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Abstract

Labor input growth during the recovery of the U.S. economy from the Great Recession of 2008-2009 has been considerably lower than expected. A number of scholars have attributed this disappointing outcome to the prospect of higher taxes, induced by the fiscal imbalances that will materialize in coming decades under current policies. The paper examines this fiscal sentiment hypothesis from the perspective of a neoclassical growth model, under the assumption that the typical household's preferences can be represented by a utility function that implies a constant intertemporal (Frisch) elasticity of substitution for aggregate hours of work, and for a hypothetical tax regime that incorporates the Congressional Budget Office's assessment of the U.S. fiscal situation. The paper finds that the empirical relevance of the fiscal sentiment hypothesis depends on whether this Frisch elasticity of labor supply is closer to the relatively large values needed to account for the observed volatility of labor input at business cycle frequencies, than to the lower values estimated by microeconomic and quasi-experimental studies.

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1 Introduction

Scientists can hardly resist the temptation of scrutinizing in great detail rare episodes that replicate at a larger scale obvious dimensions of the more familiar events from which they typically extract clues to formulate hypothesis about the nature of a phenomenon of interest. Comparison of the features of the infrequent large-scale event with those of the more commonly observed regular-size episodes can help them to establish whether the insights gained from studying the latter turned out to be correct or misleading.

This is precisely the reason why the severe economic contraction that the U.S. experienced in 2008-09, the so-called Great Recession, has attracted so much attention in the economics profession. The unusual depth of that recession, as well as its subsequent dynamics, seem to offer the right kind of evidence to eventually question or validate the different interpretations of economic fluctuations that have previously emerged from the study of more frequent and milder business cycles.

Particularly relevant to that end is the observation that the recovery that followed the Great Recession has been extremely weak as of the time of this writing. This is contrary to the predictions of a large class of models that have incorporated a variety of frictions and mean-reverting stochastic shocks in the basic analytical framework of the neoclassical growth model. As is well-known, the built-in mechanisms of this framework imply that the deeper a contraction, the stronger the subsequent expansion. The Great Recession, the most severe contraction on record since the Great Depression, should have been followed, therefore, by a vibrant expansion.

The fact that the script hasn't proceeded as expected has prompted the speculation that the difficulty that the type of models just described seem to have in accounting for the weak recovery from the Great Recession must be ultimately traced to the inherent dynamics of their analytical framework of reference. Consistent with this view, Farmer (2012) has proposed that the neoclassical growth model with a unique steady-state equilibrium should be abandoned in favor of models that feature multiple equilibria, driven by uncertainty extrinsic to the model ("sunspots").

Other scholars, such as Lucas (2011), have argued that the neoclassical growth model with a unique steady-state equilibrium shouldn't be declared inherently incompetent to account for the weakness of the recovery from the Great Recession, before considering the possibility that what has been holding the recovery back is the prospect of higher taxes, prompted by the sudden realization in the aftermath of that episode of the unprecedented size of the fiscal imbalances that the U.S. has ever faced during peacetime.

Kydland and Zarazaga (2012) explored this "fiscal sentiment" conjecture with quantitative rigor and found that it is not necessary to abandon the analytical framework of neoclassical growth model to account for a substantial fraction of the anemic job growth observed in the recovery from the Great Recession, provided: 1) the higher tax rates are expected to be concentrated almost exclusively on capital income, and 2) the technology level (total factor productivity) didn't rise above its pre-Great-Recession trend during that recovery nearly as much as suggested by traditionally calculated Solow residuals.

That study left unanswered, however, the question of the sensitivity of the results to the intertemporal elasticity of substitution, or Frisch elasticity, of the labor supply. This is a potentially important parameter from a quantitative point of view, because it controls the response of labor input to changes in the real wage profile induced by tax policies that shift the tax burden over time. Low values for the Frisch elasticity are less likely to deliver the favorable results to the fiscal sentiment hypothesis reported by Kydland and Zarazaga, who fixed that elasticity at a relatively high value.

There is, however, considerable disagreement in the literature as to whether this elasticity is high or low. This is not a trivial debate, because according to Prescott (2006), in order to generate business cycles with the properties of those seen in the U.S., the Frisch elasticity of aggregate hours of work must be considerably larger than the value of 0.75 that Chetty, Guren, Manoly, and Weber (2011) have recommended as reasonable for representative agent models, after carefully examining the results reported by microeconomic and quasi-experimental studies.

Despite the importance of the subject, Kydland and Zarazaga stayed away from conducting a sensitivity analysis of their results with respect to the Frisch elasticity of labor supply, because for consistency with previous related studies, they represented preferences with a utility function that implied that that elasticity is not constant, but changes with the level of hours worked. This feature may introduce potentially severe approximation errors in the predictions of the model if they are computed, as it was the case in Kydland and Zarazaga, with perturbation methods around the deterministic steady-state. Such methods implicitly assume that the Frisch elasticity stays constant at its steady-state level, regardless of the size of the deviations of labor input from its corresponding steady-state value.

This paper addresses that difficulty by reexamining the particular higher capital income taxes regime considered by Kydland and Zarazaga, under the lens of a neoclassical growth model that assumes that the typical households' preferences over consumption and leisure are represented by a utility function that implies a Constant Frisch Elasticity (CFE hereafter) of aggregate hours of work. Specifically, the response of aggregate hours, that is, of labor supply both at the intensive and extensive margins, to changes in the real wages profile are independent of the fraction of time that households devote to work and, in particular, of the size of the deviations of labor input from its steady-state value. This property eliminates, therefore, the source of the computational approximation errors just mentioned.

The paper finds that the fiscal sentiment hypothesis explored by Kydland and Zarazaga can still account for the lackluster job growth observed in the U.S. during the recovery from the Great Recession, provided a third condition is added to the two listed above when the utility function is in the CFE class: the Frisch elasticity of aggregate hours of work must be closer to the relatively large values proposed by the real business cycle literature, than to the much lower ones estimated with other approaches.

2 Labor Market Conditions: The Evidence

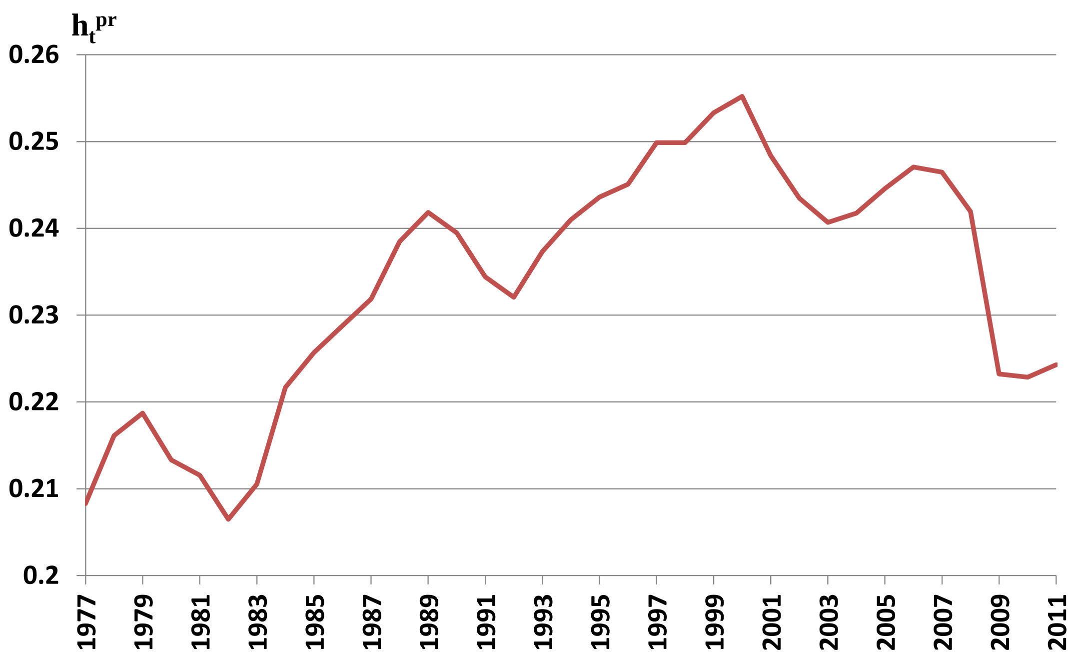
This section examines the labor market evidence that will be used to judge the performance of the model economy for different values of the constant Frisch elasticity.

The variable typically used to measure labor input in the neoclassical growth model is the fraction of available time that households allocate to work in the marketplace, instead of to household production or leisure activities. In the model economy of this paper, however, the labor input that is determined endogenously is the fraction of the available time that the typical household is at work on average in the *private sector* of the economy. The corresponding fraction allocated to work for government agencies is taken parametrically instead.

The reason for this differential treatment of the labor input absorbed by the private sector and by government agencies is that it improves the mapping between the model and the data, as extensively discussed in the above mentioned study by Kydland and Zarazaga.

Chart 1 documents the time series for the fraction of available annual time that the typical household has allocated on average to work for the private sector, from 1977 until the last available observation.

CHART 1
Fraction of Time Spent Working in the Private Sector



The fraction in the chart was obtained by taking the product of persons at work and the average hours they have been at work in the private sector each year, divided by the available discretionary time that the working-age population (over 16 years old) can typically allocate to work in any given year.

The source of the data that enter in the numerator, the number of persons at work and the average hours they are at work, is the household survey conducted by the Bureau of Labor Statistics. The discretionary time, that is, the time that each working-age member of the population can dedicate to discretionary activities is roughly 100 hours a week (or 5200 hours a year,) as commuting to and from work, the physiological need to sleep, visits to the doctor or the hairdresser, etc., use up, on average, the remaining 68 hours of chronological time in a week.

Although this discretionary time can grow as a result of technological progress that, for example, reduces the time needed to commute to and back from work, the impact of this factor is quantitatively small when compared with the growth of its other component, working age population. Thus, the fraction in the chart basically detrends total hours worked by the rate of growth of working age population.

That detrending procedure would have rendered the fraction of time that households work in the private sector stationary, if the U.S. economy had been fluctuating along a balanced-growth path. As is well known, a necessary condition for balanced growth is that the fraction of time that households devote to work is a stationary variable. In graphical terms, this means that that fraction should have fluctuated over time up and down a horizontal line.

As is obvious from the chart, however, even after removing the growth in total hours at work originated in demographic growth, the fraction of time that households were at work in the U.S. private sector displays an upward drift. This apparent lack of stationarity in the series poses a problem for the quantitative predictions of the model economy, because its parameters will be calibrated on the assumption that the actual one under study was indeed on a balanced growth path over the period under study.

The lack of conformity between theory and data doesn't imply that the balanced growth assumption is unrealistic, because the steady rise of the labor input measure in Chart 1 is mostly a manifestation of transitional dynamics effects: the abnormally high fraction of population in working age introduced by the baby-boomers generation and the rapid pace at which women were entering the labor force until approximately the beginning of the 21st century. By the very nature, these effects were bound to die over time and, as that happened, the fraction of time that households are at work in the U.S. should converge to the well-defined value predicted by balanced growth theory.[1]

In any case, temporary as the factors responsible for the non-stationarity of the historical series presented in Chart 1 may have been, they still make difficult the task of identifying the long-run value, or trend, to which this series will eventually converge. The correct identification of that parameter is critical for two reasons. First, it determines the deviations of observed labor input from that long-run trend and, therefore, the fraction of it that the model will be able to account for. Second, this parameter is part of the deterministic steady state of the model economy and plays, therefore, an important role in those quantitative predictions, obtained with perturbation methods around that steady state.

Given the lack of guidance from the literature on this hitherto unnoticed difficulty, the paper adopted the same steady state value for the fraction of time that households work in

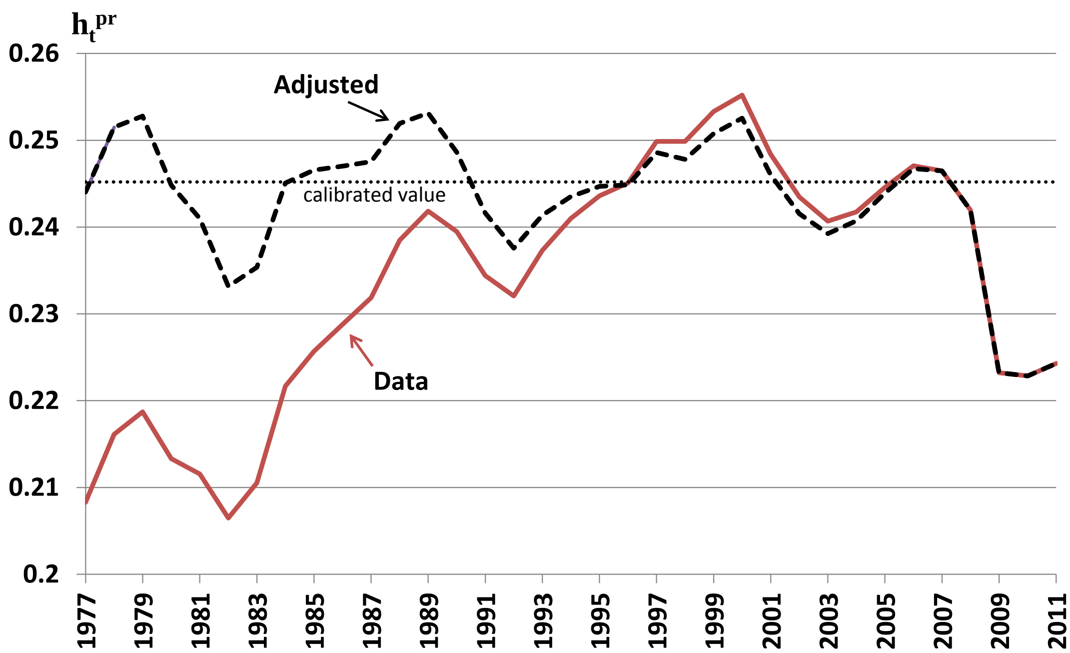
[1] It is true that this implication applies to the fraction of time that households are at work overall, regardless of whether in the private sector or in government agencies. But motivated by the evidence, the model assumes that the fraction of time that households work for those agencies is constant on average. This implies convergence of the fraction of time that households work for the private sector to a well-defined value as well.

the private sector, denoted h_{ss}^{pr}, proposed by Kydland and Zarazaga:

$$h_{ss}^{pr} = 0.24519$$

Those authors motivated that choice in the observation that the time series for h_t^{pr} seems to have settled lately near the sample peak. This suggested to them to smooth the entire series with an HP-filter and set h_{ss}^{pr} equal to the value of the filtered series in 2007, the last year of the 1977-2007 period adopted as reference for the calibration of all the parameters of the model. The result of these adjustments, described in detail in Kydland and Zarazaga, are captured in Chart 2.

CHART 2
Fraction of Time Spent Working in the Private Sector
Observed and Adjusted



The weakness of the labor market during the recovery from the Great Recession is apparent in the large decline that the fraction of time that households were at work in the private sector exhibits during that episode with respect to its trend, h_{ss}^{pr}, identified by the dotted line in the chart. The goal of the paper is to investigate the fraction of these deviations of labor input from its pre-Great-Recession trend that the model can account for under different values of the Frisch elasticity parameter.

3 The Model

The model economy is the same as in Kydland and Zarazaga, except in the utility function that represents the preferences of the typical household which, as mentioned earlier, will be assumed for this paper to be of the CFE type.

For the same reasons given in that paper, 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.

As in Kydland and Zarazaga, all real variables were obtained by dividing their nominal counterparts by the price index of non-durable goods and services. This procedure guarantees that all investment-specific technological progress is transformed in labor-augmenting technological progress, the only kind of technological progress consistent with balanced growth, as discussed in King, Plosser, and Rebelo.

Also, when applicable, all real variables are represented in terms of per population in working age and detrended by the long-run growth rate of total factor productivity. This procedure typically removes the secular trend from the variables of interest. The exception, as discussed in the previous section, is the series for the fraction of time that households were at work in the private sector, which had to be rendered stationary with the HP-filter procedure outlined above and described in detail in Kydland and Zarazaga.

3.1 The Typical Household's Choice Problem

The typical household that in the abstraction of the model stands in for the large number of them who inhabit the actual economy is assumed to have preferences defined over infinite streams of consumption $\{c_t\}_t^\infty$ and the fraction of available time devoted to work $\{h_t\}_t^\infty$, that can be represented by a time-separable CFE utility function.

Accordingly, this household solves the following maximization problem:

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

subject to the budget constraint:

$$c_t + (1+n)(1+\gamma)k_{t+1} \leqslant (1-\tau_t^h)w_t h_t + \left[1 + (1-\tau_t^k)(r_t - \delta)\right] k_t + \tau_t \tag{2}$$

where $\beta > 0$, n 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, h_t the fraction of available time the representative household allocates to work in the market, $\sigma > 0$ is the inverse of the intertemporal elasticity of consumption, $\kappa > 0$ a parameter that controls the household's valuation of consumption relative to work, φ the constant Frisch elasticity of labor supply, τ_t^h the tax rate on labor income, w_t the wage rate in terms of consumption per unit of the available time the stand-in household devotes to work, τ_t^k the tax rate on capital income, r_t the rental price of private sector capital, k_t, and τ_t lump-sum transfers (taxes if negative.)

Notice that the discount factor β appears multiplied by $(1+\gamma)^{(1-\sigma)}$. 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 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.

Implicit in the statement of the typical household's maximization problem is the assumption that such household can distribute its total available time, normalized to 1, among non-market activities (generally labeled as "leisure") and work for the private firms and public sector agencies. This household faces, therefore, the following restriction on the allocation of time:

$$1 = l_t + h_t^{pr} + h_t^{pu} \tag{3}$$

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 value added by both that private and public sectors is deemed 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 Kydland and Zarazaga, induce a severe overestimation of the labor input absorbed by the private sector and, therefore, of output, consumption, and investment.

Moreover, for consistency with the NIPA (National Income and Product Accounts) 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}:

$$(1 + n)(1 + \gamma)k_{t+1} = x_t + (1 - \delta)k_t. \tag{4}$$

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 (4) 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.

3.2 Private Sector Firms' Maximization Problem

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. For the reasons given in Kydland and Zarazaga, the decision of the latter are guided by administrative, rather than profit-maximizing considerations and are taken, therefore, as exogenous.

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, θ the proportion of the remuneration to capital services in the private sector value added, 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.

The computational approach will take into account this stochastic process in calculating the decision rules, but will assume nevertheless that TFP, given by Ae^{z_t}, stayed at its steady-state value A throughout the recovery from the Great Recession. The assumption that $z_t = 0$ during that episode is meant to pay heed to the common objection that the efficiency with which societies transform inputs into output doesn't move as much as suggested by Solow residuals.

Given that all variables have been detrended, the growth factor e^{γ} in (5), approximated by $(1+\gamma)$ in the quantitative implementation of the model, is obviously redundant and will be eliminated later. It was made explicit here, however, in order to emphasize that the model economy is characterized by secular technical progress that the Cobb-Douglas production function permits one to represent as labor augmenting. As shown by Greenwood, Hercowitz, and Krusell (1997), when the production function is of that type, an economy that exhibits investment-specific, or capital-embodied, technological change can be represented as one with labor-augmenting technical progress, provided the depreciation rate in (4) is interpreted as the economic, rather than physical, depreciation rate.[2]

The representative firm that stands for the large number of them making decisions in the economy solves, therefore, the following maximization problem:

$$\underset{h_t^{pr},\, k_t}{Max} \left[A e^{z_t} k_t^{\theta} (h_t^{pr})^{1-\theta} - w_t h_t^{pr} - r_t k_t \right] \tag{7}$$

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.

3.3 Public Sector Policies

Following Kydland and Zarazaga, for consistency with the behavioral assumptions implicit in the NIPA methodology, 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 to what extent the ability of the fiscal sentiment hypothesis to account quantitatively for the relatively poor labor market conditions observed in the recovery from the Great Recession depends on the value of the Frisch elasticity of aggregate hours of work, φ. Although the historically high fiscal deficits observed and projected after that episode are one reason for expecting higher future taxes, 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.

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

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

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 government 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

[2] The constant economic depreciation rate in (4) assumes implicitly as well a constant growth rate of investment-specific technological progress.

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.

3.3.2 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.

3.3.3 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}, 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.

It is important to note that the government budget constraint (8) implies that the additional revenues generated by the higher capital income taxes regime introduced in the next section 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.

3.3.4 Tax Policy

For the motivations offered in Kydland and Zarazaga, 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.

It is worth pointing out that the notation $t = s$ under the summation sign in the typical household's maximization problem was introduced precisely for consistency with this tax policy configuration. That is, the model is silent about households' behavior and perceptions prior to period s. Odd as it may seem, this assumption plays a critical role in alternative "consumer sentiment" stories that interpret the Great Recession and subsequent weak recovery as the result of the subjective "gloomy self-fulfilling mood" that suddenly at time s, presumably corresponding to the period right before the recession, permeated the households and businesses' views of their economic prospects.

As mentioned before, Kydland and Zarazaga established that the fiscal sentiment hypothesis can account for the slow recovery of the U.S. economy from the Great Recession, provided the higher taxes are expected to fall almost exclusively on capital income.

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

$$\left\{\{\tau_{t=i}^h\}_{i=0}^{\infty}, \{\tau_{t+i}^k\}_{i=0}^{j}, \{\tau_{t+j+n}^k\}_{n=1}^{\infty}\right\}_{t=s};\ \tau_{t+j+n}^k > \tau_{t+i}^k, \text{ for all } i \text{ and } n. \tag{12}$$

where $\tau_{t=i}^h = \tau^h$, the tax on labor income, remains fixed at its average value over the calibration reference period. This configuration of the tax regime formalizes the fiscal sentiment hypothesis 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.

3.4 Competitive Equilibrium

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:

$$\frac{\sigma\kappa\left(1+\frac{1}{\varphi}\right)h_t^{\frac{1}{\varphi}}}{1-\kappa\left(1-\sigma\right)h_t^{1+\frac{1}{\varphi}}}c_t=(1-\tau_t^h)w_t \tag{13}$$

$$\beta E_t\left[(1-\tau_{t+1}^k)(r_t-\delta)+1\right]=E_t\left[\frac{c_{t+1}}{c_t}\frac{(1+\gamma)\left(1-\kappa\left(1-\sigma\right)h_t^{1+\frac{1}{\varphi}}\right)}{1-\kappa\left(1-\sigma\right)h_{t+1}^{1+\frac{1}{\varphi}}}\right]^{\sigma} \tag{14}$$

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

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

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

$$w_t=(1-\theta)Ae^{z_t}\left(\frac{k_t}{h_t^{pr}}\right)^{\theta} \tag{15}$$

$$r_t=\theta Ae^{z_t}\left(\frac{h_t^{pr}}{k_t}\right)^{1-\theta} \tag{16}$$

Replacing (15) into (13), (16) into (14), and taking into account that $h_t=h_t^{pu}+h_t^{pr}$, consolidates the four equations above into the following two:

$$\sigma\frac{\kappa\left(1+\frac{1}{\varphi}\right)(h_t^{pu}+h_t^{pr})^{1+\frac{1}{\varphi}}}{1-\kappa\left(1-\sigma\right)(h_t^{pu}+h_t^{pr})^{1+\frac{1}{\varphi}}}\frac{c_t}{(h_t^{pu}+h_t^{pr})}=(1-\tau_t^E)(1-\theta)Ak_t^{\theta}(h_t^{pr})^{-\theta} \tag{17}$$

$$\beta E_t\{(1-\tau_{t+1}^k)[\theta Ak_{t+1}^{\theta-1}(h_{t+1}^{pr})^{1-\theta}-\delta]+1\}=E_t\left[\frac{c_{t+1}}{c_t}\frac{(1+\gamma)\left(1-\kappa\left(1-\sigma\right)h_t^{1+\frac{1}{\varphi}}\right)}{1-\kappa\left(1-\sigma\right)h_{t+1}^{1+\frac{1}{\varphi}}}\right]^{\sigma} \tag{18}$$

In addition to (17) and (18), a competitive equilibrium allocation will have to satisfy the resource constraint:

$$c_t + x_t = [1 + (vy + \varepsilon_t^{gc}) - (gy + \varepsilon_t^{ge})]\, Ae^{z_t} k_t^{\theta} (h_t^{pr})^{1-\theta} \tag{19}$$

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 (4) 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 (17) and (18).

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}.

Notice that the specification of tax policy (12) 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.

Those decision rules and, therefore, the quantitative predictions of the model will depend on the deterministic steady-state of the economy, in turn determined by the value of the parameter of interest, φ, which controls the constant Frisch elasticity of labor supply.

4 Calibration of the model

4.1 Parameters and steady-state relationships

Since the model economy is identical to that in Kydland and Zarazaga, except for the specification of the utility function, it was calibrated in the same manner, to replicate long-run averages of the relevant variables over the period 1977-2007.

The following table summarizes the resulting parameter values that coincide with those selected by Kydland and Zarazaga:

Parameter/Steady-State Relationship	Value
β (discount factor)	0.962635
x/y^{pr} (investment-output ratio)	0.185539
δ (depreciation rate)	0.05
η (working-age annual population growth rate)	0.012358
i (before-tax annual return on private capital)	0.08
γ (TFP annual growth rate)	0.00664
k/y^{pr} (private capital/private output ratio	2.686864
θ (private capital income share)	0.349292
gy (general government private sector output absorption)	0.085798
vy (value added by government enterprises)	0.012658
h^{pr} (fraction of time worked in private sector)	0.24519
h^{pu} (fraction of time worked in public sector)	0.03526
τ_t^k (capital income tax rate)	0.40
τ_t^h (labor income tax rate)	0.23

There were a few parameters that couldn't be calibrated directly from the data or by targeting steady-state relationships: the inverse of the intertemporal elasticity of substitution for consumption, σ, the constant Frisch elasticity of labor supply that is the focus of this paper, φ, and the parameter that controls the typical household's relative preference for consumption or leisure, κ.

The first of these parameters, σ, was set equal to 2, a value commonly used in the literature.

As mentioned in the introduction, there is considerable disagreement in the literature as to whether the Frisch elasticity parameter φ falls in the relatively low range of 0.3-0.75 implied by the studies by MaCurdy (1981) and Chetty *et al.*, or in the range of 2 or above suggested by the business cycle literature. Therefore, the paper investigated the predictions of the model for three different values of that elasticity: $\varphi = 0.5$, $\varphi = 1.0$, and $\varphi = 2.0$. For each of these values, the remaining preference parameter κ was adjusted so that in steady state the typical household devotes to work in the private sector the calibrated fraction of time indicated in the table above.

4.2 Higher capital income tax regime

As argued by Kydland and Zarazaga, it is eventually possible to find some increase in the capital income tax rate that can rationalize the weak recovery of employment during the recovery from Great Recession. Without restrictions to the tax regimes that can be plausibly considered, the fiscal sentiment hypothesis wouldn't be, therefore, of much scientific interest

One way to introduce the necessary quantitative discipline is to assume that the tax increases cannot be arbitrary large, but just high enough to generate the additional revenues necessary to correct the fiscal imbalances currently present in the U.S.

It seemed 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.[3]. Following Kydland and Zarazaga, this paper adopted the figure of the more benign scenario, \$3.8 trillion, which implies that the higher capital tax regime must generate additional revenues equivalent to 2.5% of GDP for a decade.

Thus, as Kydland and Zarazaga, the paper assumes that the first period of the analysis, identified as period s in the characterization of the tax policy (12), coincides chronologically with the year 2009, which marked the trough of the Great Recession. Those authors formalized the fiscal sentiment hypothesis with the assumption that it was also then that households and businesses became aware that the tax rates on capital income 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

[3]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.

higher revenues of just 0.5 % 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.

As a result, the tax policy (12) was further restricted as follows:

$$\begin{aligned} &\left\{ \{\tau^h_{t+i}\}_{i=0}^{\infty}, \{\tau^k_{t+i}\}_{i=0}^{3}, \{\tau^k_{t+3+i}\}_{i=1}^{10}, \{\tau^k_{t+13+i}\}_{i=1}^{\infty} \right\}_{t=2009}; \\ &\quad \tau^h_{2009+i} = 0.23 \text{ for } 0 \le i \le \infty; \\ &\quad \tau^k_{2009+i} = 0.40 \text{ for } 0 \le i \le 3; \\ &\quad \tau^k_{2013+i} = \tau^k_{2013} \text{ for } 0 \le i \le 9; \\ &\quad \tau^k_{2023+i} = \tau^k_{2023} \text{ for all } i > 0. \end{aligned} \tag{20}$$

Of course, the tax rates necessary to collect the targeted additional revenues between 2013 and 2022 are endogenous, and had to be recalculated for every value of the Frisch elasticity parameter φ, with an iterative procedure defined over a grid of possible tax rates τ^k such that setting $\{\tau^k_t\}_{t=2013}^{2022} = \tau^k$ would deliver the desired average extra revenues. The algorithm used to that effect, and to study the model predictions for labor input, is briefly discussed next.

5 Computational Method

The model was computed by approximating the system of two difference equations (17) and (18) 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.

Notice that the equations in question 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.

An unconventional feature of the second order perturbation method, as implemented by Dynare and discussed in more detail in Kydland and Zarazaga, 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.

In order to accommodate the possibility acknowledged earlier that the Solow residuals measure the stochastic technology level with considerable error, the computational experiments assumed that it stayed at its steady state throughout the recovery from the Great Recession.

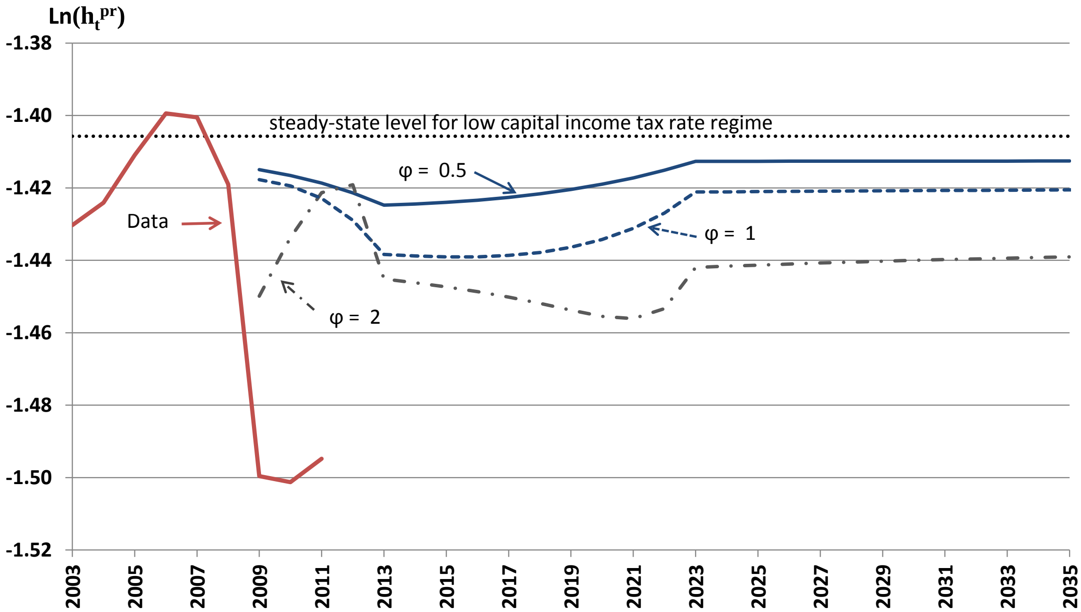
6 Findings

For each of the three different values of the Frisch elasticity considered in the simulations, the preference parameter κ and the capital income tax rates associated with the higher taxes regime (20) were recalibrated with the criteria indicated in the previous section. The table below shows the result of this recalibration:

φ	κ	τ_t^k for 2013-2022	τ_t^k from 2023 onwards
0.5	6.705147	0.56	0.46
1.0	3.045952	0.58	0.48
2.0	2.337411	0.59	0.52

Chart 3 reports the corresponding predictions of the model for labor input, influenced by a complex interaction between wealth and intertemporal substitution effects.

CHART 3
LABOR INPUT
Data and Model Predictions
for Different Values of the Frisch Elasticity of Labor Supply



The perceived higher taxes on capital income reduced perceived wealth and should, therefore, induce households to work more, given that leisure is a normal good. By the same token, households would like consume their savings (capital) before they are taxed away. This is accomplished by working less than it would be needed to save enough to replenish the fraction of the capital stock that depreciates every period.

The chart suggests that when the Frisch elasticity is 0.5, intertemporal effects dominate wealth effects and induce some deterioration of labor market conditions during the recovery from the Great Recession, but not by enough to give the fiscal sentiment conjecture the status of a quantitative relevant hypothesis. The performance of the model with respect to labor input improves somewhat, but not that much, when the Frisch elasticity of aggregate hours of work is set equal to 1. These results suggest that the model predictions for the performance of labor input during the recovery from the Great Recession will not be particularly favorable to the fiscal sentiment hypothesis if that elasticity is set equal to the value of 0.75 recommended by Chetty *et al.*

On the other hand, when that elasticity is set equal to the value of 2 that the business cycle literature would favor, the model does considerably better, to the point that it predicts nearly fifty percent of the decline of labor input from its pre-Great-Recession trend observed during the recovery from that episode. The pattern, however, is highly volatile, probably a reflection of the complicated dynamics induced by the intertemporal substitution and wealth effects intuitively described a few paragraphs above.

7 Conclusion

The value of the intertemporal substitution, or Frisch elasticity, of aggregate hours of work is the subject of a long-standing debate in the economics profession. The reason is that the low value of 0.3 estimated by MaCurdy, or of 0.75 recommended by Chetty *et al.,* is too low to account for the business cycle phenomenon.

This paper has been motivated by the perception that the resolution of the controversy is equally critical for the quantitative relevance of the hypothesis examined by Kydland and Zarazaga (2012) that the prospect of higher taxes on capital income can account for a substantial fraction of the job market weakness observed during the recovery from the Great Recession.

The paper examined that fiscal sentiment hypothesis from the perspective of a neoclassical growth model, under the assumption that the typical household's preferences can be represented by a utility function that implies a constant intertemporal (Frisch) elasticity of substitution for aggregate hours of work, and for a hypothetical tax regime that incorporates the Congressional Budget Office's assessment of the U.S. fiscal situation.

The finding of the paper is that the higher taxes hypothesis can account for the unusually weak performance of aggregate hours of work during the recovery from the Great Recession, provided the associated Frisch elasticity is closer to the large values proposed by the real business cycle literature, than to the relatively low values estimated by microeconomic and quasi-experimental studies.

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