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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 strength predicted by models that incorporate a variety of shocks and frictions in the basic analytical framework of the neoclassical growth model. It has been argued that the counterfactual predictions shouldn't be attributed to inherent features of that framework, but to the omission from the analysis of the prospects of an imminent switch to a higher taxes regime prompted by the unprecedented fiscal challenges faced by the U.S. economy in peacetime. The paper explores quantitatively this fiscal sentiment hypothesis. The main finding is that the hypothesis can account for a substantial 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

More than three years after the trough of the Great Recession of 2008-2009, the weakness of the recovery that the U.S. economy initiated then continued to pose a riddle to many models produced by the economics profession, according to which it should have been a lot stronger.

The failure to account for the anemic recovery is particularly noticeable in the subset of those models that introduce a variety of frictions and shocks in the basic analytical framework of the neoclassical growth model, but in a way that preserves the uniqueness of the stable saddle path of the corresponding detrended economy. This property, heavily exploited in the subsequent quantitative implementation of those models, is precisely the reason why they predict that the recovery from the Great Recession should have been particularly strong.

It is well-known that the dynamics of the standard neoclassical growth model is such that the further output falls below its steady-state level, the stronger the subsequent rebound to it, unless particular realizations of the shocks prevent that from happening. It hasn't proved easy, however, to identify shocks with such a "delaying effect" in the recovery. The innovations that brought total factor productivity (TFP) down below trend during that Great Recession died down fairly quickly, to the point that TFP, as measured by standard Solow residuals, was at or above trend soon after the recovery started. Likewise, the improvement in financial conditions, as measured by Jermann and Quadrini (2012), that followed their sharp deterioration during the Great Recession had the similar effect of predicting a much stronger recovery of output and hours worked than actually observed in the version of the neoclassical growth model with financial frictions studied by those authors.

The unsuccessful attempts to account for the weak recovery from the Great Recession with shocks that were in principle natural candidates to accomplish that has led to the speculation that the source of that failure is not the specific shocks considered, but the very feature of the neoclassical growth model mentioned earlier, the uniqueness of its stable saddle path and, therefore, of its steady state equilibrium (or balanced-growth path). In this interpretation, the solution to the riddle posed by the weakness of the recovery from the Great Recession is to abandon that analytical framework altogether and replace it with models with multiple equilibria generated by the presence of extrinsic uncertainty ("sunspots"), rather than by the intrinsic ("fundamental") uncertainty typically considered in the context of the neoclassical growth model. This is the approach forcefully advocated by Farmer (2012).

The alleged intrinsic inability of extensions of the neoclassical growth model to account for the weak expansion that followed the Great Recession seems premature, however, because the anomaly of an unusually anemic recovery following a particularly deep recession has been accompanied in the U.S. also by unprecedented developments in the fiscal front: record high fiscal deficits and levels of public debt during peacetime, along with projections of a significant structural rise in government spending in coming decades. The counterfactual prediction of such models might disappear once the prospects of a switch to a higher taxes regime induced by the fiscal challenges just identified are explicitly incorporated in the analysis.

The goal of this paper is precisely to check the quantitative relevance of this conjecture, referred hereafter as "fiscal sentiment" hypothesis. This expression was chosen deliberately to highlight the subtle, but substantive conceptual difference, between the hypothesis quantitatively explored in this paper, and "consumer sentiment" or "animal spirits" interpretations of the weak recovery from the Great Recession. Interpretations in the latter group, as hinted at earlier, abandon the uniqueness of the steady-state equilibrium of the neoclassical growth model in favor of model specifications that attribute the anemic recovery from that episode, and even that episode itself, to the households' and businesses' self-fulfilling beliefs (sunspots) of poor future wealth prospects. The fiscal sentiment hypothesis preserves the uniqueness of the steady-state equilibrium of the standard neoclassical growth model and traces the gloomy outlook to the fears of higher taxes induced by the objective fiscal problems that predated the Great Recession, but that were aggravated and made apparent by it. In contrast with the sunspot view of the particular episode under study, these fears are not necessarily self-fulfilling. They may or may not materialize in the end. In the latter case, the model would predict that the recovery should progressively gain strength as the expectations of higher taxes are proved wrong or exaggerated.

The view that the prospect of a switch to a higher tax regime is impairing the U.S. economic recovery from the Great Recession has been informally articulated, among others, by Cooley and Ohanian (2010), Becker, Shultz, and Taylor (2011), and Feldstein (2011). It is the following concise and eloquent characterization of the fiscal sentiment hypothesis by Lucas (2011), however, the one that has influenced the most the methodological choices for exploring it quantitatively made in the paper:

> *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."*

The assertion that it is not possible to look at the evidence because the policies that can eventually validate or dismiss the fiscal sentiment hypothesis haven't been implemented yet is somewhat puzzling, given that Lucas himself has pioneered techniques designed to do precisely that. Specifically, those techniques can be used to produce rather stark predictions about the economic outcomes that should be observed in the present if economic agents are indeed making their current consumption, employment, and investment decisions with the belief that a switch to a higher taxes regime is imminent. The comparison of those predictions with the evidence can be used in principle to assess the quantitative plausibility of the fiscal sentiment hypothesis.

The paper implements those comparisons with an off-the-shelf neoclassical growth model calibrated to long-run features of the U.S. economy and with a higher taxes regime configured to reflect the Congressional Budget Office's assessment of the U.S. fiscal situation.

A neoclassical growth model with a unique balanced-growth path subject to mean-reverting productivity shocks seemed to be an appropriate and fair choice of analytical framework, because it captures in a simple and tractable way the view that *"A healthy economy that falls into recession has higher than average growth for a while and gets back to the old trend line"* alluded to in Lucas's brief characterization of the fiscal sentiment hypothesis.

The paper focuses the attention on the case of higher capital income taxes, because standard arguments suggest that the frictionless neoclassical growth model will produce counterfactual predictions when the higher tax rates are expected to fall on labor income. Intuitively, the anticipation of higher taxes on that source of income will induce households to intertemporally substitute less leisure today for more leisure in the future, when work in market activities will be taxed more heavily. As a result, labor input and output increase above trend in the transition period between the time households foresee the change of regime and the time that it is actually implemented, the opposite pattern of that observed during the recovery from the Great Recession.

On the other hand, the predictions of the model under higher capital income taxes are, in principle, consistent with the evidence for that episode. The perception that the returns on capital will be taxed more heavily in the near future leaves the capital stock at a higher level than desired, and induces the familiar transitional dynamics of a neoclassical growth model in which the initial capital stock is above its steady-state. Households let the capital stock depreciate to its lower steady-state level by not investing as much as under the previous lower capital income taxes regime. Without the need to produce as many investment goods to keep the capital stock from depreciating, they enjoy more leisure and work less. Investment, labor input, and output decline, perhaps even undershooting their new lower trends.

For the same reason, households devote a fraction of output previously saved to consume more. As a result, real consumption rises temporarily above its pre-recession trend, while output, labor input, and investment languish below theirs. This manifestation of the dynamics of the neoclassical growth model, emphasized by Beaudry and Portier (2007), is muted in most existing models that might have something to say about the dynamics of the U.S. economy after the Great Recession, which as a consequence predict instead that consumption and output move in tandem above or below their respective trends. Subject to the limitations of the data discussed later, the different implication of the fiscal sentiment hypothesis for the behavior of consumption relative to output could thus offer a potentially useful devise to discriminate between this hypothesis and alternative ones about the ultimate causes behind the feeble U.S. economic recovery from the Great Recession.

As stated earlier, however, the paper is not about these fairly straightforward qualitative predictions of an abstract neoclassical growth model, but about the *quantitative* ability of one calibrated as indicated above to account for the evidence, when the agents in the model believe that a regime with higher tax rates on capital income is about to be adopted.

It doesn't seem unreasonable to speculate that households and businesses started to make their decisions in the wake of the Great Recession as if convinced that a switch to such a regime was about to happen. After all, the unprecedented measures implemented during and after the 2008-09 crisis may well have appeared to them as being part of fiscal and monetary policy regimes substantially different from those they had seen implemented in the past. Moreover, 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.

Before summarizing the results of the paper, it is important to reiterate that its goal is to establish how much of the weakness of the recovery from the Great Recession can be accounted for by a particular model equipped with economic agents that make their decisions as if convinced that a higher capital income taxes regime will be in place soon. The resulting predictions don't depend on whether or not subsequent developments prove that belief wrong, as hinted at by the justification for the choice of the term "fiscal sentiment" offered earlier.

In this spirit, the main finding of the paper is that the fiscal sentiment hypothesis, with the particular specifications outlined above, can account for a non-negligible fraction of the weakness of private gross private domestic investment and labor input observed in the first three years after the trough of the Great Recession. Specifically, in the model investment stays below its pre-recession trend throughout the recovery from that episode with a gap whose size is about three-fifths or more of the corresponding gap in the data.

The model predicts a similar dynamics for labor input, whose negative gap from trend can account for at least a third of the corresponding deviation from trend in the data. This is a remarkably high fraction, taking into account that models that abstract from fiscal policy and consider financial shocks in isolation, such as the one by Jermann and Quadrini mentioned earlier, predict that labor input should have rebounded back to its pre-recession trend in the early stages of the recovery from the Great Recession.

The comparison between the predictions of the model and the data for consumption is more tentative, because consumption in real terms, as measured by the National Income and Product Accounts (NIPA), includes durable consumption purchases, and is not the correct empirical counterpart, therefore, of the flow of consumption services from durables considered in the neoclassical growth model. Keeping that caveat in mind, the predictions of the model are consistent with tentative evidence, constructed from the available data, that real consumption stayed at or above its pre-recession trend during the recovery from the Great Recession.

Despite its relative success in accounting for the decline of labor input and investment from their pre-recession trends, the model cannot account for any significant fraction of the corresponding decline of output. The reason, as mentioned earlier, is that the rebound of TFP during the recovery was strong enough to offset the poor performance of the inputs in the model and leave output, therefore, basically unchanged at its pre-recession trend.

The extent to which this latter finding undermines the fiscal sentiment hypothesis hinges, therefore, on the assessment of the accuracy with which the Solow residuals approximate true TFP. A non-negligible fraction of the profession has always been of the opinion that the volatility of those residuals implies that societies too frequently forget or regain too much of the technological knowledge they had already acquired in the past. More recently, McGrattan and Prescott (2012) have also questioned the measures of TFP obtained from Solow residuals, because NIPA doesn't count investment in intangible capital as output. Taken together, these objections raise the possibility that measured TFP during the recovery from the Great Recession was not above trend by as much as suggested by traditional Solow residuals. As a way of correcting this potential upward bias, the paper reports the predictions of the model under the assumption that TFP was at trend throughout that episode.

It turns out that under that assumption the fiscal sentiment hypothesis can account for virtually all of the decline of output from trend during the period under study, as measured by the last available observation. This outcome comes about because predicted investment ends up falling somewhat more than in the data, while the predicted decline of labor input from trend is as large as fifty percent, instead of the thirty percent reported for the case in which the model is fed with the technology levels actually observed during the recovery from the Great Recession.

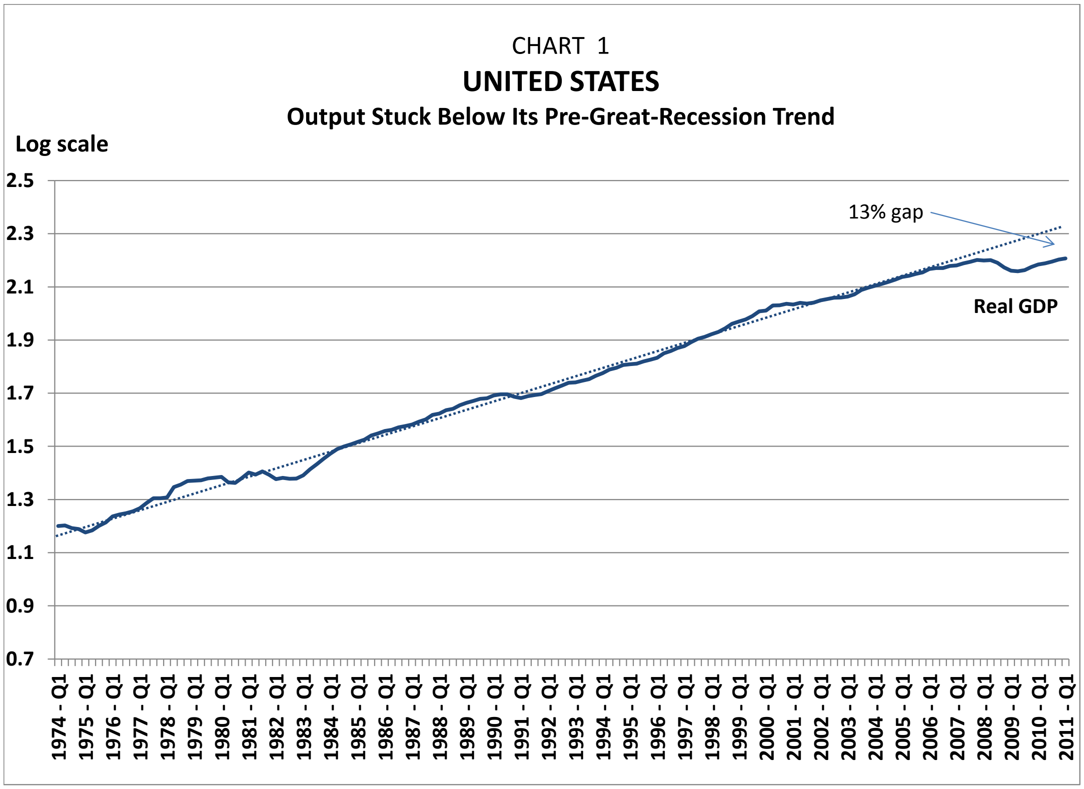
Overall, the results just summarized suggest that the analytical framework provided by the neoclassical growth model can account for a significant fraction of the weakness of the recovery from the Great Recession. As demonstrated by this paper, the perceptions to the contrary may have originated in the failure to incorporate formally in that framework the effects of the challenging fiscal situation that the U.S. will have to confront in the near future.

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 and outlines measurement issues relevant for the correct quantitative assessment of the fiscal sentiment hypothesis. Section 3 briefly motivates the choice of the neoclassical growth model to explore that hypothesis and presents the details of implementation of the model. Section 4 discusses briefly the techniques used to compute the equilibrium path of the macroeconomic aggregates of interest and reports the results of the computational experiments designed to shed light on the question addressed by the paper. Section 5 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 The Weak Recovery From the Great Recession: Measurement Issues

One possible reason for the skepticism about the ability of the fiscal sentiment hypothesis to account for the weakness of the recovery from the Great Recession is the large magnitude by which output was apparently below its pre-recession trend during that episode.

Chart 1 suggests that in 2011, the associated gap was as large as 13%. Only implausibly higher tax rates could deliver such an outcome in a neoclassical growth model with parameter values in the range of those viewed as reasonable in the literature.



Given the eminently quantitative nature of the inquiry, it was critical to establish first, therefore, if this sizable decline of output from its pre-recession trend survives a rigorous calibration of the relevant parameters and macroeconomic entities in a manner consistent with the neoclassical growth model that, as already anticipated, will be used for the quantitative exploration of the fiscal sentiment hypothesis.

The answer is no, because the crude gap presented in Chart 1 ignores important measurement issues, such as the upward drift in the fraction of time that women are at work observed in the previous decades, discussed thoroughly in subsection 3.5.7. The linear trend in Chart 1 projects that rise to the future as if it were sustainable and exaggerates, therefore, the decline of output from that trend during the Great Recession.

The reliability of the quantitative answers provided by the paper could suffer as well from the lack of correspondence between the conceptual entities in the proposed model economy and the data. In particular, the NIPA methodology 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. This asymmetry introduces a distortion in the measurement of aggregate output that may be subsequently transmitted to other key parameters and variables, such as the share of the remuneration to the capital input in total income, or the series for TFP calculated from Solow residuals.

It turns out that these measurement difficulties 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.

In any case, the effect of bringing the data in closer correspondence with the conceptual entities in the model economy was to reduce substantially the magnitude of the decline of output from its pre-recession trend suggested by Chart 1. In particular, according to the measurement approach adopted by the paper and as documented in detail in subsection 3.5.7, private sector output has been 5% or less below its pre-recession trend during the recovery from the Great Recession. Deviations of this more moderate size fall within the range of those that the fiscal sentiment hypothesis can eventually account for under reasonable parameterizations of the neoclassical growth model.

3 The Model Economy

Given the motivation of this paper, it seemed only fair to explore the quantitative implications of the fiscal sentiment hypothesis within the analytical framework of the neoclassical growth model. After all, this is the framework that Lucas seemed to have in mind in his statement of the hypothesis, as quoted in the introduction.

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). Moreover, in line with the usual tradition in applications of this approach, whenever possible the relevant parameter values were calibrated to long-run features of the U.S. economy, in the manner discussed in detail later.

3.1 Households

3.1.1 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:

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

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. It faces, therefore, the following restriction on the allocation of time:

$$1 = l_t + h_t^{pr} + h_t^{pu} \tag{2}$$

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.

The explicit distinction between the time households devote to work in the public and private sectors is uncommon, because the sum of the valued added by the private sector and by the government is considered the appropriate empirical counterpart of output in most models. Of course, this is not true in the private sector economy of this paper. In particular, calibrating the relevant parameters of such an economy without taking into account the fraction of time that households work for government agencies could, for the reasons discussed in detail in subsection 3.4.3, induce a severe overestimation of the labor input absorbed by the private sector and, therefore, of output, consumption, and investment.

Notice also 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 at the beginning 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.

3.1.2 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}:

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

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.

3.1.3 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:

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

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

3.2 Private Sector Firms

There are two kinds of firms that produce output in the stationary economy without growth and without a government final good: private firms and government enterprises. As discussed in 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:

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

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:

$$z_t = \rho z_{t-1} + \varepsilon_t, \tag{6}$$

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, there is a widespread perception that traditional Solow residuals grossly mismeasure the technology level of the actual economy. In fact, the arguments in the paper by McGrattan and Prescott mentioned there as well suggest that Solow residuals overestimate the apparent rise of the technology level above its pre-Great-Recession trend during the recovery from that episode. Accordingly, the paper incorporates those objections by reporting the results of the computational experiments under the assumption that the technology level remained constant at its steady-state level over that period.

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:

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

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.

3.3 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 exogenously.

3.3.1 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:

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

[2] Future 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.

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

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

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 detrended and measured in units of the consumption good per working age population as well.

3.3.2 Tax Policy

Given the purpose of the paper, it seemed reasonable to require that tax policies be modelled in a way that captures the essence of the fiscal sentiment hypothesis and which is as 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 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:

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

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.

3.3.3 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:

$$h_t^{pu} = h^{pu} + \varepsilon_t^{hpu} \tag{9}$$

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

3.3.4 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:

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

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

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.

3.4 Individual Choices and Equilibrium Concept

3.4.1 The Typical Household's Choice Problem

In line with the discussion in the preceding sections, the typical 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 lifetime utility (1), subject to the time-use constraint (2), the law of motion of the private capital stock (3), and the individual budget constraint (4), 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:

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

subject to:

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

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 behavior is implicit 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.

3.4.2 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 prices and the technology (5) as given:

$$\underset{h_t^{pr},\, k_t}{Max} \left[Ae^{z_t} k_t^{\theta} (h_t^{pr})^{1-\theta} - w_t h_t^{pr} - r_t k_t \right] \tag{14}$$

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.

3.4.3 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:

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

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

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 rate, that is:

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

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

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:

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

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

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 subsection 3.1.1, 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

$$c_t + x_t = \left[1 + (vy + \varepsilon_t^{gc}) - (gy + \varepsilon_t^{ge})\right] A e^{z_t} k_t^{\theta} (h_t^{pr})^{1-\theta} \tag{21}$$

derived from (38) in Appendix B, after taking into account (10), (11), 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, $t \geqslant s$, 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}.

[4] It 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 50), the stand-in household budget constraint is unchanged.

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.

3.5 Model Calibration

3.5.1 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.

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
η (working-age population annual growth rate)	0.012358
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 reiterating that the calibrated depreciation rate should be interpreted as the economic, rather than the physical, depreciation rate. This is because the data have been expressed in 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:

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

where

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

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]

[5] Equation (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.

3.5.2 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 complicated by the fact that NIPA treats the remuneration to capital in hands of the private sector differently from that in hands of the government. While the capital income originated in private sector capital income is recorded at market values, the one originated in public sector capital is the result of an imputation. Thus, as discussed in Appendix B, the ratio of total capital income payments to total income as reported in NIPA may produce a biased estimate of the capital share parameter θ. Since the private sector income flows are free of this bias, this parameter 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 one of the reasons 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.

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:

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

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:

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

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:

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

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 before-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 rate of capital, r, is equal to 0.13.

It follows from the definition of the capital income share that its stationary value must satisfy the following condition:

$$\theta = r\frac{k}{y^{pr}} \tag{26}$$

which could have been inferred as well from equation (18), after multiplying and dividing both sides by k_t.

Given the steady-state value of the rental rate of capital, r, 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 $k/y^{pr} = 2.686864$.

3.5.3 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:

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

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

3.5.4 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):

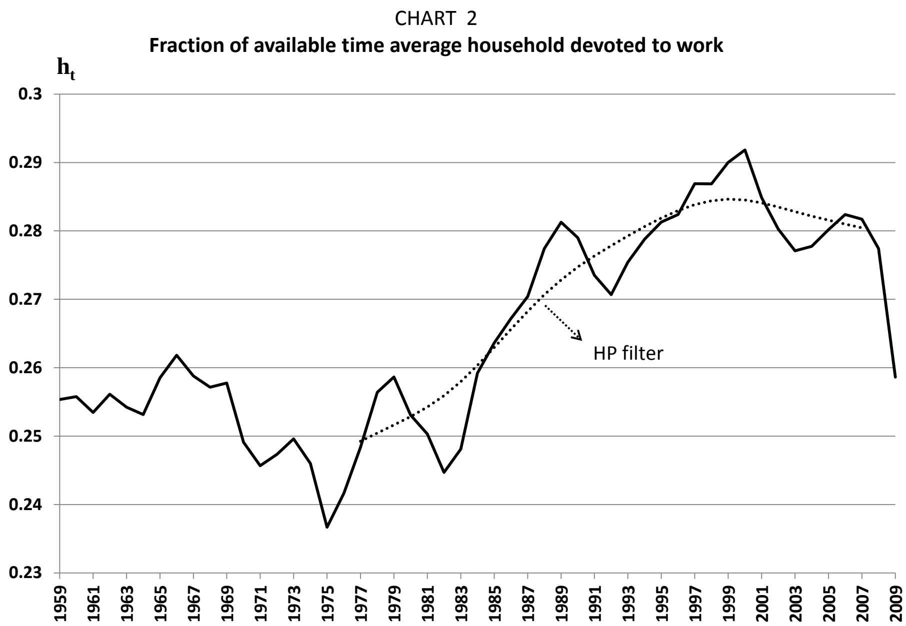
$$\alpha = \frac{1}{\frac{1-h^{pr}-h^{pu}}{h^{pr}} \frac{(1-\tau^h)(1-\theta)}{1+vy-gy-\frac{x}{y^{pr}}} + 1} \tag{28}$$

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 $\alpha = 0.335179$.

3.5.5 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 $\beta = 0.962635$.

3.5.6 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 the introduction 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 regime.

In light of the evidence for the Great Depression, those perceptions are far from irrational. 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

[6]More 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 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.

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 2022. 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.

3.5.7 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 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.

When an economy is truly on a balanced growth path, that detrending should be accomplished by dividing all commodity variables ϱ_t (output, consumption, investment, capital stock) by the annual balanced growth factor $[(1+\gamma)(1+\eta)]^t$. The success of this procedure in removing the trend should be apparent in series that fluctuate around a clearly identifiable horizontal trend. In the case of the U.S. economy, the outcome was series for the commodity variables that displayed instead a trend with a positive slope. The reason must be, of course, that the U.S. economy was not on a balanced growth path over the period 1977-2007 adopted as reference for the calibration of the model.

That should have been obvious from the non-stationarity of the fraction of time that households are actually at work, previously displayed in Chart 2. The steady rise of this measure of labor input over those three decades induced a rate of growth in output and the other commodity variables over and above that implied by TFP and working-age population growth.

As mentioned in subsection 3.5.4, the rise in h_t^{pr} easily detected in Chart 2 is the result of a transitional dynamics bound to die out sooner or later. The findings in Kaygusuz (2010) suggest that most of these transitional effects cannot be traced to quantifiable economic factors, making it all the more difficult to decide how to remove the non-stationarity from the measure of labor input plotted in Chart 2. Yet, this is a necessary step for comparing the data with the predictions of the model, which as explained earlier are expressed in terms of detrended variables.

The paper got around this difficulty with the rather pragmatic approach of 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} was removed by replacing the actually observed values of that variable with the synthetic variable $\widehat{h}_t^{pr}$ obtained as follows:

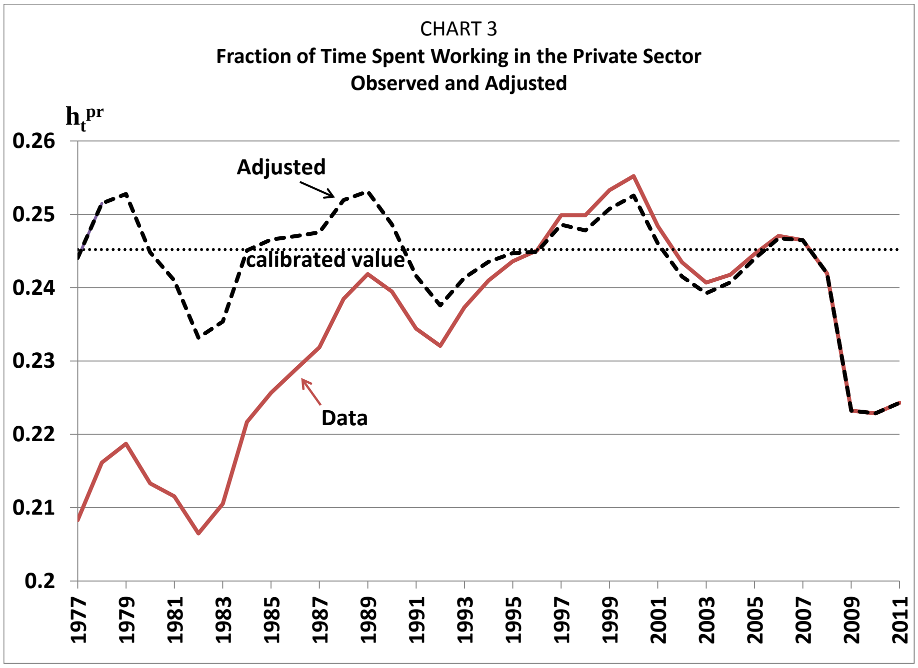
$$\widehat{h}_t^{pr} = \frac{h_t^{pr}}{h^{pr}(HPF)_t} h_{ss}^{pr} \tag{29}$$

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 in subsection 3.5.4.

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]

The chart shows that the proposed rescaling removes the transitional dynamics growth

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



from the h_t^{pr} series. As mentioned earlier and 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:

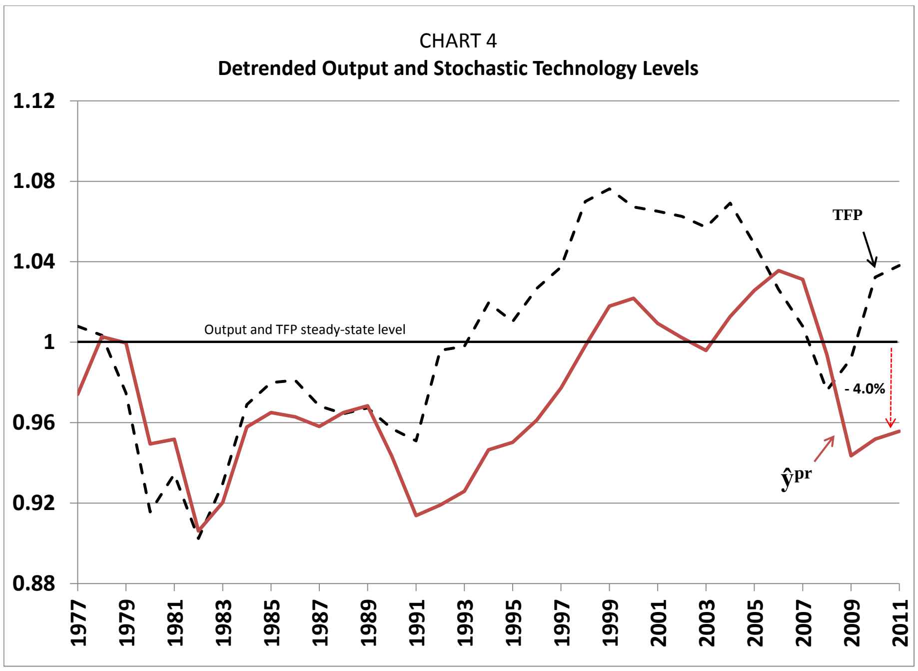
$$\widehat{y}_t^{pr} = \frac{y_t^{pr}}{A_0e^{\gamma t}}\frac{h_{ss}^{pr}}{h^{pr}(HPF)_t} = e^{\frac{z_t}{1-\theta}}A_{ss}^{\frac{1}{1-\theta}}\left(\frac{k_t}{y_t^{pr}}\right)^{\frac{\theta}{1-\theta}}\widehat{h}_t^{pr}, \tag{30}$$

where $\widehat{y}_t^{pr}$ is output per working age population in units of the consumption good, detrended by the secular TFP growth factor γ *and* by the transitional dynamics growth component of

[8] See 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.

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, $A_{ss}^{\frac{1}{1-\theta}} = \frac{1}{\left(\frac{k}{y^{pr}}\right)^{\frac{\theta}{1-\theta}} h_{ss}^{pr}}$.

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 1977-2011[9].



The chart makes noticeable the anomaly hinted at earlier that the recovery from the Great Recession seems to be the only recovery 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 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, the data counterpart of private gross domestic investment in the model, $\widehat{x}_t$, is calculated as:

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

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

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

4 Numerical experiments

4.1 Computational method

The model was computed by approximating the system of two difference equations described at the end of subsection 3.4.3 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 second, rather than the usual first order perturbation, seemed to be a natural choice, given that what matters for comparison of the predictions of the model and the data is the level of the variables of interest, rather than their moments. As is well-known, the constant terms in the decision rules obtained with the second order approximation incorporate the effects of uncertainty ignored by the certainty equivalent assumption implicit in the first order approximation

Notice that the equations underlying the computations correspond to an environment characterized by a mixture of stochastic variables and a perfect foresight tax regime change. Put differently, the model mixes stochastic shocks with deterministic shocks known in advance. The computation of the model was therefore implemented with Dynare, a free software platform that has designed an algorithm particularly useful to deal this with this kind of "mixed mode" scenarios.[10]

The only unconventional feature of the second order perturbation method, as implemented by Dynare, 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.

[10] A brief description of this mixed mode algorithm can be found in Griffoli (2011), p. 27.

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 in the absence of technology shocks and under perfect foresight for all other variables. In particular, the TFP level is kept constant at its steady-state value and the realizations of all other stochastic variables 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. This scenario corresponds to the deterministic models case in Dynare and the associated equilibrium was computed, therefore, with the perfect foresight algorithm available in that software.[11]

4.2 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. Following Christiano, Eichenbaum, and Rebelo (2011), the paper will explore the performance of the model by increasing these two different type of taxes one at a time. In particular, in one scenario, the tax regime switches to a higher capital income tax

[11] The Dynare algorithm for deterministic models is described on page 28 of the package's User Guide mentioned earlier.

rate, leaving the labor income tax rate unchanged. In the other scenario, it is this latter tax that is raised and the capital income tax rate that is left 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 the targeted revenues, the tax policy (8) was further restricted as follows:

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

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.

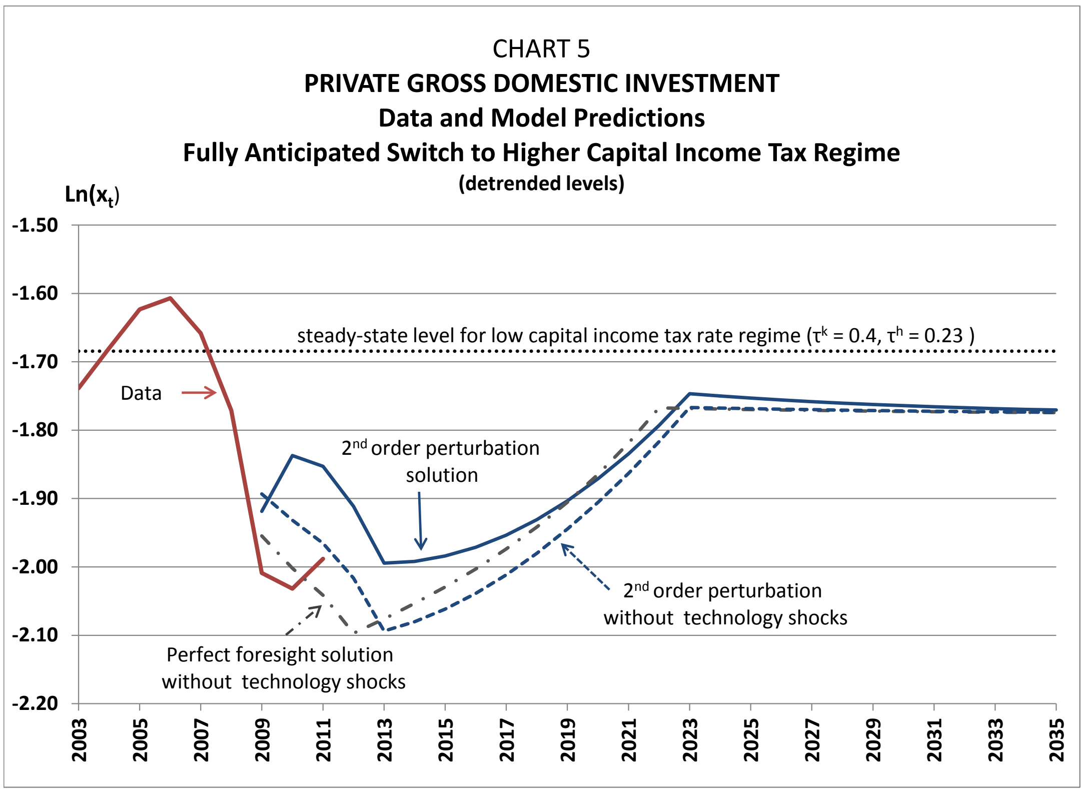
4.2.1 Tax regime with higher capital income taxes only

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:

$$\begin{aligned}
\tau^h_{2009+i} &= 0.23;\ \tau^k_{2009+i} = 0.40 \text{ for } 0 \leq i \leq 3,\\
\tau^h_{2013+i} &= 0.23;\ \tau^k_{2013+i} = 0.61 \text{ for } 0 \leq i \leq 9,\\
\tau^h_{2023+i} &= 0.23;\ \tau^k_{2023+i} = 0.45 \text{ for all } i > 0.
\end{aligned} \tag{32}$$

On top of delivering the required additional revenues, the capital income tax rate increases implied by this tax regime are of about the same size as 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, 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.

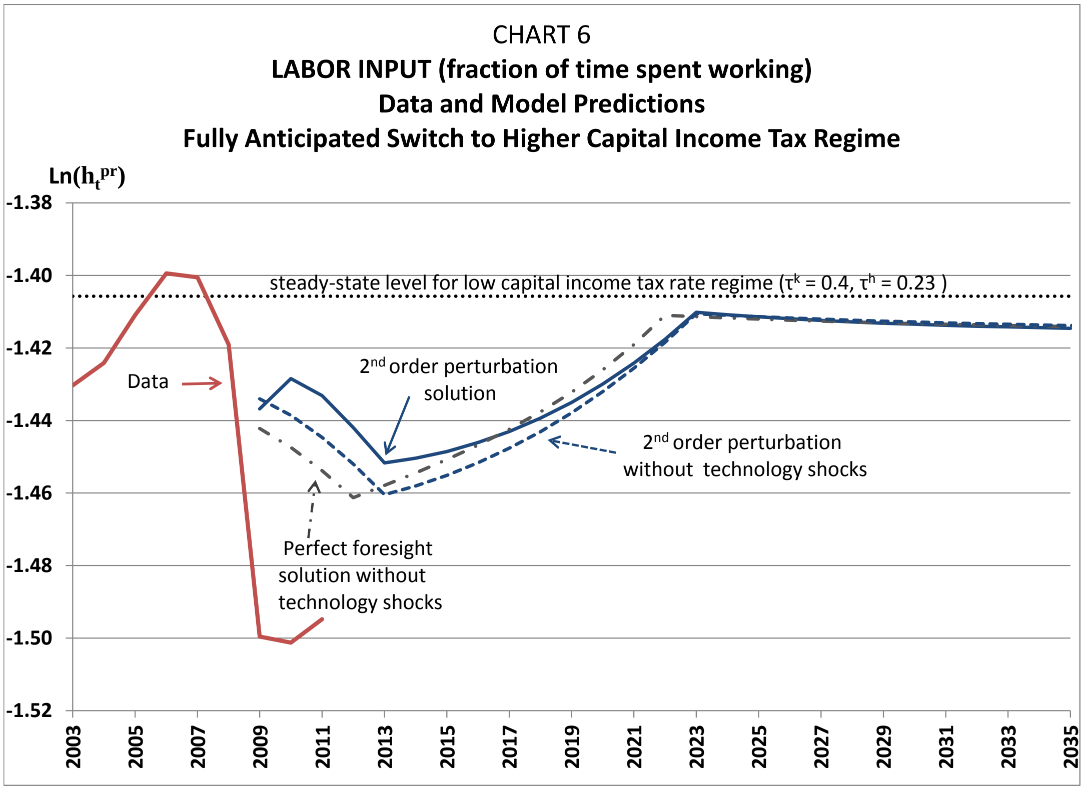
Under the alternative assumption that the Solow residuals exaggerate the fluctuations of technology shifts, which would be basically unchanged at its steady-state level ($z_t = 0$ for all t) if measured correctly, the model does even better: The predicted trajectory of investment (broken blue line) traces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

As mentioned when discussing the computational approach in section 4.1, 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).

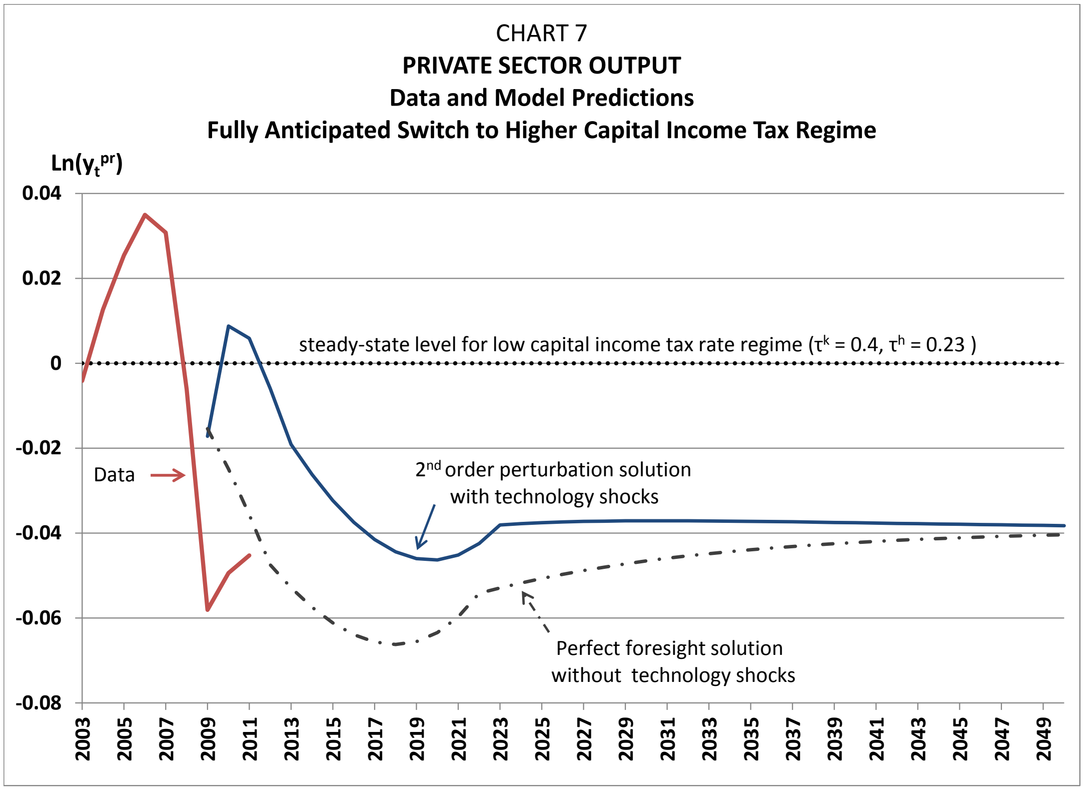
Comparison of the perfect foresight solution (dash-and-dot line) when the technology level is kept at its steady state, with the corresponding second order perturbation solution, which incorporates the effects of uncertainty, suggests that approximation issues cannot be completely ignored. The discrepancies, however, 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 domestic investment relative to trend 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, when 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 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 mentioned in the introduction.

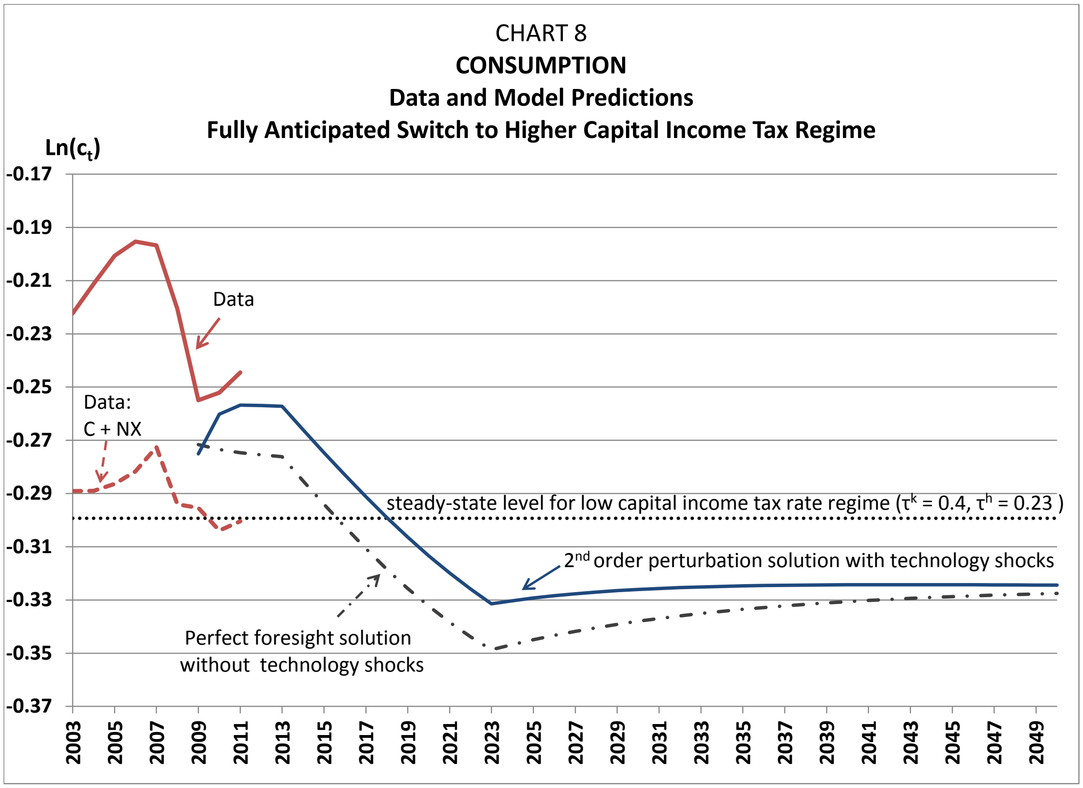


For completion, Chart 7 reports the model predictions for the trajectory of output. The chart makes apparent that the fiscal sentiment hypothesis captures the overall tendency of output to fall below its pre-Great Recession trend. However, the predictions of the model miss the actually observed dynamics of output during the first few periods immediately following the trough of the Great Recession. The reason is that, as documented in Chart 4, 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 and TFP is kept at its steady-state throughout the simulations, the model predictions for output replicate remarkably well the actually observed trajectory of that variable.

As briefly explained in the introduction, the anticipation of higher taxes on capital income should induce a temporary rise in consumption, as is typically the case in a neoclassical growth model when the initial capital stock is above its steady-state value. The model predictions for consumption plotted in Chart 8 are just a manifestation of these transitional dynamics. As documented there, consumption stays for a good number of periods above its steady-state value under the preceding lower capital income tax regime.



The economic mechanisms at work behind this result are, of course, the same as those captured by the model predictions reported in the previous charts. 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.

By contrast, most other hypothesis about the ultimate causes behind the slow recovery from the Great Recession predict that consumption remains below trend throughout that episode. Thus, the dynamics of consumption may provide particularly useful information to discriminate between those hypotheses and the fiscal sentiment hypothesis quantitatively explored in this paper.

Unfortunately, measurement problems make the comparison of the results of the model with the data less than transparent. One difficulty, already mentioned in the introduction, is that consumption in the neoclassical growth model includes the service flows from durables, not the purchase of durables recorded in the data. This problem is partially mitigated by the fact that NIPA does impute in the consumption of services aggregate the rent of owned-occupied housing, which represents a fairly large share of the typical household's overall consumption.

Another problem preventing a completely satisfactory comparison of 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.

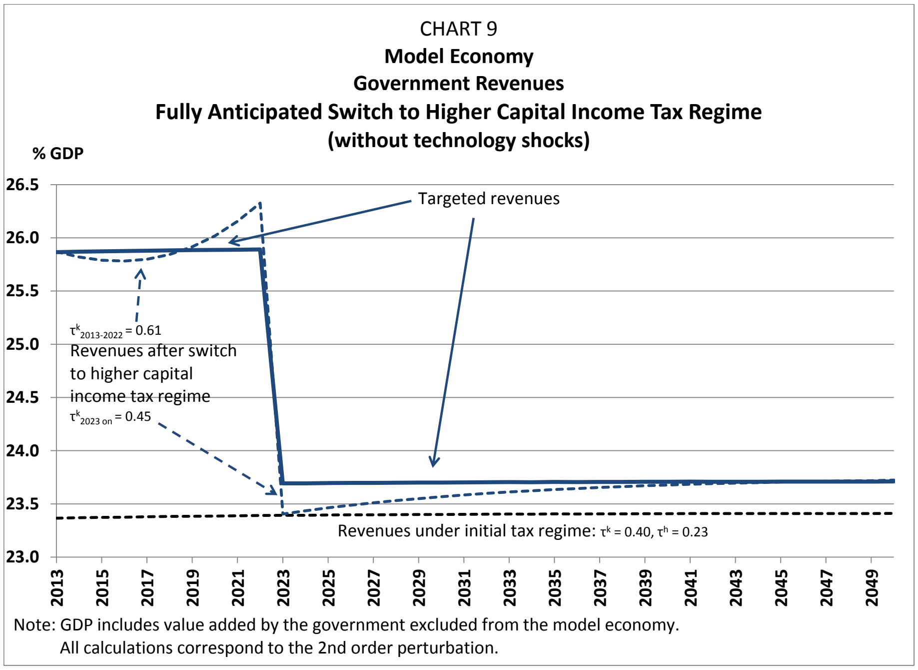
As a way to address the latter issue, the model predictions for consumption were plotted along with the data for consumption (detrended) under the alternative extreme assumption that none of the consumption good was imported (full line labeled "Data") and that all of the net exports were in consumption 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]

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 the required additional revenues.

4.2.2 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

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



tax policy:

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

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

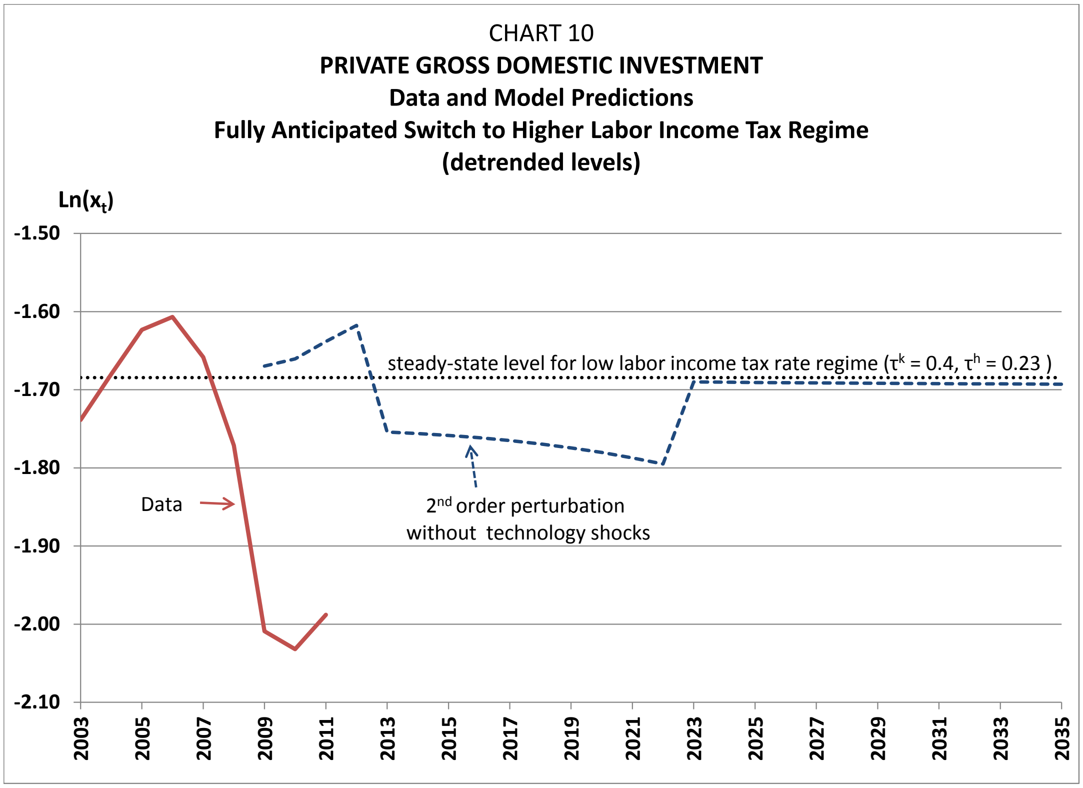


CHART 10
PRIVATE GROSS DOMESTIC INVESTMENT
Data and Model Predictions
Fully Anticipated Switch to Higher Labor Income Tax Regime
(detrended levels)
Ln(x_t)
-1.50
-1.60
-1.70
-1.80
-1.90
-2.00
-2.10
steady-state level for low labor income tax rate regime (τ^k = 0.4, τ^h = 0.23)
Data
2nd order perturbation
without technology shocks
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035

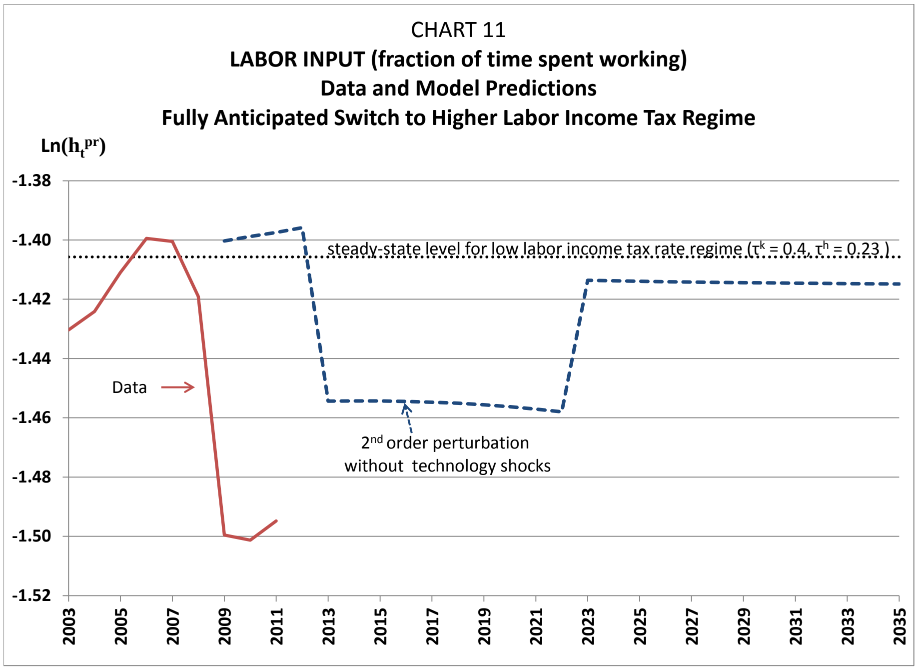


CHART 11
LABOR INPUT (fraction of time spent working)
Data and Model Predictions
Fully Anticipated Switch to Higher Labor Income Tax Regime
Ln(h_t^pr)
-1.38
-1.40
-1.42
-1.44
-1.46
-1.48
-1.50
-1.52
steady-state level for low labor income tax rate regime (τ^k = 0.4, τ^h = 0.23)
Data
2nd order perturbation
without technology shocks
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035

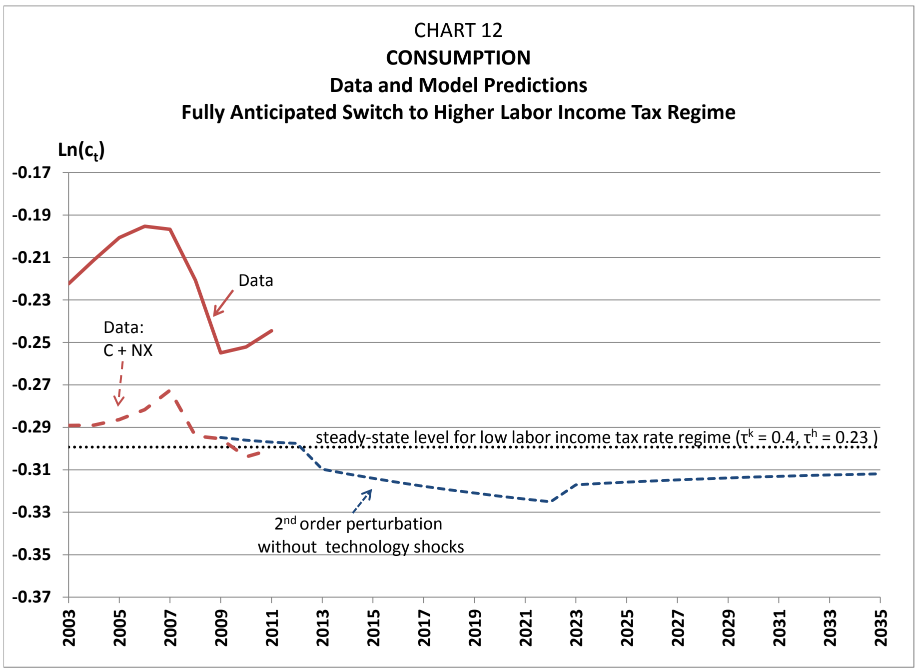


CHART 12
CONSUMPTION
Data and Model Predictions
Fully Anticipated Switch to Higher Labor Income Tax Regime
Ln(c_t)
-0.17
-0.19
-0.21
-0.23
-0.25
-0.27
-0.29
-0.31
-0.33
-0.35
-0.37
Data
Data:
C + NX
steady-state level for low labor income tax rate regime (τ^k = 0.4, τ^h = 0.23)
2nd order perturbation
without technology shocks
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035

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 Concluding Comments

Three 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.

The already mentioned paper on the size of multipliers by Christiano, Eichenbaum, and Rebelo 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 that the expansion of government consumption meant to address.

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.

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 3.5.

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:

$$gc_t = m_t + ch_t^{gc} + ck_t^{gc} = m_t + va_t^{gc}, \tag{34}$$

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

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

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

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

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

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

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

$$g_t = gc_t + x_t^{gc} + x_t^{ge} \tag{35}$$

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:

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

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:

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

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

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

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

[13] Although 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. Specifically, the government of the model economy satisfies every period the following budget constraint:

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

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 $m_t + x_t^{pu}$.

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:

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

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.

References

Becker, G. S., G. P. Shultz, and J. B. Taylor (2011): "Time for a Budget Game-Changer," *The Wall Street Journal*, April 4, p. A17.

Bureau of Economic Analysis (2005): "Government Transactions," in *Methodology Papers: U.S. National Income and Product Accounts.* U.S. Department of Commerce. Bureau of Economic Analysis.

Christiano, L. J., M. Eichenbaum, and S. Rebelo (2011): "When is the government multiplier large?" *Journal of Political Economy* 119(1): pp. 78-121.

Cociuba, S.E. and A. Ueberfeldt (2010): "Trends in Hours and the Labor Wedge," Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute, Working Paper No. 53.

Cociuba, S.E., A. Ueberfeldt, and E.C. Prescott (2009): "U.S. Hours and Productivity Behavior Using CPS Hours Worked Data: 1947-III to 2009-III," Federal Reserve Bank of Dallas. Working Paper.

Cooley, T. F. and Lee E. Ohanian (2010): "FDR and the Lessons of the Depression," *The Wall Street Journal*, August 27, p. A17.

Cole, H. and L. E. Ohanian (2004):"New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis," *Journal of Political Economy* 112(4): pp. 779-816.

Beaudry,Paul and F. Portier (2007): "When can changes in expectations cause business cycle fluctuations in neo-classical settings?," *Journal of Economic Theory* 135: pp. 458-477.

Elmendorf, D. (2011): "Testimony before the Join Select Committee on Deficit Reduction," September 13, Congressional Budget Office, available in http://cboblog.cbo.gov.

Farmer, R. E. A. (2012): "The stock market crash of 2008 caused the Great Recession: Theory and evidence," *Journal of Economic Dynamics and Control* 36: pp. 693-707.

Feldstein, M. (2011): "The Economy Is Worse Than You Think," *The Wall Street Journal*, June 8, p. A15.

Gomme, P. and P. Rupert (2007): "Theory, measurement and calibration of macroeconomic models," *Journal of Monetary Economics* 54: pp. 460-497.

Greenwood, J., Z. Hercowitz, and P. Krusell (1997): "Long-Run Implications of Investment-Specific Technological Change," *American Economic Review* 87(3): pp. 342-362.

Griffoli, T.M. (2011): "Dynare v4 – User Guide," available at http://www.dynare.org.

Jermann, U. and V. Quadrini (2012) "Macroeconomic Effects of Financial Shocks," *American Economic Review* 102 (1): 238-271.

Juillard M. (2006): "Policy Change and DSGE models," manuscript, available in http://jourdan.ens.fr/~michel/presentations/policy_change.pdf.

Kaygusuz, R. (2010): "Taxes and female labor supply," *Review of Economic Dynamics* 10: pp. 725-741.

King, R.G, C. I. Plosser, and S. T. Rebelo (1988a): "Production, Growth and Business cycles: I. The Basic Neoclassical Model," *Journal of Monetary Economics* 21: pp. 195–232.

________________________ (1988b): "Production, Growth and Business cycles: II. New Directions," *Journal of Monetary Economics* 21: pp. 309–341.

Kydland, F. E. and E.C. Prescott (1982): "Time to build and aggregate fluctuations," *Econometrica* 50: pp. 1345–1370.

Lucas, R. E., Jr. (2011): "The Weekend Interview with Robert Lucas: Chicago Economics on Trial," *The Wall Street Journal*, September 24, p. A13.

McGrattan, E. (2010): "Capital Taxation During the U.S. Great Depression," Federal Reserve Bank of Minneapolis, Working Paper 670 (October).

McGrattan, E. and E.C. Prescott (2012): "The Great Recession and Delayed Economic Recovery: A Labor Productivity Puzzle?" in *Government Policies and the Delayed Economic Recovery*, L. E. Ohanian, J. B. Taylor, and I. J. Wright. Hoover Institution Press. Stanford University. Stanford, California. USA.

Mehra, R. and E.C. Prescott (2008): "The Equity Premium: ABCs," in *Handbook of the Equity Risk Premium*, edited by R. Mehra. North Holland. Amsterdam.

Poterba, J.M. (1998): "Rate of return to corporate capital and factor shares: new estimates using revised national income accounts and capital stock data." *Carnegie–Rochester Conference Series on Public Policy* 48, 211–246.

Rupert, P. (2008): "Comment on: 'Taxes and the global allocation of capital'," *Journal of Monetary Economics* 55: pp. 62-64.

Siegel, J. (2002): Stocks for the Long Run, 3rd ed., Irwin, New York.