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Carlos Zarazaga

Federal Reserve Bank of Dallas
Research Department
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Carlos E. J. M. Zarazaga†

Federal Reserve Bank of Dallas

Abstract

Microeconomic studies keep reporting that the intertemporal substitution in consumption and the Frisch elasticity of aggregate labor supply have significantly lower values than macroeconomic models find consistent with the dynamics of aggregate variables. The paper argues that in the U.S. such dynamics have been influenced since 2013 by the temporary spending cuts imposed by the so-called budget sequestration. The paper exploits the "policy experiment" features of that measure to gauge macroelasticity values from the evidence associated with it, adopting to that effect a macroeconomic model constructed according to the methodological principles advocated by the real business cycle literature. Readings of the preliminary evidence available at the time of this writing with such a measuring device do not particularly favor high values for either of the two macroelasticities under study. Although it's too early to be conclusive, this finding illustrates how existing disagreements about the value of key macroelasticities can eventually be narrowed down by applying the approach proposed in this paper to the evidence coming out of the budget sequestration policy, as it unfolds over time.

JEL Classification: E22, E24, E32, E65, J22.

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†E-mail: carlos.zarazaga@dal.frb.org. Address: Federal Reserve Bank of Dallas, Research Department, 2200 N. Pearl St., Dallas, TX 75201.

1 Introduction

The values of key elasticities governing the dynamics of macroeconomic models remain an important unresolved issue in the economics profession. The lack of consensus on the empirically plausible values to impose on the *labor-held-constant* intertemporal elasticity of substitution in consumption (IES hereafter) and the Frisch elasticity of labor input is not a minor issue, because the quantitative accounts of important economic phenomena, such as business cycles or the impact of tax policies on employment and output, hinges critically on the values assigned to those parameters. To draw an analogy with another sciences, those parameter values are as critical to the predictions of economic models as the value of the Hubble constant is to the predictions of astronomical models. The value of that constant was the subject of heated debates among astronomers until the observations obtained with the Hubble telescope confined the discrepancy between alternative estimates to a narrow range of 10%.

Economists so far haven't been able so far to build an equally successful measuring device, and the profession remains divided about empirically acceptable values of the parameters just mentioned. Microeconomic studies that look at the evidence for particular groups of individuals or households keep reporting Frisch elasticities of aggregate labor supply that have significantly lower values than macroeconomic models infer from the dynamics of aggregate variables.

Despite this cacophonous chorus of estimates, some progress has been made. In a recent contribution, Chetty, Guren, Manoli, and Weber (2013) found that macro and microeconomic studies agree, after all the relevant adjustments have been made, on the values of the labor supply elasticities that are relevant to measure the impact of taxes on aggregate hours worked. The same study, however, casts a more sobering note on the prospects of settling existing disputes with respect to the values of the Frisch elasticity for aggregate hours that is relevant for the interpretation of business cycle fluctuations. In particular, Chetty *et* *al.* report that *"micro and macro estimates of extensive margin intertemporal substitution elasticities differ by an order of magnitude. Quasi-experimental estimates of extensive margin intertemporal substitution elasticities are around 0.25, whereas leading macro models all imply intertemporal substitution extensive margin elasticities around 2."*

Mulligan (1995) reached a similar disappointing conclusion with an approach that contained some of the elements that Chetty *et al.* incorporated in their study, which those authors describe as "quasi-experimental" in nature. Conceptually, however, what these authors did is not that different from the kind of numerical experiments that quantitative macroeconomists typically perform to evaluate public policies. It is therefore hard to resist the temptation to investigate whether this same methodology will arrive at the negative conclusion just documented, or at the more upbeat one reported earlier, when applied to policy episodes similar in nature to those considered by Mulligan and Chetty *et al.*.

This paper takes up this question, compelled by the experiment-like features of a recent fiscal policy development in the U.S. economy: the rather unexpected decade-long reduction of government consumption of goods and services that the so-called budget sequestration triggered at the beginning of 2013, often referred to simply as "the sequester." It seems reasonable to conjecture that the temporary nature of the inverted U-shape profile of annual government spending cuts scheduled by that policy, estimated to represent a non-neglibible 0.5% of output in several years, will induce similar effects in aggregate variables as did the 1987 tax holiday in Iceland, and the Self Sufficiency Project of randomized temporary earnings subsidies over 36 months introduced in Canada in the 1990s, both of which Chetty *et al.* exploited to make inferences about the values of macroeconomic elasticities that are the focus of this paper.

Given the important role that the RBC literature assigns to the IES and the Frisch elasticity of aggregate labor supply in accounting for economic fluctuations, it seemed only fair to measure the value of those parameters with one of the models developed by that tradition, rather than with the model that Chetty *et al.* found suitable for their purposes. The measurement device adopted by this paper is, accordingly, a simplified version of the "private sector" real business cycle model in Gomme and Rupert (2007), calibrated to long-run features of the U.S. economy. There is no presumption that this model is the best possible abstract representation of the U.S. economy, but the proposition of using it to measure macroeconomic elasticities for that economy should be appealing to those who favor interpretations of the business cycle phenomena with models in the same class.

One further advantage of that type of models is that they explicitly incorporate the capital stock into the analysis and eliminate, therefore, a potential bias in the elasticity estimates provided by Chetty *et al.*, a bias due to the fact that they adopted, as their measuring device, the model without capital accumulation proposed by Rogerson and Wallenius (2009). As is well known, intertemporal variations in the labor supply are influenced by the transition dynamics induced by the level of the capital stock relative to trend. Thus, one reason for the weak response of observed aggregate hours in Canada and Iceland during the policy episodes analyzed by Chetty *et al.* and the low Frisch elasticity value they inferred from those episodes might simply be that the capital stock in those countries was above its steady-state detrended value at the time. The version of the Gomme-Rupert model adopted as reference in this paper takes this transition dynamics effect into account, as do most RBC models, and is free, therefore, of the bias potentially contaminating Chetty *et al.*'s interpretation of the evidence. In addition, the model parameterization allows for an IES different from one, the value that Chetty *et al.* accepted from Rogerson and Wallenius, who assumed it for convenience, but which is not entirely consistent with the evidence reviewed by Heckman (1974), Browning and Meghir (1991), and Browning, Hansen, and Heckman (1999).

The paper proposes to find the macroeconomic elasticity values most consistent with the dynamics of aggregate variables under the sequester by running numerical experiments in the spirit of those conducted by Chetty *et al.* and Mulligan in the studies mentioned above and subsequently assessing their outcomes with a casual metric similar to the one adopted by those authors. In particular, the paper computes the detrended growth rates for selected aggregate variables predicted by the model for a range of values of the elasticities under study, and then identifies which particular combination of those parameter values minimizes the difference between predicted growth rates and those calculated from the data.

The paper finds that the evidence for 2013, the only one for which the information on the relevant variables was available at the time of this writing after the first full calendar year of implementation of the sequester, is not particularly favorable to the high values of the Frisch elasticity favored by the RBC literature. This same evidence weakly supports the view that consumption and leisure are not within-period additive separable, as implied by the value of 1 for the IES that macroeconomic models often assume for simplicity. The reference to this preliminary evidence is not meant to settle the dispute about the value of key elasticities, but to show that progress could be made by future readings of those elasticities in the same manner, as the sequester unfolds and more data capturing its impact on aggregate variables becomes available.

The rest of the paper is organized as follows: Section 2 briefly presents the relevant institutional details of implementation of the U.S. budget sequestration and an overview of some measurement issues that was necessary to address to identify with some precision the values of the elasticities under study. Section 3 describes the different elements of the model and the procedure followed to calibrate it to long run feature of the US economy. Section 4 describes the numerical experiments designed to infer the values of the IES and Frisch elasticity from the dynamics induced in that economy by the sequester. Section 5 explains the technique used to compute the competitive equilibrium of the model. Section 6 documents the findings. Section 7 concludes.

2 Some preliminaries

2.1 The budget sequestration: relevant details

Concerned about the post-WWII record high level that the U.S. government debt-output ratio reached in the aftermath of the 2007-2008 financial crisis, the US Congress passed in 2011 the Budget Control Act that was signed into law on August 2 of that year. This legislation established caps on annually appropriated programs that reduced spending by an estimated $1.5 trillion for the period 2013-2022. More relevant for the motivation of this paper, it also established a bipartisan committee, the Joint Select Committee on Deficit Reduction, assigned the task of finding another $1.5 trillion in deficit reduction over the same fiscal years. As an enforcement mechanism, the Budget Control Act included a provision stating that in the contingency that the joint committee failed to propose or Congress failed subsequently to enact legislation to cut the deficit by at least $1.2 trillion by January 15, 2012, the same goal would be achieved by automatically canceling, or sequestering (therein the origin of the term "sequestration"), beginning on January 2, 2013, "*a portion of the budgetary resources for most discretionary programs as well as some programs and activities that generate mandatory spending.*" (See Congressional Budget Office (2013), page 31).

On November 21, 2011, the Joint Committee announced to the public that it had come to the conclusion that no agreement on deficit reduction would be possible before the deadline. There was, however, wide speculation that the rather blunt nature of the across-the-board spending cuts implied by the budget sequestration would prompt Congress to find ways to cancel it or it water down considerably. This was not an unreasonable expectation, given that the US Congress had to consider in 2012 other pieces of legislation with important consequences for the budget, dealing with the expiration of the temporary tax cuts introduced in 2001 and 2003 (known together as the "Bush tax cuts".) But the hopes that the budget sequestration would be suspended indefinitely were proved wrong when the Taxpayer Relief

Act of 2012, passed in January 1, 2013, simply postponed the implementation of the spending cuts for two months, until March 1, 2013.

The brief chronicle of the events that led to the sequester seems to justify the identifying assumption, implicit in the numerical experiments performed later in the paper, that the automatic spending cuts were largely unexpected as of the beginning of 2013, and forced economic agents to adjust their behavior rather quickly, with visible effects on their consumption, investment, and labor supply decisions. The model economy will be designed precisely to quantify the impact of the sequester on those decisions for alternative values of the macroelasticities under study and subsequently establish which of those values is more consistent with the data.

An important feature of the spending cuts mandated by the budget sequestration is that they fall mostly on government purchases of goods and services, rather than on reductions of public sector employment. This made possible to address the measurement problems discussed in the next subsection by considering a model economy in which the government doesn't contribute any value added and the spending cuts simply take the form of a lower government absorption of goods and services exclusively produced by the private sector.

Equally important for the approach to infer macroelasticities proposed by this paper is the exact magnitude and distribution of those cuts over time. The details of implementation make it difficult to figure out the schedule of spending cuts from the already convoluted language of the legislation that sanction them. Fortunately, in February 2013, right before the sequester became effective, the Congressional Budget Office (2013) projected the level of government outlays over the period 2013-2023 for two alternative scenarios, one in which the budget sequestration was canceled and another one in which it proceeded as established in the law. The annual reduction of government expenditures between the two scenarios captures the schedule of spending cuts that the CBO attributed directly to the sequester, as summarized in the middle column of Table 1.

Table 1: Annual spending cuts implied by 2012 Budget Sequestration

Year	**$ billion** (*)	**% of output** (**)
2013	42	0.249
2014	89	0.506
2015	99	0.541
2016	103	0.541
2017	104	0.525
2018	105	0.510
2019	104	0.485
2020	104	0.466
2021	104	0.448
2022	94	0.389
2023	89	0.354

* Congressional Budget Office (2013), Table 1-7.
** Author's calculations, assuming model trend growth and 2% annual inflation rate.

Notice that the CBO projections imply that the actual effects of the sequester on the level of government spending will be felt past the year 2021 established in the letter of the legislation, reflecting in part inertial features of the budgetary process that will not automatically disappear at the legal expiration of the sequestration. The paper takes the stand that the schedule of spending cuts estimated by the CBO is exactly the one economic agents had in mind when making their decisions at the time the sequester came into effect in March 2013. Since the CBO doesn't provide estimates of the exact distribution of the spending cuts within a given year, the paper considered data only at annual frequencies.

2.2 Measurement issues

Given that this paper is about measuring macroelasticities, it seemed appropriate to be particularly strict about the precision of the quantitative answers provided by the model economy used to that end. Lack of correspondence between conceptual entities and their empirical counterparts could certainly distort the model readings of those elasticities. It seemed important, therefore, to take seriously the measurement issues raised by Gomme and Rupert (2007).

As pointed out by those authors, the textbook neoclassical growth model implicitly assumes that all economic decisions are made by utility-maximizing households and profit-maximizing firms. But in actual economies, measured output includes goods and services that the government provides as a result of administrative and/or political decisions, hardly dictated by the same incentives as those faced by the private sector. The absence of prices for such publicly provided goods and services reflects that reality, and it is the reason why the non-market output produced by the government is typically measured in most national accounts, as it is certainly the case of the National Income and Product Accounts (NIPA) in the U.S., by the costs of producing publicly provided goods and services, that is, by the inputs used up or "consumed" in the process of generating that output. In the U.S., the government non-market component of output, identified in NIPA as "government consumption expenditures," represents 20% of total output. This is certainly a fraction of output large enough to suspect that it will be a source of measurement inaccuracies if the predictions of the model economy assume that the quantities of all types of goods and services produced reflect the interaction of optimizing private agents that valued them at market prices.

Similar measurement issues distort the NIPA estimates of income. In particular, NIPA treats the income flows generated by the services from the capital stock differently, depending on whether that stock is owned by the public or the private sector. 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 total factor productivity (TFP) calculated from Solow residuals.

Gomme and Rupert argued in the paper already mentioned that these potentially severe measurement problems can be considerably mitigated by improving the mapping between the neoclassical growth model and the data with a model in which all output is the result of value added exclusively by the private sector. The empirical counterpart of this concept is obtained by subtracting from real GDP 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 goods and services provided by the government.

As briefly mentioned in the previous subsection, the private sector economy approach just outlined is not an obstacle to make inferences about the value of key macroelasticities implied by the budget sequestration because the temporary spending cuts implied by that measure fell mostly on the government absorption of goods produced by the private sector, rather than on the value added by the government, a large fraction of which is just the compensation of the labor services provided by government employees.

The data necessary to obtain the historical series of private sector output in a manner consistent with the way government economic activities are recorded in NIPA are available only since 1977. For that reason, the period 1977-2012 was adopted as reference for the calibration of the model. A thorough discussion of the steps required to make the data for that period consistent with the conceptual entities in the model are rather involved and would detract from the main focus of the paper. Interested readers in the details will be able to find them, however, in Kydland and Zarazaga (2013), who applied an entirely analogous procedure in the process of answering a different question.

An unrelated but particularly challenging measurement problem was posed as well by the fact that the fraction of available time that the average U.S. household devoted to work in the period 1977-2012 exhibited transitory dynamics that obscured the stationary value to which that variable should converge along a balanced growth path. The assumption that the underlying structure of the U.S. economy is indeed consistent with balanced growth in the long run made it necessary to filter out that transitory dynamics from labor input in the manner indicated in subsection 3.5.1.

3 The Model Economy

Given that the goal of this paper is to measure macroelasticities by the "rules of the game" of the RBC literature, it was important to respect the principle generally followed by that literature, as Gomme and Rupert did, that the long-run features of aggregate models should be consistent with the balanced growth facts documented by Kaldor (1961). 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.

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 16 years of age and over 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 is the fraction of available time that households are at work in the private sector, which exhibited a clearly rising trend in the U.S. until recently, and had to be rendered stationary with the procedure explained in subsection 3.5.1.

3.1 The Typical Household's Choice Problem

The typical household, which in the abstraction of the model stands for the large number of them that inhabit the actual economy, is assumed to have preferences that can be represented by a time-separable Constant Frisch Elasticity (CFE hereafter) utility function defined over infinite streams of consumption $\{c_t\}_t^\infty$ and the fraction of available time devoted to work $\{h_t\}_t^\infty$. This utility function is the only one that allows consumption and leisure to be non-separable within periods and, at the same time, implies that the Frisch elasticity of aggregate labor supply is independent of hours worked. This feature was an important consideration for adopting the CFE utility function specification, given that the quantitative statements in this paper rely on perturbation techniques that approximate the private sector's decision rules in the neighborhood of the non-stochastic steady state of the model economy. The unavoidable approximation errors introduced by this computational technique are likely to be compounded by alternative utility function specifications typically assumed in the literature, such as the one assumed by Cooley and Prescott (1995), that also assume within-period consumption and leisure non-separability, but imply that the Frisch elasticity changes with the fraction of available time devoted to market activities and is different, therefore, at the steady-state and out of it.

Accordingly, the stand-in 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:

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

where $\beta > 0$, n is the working age population annual growth rate, γ the annual growth rate of total factor productivity, 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 IES (labor-held-constant intertemporal elasticity of substitution in consumption), $\kappa > 0$ a parameter that controls the household's valuation of consumption relative to leisure, φ the constant Frisch elasticity of aggregate 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.)

The term nx_t stands for net exports, treated as a random variable whose levels can be backed out from the following AR(1) stochastic process:

$$nxy_t = (1 - \rho_{nxr})nxy_{ss} + \rho_{nxr} nxy_{t-1} + \varepsilon_t^{nxy},$$

where nxy_t is the period-t ratio of net exports to private output, nxy_{ss} the steady-state value for that variable, $\rho_{nxr} < 1$, and ε_t^{nxr} is an identically and independently distributed random variable, with mean zero and variance σ_{nxy}^2.

This shortcut, adopted by Trabandt and Uhlig (2011), is a way to mitigate the lack of correspondence between the closed economy model of this paper and the data for the US economy, whose economic interactions with the rest of the world would have been considerably more challenging to model and parameterize explicitly. Introducing this admittedly crude adjustment seemed nevertheless important, because a negative trade balance is the counterpart of the flow of income from foreign assets that households can devote to investment, a variable that will be important at the time of making inferences about the size of the Frisch elasticity consistent with the dynamics that the sequester has induced in the US economy.

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

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 actually working for the private and public sectors, respectively. Note that this concept of labor input corresponds to fraction of time actually worked, not just paid. The data were therefore adjusted to exclude the time for which workers were paid but not actually working, because they were on vacation, sick leave, etc.

The explicit distinction between the time households devote to work in the public and private sectors is uncommon, because the value added by both, the private and public sectors, is deemed the appropriate empirical counterpart of output in most models. This is not true for the model economy of this paper, in which all the value added is provided by the private sector, even if partly absorbed by government purchases not valued by the stand-in household. Calibrating the relevant parameters of such an economy without taking into account the fraction of time that households work for government agencies could lead to overestimate the labor input absorbed by the private sector and, therefore, output, consumption, and investment.

Moreover, 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}:

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

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. As pointed out by Gomme and Rupert in the paper repeatedly mentioned, the decisions 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^2.

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.[1]

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

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

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

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 and the sequester

The answer to the question addressed by the paper requires examining the quantitative predictions of the model economy under different fiscal policy regimes. This task can be accomplished, at least on a first pass, with the simplifying assumption that the government

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

budget is balanced every period. This implies that any excess of revenues over expenditures induced by the spending cuts mandated by the budget sequestration is exactly offset by a corresponding increase in lump sum transfers to the households. This is a common assumption in the literature that attempts to infer elasticities from policy episodes as the one that motivates this paper, and certainly the assumption made by Chetty *et al.* and Rogerson and Wallenius in the papers cited before. Thus, in the model the government absorption of output exclusively produced by the private sector, denoted ga_t, will be assumed to be equal every period to 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 for government enterprises.

For simplicity, it will be assumed that the fraction of private output absorbed by the government goods follows a stochastic process given by

$$\frac{ga_t}{y_t^{pr}} = gy + \varepsilon_t^{gy}, \tag{9}$$

where gy where is a constant, and ε_t^{gy} an identically and independently distributed random variable with mean zero and variance σ_{gy}^2. This assumption implies, of course, that lump sum transfers will change as needed to preserve a balanced budget.

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:

$$h_t^{pu} = h^{pu} + \varepsilon_t^{hpu} \tag{10}$$

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

3.3.3 Government Enterprises Value Added

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 this variable over time is characterized by the following stochastic processes:

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

where vy is a constant, and ε_t^{ge} an identically and independently distributed random variable with mean zero and variance σ_{ge}^2.

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 by the following two equations:

$$\frac{\sigma\kappa\left(1+\frac{1}{\varphi}\right)h_t^{\frac{1}{\varphi}}}{1-\kappa\left(1-\sigma\right)h_t^{1+\frac{1}{\varphi}}}c_t = (1-\tau_t^h)w_t \tag{12}$$

$$\beta E_t \left[(1-\tau_{t+1}^k)(r_t-\delta)+1\right] = E_t \left[\frac{c_{t+1}}{c_t} \frac{(1+\gamma)\left(1-\kappa(1-\sigma)h_t^{1+\frac{1}{\varphi}}\right)}{1-\kappa(1-\sigma)h_{t+1}^{1+\frac{1}{\varphi}}} \right]^{\sigma} \tag{13}$$

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:

$$w_t = (1-\theta)Ae^{z_t}\left(\frac{k_t}{h_t^{pr}}\right)^{\theta} \tag{14}$$

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

Replacing (14) into (12), (15) into (13), and taking into account that $h_t = h_t^{pu} + h_t^{pr}$, consolidates the four equations above into the following two:

$$\sigma \frac{\kappa\left(1+\frac{1}{\varphi}\right)(h_t^{pu}+h_t^{pr})^{1+\frac{1}{\varphi}}}{1-\kappa(1-\sigma)(h_t^{pu}+h_t^{pr})^{1+\frac{1}{\varphi}}} \frac{c_t}{(h_t^{pu}+h_t^{pr})} = (1-\tau_t^E)(1-\theta)Ak_t^{\theta}(h_t^{pr})^{-\theta} \tag{16}$$

$$\beta E_t\{(1-\tau_{t+1}^k)[\theta Ak_{t+1}^{\theta-1}(h_{t+1}^{pr})^{1-\theta}-\delta]+1\} = E_t \left[\frac{c_{t+1}}{c_t} \frac{(1+\gamma)\left(1-\kappa(1-\sigma)h_t^{1+\frac{1}{\varphi}}\right)}{1-\kappa(1-\sigma)h_{t+1}^{1+\frac{1}{\varphi}}} \right]^{\sigma} \tag{17}$$

In addition to (16) and (17), a competitive equilibrium allocation will have to satisfy the resource constraint:

$$c_t + x_t = [1 + (vy + \varepsilon_t^{gc}) - (gy + \varepsilon_t^{ge}) + (nxy + \varepsilon_t^{nxy})]\, Ae^{z_t} k_t^{\theta} (h_t^{pr})^{1-\theta} + sc_t, \tag{18}$$

where sc_t (which stands for an abbreviation of "spending cuts") is non-zero only over the period 2013-2023 for which the CBO projected the spending cuts would be effectively in place, as per schedule in Table 1.

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 (16) and (17).

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}.

3.5 Model Calibration

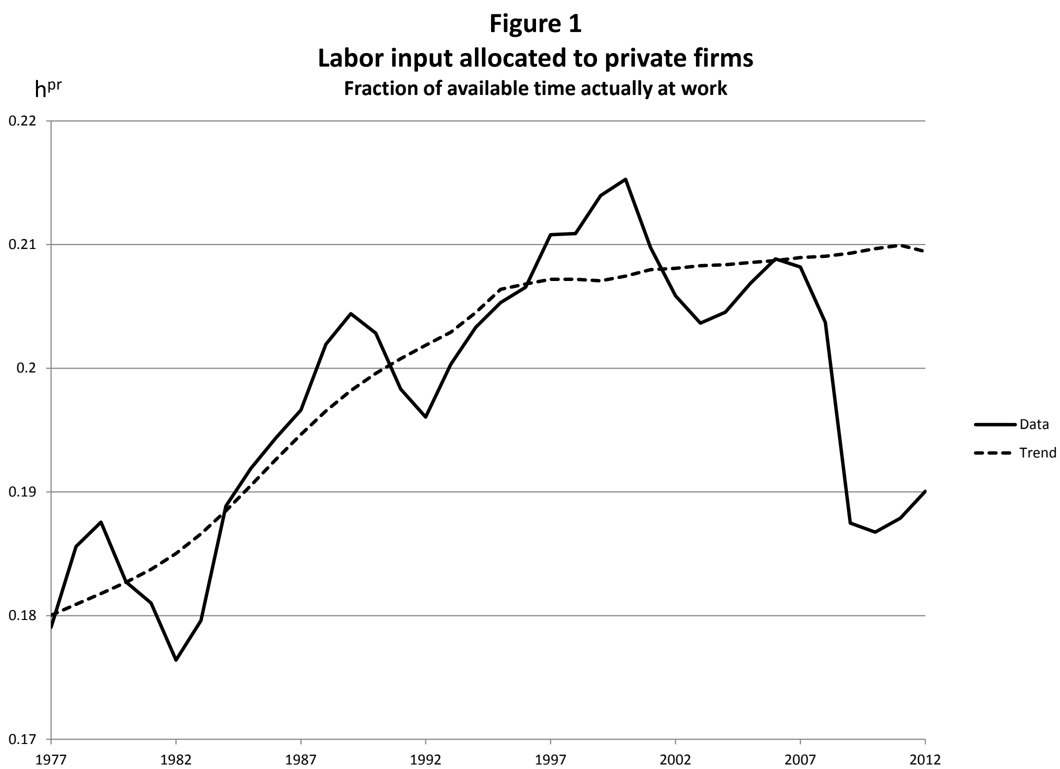
3.5.1 Detrending procedure

As mentioned before, following the standard approach in the RBC literature, the calibration of the model will be guided by the assumption that over the period 1977-2012 adopted as reference to that end, the dynamics of macroeconomic variables in the U.S. economy was consistent with that of an economy converging to a balanced growth path in the long run.

It is important to note that the common practice of detrending variables by simply dividing the relevant variables by the average growth rates of TFP and working-age population (individuals age 16 and older) over the calibration period is likely to fail to remove deterministic trends if the non-stationary dynamics of labor input over the reference period is ignored, as many quantitative studies of the U.S. economy implicitly or explicitly have.

When an economy has already converged to its balanced growth path, all commodity variables (output, consumption, investment, capital stock) should be detrended by dividing them 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 of this detrending procedure was series for the commodity variables that displayed instead a trend with a positive slope. The reason for this outcome clearly at odds with balanced growth must be, of course, that the U.S. economy was still in transition toward its balanced growth path over a significant fraction of the period adopted as reference for the calibration of the model.

That should be obvious from the fact that balanced growth implies that the fraction of time that households devote to work should be stationary and fluctuate, therefore, around the long-run value identified by the sample average. But Figure 1 documents that that hasn't been the case in the U.S. since the mid-1970s until the beginning of the 21st century.



Owing to the demographic tilt introduced by baby boomers and to the rising female labor force participation, the fraction of time the average household devotes to work increased steadily over that period. By their nature, these forces couldn't last forever, though, and as they died down over time, the upward lift they induced in labor input was bound to disappear gradually. In fact, the latest data suggest that labor input seems to be finally stabilizing around what appears to be its long-run value. Although that might well be the case, labor input surely imparted the previous transition dynamics just discussed to output. Ignoring this effect in the analysis may result in severely distorted measures of trends. In fact, the reason why the specialized press and even scholar studies often report that the U.S. has fallen from trend after the Great Recession by a large magnitude is precisely because those estimates implicitly project to the future labor input transitional dynamics that, for the reasons given above, were unlikely to survive the passage of time.

Moreover, 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 come up with a theory-based procedure to remove the transitional dynamics that Figure 1 suggest was present in labor input in the U.S. for a long time. Yet, this is a necessary step to identify the stationary value to which labor input should converge along a balanced growth path. Lacking any guidance from economic theory, the identification of that value was accomplished by adjusting the labor input data with a procedure that admittedly involved a great deal of judgement calls, discussed in detail next for the sake of transparency.

The procedure was divided in two steps, motivated by the fact that data on the fraction of time that individuals were at work in the private sector was available with much more level of detail starting in 1994. In particular, starting on that year, it is possible to establish the fraction of time devoted to work in the private sector by gender and for the following four age groups: 16 to 19 years old, 20 to 24 years old, 25 to 54 years old, and 55 years old and older. This was important, because it made possible to identify the incidence of demographic factors, such as the particularly large generation of baby-boomers, in the transitional dynamics of labor input apparently present in Figure 1. The more detailed data available since 1994 revealed, for example, that the fraction of time devoted to work in the private sector has been steadily rising for women age 55 and older, whereas it has been declining for women 16 to 19 years old.

Trends as the ones just described were identified for each gender and age group indicated above with a regression analysis over the period 1994-2012. Subsequently, the within-group trends were weighted by the participation of the corresponding age group in the overall working age population. The resulting aggregate trend of the fraction of time devoted to work is represented by the rather flat portion of the dotted line in Figure 1 that starts in

1994. The figure suggests that the fraction of time households devote to work on average in the private sector seems to be converging to 21%, which was adopted therefore as the steady-state value of this fraction for the purpose of calibrating the model economy.

The dotted line that identifies the trend for that variable in Figure 1 prior to 1994 was obtained by applying an HP-filter to the overall fraction of time that households devoted to work in the private sector between 1977 and 1993. For completeness, the segment of the dotted line in Figure 1 between the years 1993 and 1994 is simply the result of a linear interpolation of the trend values for those two years estimated with each of the procedures described above.

It is important to keep in mind that the purpose of the steps above was to remove from labor input the transitional dynamics that cannot be attributed to economic factors and cannot be accounted for, therefore, by the model economy with which this paper will proceed to measure macroelasticities. In the actual implementation of the model, this transitional dynamics was filtered out by replacing the observed fraction of time that household devote to work on average in the private sector, h_t^{pr}, with the synthetic labor input variable $\widehat{h}_t^{pr}$ obtained as follows:

$$\widehat{h}_t^{pr} = \frac{h_t^{pr}}{h^{pr}(trend)_t} h_{ss}^{pr} \tag{19}$$

where $h^{pr}(trend)_t$ is the period t value of the trend identified by the dotted line in Figure 1 and h_{ss}^{pr} is the steady-state value of the fraction of time households devote to work in the private sector, which previous arguments identified to be 21%.

As mentioned earlier, the transitional dynamics growth effects apparently present in labor input, but unrelated to labor-augmenting technological progress, has been transmitted to output and other macroeconomic variables over the years and needs to be removed from them as well.[2]

[2] 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.

Expression (19) suggests that this can be accomplished by simply multiplying both sides of the capital intensive version of the production function, (5), by $h_{ss}^{pr}/h^{pr}(trend)_t$, as follows:

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

Thus, the series of detrended private sector output is obtained from the following expression:

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

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 h_t^{pr}. Also, $A_0=A/A_{ss}^{\frac{1}{1-\theta}}$, where A is a constant that normalizes the average level of total factor productivity, z_t, to zero over the calibration reference period and the constant $A_{ss}^{\frac{1}{1-\theta}}$ is chosen to normalize steady-state output to 1, that is, $A_{ss}^{\frac{1}{1-\theta}}=\frac{1}{\left(\frac{k}{y^{pr}}\right)^{\frac{\theta}{1-\theta}}h_{ss}^{pr}}$.

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:

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

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

3.5.2 Parameter values and steady-state ratios

The detrending procedure just described, along with the theoretical relationships between variables implied by the steady-state versions of the equations characterizing the competitive equilibrium allocation summarized in section 3, implied the following calibrated values for the relevant parameters and variables:

Parameter/Steady-State Relationship	**Steady-State value**
η (working-age annual population net growth rate)	0.012
γ (TFP annual net growth rate)	0.007
δ (depreciation rate)	0.056
i (before-tax annual net rate of return on private capital)	0.08
x/y^{pr} (investment-output ratio)	0.21
k/y^{pr} (private capital–private sector output ratio)	2.67
θ (private capital income share)	0.36
gy (fraction of private sector output absorbed by general government)	0.083
vy (government enterprises value added–private sector output ratio)	0.015
nxy (net exports–private sector output ratio)	-0.028
h^{pr} (fraction of time worked in private sector)	0.21
h^{pu} (fraction of time worked in public sector)	0.03
τ_t^k (capital income tax rate)	0.40
τ_t^h (labor income tax rate)	0.25

The value for the steady-state ratios listed in the table correspond to the average value of those ratios over the period 1977-2012.

The fraction of time devoted to work in the public sector, h_t^{pu}, was fairly stable at 3% over that period and adopted therefore as the calibrated value for that variable.

The approach to measure macroelasticities adopted in this paper required to reset the values of certain parameters not listed above when they had to be inferred from economic relationships that involved the macroelasticities under study, which weren't kept constant across the different numerical experiments described in the next section. In particular, for the reasons mentioned in the introduction, the paper considered the alternative values of 0.5 and 1 for the IES, captured by the parameter σ in the utility function. This parameter, however, determines the value of the discount factor β, as the following steady-state version of the first order condition (17) makes apparent:

$$1 + (1 - \tau_k)(r - \delta) = \frac{(1+\gamma)^\sigma}{\beta}.$$

Accordingly, the value of β was recalculated for each value of σ, taking into account that the studies by Poterba (1998), Siegel (2002), and Mehra and Prescott (2008) have established with some confidence that the long-run annual real return on capital for the U.S. economy, captured by the factor $(r - \delta)$ in the equation above, is in the order of magnitude of 8%.

A similar procedure was applied to the parameter κ, which according to the steady-state version of the first order condition (16), depends on the fraction of time devoted to work in the steady state, as calibrated in the previous section, and the Frisch elasticity, φ. The value of κ was reset, therefore, to satisfy that equation for each of the three different values for those elasticities considered in the numerical experiments: 0.5, 1.0, and 1.9. The motivation for the latter Frisch elasticity value is that it is the one that Hall (2009) has argued to be empirically consistent with the dynamics of US labor markets.

4 Numerical Experiments

The purpose of the numerical experiments is to establish which of the six different combinations of values for the IES (corresponding to the parameter $1/\sigma$ in the model economy) and the aggregate hours Frisch elasticity (corresponding to the parameter φ in the model economy) listed in the previous section are more consistent with the dynamics of U.S. aggregate variables under the effects of the sequester. Given that the interest is in elasticities, it seemed natural to infer elasticities values by comparing the detrended growth rates of selected aggregate variables implied by the model with those actually observed. This simple metric is entirely in line with the one that Chetty *et al.* and Mulligan used in the papers cited before.

To that effect, the numerical experiments computed first the predictions of the model for the level of macroeconomic variables for the year 2012, feeding into the relevant decision rules the actually observed level of the state variables, that is, the capital stock, the productivity level, and net exports for that year, as well as the actual innovations that the exogenous stochastic variables experienced that same year, as estimated using the corresponding stochastic process.

The procedure was repeated for the year 2013, using also the observed level of state variables and shocks that year, but this time feeding in the whole path of scheduled (and fully believed) level of spending cuts mandated by the sequester, calculated from the magnitude of those cuts relative to output estimated in Table 1.

These spending cuts are introduced in the algorithm by reducing the level of government absorption of private sector output, ga_t, in the amount implied by the sequester during its duration. After the expiration of that measure, the level of government absorption of private output starts to fluctuate again around the average level implied by the government absorption-private sector output ratio gy in equation (9). Recall that as is standard practice in the literature, which Chetty *et al.* respected, any excess of tax revenues over government spending induced by the sequester is rebated to the representative household as a lump sum.

5 Computational Method

The decision rules governing the dynamics of the endogenous variables in the model were computed by approximating the system of two difference equations (16) and (17) with a second order perturbation around the logarithm of the steady-state values of the variables.

Notice that the equations in question correspond to an environment characterized by a mixture of stochastic variables and a perfect foresight path for the spending cuts enacted by the sequester. An unconventional feature of this approach, proposed by Juillard (2006), 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, but also the eleven variables capturing the deviations of the level of government consumption from its steady-state value implied by the budget sequestration, which progressively drop out from those decisions rules as time in the model goes by and fewer and fewer spending cuts remain scheduled for the future. The algorithm was implemented in a Dynare code available from the author upon request.

6 Findings

Given that the goal of the numerical experiments is to identify the values of the IES and the aggregate hours Frisch elasticity, it seemed natural to apply to that end the metric proposed in the previous section to aggregate variables directly influenced by those elasticities, consumption and labor input. These two variables appear prominently in the Frisch-demand systems typically used in microeconomic studies to estimate the elasticities that are the focus of this paper.

The lack of correspondence, however, between the concept of consumption in macroeconomic models such as the one adopted as reference in this paper, and the measure of consumption in the data, could distort the readings of the values of those elasticities provided by the model. The source of the distortion is that NIPA includes in consumption actual purchases of durables, whereas it is just the flow of services from the stock of consumer durable goods that enters in consumption in the model. The inclusion of the purchases of durable goods in consumption growth rates may have non-negligible effects in the observed growth rates of that variable because those purchases tend to be positively correlated with investment, a highly volatile variable.

On the other hand, precisely for that reason, exclusion of durable goods purchases from

Table 2: 2012-2013 detrended growth rate.

		Model					
		$\frac{1}{\sigma} = 1.0$			$\frac{1}{\sigma} = 0.5$		
	Data	$\varphi = 0.5$	$\varphi = 1.0$	$\varphi = 1.9$	$\varphi = 0.5$	$\varphi = 0.5$	$\varphi = 1.9$
Labor input (h_{pr})	0.39%	**0.34%**	0.51%	0.70%	**0.32%**	0.46%	– 0.28%
Investment (i)	2.84%	4.07%	4.44%	4.86%	**3.77%**	**4.02%**	0.77%

investment in the data is unlikely to introduce significant differences between the observed growth rates for that variable and the ones predicted by the model. Thus, it seemed reasonable to conjecture that the investment and the fraction of available time at work are the two variables with the best chances of capturing more precisely the value of macroelasticities driving the dynamics of the U.S. economy during the implementation of the budget sequestration.[3]

Table 2 documents the detrended growth rates of labor input and investment between 2012 and 2013 predicted by the model along with those actually observed. As mentioned earlier, at the time of this writing, 2013 was the only full calendar year of implementation of the sequester for which the NIPA data necessary to make this comparison was available. The table displays in bold numbers the two predicted detrended growth rates for each of those two variables that match more closely their data counterparts. By this metric, the dynamics of the U.S. economy under the sequester doesn't particularly favor the relatively high value of 1.9 for the aggregate hours Frisch elasticity suggested by Hall (2009) and other macroeconomic studies. The same metric is less conclusive about the value of the IES, although the value of 0.5 is the one that predominantly minimizes the distance between the model and data growth rates.

It would be certainly premature to conclude from the evidence available after the first

[3] An alternative would have been to correct all the NIPA measures with the procedure suggested by Cooley and Prescott (1995), but the assumptions required to that end are not inconsequential for the value of the macroelasticities under study inferred from the dynamics of the adjusted variables.

full calendar year of implementation of the sequester that the dynamics of the US economy under the effects of the associated temporary spending cuts is more consistent with the values for those elasticities estimated with microeconomic techniques than with those inferred by macroeconomic models. This preliminary assessment might change as the sequester unfolds and the data to make similar comparisons for subsequent years become available.

It may be worth to point out, however, that the passage of time is likely to contaminate the evidence with sources of shocks not explicitly considered in this paper. In particular, a surprising decline in oil prices hit the economy in the last quarter of 2014, precisely at the same time the Federal Reserve was widely expected to start raising the short-interest rate in the near term. None of these sources of transitional dynamics were explicitly considered in the analysis of this paper. In retrospect, it might be that information available for 2013 provides the cleanest readings of macroelasticity values that it is possible to obtain with macroeconomic models in the class considered in this paper.

The potential insights from the approach to measuring macroelasticities proposed in this paper may become clearer by isolating and quantifying the effects of the sequester on the growth rates predicted by the model shown in Table 2. This is accomplished in tables 3 and 4 which, for the each of the two IES values considered by the paper, shows in the column labeled "Shocks only" the detrended growth rates that would have been observed between 2012 and 2013 in the absence of the sequester, keeping all the stochastic shocks active as in the previous numerical experiments. The factor that separates the growth rates in this column from the ones reported in Table 2 has been entered in the columns labeled "Seq. factor" in tables 3 and 4. The product of the gross rate version of the figures in the two columns just mentioned equals by construction, up to a rounding error, the growth rates corresponding to the numerical experiments reported in Table 2, reproduced for convenience in tables 3 and 4 under the column labeled "Net." For the purpose of illustrating the quantitative influence of the sequester in the model economy, it was convenient to include in those tables as well the model predictions for the consumption growth between the two years just indicated.

Table 3: 2012-2013 detrended growth rates decomposition, IES=1.0

	$\varphi = 0.5$			$\varphi = 1.0$			$\varphi = 1.9$		
	Shocks only	Seq. factor	Net	Shocks only	Seq. factor	Net	Shocks only	Seq. factor	Net
Labor input (h_{pr})	0.43	−0.08	0.34	0.60	−0.10	0.51	0.79	−0.10	0.70
Investment (i)	3.77	0.28	4.07	4.05	0.37	4.44	4.33	0.51	4.86
Consumption (c)	−0.60	0.17	−0.43	−0.54	0.13	−0.41	−0.48	0.08	−0.39

Table 4: 2012-2013 detrended growth rates decomposition, IES=0.5

	$\varphi = 0.5$			$\varphi = 1.0$			$\varphi = 1.9$		
	Shocks only	Seq. factor	Net	Shocks only	Seq. factor	Net	Shocks only	Seq. factor	Net
Labor input (h_{pr})	0.41	−0.08	0.32	0.61	−0.15	0.46	0.77	−1.03	−0.28
Investment (i)	3.38	0.38	3.77	3.73	0.29	4.02	3.86	−2.97	0.77
Consumption (c)	−0.46	0.15	−0.31	−0.38	0.12	−0.26	−0.25	0.37	0.12

Inspection of tables 3 and 4 reveals that for all parameter values considered, the sequester has a negative impact on the growth rate of the labor input allocated to the private sector and a positive one on the growth rate of private consumption. This dynamics reflects in part the increase in the private sector wealth associated with the sequester: the spending cuts leave more of a given level of output available for private use and, given that for all the parameter values under consideration consumption and leisure are normal goods, this induces a higher demand for both.

Notice that for the particular combination of a Frisch elasticity equal to 1.9 and an IES equal to 0.5, the quantitative effects of the sequester are not negligible: it increases consumption by about 0.4% and it reduces labor input by 1%. It is worth noting also that it is only for this particular combination of parameter values that the sequester induces a decline of investment relative to the predictions of the model in the absence of the temporary spending cuts. This outcome is not entirely surprising: the wealth effect associated with the sequester has such a negative effect on hours worked that the associated decline in output, combined with a non-negligible increase in consumption, has to be absorbed by a reduction of investment.

The last observation is particularly important, because it suggests that nothing in the model prevented the sequester from inducing in aggregate variables a dynamics better captured by high than low values for the aggregate hours Frisch elasticity. It could have well been the case that for a Frisch elasticity of 1.9, the spending cuts reduced the growth rate of investment by just 1%, instead of the nearly 3% documented in the corresponding "Seq. factor" column of Table 4, in which case the growth rate of investment predicted by the model would have exactly matched the one observed and favor the high Frisch elasticity value of 1.9 over the lower values of 0.5 and 1.0 assumed for the other numerical experiments.

In any case, not all is said and done yet: the sequester was just in the first year of implementation at the time of this writing. As its effects unfold over time, more evidence will become available and reading it in the manner suggested by this paper could help to narrow down the differences of opinion about the admissible values that macroeconomic models should assign to the IES and the Frisch elasticity governing the dynamics of aggregate hours of work.

7 Conclusion

The value of two elasticities controlling the response of aggregate variables to a variety of shocks, the intertemporal elasticity of substitution in consumption, and the Frisch elasticity of aggregate labor supply, continues to be the subject of heated debates in the profession. As pointed out in recent study by Chetty, Guren, Manoli, and Weber (2013), "*macroeconomic models that seek to explain fluctuations in hours of work over the business cycle or across countries imply much larger labor supply elasticities than microeconometric evidence.*"

Those authors also noted that an important methodological principle behind the real business cycle research agenda has always been that models intended to answer quantitative questions should be treated as measuring devices and calibrated, therefore, to dimensions of the data different from those the model is meant to characterize. Those authors argued that two fiscal policy episodes, in Iceland and Canada, offered a fertile ground for the application of that principle with a model developed by the real business cycle literature that explicitly takes into account the extensive margin of labor supply and rationalizes, therefore, the possibility of Frisch elasticities much larger than those estimated by microeconomic studies. In particular, taking as reference the model proposed by Rogerson and Wallenius (2009), Chetty *et al.* examined the response of aggregate labor supply to a one-year tax holiday in Iceland in 1987, and the labor supply decisions of two homogeneous groups of individuals that received different treatment under a program of randomized temporary earning subsidies in Canada in the 1990s. In both cases, they found that the values of the Frisch elasticity of labor supply that account for the evidence from those episodes are more in line with the low values estimated by microeconomic studies than with the larger ones that the real business cycle literature has established are necessary in order for total factor productivity shocks to account for a significant fraction of business cycle fluctuations.

One possible objection to the finding reported by Chetty *et al.* is that the analytical framework within which they conducted their investigation, the Rogerson-Wallenius model, abstracts from capital accumulation. Confidence in their readings of macroelasticity values might suffer, therefore, from the absence of this key channel for the transmission of intertemporal effects. This paper was motivated by the desire to remedy that omission, taking advantage of a policy event that, for its characteristics, may produce evidence similar in nature to that examined by Chetty *et al.*: the temporary decade-long spending cuts implemented by the U.S. budget sequestration in 2013.

In particular, the paper shows how the dynamics that the sequester has induced and will keep inducing in US aggregate economic variables could be exploited to measure the IES and Frisch elasticity of aggregate labor supply with a "private sector" version of the neoclassical growth model proposed by Gomme and Rupert (2007). The attractive feature of this framework is that it eliminates many of the measurement problems that could distort the readings of macroelasticities provided by models that abstract from capital accumulation and/or implicitly assume that the public sector employment and output decisions are driven by the same incentives as those faced by privately-owned firms.

The paper proposes to measure macroelasticities by comparing the adequately measured detrended growth rates of key aggregate variables, such as the fraction of time the stand-in household devotes to work and investment, with those the model predicts should have been observed under the sequester. The paper illustrates the proposed approach to measuring macroelasticities by applying it to the evidence for 2013, the only year for which the necessary information was available at the time of this writing. The paper documents that if a real business cycle were going to calibrate the Frisch elasticity of labor supply by the standards of this evidence, the value of that elasticity should be one or lower, rather than 2 or higher, as typically advocated by the real business cycle literature. Although somewhat less conclusively, the same evidence also supports an IES lower than one.

It is far from the intention of this paper to claim, however, that the preliminary evidence just documented settles existing disagreements about macroelasticity values. Instead, the goal of the paper is to illustrate how such differences could be narrowed by obtaining future, more precise readings of the effects of the budget sequestration on the US economy as it unfolds over time, with a measuring device constructed following the "rules of the game" laid out by the real business cycle literature.

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