat surprising implementation of the budget sequestration government spending cuts mentioned in subsection 4.1. It is unclear the extent to which these developments may have led households and businesses to revise their expectations about the future course of fiscal policy relative to those the paper assumes they had until then. There are certainly reasons to be skeptical that the budget sequestration had such an effect, because the spending cuts it triggered were rather mild and watered down and/or successively postponed by subsequent legislation. Nevertheless, just to avoid issues of interpretation in case they did, the paper stops comparing the predictions of the model with the data beyond 2013.¹³

Without technology shocks This subsection reports the results of investigating the fiscal sentiment hypothesis with the technology shocks shut down. As briefly discussed in the next subsection, the ability of the fiscal sentiment hypothesis to account for the weak

¹²See Office of Management and Budget (2015), p. 57.

¹³Another reason to stop the analysis in 2013 is the large decline that oil prices experienced in 2014, an in principle favorable terms-of-trade shock for the US economy, whose positive effects on the level of economic activity the model is not fully prepared to capture.

recovery from the Great Recession by the measure proposed below is largely independent of whether or not TFP shocks are present, but there are two reasons to first consider the predictions of that hypothesis without them. First, as seen in Figure 2, those shocks were fairly large and positive during the recovery from the Great Recession, inducing in the economy a circumstantial dynamics that may mask the impact of the expected policy regime change emphasized by the fiscal sentiment hypothesis. Second, the results with the technology shocks might be received with skepticism by those members of the profession who take the view that true technology shocks are poorly approximated by the Solow residuals implied by stylized versions of the neoclassical growth models such as the one considered in this paper.

Accordingly, the simulated paths of all the variables documented in this subsection have been obtained by feeding the observed initial conditions for all the state variables in the year 2009 (with the obvious exception for z_t), as well as the actually observed innovations ε_t^{gc} , ε_t^{ge} , ε_t^{hpu} , and $\varepsilon_{niy,t}$, in the decision rules corresponding to the second order perturbation approximation.¹⁴

Before getting into the details, however, an overview of the results presented below will help to gain intuition on the economic mechanisms driving them. Overall, the predictions of the model are consistent with the fiscal sentiment hypothesis that the prospect of higher capital income taxes may have been a quantitatively relevant factor in the weakness of the recovery from the Great Recession over the period 2009-2013 covered by this paper. The perception as that contraction is coming to an end that the returns on capital will be taxed more heavily in the near future leaves the capital stock at a higher level than desired, and

¹⁴Unfortunately, only computationally costly global solution methods can shed some light on the accuracy of the second order perturbation approximation implemented in this paper to compute the Walrasian equilibrium of the model economy under different scenarios. In any case, as a way of checking the sensitivity of the results to alternative computational techniques, the equilibrium was computed also under the assumption of perfect foresight which, although unrealistic, is mathematically exact up to machine precision. The results, available upon request, didn't show significant departures from those reported below, with the obvious differences predicted by theory in the absence of forecast errors.

induces the familiar transitional dynamics of a neoclassical growth model in which the initial capital stock is above its steady-state. As a result, households let the capital stock depreciate to its lower steady-state level by not investing as much as under the previous lower capital income taxes regime. Without the need to produce as many investment goods to keep the capital stock from depreciating, they enjoy more leisure, work less, and devote a larger share of the lower output to consumption. Investment, labor input, and output decline, even undershooting their new lower steady states.

The quantitative effects of the economic forces just described are summarized below in figures and a table which, in order to facilitate a compact and precise presentation of the findings of this paper, have been equipped with the common expositional devices described next. All the figures will plot the relevant information for the level of one particular *detrended* variable. The data for the variable under study will be traced by a thick full line. The simulated path of the variable in the model economy when tax rates are kept constant at their calibrated value prior to the Great Recession will be captured by a thin full line labeled "counterfactual scenario," to indicate that it corresponds to a scenario free of the fiscal imbalances that motivate the hypothesis studied in this paper or, alternatively, in which those imbalances could have been counterfactually addressed with nondistortionary lump-sum taxes. The simulated path of the variable corresponding to the benchmark higher capital income tax rate scenario will be represented by a broken line, labeled "benchmark scenario." The analogous path for the alternative higher capital income tax rate scenario will be identified by a dotted line. The performance of the fiscal sentiment hypothesis will be measured by its ability to account for the distance that separates the predictions of the model for the counterfactual scenario (the thin full line) and the data (the thick full line), referred to as the "gap" of a variable under consideration. Finally, all figures include a thinner dotted horizontal line that identifies the steady-state of the variable under the initial, low taxes regime. It must be kept in mind, however, that the decision rules are always approximated

around the steady state implied by the permanently higher capital income tax rate assumed in place after 2022.

With these conventions in mind, the outcomes of the numerical experiments described above for gross private domestic investment are summarized in Figure 3. Notice that investment in the counterfactual scenario is *below* its steady-state level corresponding to the low capital income tax regime, mainly because the capital stock is initially *above* its analogous steady-state level. The initial conditions will, of course, influence all the simulated paths of the variables discussed below. The same is true of net imports which, as anticipated in the introduction, were in 2009 above its pre-Great-Recession trend as measured in this paper.

<insert Figure 3 around here>

In any case, the figure shows that the "investment gap," by the convention established above, has been rather large in the wake of the Great Recession, ranging from about 25% in 2009 to about 18% in 2013, the last year for which the analysis in this paper was considered valid for the reasons given in the previous subsection. Inspection of the figure readily suggests that in the benchmark scenario, the fiscal sentiment hypothesis accounts for two-thirds of that gap in 2009 and for all of it later on. The analogous fractions are lower, but still sizable, under the alternative higher capital income tax scenario.

A topic at the center of the debates that motivated the formulation of the fiscal sentiment hypothesis is its ability to account for the dismal performance of employment after the Great Recession. The findings of this paper in that dimension are summarized in Figure 4. As it can be inferred from the figure, in the benchmark scenario the fiscal sentiment hypothesis can account for between one-third and two-thirds of the gap in labor input absorbed by the private sector. These fractions are again somewhat lower in the alternative scenario.

<insert Figure 4 around here>

Although the performance of the fiscal sentiment hypothesis is less satisfactory with respect to labor input than to investment, it is successful by the standard of many models that would have predicted a strong rebound of labor input after the Great Recession. As mentioned earlier, that is the counterfactual prediction of models that abstract from fiscal policy considerations and focus the attention instead on financial frictions, such as the one proposed by Jermann and Quadrini (2012). More relevant, however, is the observation in section 3. that the calibration methodology adopted in this paper prevents the low realization of labor input during the Great Recession and its aftermath from influencing the identification of the trend for that variable. Without that discipline, the estimated trend for labor input would have been lower during the period under consideration and the fiscal sentiment hypothesis, it seems fair to conjecture, would be able to account for larger fractions of the labor input gap than those just reported. A similar improvement in the ability of the model to replicate this gap ought to be expected from explicitly incorporating in the analysis the effects of the disincentives to work implied by many of the measures actually introduced during the Great Recession mentioned in footnote 10 as well others more thoroughly analyzed by Mulligan (2012).

As to the private sector output gap, understood as above, Figure 5 shows that the fiscal sentiment hypothesis can account for about one-third of it at the earlier stages of the recovery from the Great Recession and for all of it at the later stages. The fact that the model doesn't account for a larger fraction of the output gap initially is a manifestation, of course, of a similar performance of the model with respect to labor input.

<insert Figure 5 around here>

Of interest also is the dynamics of private consumption, but the comparison between the predictions of the model and the data is more elusive for this variable. In the model it is supposed to capture the flow of services from non-durable and durable goods, but that

in the data includes the *purchases* of the latter. Fortunately, this measurement problem is mitigated by the fact that NIPA does impute in consumption the flow of services from owner-occupied dwellings, which represent a sizable fraction of the services provided by the households' stock of durable consumption goods. Subject to this caveat, consumption during the Great Recession and its aftermath remained above its pre-Great-Recession trend, as documented in Figure 6. The simulation for the counterfactual scenario insinuates that that outcome is mostly a reflection of the fact mentioned earlier that, by the measures of the model, the capital stock and net imports were above their low-tax-rates steady-state levels.

The dynamics induced by those initial conditions are present, of course, in the simulated path of consumption for the benchmark and alternative high tax rates scenarios, which in addition register the influence of the mechanism succinctly mentioned above and highlighted by Beaudry and Portier (2007): the anticipation that the returns to investment will be taxed more heavily induces households to shift a larger share of output to consumption. The presence of this mechanism invites to take with a grain of salt the optimism about future output growth rates that might be sparked by occasionally strong consumption during the recovery from the Great Recession. In any case, because the prospect of higher capital income taxes induces declines in output as well, it is far from obvious that the effect of the increased share of consumption in aggregate expenditures is large enough to account for the initial overshooting of this variable predicted by the fiscal sentiment hypothesis. More likely, it is a manifestation of the fact that the predictions of the model fall short, as documented above, of accounting for the considerable weakness that labor input and output exhibited at the beginning of the recovery.

<insert Figure 6 around here>

Although the findings for macroeconomic quantities just documented validate, in general, the empirical relevance of the fiscal sentiment hypothesis, that might be at the expense of

implausible price dynamics. The comparison of the model predictions with the data is more challenging along this dimension, however, because of well-known measurement problems in obtaining accurate empirical counterparts estimates of the rental prices of labor and capital in the model.

In any case, for the purposes of evaluating the quantitative performance of the fiscal sentiment hypothesis with respect to prices, it may be useful to take into account that according to discussions often held in policy circles, especially those about the degree of monetary policy accommodation in the aftermath of the Great Recession, the equilibrium real interest rate has been abnormally low during that episode and subsequent recovery. The dynamics of the equilibrium after-tax real interest rate in the model economy for the higher capital income tax scenarios documented in Table 2 is not inconsistent with that assessment. The intuitive reason why that rate, calculated as $(1 - \tau_t^k)(r_t - \delta)$, in those scenarios is low by the standard of the counterfactual one is that savings are still at the level associated with that scenario as the demand for investment falls due to the prospect of higher capital income taxes. Notice that the interest rate differential just mentioned is particularly steep in the last period of the simulation, when the anticipated higher capital income tax rate does indeed rise.

<insert Table 2 around here>

Similar economic arguments would feed the suspicion, however, that the fiscal sentiment hypothesis will not be equally successful at capturing the dynamics of real wages. The reason is that, as is well known, real wages are proportional to labor productivity in the neoclassical growth model. With the capital stock initially predetermined and the prospect of higher capital income taxes inducing households to work less, labor productivity and thus, real wages, must rise on impact. By most accounts, however, real wages have fallen or at best remained flat during the Great Recession and the rebound that followed it. Thus, the model

predictions, summarized in Table 2, that real wages initially rise slightly above 1% in the high capital income tax rates scenarios relative to the counterfactual scenario is contrary to the evidence. Note, however, that the subsequent decline in real wages is more pronounced in the benchmark and alternative scenarios than in the counterfactual scenario, resembling better the pattern of falling real wages implied by a widely used measure of employment costs included in the table. It seems fair to conclude that, overall, the implications of the fiscal sentiment hypothesis for labor market variables don't fundamentally undermine its empirical relevance, but they do suggest that its ability to account for key aspects of the weak recovery from the Great Recession might improve in models enriched with features that have further detrimental effects on the demand for labor.

With technology shocks As already anticipated, none of the findings reported above are fundamentally altered by feeding the decision rules with the actually observed technology shocks z_t . The reason is that those shocks just induce level shifts in the variables in all scenarios, leaving essentially unchanged the fraction of their corresponding gaps that the fiscal sentiment hypothesis is capable to account for. Representative of these results are those for labor input presented in Figure I - D of the online appendix D.

5.2.2. Tax regime with higher labor income taxes

The same algorithm as before establishes that the labor income tax rate should be increased from 0.23 in the counterfactual scenario to 0.29 to deliver the additional revenues required in the benchmark scenario. Accordingly, this subsection investigates the predictions of the fiscal sentiment hypothesis under the following tax regime configuration:

$$\begin{aligned}
 \tau_{2009+i}^h &= 0.23; \tau_{2009+i}^k = 0.35 \text{ for } 0 \leq i \leq 3, \\
 \tau_{2013+i}^h &= 0.29; \tau_{2013+i}^k = 0.388 \text{ for } 0 \leq i \leq 9, \\
 \tau_{2023+i}^h &= 0.23; \tau_{2023+i}^k = 0.388 \text{ for all } i > 0.
 \end{aligned} \tag{18}$$

The only reason to examine the fiscal sentiment hypothesis under the higher labor income tax rate specification is to confirm that, as predicted by theory, it will produce results contradicted by the evidence. Intuitively, the anticipation of higher taxes on that source of income will induce households to intertemporally substitute less leisure today for more leisure in the future, when work in market activities will be taxed more heavily. As a result, labor input (and output) will tend to rise before the labor income tax goes up and collapse once that higher tax rate becomes effective, the opposite pattern of that observed during the recovery from the Great Recession. The results of simulations analogous to those conducted for the higher capital income tax rate benchmark scenario are entirely consistent with this economic intuition: investment, labor input, and output are all above their levels in the counterfactual scenario before the period in which the labor income tax rate increases in the abstraction of the model. The predictions for labor input summarized in Figure 7 make apparent that they badly miss the observed performance of that variable during the allegedly weak economic expansion under study.

<insert Figure 7 around here>

6. Concluding Comments

Six years after the trough of the Great Recession, the US economy was still struggling to recover as fast as many well-established economic models suggest it ought to, given the depth of that contraction. The situation is reminiscent of the painful and slow-motion rebound from the Great Depression and has prompted several conjectures to account for it. The one explored in this paper is the fiscal sentiment hypothesis, according to which the poor performance of the economy after the Great Recession can be accounted for by the fears of an imminent switch to a higher-taxes regime.

Such fears don't seem unreasonable given the policy responses to similar events in the

past, the record level that government debt reached after the Great Recession, and the projections that structural fiscal problems, aggravated by that contraction, will have to be addressed sooner rather than later by increasing revenues and/or reducing spending.

The quantitative exploration of the fiscal sentiment hypothesis is deliberately pursued with a suitably modified version of the frictionless neoclassical growth model that appears to have inspired the formulation of that hypothesis. The paper proposes to measure the performance of the fiscal sentiment hypothesis in terms of its ability to account for the gap of key macroeconomic variables, defined as the difference between the actually observed level of those variables and the one that the model would have predicted in the absence of expectations of an imminent switch to a higher-taxes regime. Considerable discipline was introduced in the analysis by restricting the specifications of the higher-taxes regimes to those that households and businesses could have plausibly envisioned at the trough of the Great Recession, in light of the fiscal deficit reduction targets that the CBO recommended around that time to correct pre-existing fiscal imbalances aggravated by that downturn.

The main finding of the paper is that the fiscal sentiment hypothesis has quantitative merit, with the caveat that the higher-taxes regime must include mostly higher capital income tax rates. This is not an unreasonable qualification: It suggests that economic agents suspect that at times of stress, the tax structure that will be implemented to keep the government debt on a sustainable path will be far from optimal. On the contrary, it will be precisely then that policymakers will find it harder than ever to resist the calls to replace optimal but time inconsistent tax policies with time consistent but suboptimal ones that typically tax capital income more heavily. This conjecture has the flavor of a similar one made by Fernández-Villaverde *et al* and Born and Pfeifer in the studies mentioned earlier. Those authors suggest that one possible implication of their findings is that the fiscal policy uncertainty they study could have considerably larger negative effects on the level of economic activity when economic agents have more doubts about the size of future tax

increases than about the level of government spending.

A more precise restatement of the findings just outlined is that, when the targeted additional revenues are collected with higher capital income taxes, the fiscal sentiment hypothesis can account, in the benchmark scenario, for between two-thirds and all of the private gross domestic investment gap and for between one-third and two-thirds of the labor input gap observed during the recovery from the Great Recession over the period covered by this paper. The analogous figures for the alternative scenario are lower, but still significant. On the other hand, the fiscal sentiment hypothesis implies counterfactual predictions if the targeted additional revenues are collected mainly with higher tax rates on labor income.

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Figure 1
Fraction of available time average U.S. household was actually *at* work

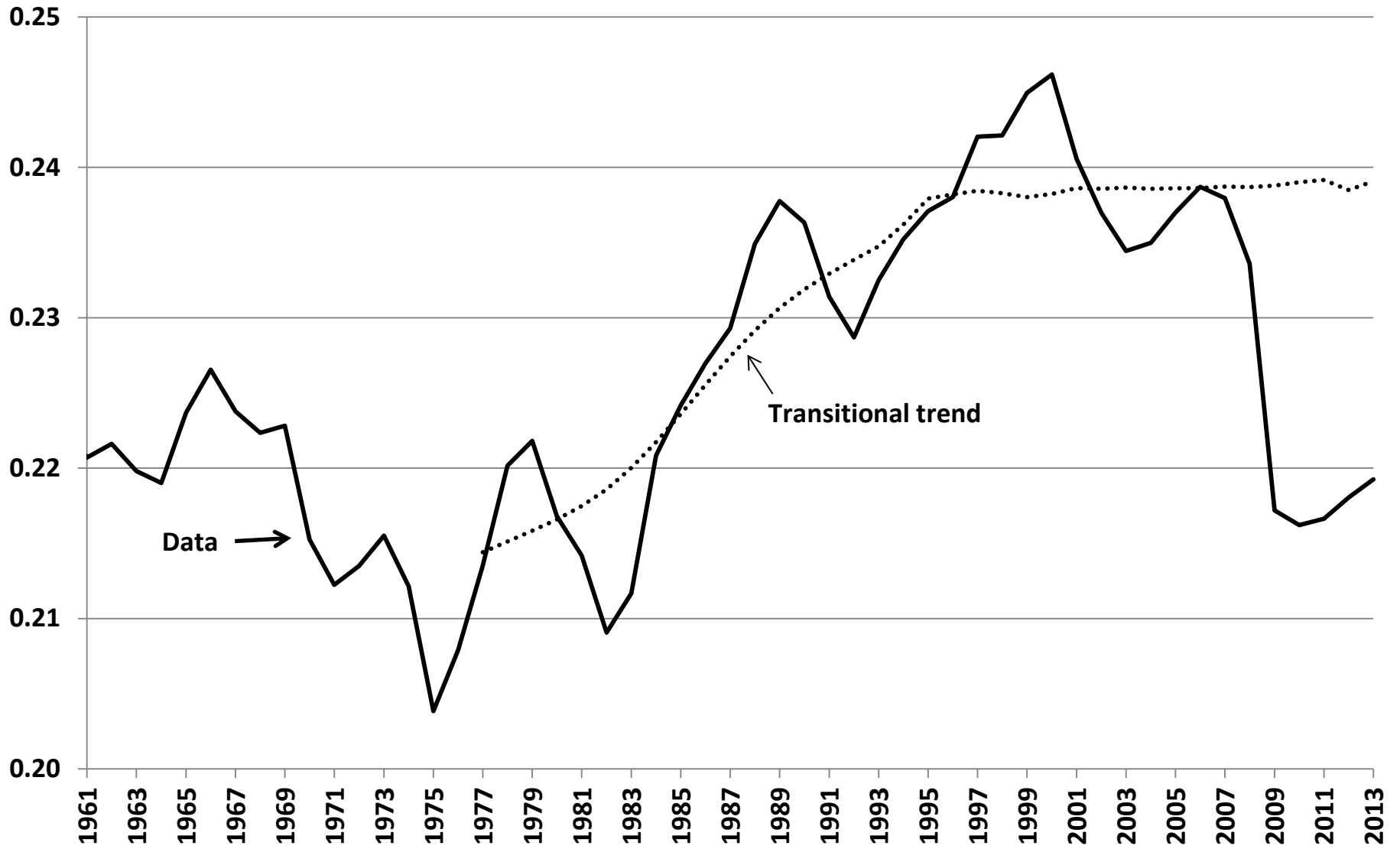


Figure 2
Detrended Private Sector Output and Stochastic Technology Levels

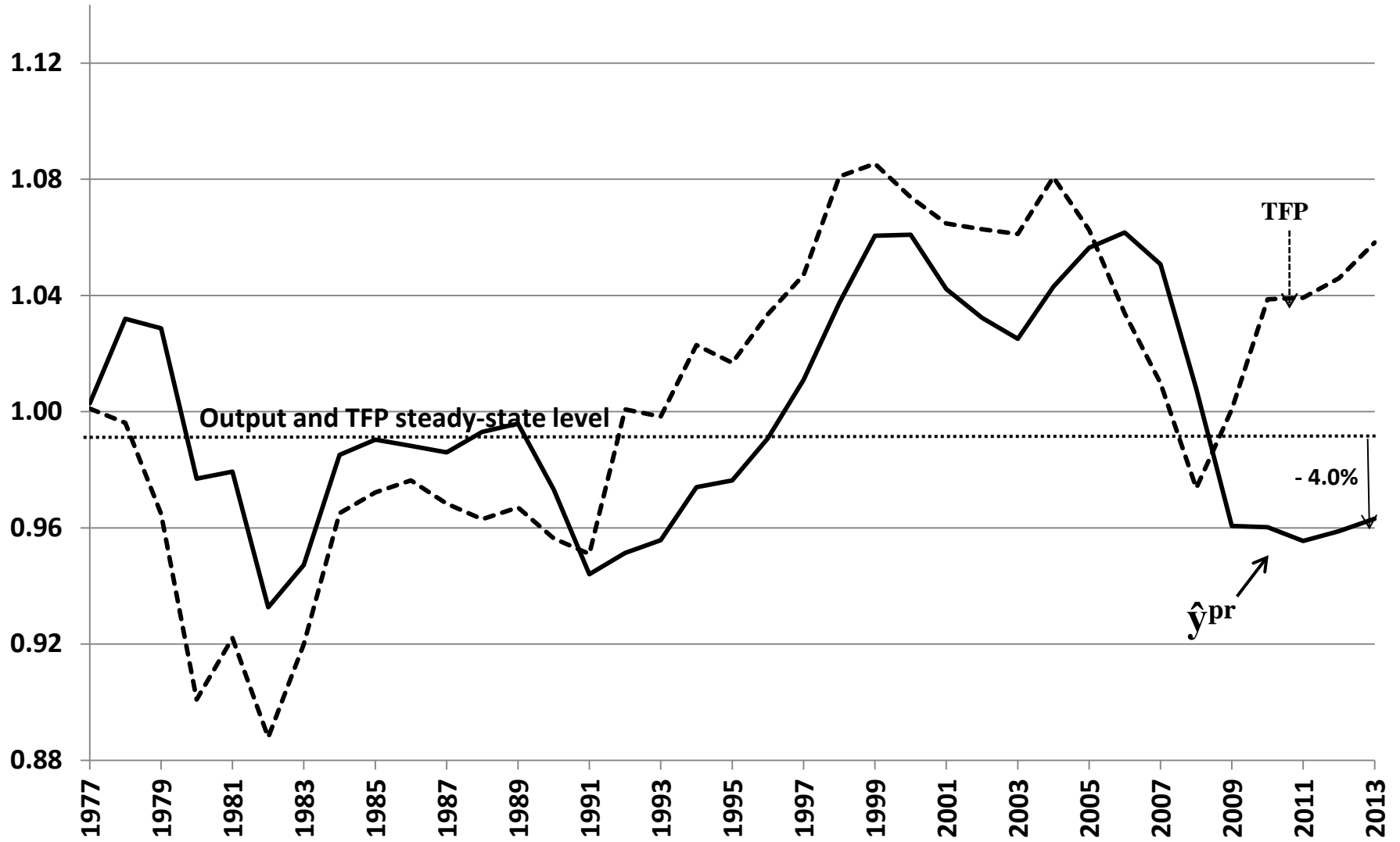


Figure 3
PRIVATE GROSS DOMESTIC INVESTMENT
Data and Model Predictions
Fully Anticipated Switch to Higher Capital Income Tax Regime
 (detrended levels)

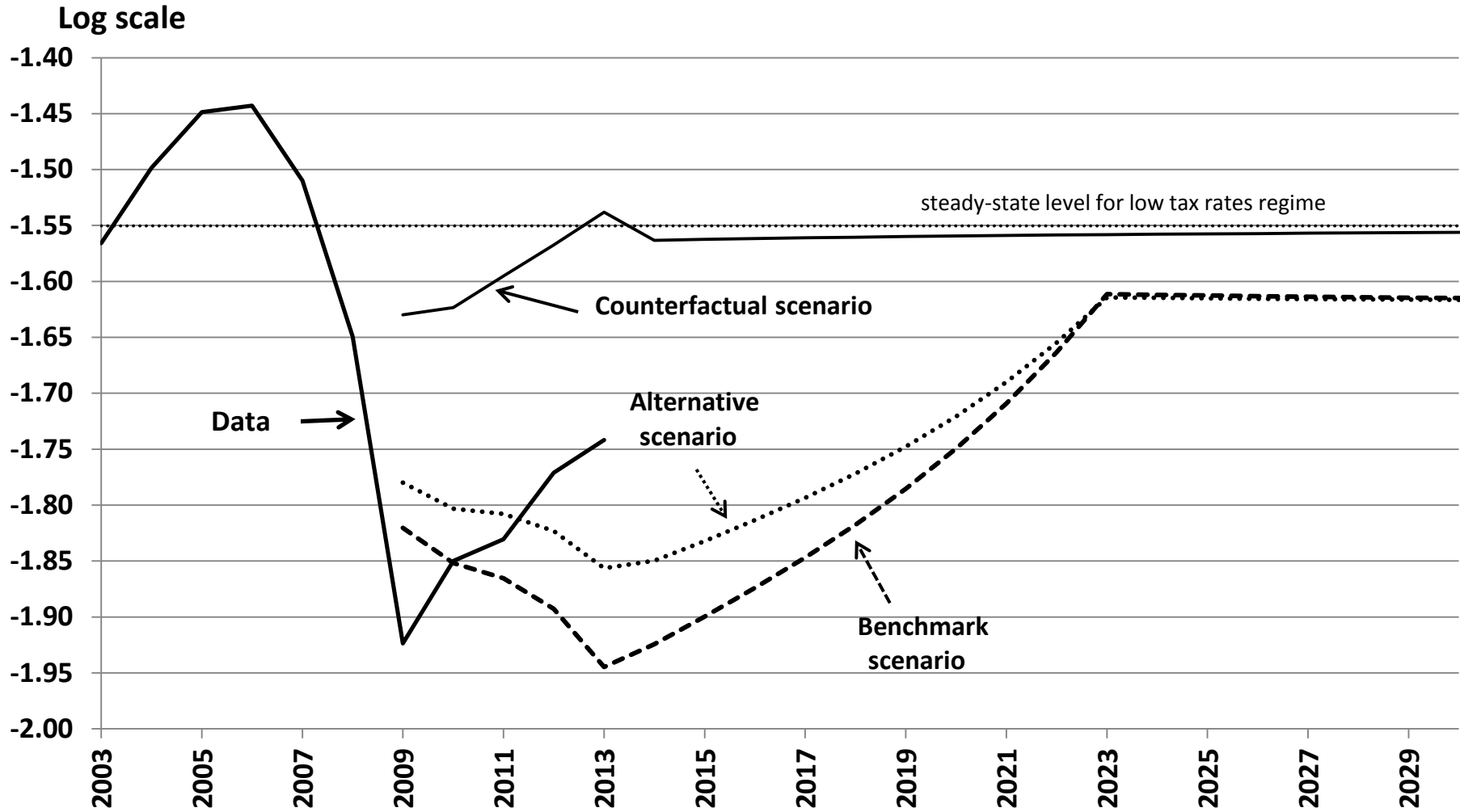


Figure 4
LABOR INPUT ABSORBED BY PRIVATE SECTOR FIRMS
Data and Model Predictions
Fully Anticipated Switch to Higher Capital Income Tax Regime
 (detrended levels)

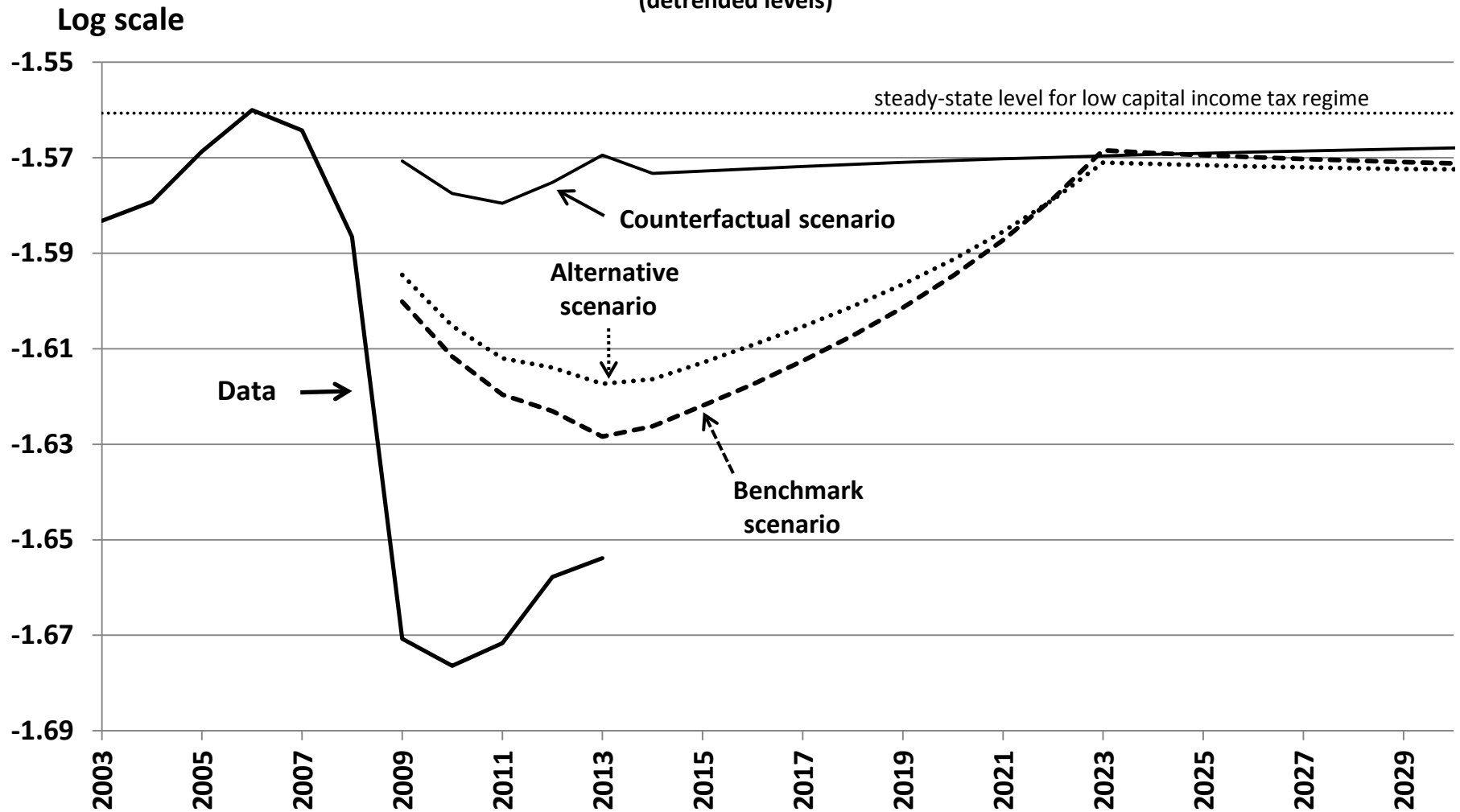


Figure 5
PRIVATE SECTOR OUTPUT
Data and Model Predictions
Fully Anticipated Switch to Higher Capital Income Tax Regime
 (detrended levels)

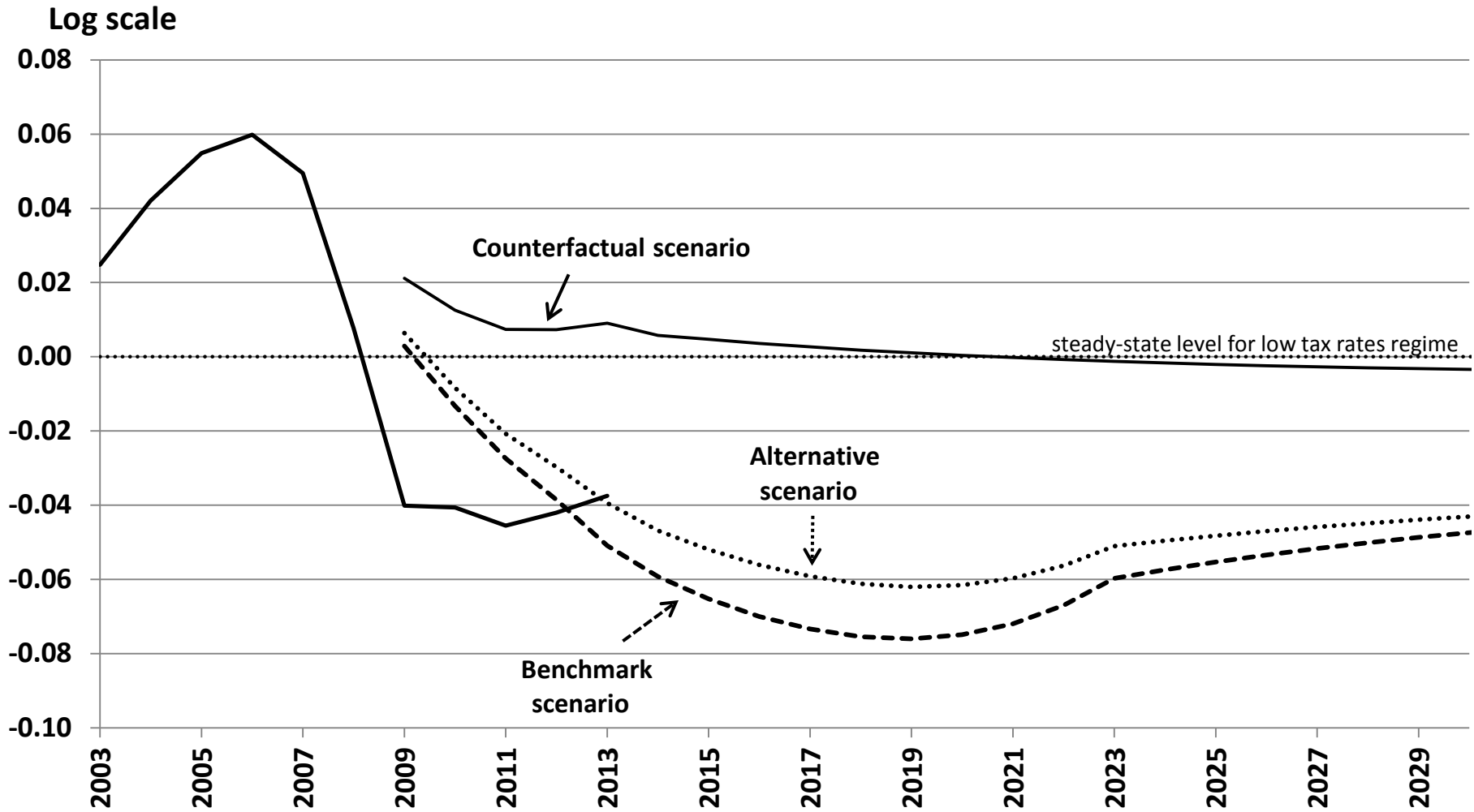


Figure 6
PRIVATE CONSUMPTION
Data and Model Predictions
Fully Anticipated Switch to Higher Capital Income Tax Regime
(detrended levels)

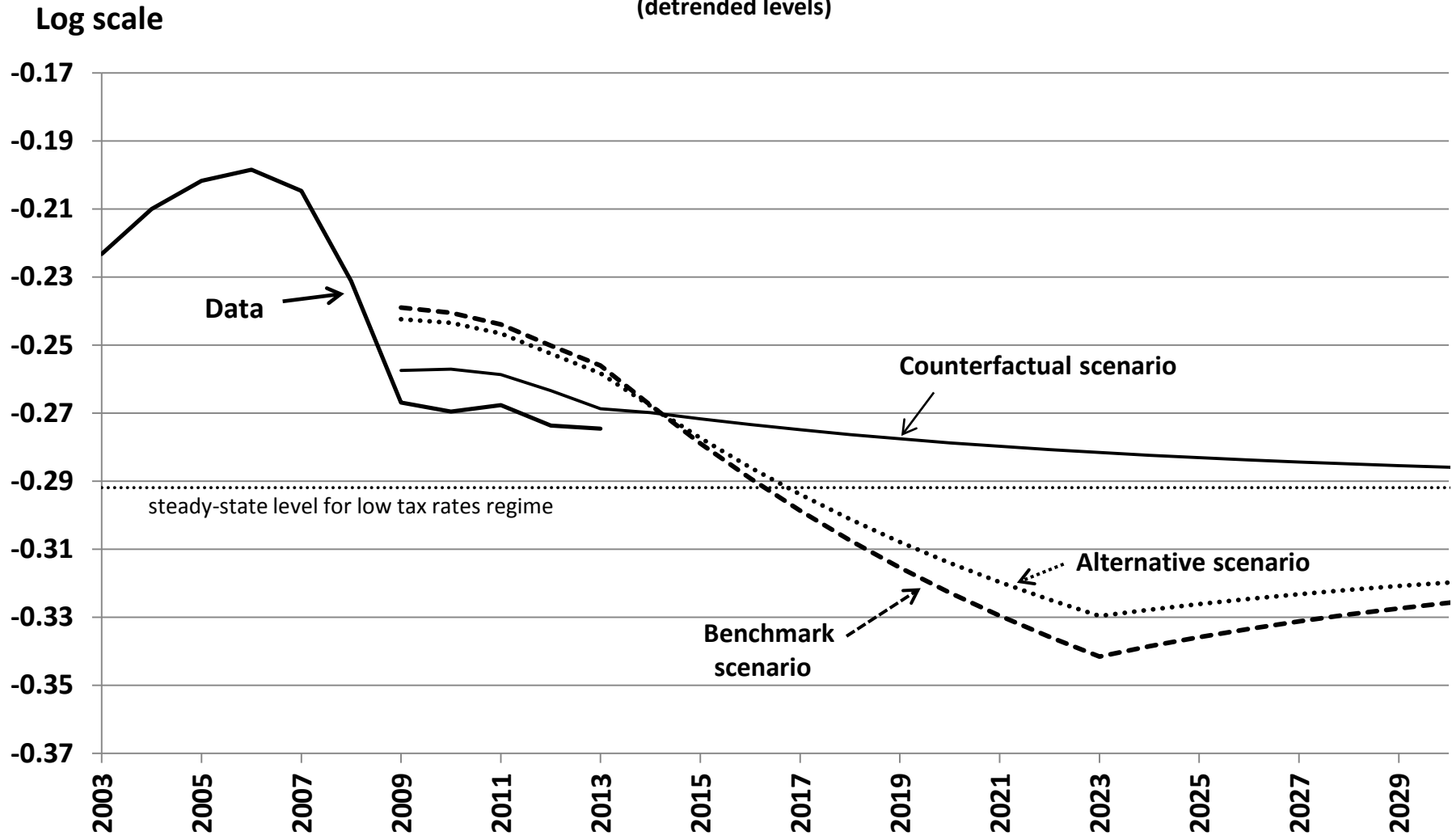
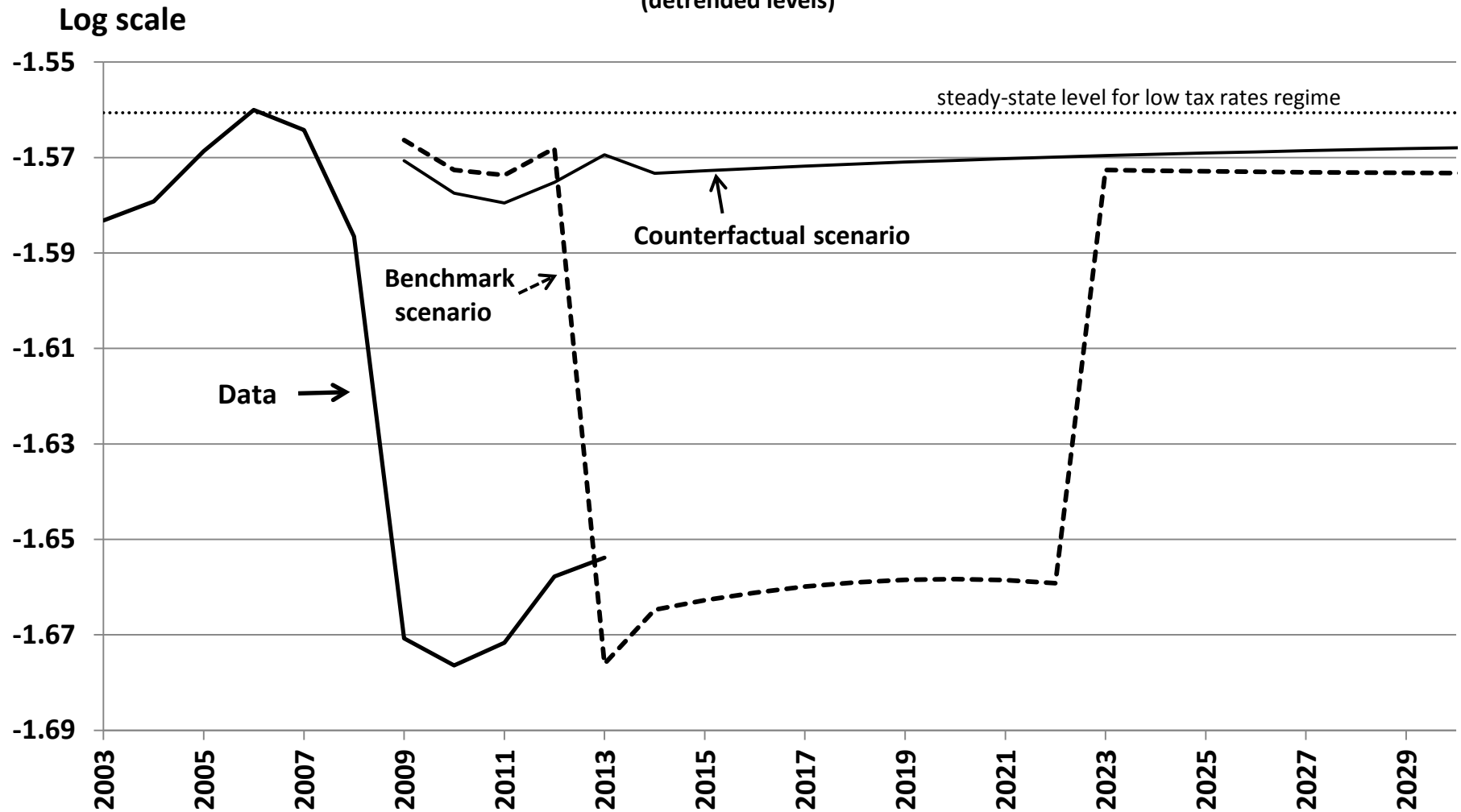


Figure 7
LABOR INPUT ABSORBED BY PRIVATE SECTOR FIRMS
Data and Model Predictions
Fully Anticipated Switch to Higher Labor Income Tax Regime
 (detrended levels)



Variable	Description	Value	Source
η	net annual growth of population 16 years of age and older	0.0126	Average 1977-2007
x/y	steady-state investment-private sector firms output ratio	0.212	Average $\frac{x_t}{y_t^{pr}}$ 1977-2007
k/y	steady-state capital-private sector firms output ratio	2.57	Average $\frac{k_t}{y_t^{pr}}$ 1977-2007
niy	net imports-private sector firms output ratio	0.026	Average $\frac{ni_t}{y_t^{pr}}$ 1977-2007
gy	share of private sector firms output absorbed by government	0.082	Average $\frac{g_t}{y_t^{pr}}$ 1977-2007
vy	government enterprises value added-to-private sector firms output ratio	0.0156	Average $\frac{va_t}{y_t^{pr}}$ 1977-2007
h^{pu}	labor input absorbed by government agencies	0.03	Average h_t^{pu} 1977-2007
h^{pr}	labor input absorbed by private sector firms	0.21	Appendix C
θ	capital share parameter	0.38	Appendix C
γ	net annual growth of total factor productivity	0.0078	Appendix C
δ	annual depreciation rate	0.062	Implied
τ^k	capital income tax rate	0.35	Appendix C
τ^h	labor income tax rate	0.23	Appendix C
α	preference share parameter	0.302	Implied
σ	reciprocal of intertemporal elasticity of substitution	2	Assigned
β	discount factor	0.957	Implied
ρ	autocorrelation coefficient of technology shocks	0.9	Estimated
ρ_{niy}	autocorrelation coefficient of net imports-output ratio	0.986	Estimated
σ_z	standard deviation ε_t	0.025	Estimated
σ_{gc}	standard deviation ε_t^{gc}	0.096	Data
σ_{ge}	standard deviation ε_t^{ge}	0.086	Data
σ_{hpu}	standard deviation ε_t^{hpu}	0.018	Data
σ_{niy}	standard deviation ε_t^{niy}	0.006	Estimated

Table 1. Parameter values

Year	Real interest rate					Real wage						
						Annual growth rates (%)						
	Counter-factual scenario	Benchmark scenario	Alternative scenario	Counter-factual scenario	Level	Counter-factual scenario	Benchmark scenario	Alternative scenario	Data ¹	Counter-factual scenario	Benchmark scenario	Alternative scenario
2009	5.10	4.93	4.96	3.046	3.080	3.074	1.016	N.A. ²	N.A.	N.A.	N.A.	
2010	5.12	5.00	5.02	3.041	3.066	3.061	-0.594	-0.177	-0.464	-0.407		
2011	5.17	5.09	5.11	3.031	3.047	3.044	-1.647	-0.312	-0.616	-0.555		
2012	5.24	5.21	5.21	3.018	3.024	3.023	-0.922	-0.445	-0.765	-0.700		
2013	5.30	3.68	4.00	3.005	3.003	3.004	-0.276	-0.401	-0.698	-0.635		
1. Calculated by deflating the nominal Employment Cost Index reported by the Bureau of Labor Statistics by the consumer price index inflation rate and the calibrated annual total factor productivity growth rate, $(1+\gamma)$.												
2. N.A.: not available.												

Table 2. Data and Model Predictions for Real Interest Rate and Real Wage

Appendix A

Data Sources and Treatment

The National Income and Product Accounts (NIPA) don't start reporting with the required level of disaggregation many of the public sector variables in the model economy, like the value added by government enterprises, until 1977. Therefore, the data correspond to annual figures over the period 1977-2013.

All macroeconomic aggregates have been expressed in units of the consumption good by deflating nominal variables by the implicit price deflator for nondurable goods and services. Specifically, with the exception of the capital stock, all period t nominal variables were deflated by that price index. The beginning-of-period annual nominal capital stock K_{t+1} was deflated by the period t consumption price index, in order to incorporate the possibility of investment-specific technical progress with the procedure suggested by Greenwood, Hercowitz, and Krusell (1997).

Sources:

For national accounts variables: Bureau of Economic Analysis, National Income and Product Accounts as measured by the new methodology adopted in 2013.

For the capital stock: Bureau of Economic Analysis, "Fixed Assets and Consumer Durable Goods."

For hours worked in the private and public sectors: Bureau of Economic Analysis, Income and Employment by Industry, Hours Worked by Full-Time and Part-Time Employees.

For civilian population, military personnel, persons at work, aggregate average hours worked: Cociuba, Ueberfeldt, and Prescott (2009), Department of Defense, and Household Survey from Bureau of Labor Statistics.

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Appendix B

From the National Income and Product Accounts (NIPA) to the Budget Constraint

The assumption that the economy is populated by a large number of identical households implies the property that their decisions, in equilibrium, are being made as if by a stand-in representative household, with utility function (1), subject to the stand-in household's aggregate budget constraint. Consequently, this budget constraint can be derived in a logically consistent manner from aggregate national income identities. As it turns out, this derivation provides useful insights on how to model the decisions that determine the dynamics of the variables of interest for the purpose of this paper. The necessary steps require keeping in mind the treatment of public sector economic activities in the NIPA methodology, as documented by the Bureau of Economic Analysis (2005). The aspects of this methodology relevant for the purposes of this paper are summarized next.

The NIPA methodology reflects the fact that public sector agencies generate two types of government output: market and non-market output. The non-market output refers to services that the government provides at no charge or at well below costs, such as public education, public health, law enforcement, etc. The market output refers to goods and services produced by government entities and sold in market transactions.

Consistent with this conceptual distinction, NIPA classifies the non-market output of the public sector as "general government" output and the market output as "government enterprises" output. By its very nature, the general government non-market output cannot be recorded at market valuations. The conventional approach adopted by NIPA is to value this type of output at the costs of producing it, as estimated from measuring the inputs used up or "consumed" in the process of generating this output. For this reason, this non-market output is identified in NIPA as "government consumption expenditures" and treated as if it were one of the final goods of the economy, denoted in what follows by gc_t .

As already mentioned, this general government non-market output is measured by the costs of producing it, estimated by adding the value of the intermediate inputs, denoted m_t , and the compensation for the services of the factors of production required to transform those intermediate inputs into the non-market government output. The sum of the compensation for labor and capital services provided to the general government is recorded in NIPA as the value added by that entity, denoted va_t^{gc} , for the obvious reason that that is the value that general government units add to the intermediate inputs incorporated in the non-market final good gc_t . This value added is the actual economic value that the general government

creates in the process of fulfilling its functions and represents, therefore, the contribution of that sector to total output.

The procedure for measuring the general government non-market output just outlined is formally captured by the following relationships:

$$gc_t = m_t + ch_t^{gc} + ck_t^{gc} = m_t + va_t^{gc}, \quad (19)$$

where m_t represents the general government purchases of intermediate goods and services, ch_t^{gc} the compensation for labor services, and ck_t^{gc} the compensation for the services provided by the fixed capital stock controlled by the general government. Recall that the discussion proceeds on the understanding that it applies to the stationary, no-growth version of a model economy that, in its original formulation, exhibits balanced growth and, therefore, that all macroeconomic aggregates in expression (19) and subsequent ones have been detrended by the common growth factor $(1 + \eta)(1 + \gamma)$ when applicable.

As mentioned in the body of the paper, in NIPA only the labor component of va_t^{gc} is recorded at market values, that is, at the actual costs of the labor services hired by the general government. The compensation for capital services is the result of an imputation, which sets that compensation equal to the value of the capital stock consumed, or depreciated, over the reference period. This detail is relevant because the corresponding concept for the private sector is recorded at market prices and this asymmetric treatment, as mentioned earlier, will introduce a bias in the share of the remuneration to capital in total income, at least as usually estimated with the NIPA income flows.

For future reference, it is important to keep in mind that the imputed compensation of capital services ck_t^{gc} will not appear as income for the stand-in household because NIPA enters it simultaneously as revenue in the government sector accounts. As will become clearer after introducing the government budget constraint, it is as if the general government compensated households for the services of the capital stock they ultimately own, but at the same time collected from them the necessary revenues as a lump-sum tax.

In contrast with general government non-market output, the government enterprises output is recorded at market values. However, the economic transactions associated with the generation of that output receives an ambiguous treatment in NIPA: For some purposes, they are treated the same as those of private firms and for others, the same as those of general government. This is a reflection of the special nature of government enterprises: They are government units whose output, unlike that of general government, is sold at or near market prices.

The output of government enterprises is treated like that of any private firm: It can be any of the final goods in the economy, other than gc_t , or an intermediate input for the private sector and/or the general government. However, there are a lot of ambiguities in the treatment of their value added, va_t^{ge} . The overall amount is reported in the corporate sector of NIPA, along with the value added by private businesses. But some of the individual components are not treated the same as the corresponding ones in the private sector.

This ambiguity is particularly noticeable for the compensation of services provided by the capital stock under control of government enterprises, denoted hereafter ck_t^{ge} . On the one hand, that compensation is treated like the corresponding component of the general government, because it is not recorded at market prices, but imputed the value of the estimated depreciation of the capital stock over the reference period. On the other hand, it is treated like the analogous compensation component of the private sector because the same amount is not entered simultaneously as government revenue and will show up, therefore, as a source of income for the stand-in household.

One of the components, however, of the government enterprises value added—their surpluses and deficits—does appear in the NIPA government accounts, as revenues or expenses, respectively. The net result of these entries is that government transfers the profits or losses of the governments enterprises to the whole population indirectly, by reducing or increasing the revenues that need to be raised with taxes. This implies that the government enterprises are not responsible in the end for the consequences of their business decisions, which are not guided therefore by the same profit maximizing incentives as those of private firms. It follows that their investment decisions are not driven either by profit maximization considerations. Accordingly, NIPA treats the investment expenditures of these firms, x_t^{ge} , the same as those of the general government.

Specifically, NIPA sums government consumption expenditures, gc_t , investment by the general government investment, x_t^{gc} , and investment by government enterprises, x_t^{ge} , into the category "government consumption expenditures and gross investment," denoted here g_t , as formally captured by the following expression:

$$g_t = gc_t + x_t^{gc} + x_t^{ge} \tag{20}$$

where all the variables are detrended and measured, as before, in terms of consumption units per working age person.

The preceding somewhat tedious discussion of the relevant aspects of the NIPA methodology was nevertheless necessary to guide the next steps in the derivation of the household budget constraint from the following national account identities, under the assumption of a

closed economy maintained in the paper:

$$c_t + x_t + g_t \equiv va_t^{pr} + va_t^{ge} + va_t^{gc} \equiv y_t, \quad (21)$$

where x_t stands for private gross domestic investment, va_t^{pr} for value added by the private sector, and y_t for real gross income. All variables are measured in units of the consumption good per working age person, for consistency with those introduced earlier. According to those identities, output, the sum of the value of all final goods and services produced by labor and capital located in the economy under study, is equal to the sum of the value added by the private and public sectors, equal to the sum of factor incomes, or real gross aggregate income, y_t .¹

As mentioned before, a critical parameter for the quantitative inquiry of this paper will be the share of the remuneration to capital in gross aggregate income, which identity (21) suggests could be readily calculated by simply adding up the corresponding components in the value added by the private and public sectors, and dividing the result by aggregate income, y_t . However, this procedure may significantly distort the value of that parameter because, as explained above, NIPA doesn't record at market prices the compensation for the services of the capital stock under control of the public sector.

One way around the problem, as suggested by Gomme and Rupert (2007), is to subtract the element responsible for the bias, va_t^{gc} , from all the identities in (21), which results in the following alternative identities:

$$c_t + x_t + (g_t - va_t^{gc}) \equiv va_t^{pr} + va_t^{ge} \equiv y_t - va_t^{gc}. \quad (22)$$

Substituting the far right of (19) into (20) and the resulting expression into (22) yields

$$c_t + x_t + (m_t + x_t^{pu}) \equiv va_t^{pr} + va_t^{ge} \equiv y_t^{qp}, \quad (23)$$

where $x_t^{pu} = x_t^{gc} + x_t^{ge}$ and $y_t^{qp} = y_t - va_t^{gc}$. Several aspects of the modified version of the original economy represented by these identities are worth noticing.

First, the modified economy is a quasi-private-sector economy from the point of view of output, in the sense that the only entities engaged in production are private businesses and government enterprises.

Second, as the general government doesn't produce any output or adds any value, the quasi-private-sector economy is free of the distortion in the measurement of the capital

¹Although in theory real gross domestic product should be the same, regardless of which of the three approaches implicit in (21) is used to measure it—the expenditure approach, the gross value added approach, and the gross income approach from left to right—statistical discrepancies will prevent this equivalence from holding in practice.

income share introduced by the way the NIPA methodology imputes the value of services of the general government capital stock.

Third, the output of the quasi-private-sector economy is, like that of the original economy, a single commodity that the private and public sectors can consume or accumulate for future use. The only difference with the original economy is that part of the commodity absorbed by the general government is no longer turned into a government consumption good, gc_t , as assumed in the national account identities, but remains unprocessed at the intermediate good stage, m_t . The reason why it is possible to reduce the final good gc_t to just its intermediate inputs components m_t in the quasi-private-sector economy is that, by definition, the general government adds value in the original economy only in the process of producing that final good.

Fourth, that reduction is valid only to the extent that the stand-in household doesn't derive any satisfaction from the level of provision of the final good gc_t , an assumption satisfied by the utility function representation of preferences (1).

This last assumption is implicit in the Gomme-Rupert approach and explains why it cannot be used to eliminate the remaining bias in the capital income share introduced by the NIPA treatment of the income flows generated by the capital stock under control of the government enterprises. The subtraction of va_t^{ge} from the identities (21) will not produce the same neat result as the subtraction of va_t^{gc} because, unlike the general government non-market output, the government enterprises market output can be any final good (other than gc_t) or used up as intermediate goods by the general government and the private sector. Thus, there isn't any specific good on the far left of (23) from which to subtract va_t^{ge} . But even if possible, that step wouldn't make economic sense, because it would eliminate from the quasi-private-sector economy the only final good from which the households do derive satisfaction, c_t , as assumed in (1), or the investment good, x_t , that is essential when the production of any output requires strictly positive levels of a capital stock subject to depreciation, as assumed below.

Nevertheless, the Gomme-Rupert approach is still useful, because it suggests plausible conditions under which it will be safe to assume that the capital income share of the quasi-private-sector economy is the same as the proportion of the private sector value added originated in the compensation of capital services by that sector. One of those conditions, theoretical in nature, is that market output is produced with the same technology, regardless of whether by private firms or government enterprises. It is worth keeping in mind that it was the implausibility of a similar assumption for the production of general government non-market output that motivated the adoption of the Gomme-Rupert approach in the first

place. Another condition, quantitative in nature, is that the government enterprises output represents a small fraction of the total output of the quasi-private-sector economy. It turns out that the US economy satisfied this condition during the period used as reference for the calibration of the parameters of the model economy.

The next step in the process of deriving the stand-in household's budget constraint is suggested naturally by the fact that the general government needs to finance the mixed good $m_t + x_t^{pu}$ (part intermediate good, part investment good) with tax revenues that it collects from the private sector. Specifically, the government of the model economy satisfies every period the following budget constraint:

$$m_t + x_t^{pu} = g_t - va_t^{gc} = \tau_t^h w_t (h_t^{pr} + h_t^{pu}) + \tau_t^k (r_t - \delta) k_t + s_t^{ge} - \tau_t - w_t h_t^{gc}, \quad (24)$$

where τ_t^h is the tax rate on labor income, w_t the wage rate in terms of consumption per unit of the available time the stand-in household devotes to work, τ_t^k the tax rate on capital income, r_t the rental price of capital, δ the capital stock depreciation rate, s_t^{ge} the government enterprises surpluses, τ_t lump-sum transfers (taxes if negative), h_t^{gc} the fraction of time the stand-in household spends working for the general government, and $h_t^{pu} \equiv h_t^{gc} + h_t^{ge}$. In this last identity, h_t^{ge} denotes the fraction of time the stand-in household works for government enterprises. Needless to say, for consistency with the private sector budget constraint, all variables corresponding to physical quantities in the government budget constraint are measured in units of the consumption good per working age population as well.

It is worth noticing that implicit in (8) is the assumption that labor markets are competitive and all employers, be they the general government, government enterprises, or private firms, pay the same wage rate w_t per unit of time the household works for any of them.

According to (8), the government collects revenues from labor and income taxes and from lump-sum taxes if τ_t is negative and from the government enterprises net operating surplus if s_t^{ge} is positive. The expenses are represented by the compensation for the labor services employed by the general government, by lump-sum transfers if τ_t is positive, and by the government enterprises deficits if s_t^{ge} is negative.

Notice that the compensation of capital services doesn't show up in the government budget constraint because, as discussed earlier, the NIPA methodology records this expense simultaneously as general government revenue. The excess of revenues over expenses represents the amount of general government purchases of the mixed good $m_t + x_t^{pu}$.

The substitution of (8) into (23) is the last step in the derivation of the household budget constraint which, after some algebraic manipulations, produces the desired expression:

$$c_t + x_t = (1 - \tau_t^h) w_t (h_t^{pr} + h_t^{ge} + h_t^{gc}) + [r_t - \tau_t^k (r_t - \delta)] k_t + c k_t^{ge} + \tau_t \quad (25)$$

where ck_t^{ge} captures the imputation of the compensation for the services of the capital stock under direct control of the government enterprises, which in the NIPA methodology is one of the sources of income of the stand-in household, the ultimate owner of that stock. Recall, however, that the implicit assumption in the NIPA methodology is that this source of income is not under control of the household, because it is the government that decides the government enterprises investment expenses and, therefore, the level of their capital stock. Consistent with that methodology, in the model economy this source of income will be treated as a lump-sum transfer, independent of the households' behavior.

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Appendix C

Model Calibration

This appendix documents in detail the arguments and procedures followed to set the values of parameters and steady-state relationships in the model that could not be obtained by just taking averages of their corresponding empirical counterparts over the period 1977-2007.

Capital share The calculation of the capital income share from the private sector income flows is not as straightforward as it may seem. Although the NIPA methodology doesn't introduce any bias in those flows, it still doesn't permit a neat distinction between capital income and labor income. That is because part of the private sector income is classified as proprietors' income, an ambiguous category which includes the compensation, in unknown proportions, of the labor services that businesses' owners provide to their own firm, as well as the compensation for the services of their own capital. Different assumptions about the distribution of that ambiguous income between the labor and capital components produce different estimates for θ .

For consistency with the previous literature also focused on the economic effects of taxation, this paper set $\theta = 0.38$, the value adopted by the paper by Trabandt and Uhlig mentioned in the text.

Total Factor Productivity Growth This growth rate was estimated from the Solow residuals implied by the intensive version of the production function (6) in the text, with the following formula:

$$\gamma = \frac{1}{30} \left[\sum_{t=1977}^{2007} \ln \frac{y_{t+1}^{pr}}{y_t^{pr}} - \frac{\theta}{1-\theta} \sum_{t=1977}^{2007} \ln \frac{\frac{k_{t+1}}{y_{t+1}^{pr}}}{\frac{k_t}{y_t^{pr}}} - \sum_{t=1977}^{2007} \ln \frac{h_{t+1}^{pr}}{h_t^{pr}} \right], \quad (26)$$

which implies $\gamma = 0.0078$.

Technology Level Series Once the long-run TFP growth rate has been estimated as above, the time series for the stochastic technology level, z_t , can be inferred from the equation:

$$e^{z_t} = \frac{y_t^{pr}}{e^{\gamma t}} \frac{1}{A \left(\frac{k_t}{y_t^{pr}} \right)^{\frac{\theta}{1-\theta}} h_t^{pr}}, \quad (27)$$

where A is a normalizing constant chosen so that the average stochastic level z_t over the calibration reference period is zero.

Depreciation rate The depreciation rate was that implied by the steady-state version of the law of motion of capital, given by equation (3) in the text. It is worth reiterating that the calibrated depreciation rate should be interpreted as the economic, rather than the physical, depreciation rate. This is because the data have been expressed in units of the consumption good, by dividing all nominal variables in any given equation by the period t implicit price index for non-durable consumption goods and services, p_t^c . As mentioned in appendix A, Greenwood *et al.* have shown that when the production function is Cobb-Douglas, this method of deflating nominal variables incorporates any long-run investment-specific technological progress eventually present in the data into the labor-augmenting progress γ , provided the depreciation rate is reinterpreted as the economic depreciation rate.

Specifically, the depreciation rate is required to satisfy the steady-state version of the following version of law of motion of capital, prior to detrending:

$$\frac{K_{t+1}}{p_t^c} = (1 - \delta) \frac{K_t}{p_{t-1}^c} + \frac{X_t}{p_t^c}, \quad (28)$$

where K_t is the nominal capital stock and X_t nominal investment.¹

Dividing the above expression through by y_t^{pr} , taking into account that output grows over time at the annual deterministic rate $(1 + n)(1 + \gamma)$, yields the steady-state relationship

$$(1 + n)(1 + \gamma) \frac{k}{y} = \frac{x}{y} + (1 - \delta) \frac{k}{y},$$

which implies a depreciation rate of 0.062.

Tax rates There have been several attempts in the literature to figure out effective tax rates on capital and labor income from the data. There is some variance on the results, the natural consequence of methodologies that make different assumptions about how to allocate income to the different factors of production and the tax rates applicable to different forms of income. This paper has adopted the estimates provided by Carey and Rabesona (2002), because when fed into the model, they imply fiscal revenues closer to those observed historically in the US than the higher tax rates in Mendoza (1994) and in the paper by Trabandt and Uhlig mentioned earlier. Specifically, the effective tax rate on capital income for the US that Carey and Rabesona report in Table 2 of their study ranges roughly between 40% and 30%, depending on the method used to calculate it. Accordingly, the present paper

¹Equation (28) implies that the physical units of capital stock available for production at period $t+1$ have been valued at the previous period prices, an assumption roughly consistent with the way the BEA measures the annual capital stock in nominal terms. The constant economic depreciation rate in this equation assumes implicitly as well a constant growth rate of investment-specific technological progress.

set $\tau^k = 0.35$, the average of those two figures. That same table documents that in the period closer to the Great Recession, the effective labor income tax rate was 23.4%. Consistent with that estimate, the paper set $\tau^l = 0.23$.

Labor input stationary value The parameter α that determines the relative weights of consumption and leisure in the household's utility function could in principle be determined from the following relationship implied by the steady-state version of the intratemporal equilibrium condition (13) in the text:

$$\alpha = \frac{1}{\frac{1-h}{h^{pr}} \frac{(1-\tau^h)(1-\theta)}{1+vy+niy-gy-\frac{x}{y^{pr}}} + 1}. \quad (29)$$

The only parameter needed to infer α whose value has not been pinned down yet by the data or otherwise is h , the stationary fraction of available time that households are effectively at work. Once that value is determined, the component of that fraction absorbed by the private sector, h^{pr} , can be obtained by simply subtracting from h the component h^{pu} absorbed by government agencies, which has shown very little fluctuations around the value 0.03 over the calibration period.

The usual approach of setting the value of h to the average over the calibration period assumes the absence of transitional dynamics in that variable, a hypothesis difficult to maintain in light of the evidence examined in the text. For the reasons given in the paper, a hybrid procedure was implemented to identify the transitional trend of labor input, that is, of the variable h_t in the model, and the stationary value h_{ss} it seemed to be converging to.

The trend for the period 1977-1993 was estimated with a Hodrick-Prescott filter, parameterized to annual frequencies, using data from the whole calibration reference period, that is, for the period 1977-2007. The reason not to rely on the Hodrick-Prescott filter after the year 1993 was that, as it is well-known, that filter tends to capture actual trends quite poorly at the end of samples. Therefore the trend for the remaining years, that is, for the period 1994-2013 was estimated using more detailed information about the age distribution of persons actually at work (as opposed to paid, but on vacation, sick leave, leave of absence, unable to show up to work etc.,) available since 1994.

The analysis of those more disaggregated data revealed the presence of trends in the allocation of the available time by different age groups that was necessary to take into account for properly estimating the transitional trend behind the upward drift of that variable apparent in Figure 1 in the text. The steps to infer that trend for the latter period under consideration were as follows: 1) the trend for each age group for which the necessary information was available (individuals 16 to 19, 20 to 24, 25 to 54, and 55 years of age and

over) was estimated with a regression analysis using quarterly data for the period 1994-2007, 2) the resulting trend for each age group was projected to subsequent years, up to 2013, the last year for which the paper compares the model prediction with the data for the reasons given in the text, and 3) the trend for labor input in the aggregate was obtained by weighting that of each age group by its corresponding share in the working-age population.

The resulting transitional dynamics trend was documented by the dotted line in Figure 1. As indicated in the text, since that trend seemed to be converging to the value of 0.24, that was the stationary value adopted by the paper, that is, $h_{ss} = 0.24$. This value, along with that of all the other parameters already pinned down, implied that $a = 0.302$.

Discount factor Following standard practice, the discount factor β was set to the value implied by the steady-state version of the intertemporal equilibrium condition (14) in the text, that is, by the equation:

$$\beta = \frac{(1 + \gamma)^{1-\alpha(1-\sigma)}}{(r - \delta)(1 - \tau^k)},$$

where r is the steady-state value of the rental price of capital or, equivalently, the marginal product of capital at the steady state, whose value of 0.148 follows from the fact that in the neoclassical growth model, $r_t \frac{k_t}{y_t} = \theta$. This value, along with all the others determined earlier, and the assumption $\sigma = 2$, imply $\beta = 0.957$.

Autocorrelation coefficients The autocorrelation coefficient ρ corresponding to the TFP shocks was estimated by running the regression implied by the stochastic process (7), using the series of technology levels z_t for the period 1977-2007 obtained as indicated above. The autocorrelation coefficients ρ_{niy} for the net imports-to-output ratio, niy_t , was obtained similarly, by running the regression implied by the corresponding stochastic process (5), using the data for that variable over the same period.

References

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Appendix D

Additional Numerical Experiments

Section 5. of the paper documented the results of the quantitative experiments with the technology shocks shut down. As mentioned therein, the main findings are not altered in any significant way when the actually observed technology shocks, z_t , are allowed to influence the trajectory of the macroeconomic variables examined in the paper. The reason for that, as explained in the paper, is that those shocks induce level effects in those variables that are similar in all scenarios and leave basically unchanged, therefore, the gaps by which the paper proposed to measure the empirical relevance of the fiscal sentiment hypothesis. The point is eloquently illustrated by Figure I - D, which reports the results for labor input in the benchmark and counterfactual scenarios with and without technology shocks.

