

Fiscal Sentiment and the Weak Recovery from the Great Recession: A Quantitative Exploration^{*}

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Abstract

The U.S. economy isn't recovering from the deep Great Recession of 2008-2009 with the anticipated strength. A widespread conjecture is that this weakness can be traced to perceptions of an imminent switch to a higher taxes regime. The paper explores quantitatively this fiscal sentiment hypothesis. The main finding is that the hypothesis can account for a significant fraction of the decline in investment and labor input in the aftermath of the Great Recession, relative to their pre-recession trends. These results require, however, a qualification: The perceived higher taxes must fall almost exclusively on capital income.

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1 Introduction

The Great Recession of 2008-2009 has triggered a debate about its nature and causes that, almost in the same terms, reenacts that motivated by the Great Depression. This should come as no surprise, as both episodes have their similarities and the debate prompted by the earlier episode was far from settled at the time the later one started.

In the case of the U.S. economy, in those two episodes output, employment, and investment experienced larger declines than in the average recession and the recoveries that followed were allegedly weaker than they should have been. This paper is motivated precisely by this feature of the Great Recession, that is, by the fact that the main macroeconomic variables failed to recover after that episode as strongly as they should have, given the depth of the contraction and the subsequent normal or above-normal rebound in productivity.

Cooley and Ohanian (2010), Becker, Shultz, and Taylor (2011), Feldstein (2011), and Lucas (2011), among others, have conjectured that the seeming inability of the U.S. economy to recover from the Great Recession could be traced to the prospects of a switch to a higher tax regime. Such gloomy "fiscal sentiment" is far from unwarranted in the presence of the peacetime record high fiscal deficits observed during the Great Recession and the projections that, in combination with pre-existing structural fiscal imbalances, they would lead to an unsustainable public debt path over time.

Despite the frequency with which the fiscal sentiment conjecture is heard in academic circles and policy forums, its quantitative ability specifically to account for the seeming lack of dynamism of the U.S. economy after the Great Recession has not been carefully established. The goal of the paper is precisely to provide such an assessment from the perspective of a neoclassical growth model calibrated to the relevant pre-recession long-run features of the U.S. economy.

The paper formalizes the fiscal sentiment hypothesis with the conjecture that the Great Recession had the effect, detected by Reinhart and Rogoff (2009) in similar past episodes, of inducing in households and businesses the perception of an imminent switch to a higher-taxes regime. In order to introduce quantitative discipline in the eventual size of the tax hikes, the paper relies on publicly available information most likely to influence those perceptions, such as the reports produced by the non-partisan Congressional Budget Office periodically quoted in the media.

The finding of the paper is that the fiscal sentiment conjecture can account rather well for the weakness of the U.S. recovery from the Great Recession, provided the higher-tax regime includes exclusively higher capital income tax rates. This is not an unreasonable condition,

as it is precisely at times of crises and confusion that societies are most likely to surrender to the time-inconsistency temptation. As is well known, the capital income tax rates of a time-consistent but suboptimal tax regime can be significantly higher than in the optimal but time-inconsistent regime.

Specifically, in the higher capital income tax scenario, the model predictions for the path of private gross domestic investment trace rather closely the actual trajectory of that variable during the Great Recession and its aftermath. This particular incarnation of the fiscal sentiment hypothesis can also account for between one-third and one-half of the decline in labor input relative to its pre-recession trend observed over that same period. Finally, the version of the model with higher capital income tax rates is consistent with the apparent downward level shift in the long-run trend for output that can be detected in the data in the aftermath of the Great Recession, as documented later.

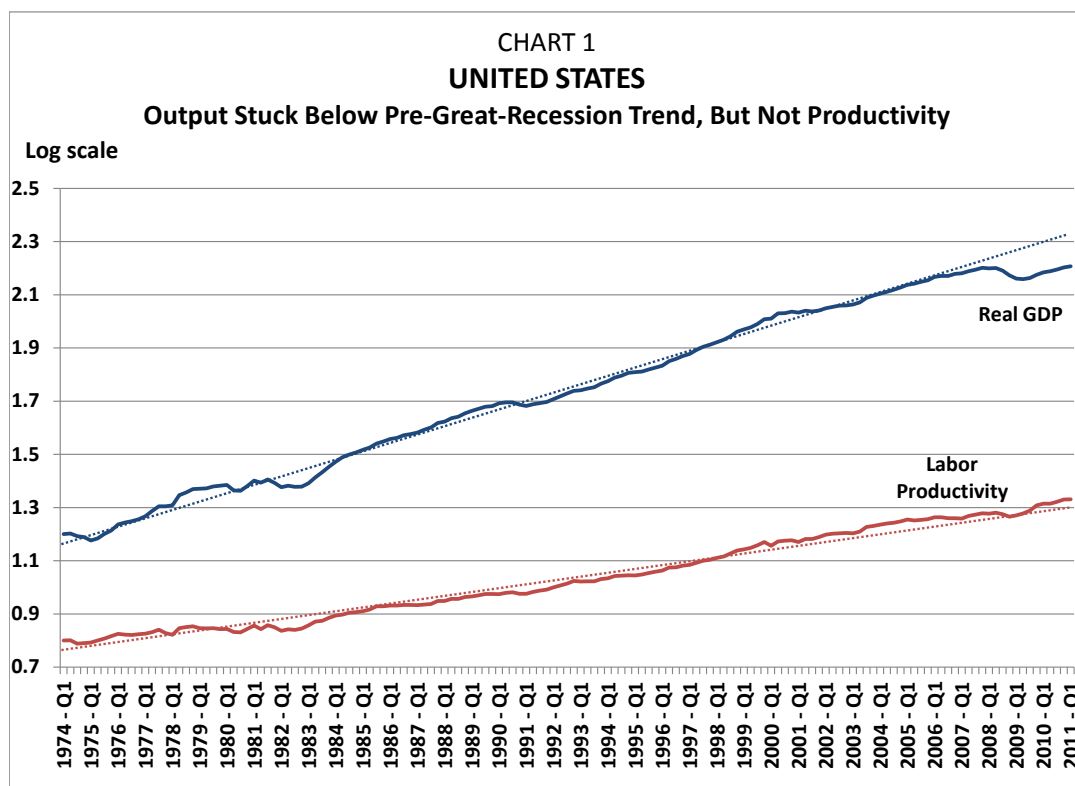
Against this success, the fiscal sentiment hypothesis also scores a failure: A higher-tax regime consisting of exclusively higher labor income tax rates produces counterfactual predictions. This implies that advocates of the fiscal sentiment hypothesis about the weakness of the U.S. economic recovery from the Great Recession must endorse as well the view that the underlying switch to a higher taxes regime will include mostly higher capital income tax rates.

It is unclear whether these findings are in line with those expected by both, subscribers and critics, of the fiscal sentiment hypothesis. It is quite possible, therefore, that they will stir further controversies. But the hope is that the quantitative exploration of the fiscal sentiment hypothesis pursued in this paper will introduce, as well, more quantitative rigor in future debates prompted by the subject.

The rest of the paper is organized as follows: Section 2 documents the weakness of the U.S. economic recovery in the aftermath of the Great Recession. Section 3 briefly summarizes the fiscal sentiment conjectures that have been advanced to account for that evidence. Section 4 introduces a model suitable for assessing the quantitative plausibility of those conjectures, addresses measurement issues relevant for the reliability of the results, and introduces the equilibrium concept that will govern the relationships between endogenous and exogenous variables in the model. Section 5 discusses briefly the techniques used to compute the equilibrium of the model and reports the results of numerical experiments with tax regime changes designed to shed light on the question addressed by the paper. Section 6 concludes. Appendix A describes the data and their sources, while Appendix B goes through the details of the National Income and Product Accounts methodology that is necessary to take into account to obtain the empirical counterparts of the conceptual variables in the model.

2 Economic Recovery Proceeding at Below Pre-Recession Trend

Chart 1 documents the evidence mentioned in the introduction, that is, that U.S. output after the Great Recession seems to be tracing a new long-run trend, displaced in level a few notches down from the one that that aggregate was tracking prior to that episode:



Taken in isolation, however, there isn't necessarily anything special about this downward shift in the trend for output: It could have been induced by a similar shift in the trend of total factor productivity (TFP). But the evidence for labor productivity—a proxy for TFP in the U.S.—also documented in Chart 1 makes that interpretation difficult to maintain. In contrast with what happened in past severe recessions, like the one at the beginning of the 1980s, labor productivity seems to have stayed more or less on trend, even if output declined significantly below it.

It is this lack of an apparent straightforward explanation for the slow recovery of the U.S.

economy from the Great Recession that has motivated the fiscal sentiment conjecture that the prospect of higher future taxes is one of the key reasons why the U.S. economy hasn't recovered from the Great Recession as strongly as it should.

3 The Fiscal Sentiment Hypothesis

Of the many scholars mentioned in the introduction who have offered arguments in support of the hypothesis, those by Lucas (2011) are particularly relevant for the quantitative exploration of the hypothesis with the methodological approach adopted in this paper. According to Lucas:

"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."

Lucas's suspicion that the U.S. economy has failed to mount a strong recovery after the severe Great Recession because people fear higher tax rates in the future captures the essence of the fiscal sentiment hypothesis. His assertion that it is not possible to look at the evidence because the policies that can eventually account for it haven't been implemented yet is somewhat puzzling, however, because he 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 in the present if forward looking agents are indeed making their current consumption, employment, and investment decisions with the expectation of a policy regime change that features tax hikes in the immediate future. The comparison of those predictions with the evidence can be used in principle to assess the quantitative plausibility of the fiscal sentiment hypothesis. This is precisely what the paper will set out to explore.

4 The Model Economy

4.1 Overview

Given the quantitative nature of the question addressed by the paper, it seems natural to attempt to answer it with a model economy that delivers reliable results with respect to

other well-studied aspects of the data. It would be hard to trust the quantitative answers of a model that cannot replicate important long-run features of the U.S. economy, such as the approximately constant rates at which consumption, investment, the capitals stock, and other relevant macroeconomic aggregates grew for many decades prior to the Great Recession. Accordingly, preferences, technology, and government policies have been restricted to the types that are consistent with balanced growth, as characterized by King, Plosser, and Rebelo (1988a, b).

The reliability of the quantitative answers obtained with the model economy could suffer as well from an ambiguous or imprecise mapping between its conceptual entities and their empirical counterparts. For that reason, the design of the model economy was guided also by the need to address challenging measurement issues presented by the way the National Income and Product Accounts methodology records the output generated by government agencies.

In particular, NIPA treats the income flows generated by the services from the capital stock differently, depending on whether that stock is owned by the public or the private sector. That asymmetric treatment introduces a bias in the share of the remuneration to the capital input in total income when calculated from NIPA income flows. For the purposes of this paper it will be important to minimize that bias, because the capital income share will appear in the calibration of the capital-output ratio and it is well known that the quantitative properties of a neoclassical growth model such as that studied below are particularly sensitive to that ratio (see, for example, Fisher 2001).

It turns out that the measurement problem just described can be mitigated with a version of the approach suggested by Gomme and Rupert (2007). In this approach, output in the model economy is produced exclusively by the private sector. The empirical counterpart of this concept is obtained by subtracting from real GDP, as reported in NIPA, the value added by the general government in the process of producing non-market goods and services. This is a legitimate procedure, as long as the representative household's preferences are not defined over that category of goods.

The exact sequence of steps necessary to obtain the historical series of private sector output in a manner consistent with the way government economic activities are recorded in the national accounts requires a good deal of familiarity with the NIPA methodology, certainly more than that uninitiated readers would gain from the rather succinct treatment of the subject in Gomme and Rupert. In fact, their procedure had to be revised and updated, to take into account the many changes that that methodology has undergone over the years. Discussion of all those details would require, however, a long detour in the exposition, likely

to detract from the main focus of the paper. For that reason, they have been relegated to Appendix B, with the caveat that the steps described therein, tedious as they might be, are crucial to establish the size and direction of the deviations from trend of output, labor input, and investment that the fiscal sentiment hypothesis ought to account for. In particular, it is important to emphasize that the treatment of the data with the updated version of the Gomme-Rupert approach will have an impact on the deviations of output and productivity with respect to their trends, whose magnitudes will turn out not to be the same as those documented in Chart 1.

The focus in the model predictions for private sector output could create the impression that the analysis can be carried out, as in Gomme and Rupert, without reference to the labor input used by the public sector. That would be a mistake, however, because for the purposes of assessing the quantitative relevance of the fiscal sentiment hypothesis, what matters is the predictions of the model for the levels of key macroeconomic variables, which are not independent of the fraction of available time households spend working for government agencies.

In particular, virtually any model capable of assessing the quantitative significance of the fiscal sentiment conjecture will have to assume that preferences are defined over leisure time, whose marginal valuation typically will be independent of whether it has been reduced by the time spent working for the private sector or the public sector. As a result, for the reasons discussed in detail in section 4.5.3, a model economy whose relevant parameters are calibrated to the overall time use by households, but ignores the fraction of time they spend working for the government, will tend to overestimate the labor input absorbed by the private sector and, therefore, output, consumption, and investment.

But even in absence of such overestimation, abstracting from the fraction of time household spend working in the public sector may be misleading when the labor demand from that sector responds to different shocks than the private sector labor demand, as will be the case in the model economy introduced next.

4.2 Households

4.2.1 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:

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

where $\beta > 0$, $\sigma > 0$, $0 < \alpha < 1$, η is the working age population annual growth rate, γ the annual growth rate of total factor productivity (TFP), c_t is detrended consumption per working age person, and l_t the fraction of available time the representative household devotes to non-market activities.

The household can distribute its total available time, normalized to 1, among non-market activities and work for the private firms and public sector agencies that also will be present in the economy. It faces, therefore, the following restriction on the allocation of time:

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

where h_t^{pr} and h_t^{pu} denote the fraction of its available time that the households spend working for the private and public sectors, respectively. This time-use distinction is typically absent in the literature and is motivated by the measurement considerations mentioned in the overview of this section and discussed in detail later.

Notice that the discount factor β in (1) appears multiplied by $(1 + \gamma)^{\alpha(1-\sigma)}$. This is one adjustment required to make stationary economic variables that otherwise would display secular growth. This transformation is valid because, as mentioned in the overview of this section, the model economy will meet the conditions required for balanced growth. The already mentioned work of King, Plosser, and Rebelo, as well as others cited therein, has shown that such an economy can be transformed into an economy without growth, provided the relevant variables are detrended by their underlying secular growth rates and the appropriate parameters, such as the discount factor, are adjusted as dictated by theory.

The economy without growth displays the same transitional dynamics as the original one, but is more convenient to work with when, as in the case of this paper, the technique for computing the equilibrium allocations involves Taylor expansions of the first-order conditions around the steady-state or stationary equilibrium of the economy in the absence of shocks.

For that reason, the discussion that follows will refer exclusively to the model economy without growth, in which all the adjustments with respect to the original economy with growth have been performed already. In particular, the discount factor in (1) has been adjusted as indicated above and the consumption good that appears as an argument in the utility function has been detrended by the average growth rate of U.S. output.

That growth rate is given by the product of the long-run gross growth rates of working

age population $(1 + \eta)$ and labor augmenting technical progress $(1 + \gamma)$. The reason for assuming this particular form of technical progress is that when the analysis is confined to constant returns to scale production functions, balanced growth is feasible only if technical progress of any kind is expressible as labor augmenting, a requirement that will be satisfied by the specification of technology presented later.

4.2.2 Capital Stock Law of Motion

For consistency with the 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 following law of motion, which links the private capital stock available for production at the beginning of a period, k_t , with the households' investment decisions during that same period, x_t , and with the private capital stock that will be available at the beginning of the following period, k_{t+1} :

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

where δ is the depreciation of the private sector capital stock.

In line with the treatment of macroeconomic aggregates introduced before, those in the law of motion (3) have also been detrended and are measured in units of the consumption good per working age person. In fact, the correction of the beginning-of-period $t + 1$ capital stock by the gross growth rate factor $(1 + n)(1 + \gamma)$ is the other adjustment that is necessary to transform the original balanced growth economy into one without growth, but with the same quantitative properties in terms of impulse-responses and transitional dynamics.

4.2.3 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. They can devote the revenues from these sources of income, net of taxes, to consumption and investment, as formalized by the following budget constraint:

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

where 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 private sector capital, and τ_t lump-sum transfers (taxes

if negative.) For consistency with the NIPA methodology, the variable ck_t^{ge} captures the imputation of the compensation for the services of the capital stock under direct control of the government enterprises, which that methodology treats as income for households, the ultimate owners of that stock. As explained in Appendix B, however, that 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 model economy this source of income will be treated as a lump-sum transfer, independent of the households' behavior.

4.3 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 Appendix B, the NIPA methodology treats the investment activities and net operating surpluses (or deficits) of government enterprises differently from the corresponding 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 exogenously, in the Public Sector Policies section below.

The behavior of private firms is instead modeled explicitly, an approach that requires one to be specific about the restrictions those firms face in the production of output. The paper adopts the standard assumption that 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 exhibits labor-augmenting technical progress and unitary elasticity of substitution between inputs. Under those conditions, the aggregate output of the model economy corresponds to that generated by a single representative firm endowed with a Cobb-Douglas production function:

$$y_t^{pr} = \frac{1}{e^{(1-\theta)\gamma t}} A e^{z_t} k_t^\theta [e^{\gamma t} h_t^{pr}]^{1-\theta}, \quad (5)$$

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:

$$z_t = \rho z_{t-1} + \varepsilon_t, \quad (6)$$

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

In the quantitative section of the model, the paper will adopt the standard practice in the real business cycle literature of measuring the technology level z_t from detrended Solow residuals. However, as mentioned in the introduction, the paper also takes seriously the common objection that those residuals, by their very nature, grossly mismeasure the technology levels in the actual economy. Critics of this approach are skeptical that the efficiency with which societies transform inputs into output moves as much as suggested by the fluctuations that Solow residuals tend to exhibit. The paper pays heed to those objections by presenting, as an alternative, the results of the model when the technology levels remain constant at their steady-state level. As it turns out, the quantitative predictions of the model are even more favorable to the fiscal sentiment hypothesis under this assumption than under the alternative one that technology fluctuates as much as measured by the Solow residuals.

Given that all variables have been detrended, the growth factor e^γ in (5), approximated by $(1 + \gamma)$ in the quantitative implementation of the model, is obviously redundant and will be eliminated later. It was made explicit here, however, in order to emphasize that the model economy is characterized by secular technical progress that the Cobb-Douglas production function permits one to represent as labor augmenting. As shown by Greenwood, Hercowitz, and Krusell (1997), when the production function is of that type, an economy that exhibits investment-specific, or capital-embodied, technological change can be represented as one with labor-augmenting technical progress, provided the depreciation rate in (3) is interpreted as the economic, rather than physical, depreciation rate.¹

As is well known, the production function (5) implies that payments to the factors of production exhaust output, that is:

$$y_t^{pr} = w_t h_t^{pr} + r_t k_t = v a_t^{pr}.$$

Furthermore, the proportion of the remuneration to capital services in the private sector value added is equal to the parameter θ of the production function. This is the key property that will be exploited later to calibrate the capital income share of the private sector economy.

4.4 Public Sector Policies

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

¹The constant economic depreciation rate in (3) assumes implicitly as well a constant growth rate of investment-specific technological progress.

exogenously.

4.4.1 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.²

Thus, in this private sector economy, the government absorption of private sector output, denoted ga_t ,³ must equal government revenues from all sources, as indicated by the following government budget constraint:

$$ga_t = \tau_t^h w_t (h_t^{pr} + h_t^{pu}) + \tau_t^k (r_t - \delta) k_t + s_t^{ge} - \tau_t - w_t h_t^{gc}, \quad (7)$$

where s_t^{ge} stands for government enterprises surpluses, h_t^{gc} 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. 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.

4.4.2 Tax Policy

Given that the goal of the paper is to check the quantitative relevance of the fiscal sentiment hypothesis, it seems reasonable to require that tax policies be modelled in a way that captures the essence of that hypothesis and which is at the same time 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 $\{\tau_t^h, \tau_t^k\}_{t=s}^{\infty}$, perfectly known to households from period s onwards.

In the quantitative implementation of the model, the period s is identified with the trough of the Great Recession. This assumption attempts to capture the one implicit in the

²Future research should validate the conjecture that the quantitative results will not change much if the government is allowed to run deficits, because they will have to be reversed with higher future taxes under the usual no-Ponzi scheme condition.

³This variable relabels those denoted $m_t + x_t^{pu}$ and $g_t - va_t^{gc}$ in equation (39) of Appendix B.

fiscal sentiment hypothesis that it was then, after observing historically high fiscal deficits in peacetime, that households and businesses woke up to the severity of the fiscal imbalances that predated that episode and started to make their consumption and investment decisions accordingly, with the perception that those imbalances would be addressed with higher taxes in the near future.

The perceptions of an imminent switch to a higher taxes regime can be captured by deterministic tax regimes with the following generic configuration:

$$\left\{ \left\{ \tau_{t+i}^h, \tau_{t+i}^k \right\}_{i=0}^j, \left\{ \tau_{t+j+n}^h, \tau_{t+j+n}^k \right\}_{n=1}^{\infty} \right\}_{t=s}; \tau_{t+j+n}^h > \tau_{t+i}^h \text{ and/or } \tau_{t+j+n}^k > \tau_{t+i}^k, \text{ for all } i \text{ and } n. \quad (8)$$

In words, this formulation of the government tax policies formalizes the fiscal sentiment hypothesis with the assumption that households and businesses start making their consumption and investment decisions in period s , taking for granted a switch to a higher taxes regime $j + 1$ periods later.

4.4.3 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:

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

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

4.4.4 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 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:

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

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

where gy and vy are constants, 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.

Notice that the government budget constraint (7) implies that the additional revenues generated by policy (8) after period $s + j$ will be rebated to households in the form of higher lump-sum transfers τ_t , after taking into account the effects that the exogenous processes (9), (10), and (11) have on the general government expenses and other sources of revenues. This is a realistic feature of the model, as it captures the fact that current government budget projections foresee that the main source of higher government expenses in the coming decades will be transfer payments originated in entitlement programs such as Social Security, Medicaid, and the Obama administration health reform, rather than government purchases, expected to remain constant or even decline slightly going forward.

4.5 Individual Choices and Equilibrium Concept

4.5.1 Stand-in Household's Choice Problem

In line with the discussion in the preceding sections, the household that in the abstraction of the model stands in for the large number of them who inhabit the actual economy cannot influence prices or government policies. In equilibrium, the stand-in household makes decisions on the variables it does control, with the goal of maximizing its utility (1), subject to the time-use constraint (2), the individual budget constraint (4), and the law of motion of the private capital stock (3), taking prices and government policies as given. The latter include, of course, the sequence of deterministic tax policies characterized by (8).

Formally, the stand-in household sets the variables under its control to the levels determined by the solution to the following problem:

$$Max_{\{c_t, l_t, k_{t+1}\}} E \sum_{t=s}^{\infty} [\beta(1+n)(1+\gamma)^{\alpha(1-\sigma)}]^t \frac{[c_t^\alpha(1-h_t)^{1-\alpha}]^{1-\sigma} - 1}{1-\sigma} \quad (12)$$

subject to:

$$c_t + (1+n)(1+\gamma)k_{t+1} \leq (1-\tau_t^h)w_t h_t + [1 + (1-\tau_t^k)(r_t - \delta)] k_t + ck_t^{ge} + \tau_t \quad (13)$$

where the time-use constraint has been replaced into the utility function (1) taking into account that $h_t = h_t^{pr} + h_t^{pu}$, that is, that h_t is the fraction of its available time that the household devotes to work for all private and public entities in any given period.

The only remaining constraint of the problem, equation (13), is the result of elementary

algebraic manipulations after substituting the law of motion (3) into the original budget constraint (4).

Notice that for consistency with the considerations that motivated the formulation of the tax policy (8), the notation $t = s$ under the summation sign in (12) implies that the behavior just described characterizes the stand-in household's problem from period s on. That is, the model is silent about households' behavior and perceptions prior to that time. Odd as it may seem, this kind of break in behavior plays an even more critical role in alternative "consumer sentiment" stories that interpret the Great Recession and subsequent weak recovery as the result of the subjective "gloomy self-fulfilling mood" that suddenly at time s , presumably corresponding to the period right before the recession, permeated the households and businesses' views of their economic prospects.

4.5.2 Representative Private Firm's Choice Problem

As hinted at in many occasions before, the representative firm that stands for the large number of them making decisions in the economy hires capital and labor services to maximize profits every period, taking as given prices, the technology (5), and the stochastic process (6) governing the evolution of technology shifts over time:

$$Max_{h_t^{pr}, k_t} [Ae^{z_t} k_t^\theta (h_t^{pr})^{1-\theta} - w_t h_t^{pr} - r_t k_t] \quad (14)$$

Notice that in this economy, it is the stand-in household that makes the investment decisions. Absent the intertemporal dimension, the representative firm's problem reduces to a sequence of static, single-period problems.

4.5.3 First Order Necessary Conditions for a Competitive Equilibrium

Since the competitive equilibrium for economic environments such as that described above has been abundantly studied in the literature, the discussion in this subsection will be limited to those features of the maximization problems faced by the stand-in household and the representative firm that are relevant for the quantitative assessment of the fiscal sentiment hypothesis.

One obvious property to exploit for studying the quantitative predictions of the model economy is that any candidate competitive equilibrium allocation must satisfy the first order necessary conditions from the stand-in household's maximization problem, summarized in

the following two equations:

$$c_t = \frac{\alpha}{1-\alpha}(1-h_t)(1-\tau_t^h)w_t \quad (15)$$

$$E_t [(1-\tau_{t+1}^k)(r_{t+1}-\delta)+1] = \frac{(1+\gamma)}{\beta(1+\gamma)^{\alpha(1-\sigma)}} E_t \left[\frac{c_{t+1}}{c_t} \left[\left(\frac{c_{t+1}}{c_t} \right)^\alpha \left(\frac{1-h_{t+1}}{1-h_t} \right)^{1-\alpha} \right]^{\sigma-1} \right] \quad (16)$$

The first of these equations is the familiar intratemporal condition that the marginal rate of substitution between consumption and leisure must equal the opportunity cost of leisure in terms of the consumption good, given by the wage rate w_t .

The second equation is the standard intertemporal condition that the discounted expected marginal rate of substitution between consumption at period t and period $t+1$, adjusted by the growth factor $(1+\gamma)$, must equal the expected after-tax gross interest rate.

An equilibrium allocation must also maximize the representative firm's profits and satisfies, therefore, the first order conditions for the corresponding problem which, as usual, simply establish that the marginal product of an input must equal its rental price, that is:

$$w_t = (1-\theta)Ae^{z_t} \left(\frac{k_t}{h_t^{pr}} \right)^\theta \quad (17)$$

$$r_t = \theta Ae^{z_t} \left(\frac{h_t^{pr}}{k_t} \right)^{1-\theta} \quad (18)$$

Replacing (17) into (15), (18) into (16), and taking into account that $h_t = h_t^{pu} + h_t^{pr}$, consolidates the four equations above into the following two:

$$c_t = \frac{\alpha}{1-\alpha}(1-h_t^{pu}-h_t^{pr})(1-\tau_t^h)(1-\theta)Ae^{z_t} \left(\frac{k_t}{h_t^{pr}} \right)^\theta. \quad (19)$$

$$E_t (1-\tau_t^k) \left[\theta Ae^{z_{t+1}} \left(\frac{h_{t+1}^{pr}}{k_{t+1}} \right)^{1-\theta} - \delta \right] + 1 = \frac{(1+\gamma)}{\beta(1+\gamma)^{\alpha(1-\sigma)}} E_t \left[\frac{c_{t+1}}{c_t} \left[\left(\frac{c_{t+1}}{c_t} \right)^\alpha \left(\frac{1-h_{t+1}^{pu}-h_{t+1}^{pr}}{1-h_t^{pu}-h_t^{pr}} \right)^{1-\alpha} \right]^{\sigma-1} \right] \quad (20)$$

Notice that equation (19) is the same intratemporal condition that would obtain in a model that doesn't distinguish between the private sector and the public sector labor demand, provided the time available to the household is reduced by h_t^{pu} , the discretionary labor demand of the public sector. This reinterpretation of the standard condition makes

apparent why it is not possible to ignore the fraction of time the household spends working for the public sector, government enterprises and the general government, even if the latter is not engaged in production activities in the quasi-private-sector model economy. The time the household works for the public sector influences its marginal valuation of leisure and, therefore, the wage rate at which it offers its labor services to all employers. It follows that its eventual omission from equation (19) is not inconsequential for the equilibrium allocation.

In particular, as mentioned in the overview of this section, abstracting from the presence of h_t^{pu} will tend to overestimate some important macroeconomic variables, such as consumption and investment, a distortion that is critical to avoid when the goal of the quantitative exploration of the fiscal sentiment hypothesis is precisely to establish to which extent it can account for the level of those and other key variables during the anemic post-Great-Recession recovery.

To see the intuition behind that potential distortion, start from some equilibrium allocation with $h_t^{pu} > 0$. Next, set $h_t^{pu} = 0$. The right-hand side of equation (19) will be larger than the level of consumption corresponding to the original equilibrium. The equality will have to be restored by increasing hours worked in the private sector, which will result in an increase of that sector's output. Since consumption is still at the previous level, the additional output will increase investment above its level in the original equilibrium with $h_t^{pu} > 0$. Alternatively, the equilibrium could be restored by increasing the left-hand side of the equation, c_t .

Of course, the omission of h_t^{pu} from the analysis will also have an impact on the intertemporal condition (20), but its effects on the intratemporal condition just discussed illustrates that it will tend to predict higher levels of consumption and investment relative to a model that takes into account that households do spend time working for the public sector. Moreover, the two models could induce different dynamics when the labor demand of the public sector is driven by different shocks from those of the private sector, a condition present in the model, as should be obvious from the absence of technology shocks in the exogenous process (9) assumed to govern the evolution of the public sector labor demand h_t^{pu} .

In addition to (19) and (20), a competitive equilibrium allocation will have to satisfy, of course, the resource constraint consistent with equation (38):

$$c_t + x_t = [1 + (vy + \varepsilon_t^{gc}) - (gy + \varepsilon_t^{ge})] Ae^{z_t} k_t^\theta (h_t^{pr})^{1-\theta} \quad (21)$$

This constraint is obtained from (38) after taking into account (9) and the observation made earlier that the assumed competitive equilibrium and constant returns to scale technology

imply zero profits for the private firm and, therefore, that the payments to the factors of production fully exhaust its value added or output.⁴

The equilibrium allocation of this economy will be characterized by the system of two difference equations in h_t^{pr} , h_{t+1}^{pr} , k_{t+1} , and k_{t+2} that results from replacing x_t with the law of motion (3) in the resource constraint, solving that equation for c_t , and substituting the resulting expression, with the time index appropriately shifted, for c_t and c_{t+1} in equations (19) and (20).

The computation of a competitive equilibrium of the model involves finding time-invariant decision rules that in every period t , $t \geq s$, map the current state of the economy, as inferred from all information available at period t , into the time allocated to work in the private sector, h_t^{pr} , and the resources allocated to capital accumulation, k_{t+1} .

Notice that the specification of tax policy (8) implies that all future taxes are known with certainty at time s (perfect foresight). As is well known, the equilibrium decision rules in model economies such as that just described don't admit closed form solutions and have to be found numerically. The paper will approximate the equilibrium decision rules with standard perturbation techniques that involve Taylor expansions around the steady-state of the system of two difference equations just described.

The quantitative results of the model will depend heavily, therefore, on the steady-state values of the model economy, which given the self-imposed quantitative discipline adopted in this paper will have to be consistent with observed long-run features of the economy under study. To that end, the model economy was calibrated to the actual one with the data and methods discussed next.

4.6 Model Calibration

Calibration to Reference Period Averages The self-imposed requirement that the steady-state of the model be consistent with the long-run performance of the U.S. economy can be satisfied by setting the relevant parameters and steady-state values equal to their average values actually observed over the calibration reference period, 1977-2007 for this paper, provided reliable time series and auxiliary data required for the calculations are available.

⁴It is worth mentioning that the government enterprises policy (11) doesn't determine separately the components of the value added by government enterprises. However, as should be clear from (21), this indeterminacy doesn't affect the equilibrium allocation. The reason is that any change in one of the components will have to offset by a change of the same size but opposite sign of the other component. Since the government enterprises surpluses are in the end rebated back to households (see discussion in Appendix B, page 46), the stand-in household budget constraint is unchanged.

That was the procedure followed to calibrate the investment-output ratio, the depreciation rate, the ratios of general government absorption of output, and government enterprises value added to private output, and tax rates prior to the hypothetical tax regime change after time s implied by the tax policy (8).

The following table summarizes the parameter values and steady-state relationships implied by 1977-2007 averages:

Parameter/Steady-State Relationship	Value
x/y (investment-output ratio)	0.185539
δ (depreciation rate)	0.05
gy (general government private sector output absorption)	0.085798
vy (value added by government enterprises)	0.012658
τ_t^k (capital income tax rate)	0.40
τ_t^h (labor income tax rate)	0.23

It is worth emphasizing 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 term of 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 shown by Greenwood *et al.*, 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.

This implies that the calibrated depreciation rate is the average of the economic depreciation rates observed over the calibration reference period, calculated from the data using the following law of motion for the private capital stock before detrending:

$$\frac{K_{t+1}}{p_t^c} = (1 - \delta) \frac{K_t}{p_{t-1}^c} + \frac{X_t}{p_t^c}, \quad (22)$$

where

$$1 - \delta = (1 - \delta^p) \frac{\frac{p_{t-1}^c}{p_t^c}}{\frac{p_{t-1}^i}{p_t^i}}.$$

In this expression, δ^p denotes the physical depreciation rate and p_t^i the period t implicit price deflator of private gross domestic investment. Notice that in the absence of investment-specific technological progress, $p_{t-1}^c/p_{t-1}^i = p_t^c/p_t^i$, and the economic and physical depreciation

rates coincide.⁵

TFP Growth Factor, the Capital Income Share Parameter, and Capital-Output Ratio Owing to data limitations, the sample average criterion above will tend to produce unreliable values for the TFP growth factor γ , the capital income share parameter θ , and the steady-state capital-output ratio $\frac{k}{y}$.

The calibration of the capital income share parameter is particularly challenging. For the reasons discussed at length in section 5.3, the 1977-2007 average of the ratio of total capital income payments to total income as reported in NIPA will produce a biased estimate of that parameter. Since the private sector income flows are free of the bias introduced by the NIPA methodology, the parameter θ for the whole economy could be set instead equal to the corresponding ratio for the private sector only, on the assumption that the technology for producing general government non-market output and quasi-private market output are the same.

The implausibility of that assumption is the reason to work instead with the quasi-private-sector economy. The parameter θ for that economy can be reliably estimated from the private sector income flows alone either because the technology of private firms and government enterprises is the same—a plausible assumption—or because the contribution of the latter to total output is relatively small. This latter condition is satisfied in the U.S. over the calibration reference period, as documented in the previous section.

Unfortunately, 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 . This is a potentially serious limitation of the approach, because any mismeasurement of this parameter will be transmitted to the capital output ratio and, as already mentioned, the quantitative properties of model economies like the one studied in this paper tend to be particularly sensitive to that ratio.

⁵Equation (22) 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 reason why the parameter θ influences the steady-state capital-output ratio is that that ratio cannot be reliably estimated with the sample average approach either. As pointed out by Rupert (2008), estimates of the private capital stock *level* are subject to large revisions that induce significant changes on the average capital-output ratio from one data release to the next. Since investment is estimated presumably with more accuracy than the capital stock, Gomme and Rupert proposed instead to set the steady-state capital-output ratio equal to the sample average implied by the steady-state version of the law of motion (3), that is, from the equation:

$$\frac{k}{y} = \frac{\frac{x}{y}}{(1 + \eta)(1 + \gamma) - (1 - \delta)} \quad (23)$$

where k/y and x/y denote the steady-state capital-output and investment output ratios, respectively.

Although not obvious from this equation, the channel through which θ determines the steady-state capital-output ratio is the TFP growth factor γ . This growth factor is typically set equal to the value of the sample average growth rate of the Solow residuals, as determined from the logarithmic transformation of the capital intensive version of the private sector production function (5), after detrending by the growth rate of working age population η , but before detrending by the TFP growth factor γ :

$$y_t^{pr} = e^{\frac{z_t}{1-\theta}} e^{\gamma t} A^{\frac{1}{1-\theta}} \left(\frac{k_t}{y_t^{pr}} \right)^{\frac{\theta}{1-\theta}} h_t^{pr}. \quad (24)$$

Taking logarithms on both sides and setting the average growth rate of the stationary stochastic component of the technology level, z_t , to zero over the calibration period, the TFP growth rate factor γ can be calibrated to the sample average with the following expression:

$$\gamma = \frac{1}{30} \left[\sum_{t=1977}^{2007} \ln \frac{y_{t+1}^{pr}}{y_t^{pr}} - \frac{\theta}{1-\theta} \sum_{t=1977}^{2007} \ln \frac{\frac{k_{t+1}}{y_{t+1}^{pr}}}{\frac{k_t}{y_t^{pr}}} - \sum_{t=1977}^{2007} \ln \frac{h_{t+1}^{pr}}{h_t^{pr}} \right]. \quad (25)$$

This expression makes apparent the dependence of the calibrated value of the TFP growth factor on the parameter θ .

The incorrect guess about the allocation of proprietor's income between its labor and capital income components is yet another source of potential bias in the value of that parameter, which will be transmitted to the steady-state value of the capital-output ratio obtained from (23) via the mismeasurement of the TFP growth factor in equation (25).

Fortunately, a number of studies, such as those of Siegel (2002), Poterba (1998), and

Mehra and Prescott (2008) have made it possible to establish with some confidence that the long-run pre-tax annual real return on capital for the U.S. economy is on the order of magnitude of 8.0%. This value is the empirical counterpart of the steady-state value of the expression $r_t - \delta$ in the model and implies, given that the depreciation rate has been set equal to 0.05, that the steady-state value of the rental price of capital, r , is equal to 0.13. It is extremely convenient to have at least a reliable estimate for one of the variables of the model, because this piece of information can be exploited to turn the definition of the capital income share into a third equation which, added to the previous two, makes it possible to infer the three unknowns, θ , γ , and k/y^{pr} simultaneously, in an internally consistent manner.

In particular, it follows from the definition of the capital income share that its stationary value must satisfy the following condition:

$$\theta = r \frac{k}{y^{pr}} \quad (26)$$

which could have been inferred as well from equation (18), after multiplying and dividing both sides by k_t . Given that the steady-state value of the rental price of capital, r , is known, this expression defines the third equation that, along with (23) and (25), defines the system of three equations whose solution jointly determines the values for θ , γ , and k/y^{pr} consistent with the long-run features of the U.S. economy over the calibration reference period.

The solution is actually implemented by solving (26) for the capital-output ratio and substituting the resulting expression for the left-hand side of (23) and by replacing γ in the right-hand side of that expression with the right-hand side of (25). The result is a quadratic equation in θ , with solutions $\theta_1 = 0.349292$ and $\theta_2 = 0.938221$. The smaller solution is the only one that falls within the range of values that could be calculated directly from the private sector income flows if all proprietor's income were treated alternatively as labor income or capital income. Therefore, the capital income share parameter was set equal to 0.349292. Incidentally, notice that this value is almost exactly the average of those used by Kydland and Prescott (1982) and by Gomme and Rupert in the study already mentioned.

Feeding the calibrated value of θ into equations (25) and (26) produces the following estimates for the TFP growth factor and the steady-state capital-output ratio: $\gamma = 0.006614$ and $k/y^{pr} = 2.686864$.

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

(24) for z_t , which yields the following expression:

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

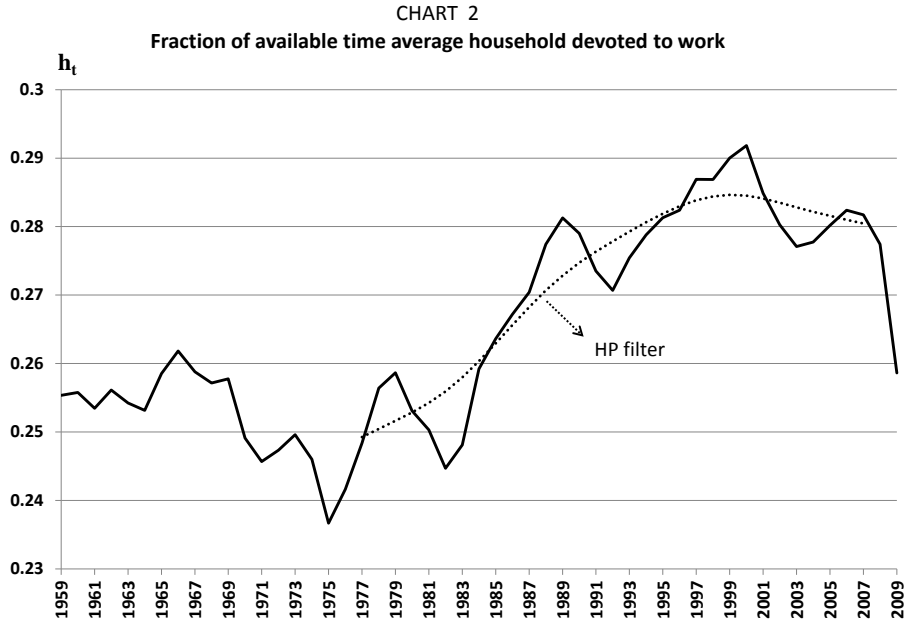
where A is a normalizing constant chosen so that the average stochastic level z_t over the calibration reference period is zero.

Preferences Consumption Weight 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 first order condition (19):

$$\alpha = \frac{1}{\frac{1-h^{pr}-h^{pv}}{h^{pr}} \frac{(1-\tau^h)(1-\theta)}{1+vy-gy-\frac{x}{y^{pr}}}} \quad (28)$$

This equation is the result of dividing and multiplying the right-hand side of the steady-state version of (19), replacing the left-hand side of that equation with the steady-state version of the resource constraint (21), and subsequently dividing both sides of the resulting expression by y^{pr} , after taking into account (5). The only parameter values that have not yet been pinned down are those related to the fraction of time the household spends working. Therefore, it seems that all it takes to calculate α is to set the relevant time-use fractions equal to the corresponding averages over the calibration reference period. That procedure in principle makes sense because the fraction of time the households devote to work, in theory, is a stationary variable and should fluctuate, therefore, around the long-run value identified by the sample average.

Unfortunately, as is well known, in the U.S. the fraction of time that households devoted to work for all employers, h_t , was far from stationary during the calibration reference period. Owing to the demographic tilt introduced by baby boomers and, in particular, to the rising female labor force participation, the fraction of time the average household devotes to work has been rising steadily since the mid-1970s, as documented in Chart 2:



The chart makes apparent that this fraction, over the calibration period, has not been fluctuating around a stationary value, but around a rising trend. This dynamics complicates considerably the task of deciding the time-use values that can be safely associated with a long-run level. The final choice was motivated by the observation that the time series for h_t seems to have settled lately near the sample peak. For lack of better criterion, the series was smoothed with an HP-filter and the steady-state value for the fraction of time at work was set equal to the value of the filtered series in the last year of the calibration reference period, that is:

$$h = h(HPF)_{2007} = 0.28045$$

where $h(HPF)_{2007}$ denotes the value in 2007 of the HP-filtered h_t series.

Since the series for the fraction of time spent working for the private sector exhibited similar patterns, the same criterion was applied to select the long-run value of the fraction of time spent working for the private sector, h^{pr} :

$$h^{pr} = h^{pr}(HPF)_{2007} = 0.24519$$

The corresponding steady-state value for the fraction of time spent working for the public

sector was set, naturally, equal to the difference between the two values above, that is:

$$h^{pu} = h - h^{pr} = 0.03526$$

The value of the utility function consumption weight parameter that will induce the household of the model economy to work in each sector the total fraction of time determined above can be pinned down now from equation (28), which implies $\alpha = 0.335179$.

Discount Factor The previous step determined the last unknown, the parameter α , that was necessary to figure out the discount factor β from the steady-state version of the intertemporal condition (20), which implies $\beta = 0.962635$.

Restrictions on Tax Regime Change As mentioned in the paragraphs following the government budget constraint (7), a possible objection to the fiscal sentiment hypothesis is that it may always be possible to find a tax increase configuration that accounts for the performance of some of the variables of interest during the weak recovery from the Great Recession. For example, the capital income tax rate could be made sufficiently large so that investment in the model economy in the aftermath of that episode remains below its pre-Great-Recession trend by as much as it does in the data. Thus, the findings reported in this paper will inspire more confidence when obtained in the presence of restrictions on the kind of tax regime changes that can be considered.

A natural restriction seems to be that the tax increases shouldn't result in additional revenues larger than necessary to correct the fiscal imbalances eventually inducing in households and business the fiscal sentiment of an imminent switch to a higher taxes regime. Coming up with a specific figure is not particularly easy, 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. However, this would be at odds with the fiscal sentiment hypothesis, because the accounts of that hypothesis summarized in section 3 suggest that its key claim is that the slow recovery of the U.S. economy from the Great Recession can be traced to the perception that the structural budget problems will not be addressed with anything that resembles an optimal tax structure.

In light of the evidence for the Great Depression, those perceptions are far from irra-

tional. Cooley and Ohanian (2010) have argued that the large increases in capital income tax rates introduced in the U.S. after the Great Depression lend support to the fiscal sentiment hypothesis. McGrattan (2010) provides more specific details about how and when those policies were introduced during that episode and analyzes their effects with a purpose similar to that of this paper. Moreover, Cole and Ohanian (2004) have argued that the introduction of inefficient labor policies played a key role in the U.S. economy's lingering weakness after the Great Depression.

It doesn't seem fair, therefore, to assess the quantitative plausibility of the fiscal sentiment hypothesis under the assumption the U.S. structural fiscal problems will be addressed with optimal tax policies. It is precisely at times of unusual economic distress, like the ones associated with the Great Depression and, more recently, with the Great Recession, that policymakers seem to be specially prone to repudiate past tax policies, on the grounds that they no longer look optimal going forward. This is, of course, a manifestation of the time-inconsistency trap. As is well known, a time-consistent but suboptimal tax regime will tend to tax capital more heavily than an optimal, but time-inconsistent tax policy.

In any case, the consensus of all the participants in the debate seems to be that current fiscal policies imply an explosive path for the U.S. government debt that sooner or later will force an increase in taxes and/or reduction in spending. The arguments behind the fiscal sentiment hypothesis imply that households and businesses are convinced that in the end the correction will come mostly in the form of higher taxes. As already pointed out, however, the fiscal sentiment hypothesis can be considered a scientific proposition only if it is associated with some target for the size of the additional revenues required to fix the U.S. structural fiscal imbalances.

It seems reasonable to conjecture that households and businesses will infer that target from publicly available assessments of the U.S. fiscal situation by non-partisan official agencies, such as the Congressional Budget Office. The director of this agency, Douglas Elmendorf, has publicly offered an specific answer to the question of how much fiscal deficit reduction the U.S. should accomplish: between \$3.8 trillion and \$6.2 trillion over the next ten years.⁶ The average of these two figures, \$5 trillion, implies annual spending cuts or tax

⁶More specifically, Elmendorf (2011) offered the following assesment of the U.S. fiscal situation to the U.S. Congress Joint Select Committee on Deficit Reduction:

Lawmakers might determine that debt should be reduced to amounts closer to those we have experienced in the past, relieving some of the long-term pressures on the budget diminishing the risk of a fiscal crisis, and enhancing the government's flexibility to respond to unanticipated developments. If, for example, the Committee chose to make recommendations that would lower debt held by the public in 2021 to 50 percent of GDP, roughly the level recorded in the

increases equivalent to 3.3% of GDP during ten years. Nevertheless, just to err on the side of caution, this paper adopts the figure of the more benign scenario, \$3.8 trillion, as the target for the additional revenues that the higher tax regime should deliver in empirically plausible numerical experiments designed to assess the quantitative relevance of the fiscal sentiment hypothesis

More specifically, the calibration target for the higher tax regime that policy (8) assumes will be in place in period $t + j$ was to generate additional annual revenues equivalent to about 2.5 % of GDP between 2013 and 2023. That is, as mentioned earlier, the paper assumes that the first period of the analysis, identified as period s in the characterization of the tax policy (8), coincides chronologically with the year 2009, which marked the trough of the Great Recession. The fiscal sentiment hypothesis is formalized with the assumption that it was also then that households and businesses became aware that the tax rates then in place, calibrated to the historical average as indicated above, would be increased four periods later, in 2013 (thus, $j + 1 = 4$) as much as necessary to deliver the targeted extra revenues for the subsequent ten years, until 2022. On the assumption that these temporarily higher taxes succeed in stabilizing the debt/GDP ratio at the levels proposed by the CBO, the tax rates are lowered again after 2022, although not to the levels of the initial low taxes regime, but to those necessary to generate modestly higher revenues of just 0.3 % of GDP a year thereafter. This is a way to capture the long-term budget projections that the CBO has documented elsewhere, according to which the ageing of the U.S. population implies an increase for the foreseeable future in the transfer payments originated in entitlement programs such as Social Security and Medicaid that will have to be covered with higher revenues, unless the benefits are reduced.

Of course, because tax revenues are endogenous, the specific tax rates of the higher tax regime just described had to be determined with trial and error numerical experimentation.

Detrending the Data for Comparison with Model Predictions As discussed in detail below, the technique used to compute the equilibrium allocation of the model under

mid-1990s, it would need to propose changes in policies—relative to those embodied in current law, which underlie CBO’s baseline projections—that reduced deficits by a total of about \$3.8 trillion over the coming decade, rather than the \$1.2 trillion needed to avoid automatic budget cuts.

Furthermore, lawmakers might decide that some of the current tax and Medicare payment rate policies (described above) scheduled to expire under current law should be continued. In that case, reducing debt in 2021 to the 61 percent of GDP projected under current law would require other changes in policy to reduce deficits over the next 10 years by a total of \$6.2 trillion

different tax regime configurations will produce predictions for the trajectory of detrended variables. The assessment of the quantitative performance of the model requires therefore to make sure that the data counterparts of those variables have been appropriately detrended as well.

The fact that the model presented above is consistent with balanced growth at the annual rate of $(1 + \gamma)(1 + \eta)$ suggests that detrending the data involves the simple step of dividing any period t variable that exhibits secular growth, such as real GDP, consumption, or private gross domestic investment, by the factor $[(1 + \gamma)(1 + \eta)]^t$. This is because, along the balanced growth path, the fraction of time that households devote to work cannot move out of the $[0, 1]$ range and must be, therefore, a stationary variable.

Unfortunately, as made apparent by Chart 2 on page 23, that is not necessarily true in small samples: Over the last three decades the fraction of time that U.S. households devote to work has been rising steadily, thereby increasing the pace of output growth over and above that implied by TFP and working-age population growth.

The rise in h_t^{pr} easily detected in Chart 2 is necessarily the result of a transitional dynamics bound to die out sooner or later, but which nevertheless contaminates the data that will be used to judge the quantitative performance of the fiscal sentiment hypothesis. Since the model economy doesn't incorporate explicitly the factors underlying that transitional dynamics, the comparison with the data will be misleading without removing from them first the temporarily higher growth induced by that dynamics.

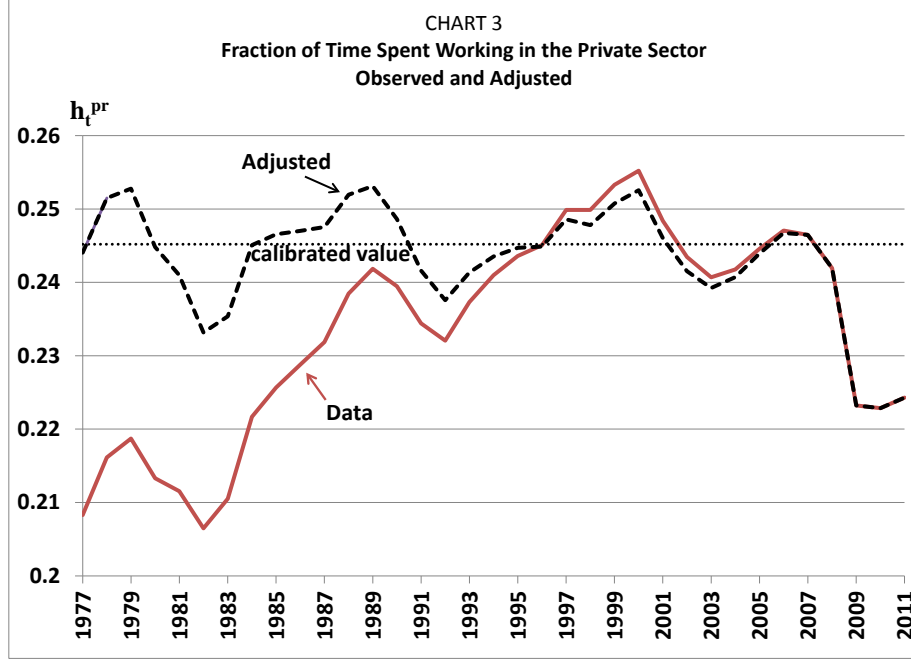
That can be accomplished by rescaling the deviations of the h_t^{pr} series with respect to its HP-trend by the calibrated steady-state value of h_t^{pr} . That is, the growth effect induced by the transitional dynamics seemingly present in h_t^{pr} can be removed by replacing the actually observed values of that variable with the synthetic variable \widehat{h}_t^{pr} obtained as follows:

$$\widehat{h}_t^{pr} = \frac{h_t^{pr}}{h^{pr}(HPF)_t} h_{ss}^{pr} \quad (29)$$

where $h^{pr}(HPF)_t$ is the HP-filtered value of the series h_t^{pr} in period t and h_{ss}^{pr} is the steady-state value of that variable, determined as discussed during the calibration of the consumption weight parameter of the utility function.

Chart 3 illustrates the effect of this transformation on the fraction of time households spent working on the private sector between 1977 and 2011.⁷

⁷The figure for the year 2011 corresponds to an estimate based on available data up to the third quarter of that year.



The chart shows that the proposed rescaling removes the transitional dynamics growth from the h_t^{pr} series. As should be clear from (24), this transitional dynamics growth effect in labor input, unrelated to labor-augmenting technological progress, is transmitted to output and needs to be removed from that variable as well.⁸

Expression (29) suggests that this can be accomplished by simply multiplying both sides of the capital intensive version of the production function, (24), by $h_{ss}^{pr}/h^{pr}(HPF)_t$, as follows:

$$y_t^{pr} \frac{h_{ss}^{pr}}{h^{pr}(HPF)_t} = e^{\frac{z_t}{1-\theta}} e^{\gamma t} A^{\frac{1}{1-\theta}} \left(\frac{k_t}{y_t^{pr}} \right)^{\frac{\theta}{1-\theta}} h_t^{pr} \frac{h_{ss}^{pr}}{h^{pr}(HPF)_t}.$$

Thus, the detrended private sector output that should be compared with the model predictions corresponds to the left-hand side of the following expression:

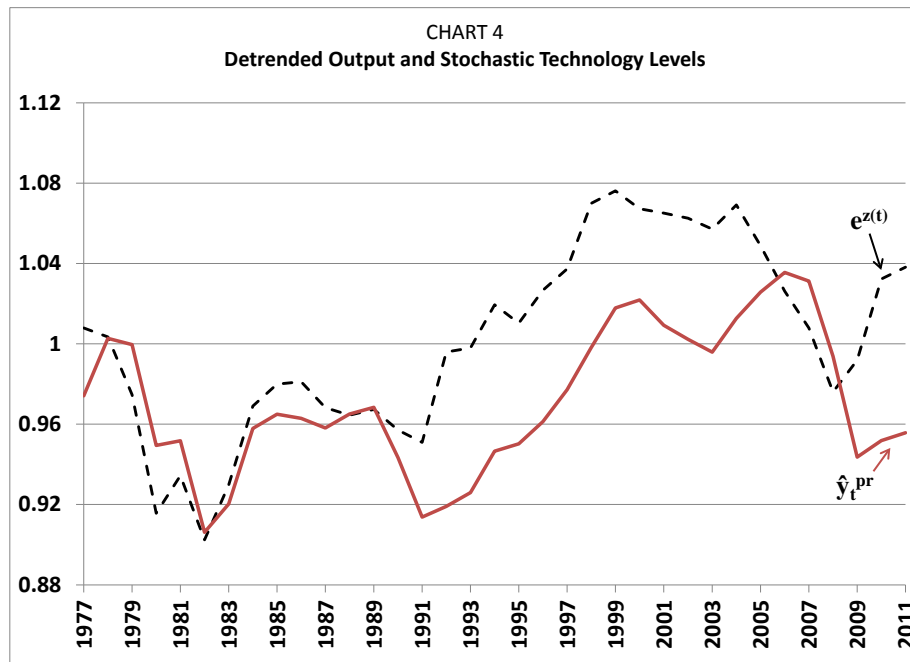
$$\widehat{y}_t^{pr} = \frac{y_t^{pr}}{A_0 e^{\gamma t}} \frac{h_{ss}^{pr}}{h^{pr}(HPF)_t} = e^{\frac{z_t}{1-\theta}} A_{ss}^{\frac{1}{1-\theta}} \left(\frac{k_t}{y_t^{pr}} \right)^{\frac{\theta}{1-\theta}} \widehat{h}_t^{pr}, \quad (30)$$

where \widehat{y}_t^{pr} is output per working age population in units of the consumption good, detrended

⁸See Cociuba and Ueberfeldt (2010) for a more detailed analysis of the non-technical progress factors behind the transitional dynamics seemingly present in the households' allocation of time.

by the secular TFP growth factor γ and by the transitional dynamics growth component of h_t^{pr} . Also, $A_0 = A/A_{ss}^{\frac{1}{1-\theta}}$, where A is the same normalizing constant as in expression (27), and the constant $A_{ss}^{\frac{1}{1-\theta}}$ is chosen to normalize steady-state output to 1, that is, $A_{ss}^{\frac{1}{1-\theta}} = \frac{1}{\left(\frac{k}{y^{pr}}\right)^{\frac{1}{1-\theta}} h_{ss}^{pr}}$.

Chart 4 plots the detrended output that results from applying to the data the procedure just described, along with the evolution of the technology level z_t over the period 1977-2011⁹:



Notice that the chart makes even more noticeable an anomaly already detected in a Chart 1 in section 2: The Great Recession is the only instance in the last three decades in the U.S. in which sustained productivity gains were not accompanied by a commensurate rise in output, which instead barely recovered from the level it touched at the trough of that episode.

The remaining variables whose growth rates over the same period have been contaminated as well by the non-stationary component of h_t^{pr} were detrended by multiplying their ratios to output by the truly detrended or "synthetic" detrended output \widehat{y}_t^{pr} . Thus, for example,

⁹Of course, the technology level series $\{z_t\}$ is the same, whether calculated with (27) or (30).

the data counterpart of private gross domestic investment in the model, \widehat{x}_t , is calculated as:

$$\widehat{x}_t = \frac{x_t}{y_t^{pr}} \widehat{y}_t^{pr}$$

The detrended level of consumption, the capital stock, and other macroeconomic aggregates were calculated in a similar manner.

5 Numerical experiments

5.1 Computational method

The model is computed with standard perturbation methods, by approximating the system of two difference equations described at the end of section 4.5.3 with a second order perturbation around the logarithm of the steady-state values of the variables under the permanently higher tax regime assumed to be in place from 2023 onwards. The reason why the approximation is performed in logs (or percentage deviations from the steady-state) rather than in levels is that Christiano (1987) has documented that the approximation in levels can produce non-monotone decision rules that appear to be economically counterintuitive.

The only unconventional feature of the second order perturbation method implemented in this paper is that the state variables that appear in the decision rules are not only predetermined exogenous and control variables known at the beginning of each period, such as the technology level z_t and the capital stock k_t , but also future tax rates known in advance, when different from their steady-state values.

Thus, the decision rules for the first period in which households are assumed to make decisions in the model, period $s = 2009$, are a function not only of the usual state variables, but also of fourteen additional "leading state variables," one for each of the tax rates assumed to be in place between 2009 and 2022. Between 2009 and 2012 the tax rates are the same low ones that prevailed on average over the calibration reference period, while for the subsequent ten periods, between 2013 and 2022, the tax rates are the higher ones necessary to deliver the additional targeted revenues for ten years.

It is not necessary to include leading state variable for the tax rates after 2023 because, by assumption, they are set to the level corresponding to the new steady-state with permanently higher taxes. Obviously, there is no point in keeping track of leading state variables whose deviations from the steady-state are nil and, therefore, will in the end vanish from the approximated decision rules. Given that past tax rates don't have an independent impact in

current and future allocations, the same logic implies that the number of leading state variables in the decision rules is reduced by one on each subsequent period, until they completely disappear from the solution when the tax rates begin to be equal to their steady-state values. A more thorough discussion of this method can be found in Juillard (2006).

In order to accommodate the possibility acknowledged earlier that the Solow residuals measure the stochastic technology levels with considerable error, the paper also reports the second order perturbation solution in the absence of shocks to technology, whose level therefore is assumed to remain constant at its steady-state level.

Unfortunately, it is not possible to say anything about the accuracy with which the second order perturbation method approximates the exact solution. The perfect foresight solution could provide some insights into this issue because, although unrealistic, it is mathematically exact. For that reason, the paper reports as well the solution of the model without technology shocks under perfect foresight. For the case of this solution, all realizations of the stochastic variables other than the omitted technology shocks are assumed to be known in advance in 2009 and set, accordingly, equal to their observed realizations between that year and 2011 and to their expected values thereafter.¹⁰

5.2 Findings

As anticipated in the introduction, the quantitative ability of the fiscal sentiment hypothesis to account for the lackluster recovery of the U.S. economy from the Great Recession depends critically on whether the higher future taxes envisioned by the hypothesis fall mostly on capital or labor. It is useful therefore to explore the predictions of the model for two extreme scenarios, one in which the tax regime switches to a higher capital income tax rate, leaving the labor income tax rate unchanged, and another one in which it is this latter tax that is raised and the capital income tax rate that is unchanged.

Of course, both extreme regimes had to satisfy the additional revenue restrictions established in the previous section. To facilitate the search over the tax rates that could attain

¹⁰The data for 2011 correspond actually to projections based on information available for the first three quarters of that year.

the targeted revenues, the tax policy (8) was further restricted as follows:

$$\begin{aligned}
& \left\{ \left\{ \tau_{t+i}^h, \tau_{t+i}^k \right\}_{i=0}^3, \left\{ \tau_{t+3+i}^h, \tau_{t+3+i}^k \right\}_{i=1}^{10}, \left\{ \tau_{t+13+i}^h, \tau_{t+13+i}^k \right\}_{i=1}^{\infty} \right\}_{t=2009}, \\
& \tau_{2009+i}^h = 0.23; \tau_{2009+i}^k = 0.40 \text{ for } 0 \leq i \leq 3, \\
& \tau_{2013+i}^h = \tau_{2013}^h; \tau_{2013+i}^k = \tau_{2013}^k \text{ for } 0 \leq i \leq 9, \\
& \tau_{2023+i}^h = \tau_{2023}^h; \tau_{2023+i}^k = \tau_{2023}^k \text{ for all } i > 0.
\end{aligned} \tag{31}$$

That is, the period s in which the economic agents in the model economy perceive an imminent switch to a higher tax regime is identified with the trough of the Great Recession in the data, the year 2009. The tax rates between then and the year 2012 are assumed to be the same as those prevailing on average over the calibration reference period, 1977-2007. In year 2013, the anticipated higher tax rate either on capital or labor income necessary to increase revenues by about 2.5% of GDP for ten years becomes effective and stays at that constant level through 2022. After that, the tax rate on either capital or labor is reset forever to the level required to increase by 0.3% of GDP the revenues that would have been collected in the absence of the tax regime switch.

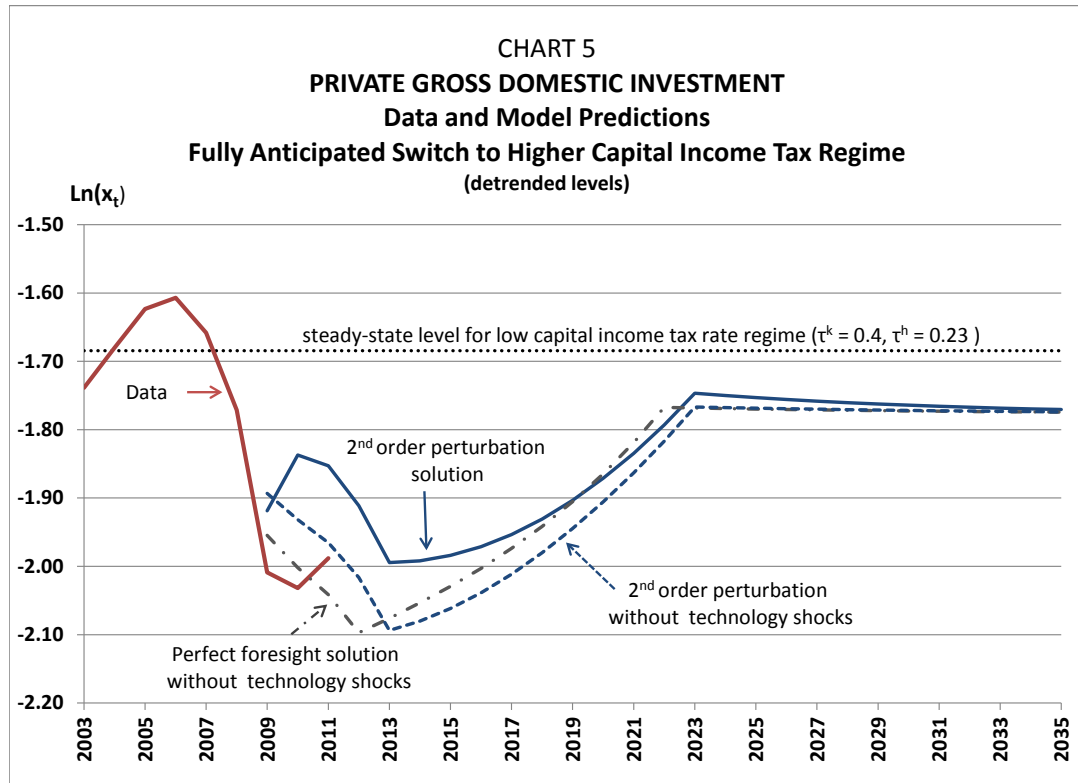
5.2.1 Tax regime with higher capital income taxes only

Experimentation with several capital income tax rates that satisfied the tax policy configuration (31) suggested that the transitional dynamics induced by the anticipated switch to a higher capital income tax rate was fairly well represented by the following tax policy:

$$\begin{aligned}
\tau_{2009+i}^h &= 0.23; \tau_{2009+i}^k = 0.40 \text{ for } 0 \leq i \leq 3, \\
\tau_{2013+i}^h &= 0.23; \tau_{2013+i}^k = 0.58 \text{ for } 0 \leq i \leq 9, \\
\tau_{2023+i}^h &= 0.23; \tau_{2023+i}^k = 0.45 \text{ for all } i > 0.
\end{aligned} \tag{32}$$

On top of delivering the required additional revenues, the capital income tax rate increases implied by this tax regime are moderate relative to those contained in legislation passed or about to be passed by the U.S. Congress at the time of this writing. For example, if the tax cuts implemented during the Bush administration expire as scheduled, in 2013, the tax rates on qualified dividends will rise by between 15 and 24 percentage points relative to the statutory tax rates in place during the period 2008-2012. Moreover, in the section discussing the imposition of restrictions to the tax regime change, capital income tax rates in the same orders of magnitude as in the numerical experiment are not unprecedented in U.S. history.

The full blue line in Chart 5 documents the predictions of the model for the trajectory of private gross domestic investment (in logs) obtained with the second-order perturbation approach after feeding into the corresponding decision rule the technology shocks ε_t actually observed between 2009 and 2011.



Recall that the computations rely on an approximation around the steady state implied by the permanently higher capital tax rate of 0.45 assumed to be in place from 2023 onwards. However, the relevant measure for assessing the quantitative relevance of the fiscal sentiment hypothesis is the extent to which this hypothesis can account for the poor performance of the U.S. economy after the Great Recession, relative to the trends prior to that episode. In the case of gross private domestic investment, its pre-Great-Recession trend is captured by the steady-state associated with the tax rates prevailing over the calibration period, represented in Chart 5 by the dotted horizontal line.

The chart readily suggests that the higher capital income tax regime can account for three-fifths of the decline in investment with respect to its pre-recession trend for the last

year for which information was available at the time of this writing, 2011.

Under the alternative assumption that the Solow residuals exaggerate the fluctuations of technology shifts, which would be basically unchanged at its steady-state level ($z_t = 0$ for all t) if measured correctly, the model does even better: The predicted trajectory of investment (broken blue line) traces very closely the one actually observed.

As mentioned when discussing the computational approach in section 5.1, one potential problem with the perturbation method is that its predictions are reliable only for small deviations around the steady state. The deviations of the capital income tax rate during the period 2013-2022 from the permanently higher one of 0.45 associated with the steady-state used to compute the decision rules are certainly not small and could raise issues about the precision of the approximation. For that reason, the chart documents as well the predictions for the perfect foresight solution, because despite the unrealistic assumption that economic agents perfectly foresee all future technology shocks, it is at least mathematically exact (up to machine precision).

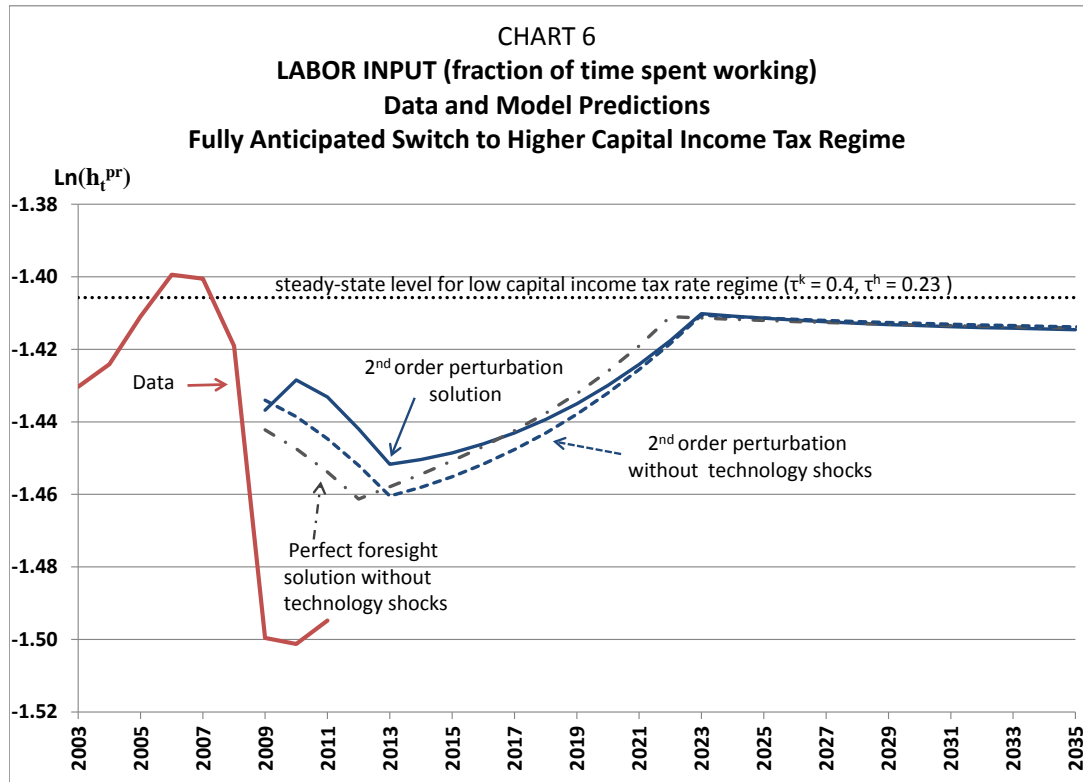
The perfect foresight solution (dash-and-dot line) suggests that approximation issues cannot be completely ignored. For example, the trajectory of investment reaches its trough in 2012, one period earlier than for the corresponding trajectory calculated with the second order perturbation.¹¹ Nevertheless, the discrepancies between these two solutions don't seem severe enough to invalidate the conclusion that the fiscal sentiment hypothesis can account for a large fraction of the decline of private gross investment relative to trend z_t observed in the aftermath of the Great Recession.

Of course, a topic that is at the center of the debates prompted by the fiscal sentiment hypothesis is its ability to account for the dismal performance of employment after the Great Recession. According to Chart 6, that hypothesis can account for about a third of the decline relative to the pre-Great-Recession trend of the fraction of time households devote to work for the private sector, under the following scenario: The transitional dynamics implied by the switch to a higher capital income tax regime is computed with a second order perturbation approximation and the technology shocks ε_t actually observed between 2009 and 2011 are fed into the corresponding decision rules (full blue line). That fraction increases to fifty percent for the perfect foresight solution with the technology levels z_t set equal to zero.

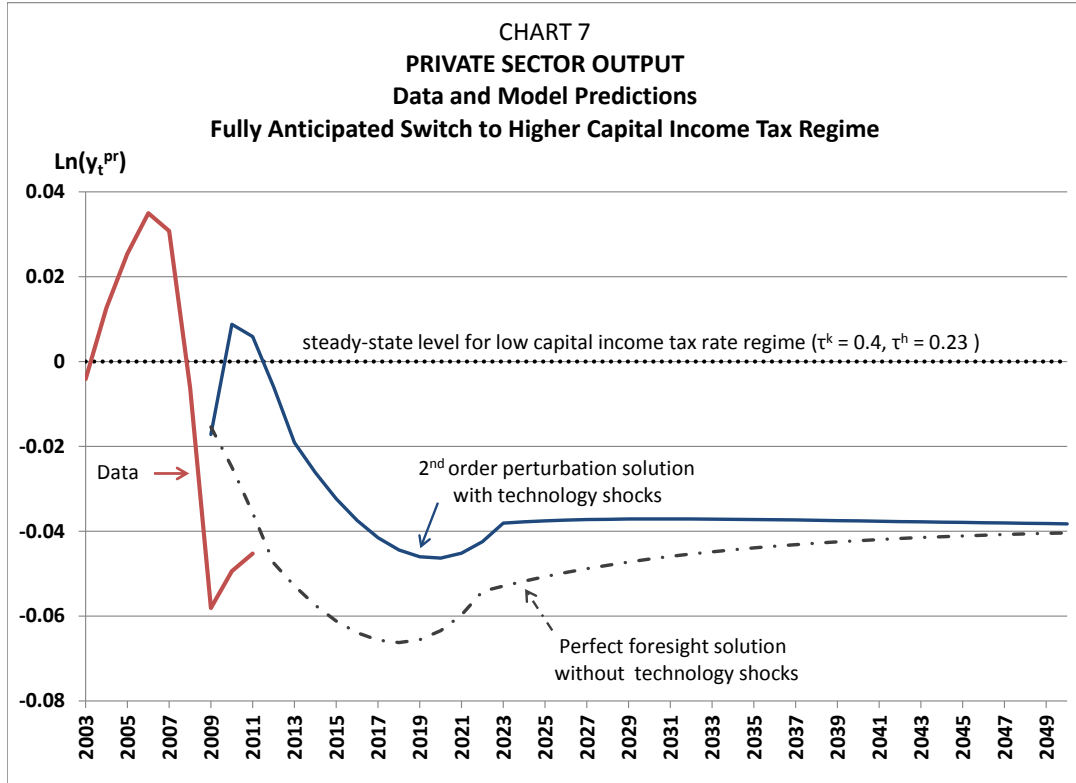
Although these fractions are less remarkable than for investment, they are nevertheless surprisingly high, as they imply that the fiscal sentiment hypothesis can account for at least as much, if not more, of the decline in labor input accounted for by models that abstract from

¹¹Kydland and Zarazaga (2007) reported a similar discrepancy between the perfect foresight and approximated solutions in their study of a decade-long recession in Argentina.

fiscal considerations, but emphasize instead the role of financial frictions during the Great Recession and its aftermath, such as the one recently studied by Jermann and Quadrini (forthcoming.)



For completion, Chart 7 reports the model predictions for the trajectory of output. The chart makes apparent that the fiscal sentiment hypothesis captures the overall tendency of output to fall below its pre-Great Recession trend. However, the predictions of the model miss the actually observed dynamics of output during the first few periods immediately following the trough of the Great Recession. The reason is that, as documented in Chart 5, that period was characterized by large productivity gains and that the technology shifts enter multiplicatively in the production function (24).

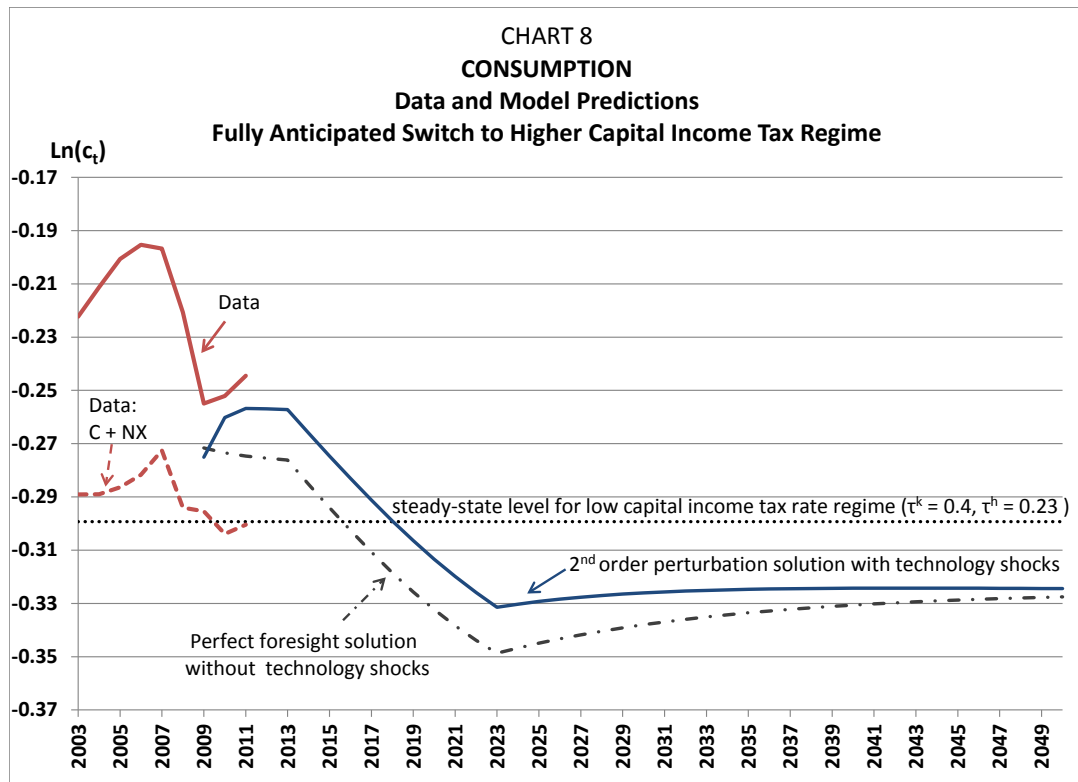


On the other hand, when the assumption that the Solow residuals provide a reliable measure of the stochastic technology levels z_t is abandoned, the model predictions for output replicate remarkably well the actually observed trajectory of that variable.

When taken together, the evidence presented in Charts 5 to 7 suggests that either the measures of the stochastic technology levels provided by the Solow residuals should be taken with a grain of salt, or the presence of another friction that in the aftermath of the Great Recession prevented the large productivity gains then observed from manifesting themselves in increases in labor input and, correspondingly, of output.

The predictions of the model for consumption present a good opportunity to discuss the economic intuition behind the results reported in the previous three charts. One problem in comparing the model predictions with the data is that the model in this paper represents a single-country, closed economy, in which private output can be either a consumption good or an investment good. In the actual economy, the final output can also take the form of net exports.

As a way to address that problem, Chart 8 reports the model prediction for consumption, along with the data for consumption (detrended) under the alternative extreme assumption that none of the consumption good was imported (full line labeled "Data") and that all of the net exports were in consumption goods (broken line labeled "Data C + NX"). As can be seen in the chart, the predictions of the model fall in between those two extreme cases, in line with the realistic situation in which only part of the net exports in the data correspond to final consumption goods.¹²

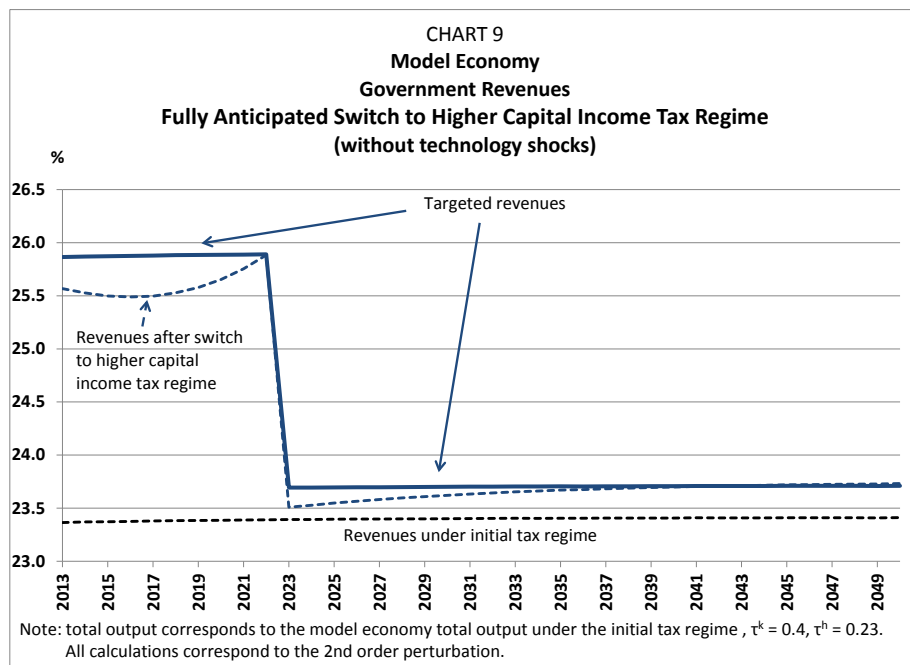


An interesting feature of the model prediction for consumption in the higher capital income tax scenario is that it manages to stay above the steady-state corresponding to the permanently higher capital income tax rate of 0.45 for a good number of periods. This dynamics sheds light into the mechanism at work in the transitional dynamics documented in the previous charts.

¹²Unfortunately, the available data do not make it possible to distribute net exports between the different type of final goods (consumption and investment.)

As agents realize that their capital income will be taxed more heavily in the future, they reduce their holdings of the capital stock by not completely replenishing the part of it that depreciates every period and by changing the composition of output in favor of consumption. The first channel implies that households can afford to work less, as documented in Chart 6, because they don't need to produce as many investment goods as before. The second channel explains why, despite the downward trending output, households are able to smooth the decline in consumption before it settles at the permanently lower level implied by the higher tax regime (32). Both channels are in action in the initial decline of investment below its steady-state level in the permanently higher capital income tax rate regime documented in Chart 5.

Finally, Chart 9 documents the revenue effects of the tax regime configuration discussed in this section. As can be verified in the chart, in the absence of shocks to technology, this regime delivers additional revenues that are only slightly below target.

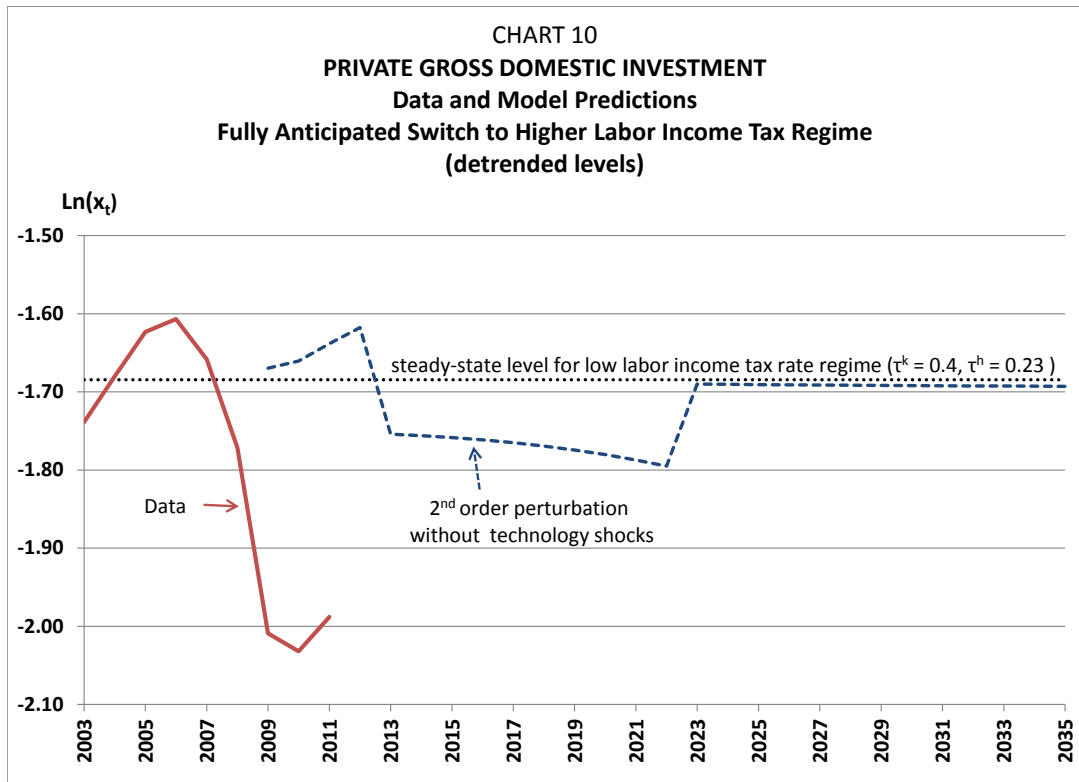


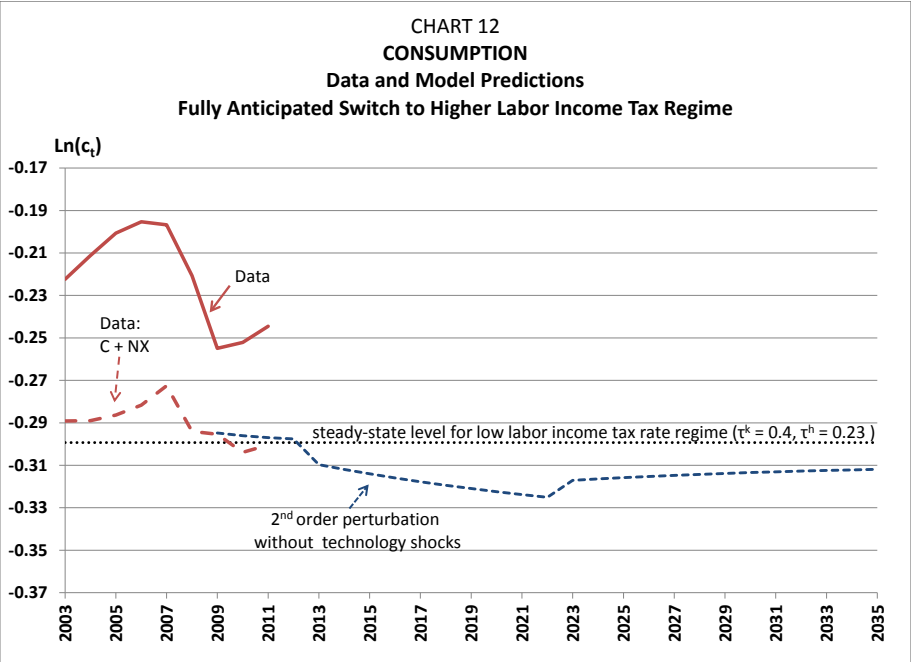
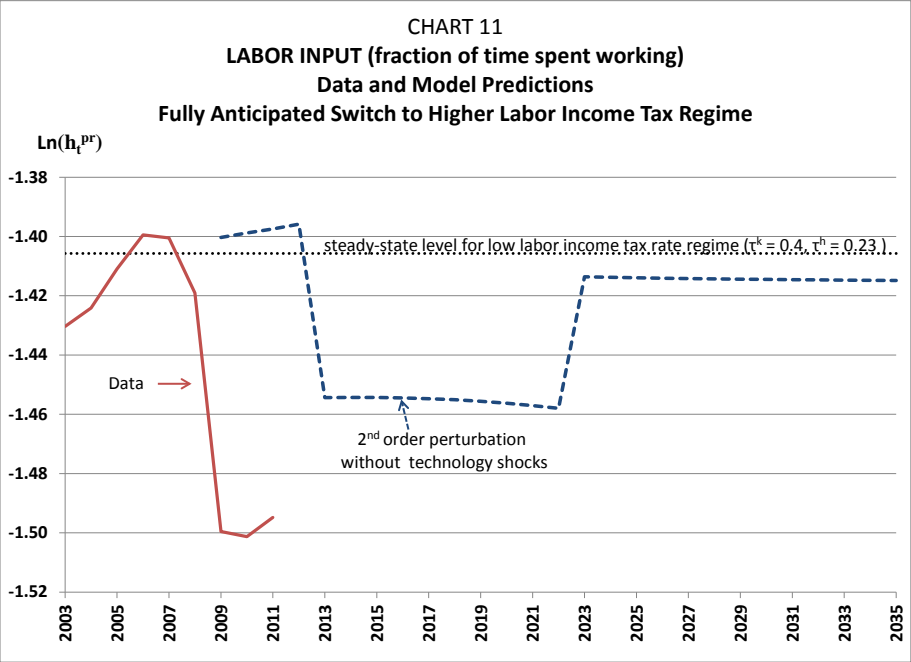
5.2.2 Tax regime with higher labor income taxes only

Experimentation with labor income tax rates that satisfied the tax policy configuration (31) suggested that the transitional dynamics induced by the anticipated switch to a regime that includes only a higher labor capital income tax rate is adequately captured by the following tax policy:

$$\begin{aligned}
 \tau_{2009+i}^h &= 0.23; \tau_{2009+i}^k = 0.40 \text{ for } 0 \leq i \leq 3, \\
 \tau_{2013+i}^h &= 0.27; \tau_{2013+i}^k = 0.40 \text{ for } 0 \leq i \leq 9, \\
 \tau_{2023+i}^h &= 0.24; \tau_{2023+i}^k = 0.40 \text{ for all } i > 0.
 \end{aligned}
 \tag{33}$$

Charts 10 to 12 document the predictions of the model under this tax regime for gross private domestic investment, labor input, and consumption.





As is obvious from the charts, the tax policy (33) delivers counterfactual predictions even when the technology shifts are assumed to remain constant at their steady-state level. That is because the economic mechanism is exactly the opposite from the one at work when the tax regime includes a tax rate hike only for capital income.

The consumption smoothing incentive is present in both regimes, but the incentives to do so by accumulating capital was annihilated in the higher capital income tax rate regime. This incentive, however, is still in place when the higher taxes fall only on labor. In this case, the households work harder and devote a larger share of the resulting higher level of output to investment goods, before the higher labor income tax rate kicks in. This intertemporal substitution allows them to increase the capital stock with which to smooth consumption later on, when the higher labor tax effectively discourages them from working and, therefore, from producing as much output.

Clearly, a tax regime with only higher labor income tax rates induces a transitional dynamics that is at odds with the evidence for the aftermath of the Great Recession. The discrepancy between the model predictions and the data is even greater if the actually observed productivity gains observed after the Great Recession were fed into the decision rules, because in that case households would want to work and invest even more.

5.3 Concluding Comments

Two years after the trough of the Great Recession, the U.S. economy is struggling to recover as fast as 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 U.S. economy after the Great Recession can be accounted for by the fears of an imminent switch to a higher tax regime.

Such fears don't seem unreasonable given the historical evidence documented by several experts, the current record high fiscal deficits of the U.S. during peacetime, and the projections that the structural fiscal problems that predated the Great Recession will have to be addressed sooner rather than later by increasing revenues and/or reducing spending.

The main finding of the paper is that the fiscal sentiment hypothesis can quantitatively account for the evidence, provided it adds the caveat that the higher tax regime must include mostly higher capital income tax rates. This is not an unreasonable condition either: It suggests that economic agents suspect that at times of stress, the tax structure that will be implemented to address fiscal imbalances will be far from optimal. On the contrary, it will

be precisely then that policymakers will find 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 more heavily.

With that important caveat and for reasonable targets for the additional revenues that the higher taxes need to deliver, the fiscal sentiment hypothesis can account for between three-fifths and all of the decline in private gross domestic investment, as well as for between one third and one half of the decline of labor input observed since the trough of the Great Recession. 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.

Overall, the quantitative findings of the paper suggest that fiscal considerations will have to be part of any successful attempt to account for the weak recovery of the Great Recession, but they will have to be reinforced by the presence of other frictions.

An obvious candidate friction to consider in future work is the presence of distortions in the intermediation of capital. In particular, future research should explore the possibility that the prospect of higher taxes on capital income reduces the value of the collateral that credit-constrained households must post to get access to credit. In that case, the same mechanisms that account for the partial success of the fiscal sentiment hypothesis established in this paper will exacerbate financial frictions and eventually account even more convincingly for the facts.

Recent work on the size of multipliers by Christiano, Eichenbaum, and Rebelo (forthcoming) hints at the promise of that line of research. They found that in their model the attempt to finance higher government consumption with higher capital income taxes may end up hindering the intermediation of capital and fail, therefore, to correct the insufficient aggregate demand problem it meant to address. In the same direction points the already mentioned study by Jermann and Quadrini.

In any case, the goal of this paper was to establish a clear and transparent assessment of the kind of quantitative results that the fiscal sentiment hypothesis is capable of delivering, when examined under the lens of a neoclassical growth model carefully calibrated to the U.S. economy. Hopefully, the findings documented herein will contribute to introducing more quantitative rigor in the debates that the slow recovery of the U.S. economy from the Great Recession is likely to keep prompting going forward.

Appendix A

Data Sources and Treatment

The National Accounts didn'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 1977-2011. The data for the later year correspond to projections based on information available for the first three quarters of that year.

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 *et al.* briefly discussed in section 4.6.

Sources:

For national accounts variables: Bureau of Economic Analysis.

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.

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:

$$gc_t = m_t + ch_t^{gc} + ck_t^{gc} = m_t + va_t^{gc}, \quad (34)$$

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 (34) and subsequent ones have been detrended by the common growth factor $(1 + \eta)(1 + \gamma)$ when applicable.

As anticipated in the overview of this section, 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:

$$g_t = gc_t + x_t^{gc} + x_t^{ge} \quad (35)$$

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:

$$c_t + x_t + g_t \equiv va_t^{pr} + va_t^{ge} + va_t^{gc} \equiv y_t, \quad (36)$$

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 .¹³

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 (36) 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 (36), which results in the following alternative identities:

$$c_t + x_t + (g_t - va_t^{gc}) \equiv va_t^{pr} + va_t^{ge} \equiv y_t - va_t^{gc}. \quad (37)$$

Substituting the far right of (34) into (35) and the resulting expression into (37) yields

$$c_t + x_t + (m_t + x_t^{pu}) \equiv va_t^{pr} + va_t^{ge} \equiv y_t^{qp}, \quad (38)$$

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

¹³Although in theory real gross domestic product should be the same, regardless of which of the three approaches implicit in (36) 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.

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 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 (36) 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 (38) 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 U.S. 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. In making this connection, 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.

Specifically, the government of the model economy satisfies every period the following budget constraint:

$$m_t + x_t^{pu} = g_t - va_t^{gc} = \tau_t^h w_t (h_t^{pr} + h_t^{pu}) + \tau_t^k (r_t - \delta) k_t + s_t^{ge} - \tau_t - w_t h_t^{gc}, \quad (39)$$

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 (7) 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 (7), 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 $m_t + x_t^{pu}$.

A possible objection to this formulation of the government budget constraint is that it may always be possible to find prospect tax increases of the right magnitudes that account for at least some aspects of the weak post-Great-Recession recovery and that at the same time preserve a balanced budget by simply changing the lump-sum transfers τ_t in the required amount. Those concerns are addressed in the calibration section of the paper by the imposition of restrictions on the size of the tax increases that can be realistically considered.

The substitution of (7) into (38) is the last step in the derivation of the household budget constraint which, after some algebraic manipulations, produces the desired expression:

$$c_t + x_t = (1 - \tau_t^h)w_t(h_t^{pr} + h_t^{ge} + h_t^{gc}) + [r_t - \tau_t^k(r_t - \delta)]k_t + ck_t^{ge} + \tau_t \quad (40)$$

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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