The Heterogeneous Effects of Government Spending: It's All About Taxes*

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Abstract

Empirical work suggests that government spending generates large expansions of output and consumption. Most representative-agent models predict a moderate expansion of output, and a crowding-out of consumption. We reconcile these findings by taking into account the distribution of taxes. Using US data from 1913 to 2012, we provide evidence that government spending induces larger expansions in output and consumption when financed with more progressive taxes. We then develop a model with heterogeneous households and idiosyncratic risk, to show that a rise in government spending can be expansionary, both for output and consumption, only if financed with more progressive labor taxes. Key to our results is the model endogenous heterogeneity in households' marginal propensities to consume and labor supply elasticities. In this respect, the distributional impact of fiscal policy is central to its aggregate effects.

Keywords: Fiscal Stimulus, Government Spending, Transfers, Heterogeneous Agents.

JEL Classification: D30, E62, H23, H31, N42

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1 Introduction

What are the effects of a temporary increase in government spending on private consumption and output? Although a recurrent question in policy debates, there exists a wide range of empirical and theoretical findings in the literature. While some empirical work finds that an increase in government spending induces large expansions on output and private consumption, others argue for mild responses only.[1] At odds with these results, most commonly used models in macroeconomics predict a strong decline in private consumption after an increase in government spending, and a limited expansionary response in output. The response in output even turns contractionary when distortionary taxes are used.[2]

In this paper, we aim to reconcile these findings by emphasizing the importance of the distribution of taxes. First, we provide evidence that government spending induces an expansion on private consumption only when financed with more progressive taxes; and similarly, spending multipliers on output are statistically larger in this case.[3] Figure 2 plots a century of our constructed measure of US federal tax progressivity for the years 1913-2012: progressivity of taxes has significantly changed over time in the United States.[4] We use this variation in tax progressivity to identify its effect on government spending multipliers: our results are robust to several methodologies, including local projection methods as in Ramey and Zubairy (2014), or an agnostic VAR approach as in Mountford and Uhlig (2009).

Second, we develop a model suitable to discuss how tax progressivity shapes the effects of government spending. In particular, we use a model with heterogeneous households and idiosyncratic risk (Aiyagari, 1994) to assess the effects of government spending. As compared to models with a representative household, the new component is the existence of a distribution of taxes across households. In line with the evidence, we find that the progressivity of taxes is a key determinant

[1] See Ramey (2011a) and Ramey (2016) for recent surveys.

[2] See Baxter and King (1993) or Uhlig (2010) more recently.

[3] Government spending multipliers are defined as the amount of dollars that consumption or output increase by after a \$1 increase in government spending. See Section 2 for formal definitions.

[4] As a measure of progressivity, we compute the elasticity of *after-tax income* with respect to *pre-tax income*: $\gamma(y) = -\frac{\partial 1-\tau(y)}{\partial y}\frac{y}{1-\tau(y)}$, where $\tau(y)$ is the tax rate function for an income level y. A higher value of $\gamma(y)$ implies a tax rate that increases faster with income, and thus a more progressive tax schedule. We use this definition of progressivity because it coincides with the measure of progressivity in our model. See Section **??** and Appendix for details on $\tau(.)$ and its estimation.

of the effects of government spending. A rise in public consumption can be expansionary, both for output and private consumption, if financed with more progressive labor taxes. It is contractionary otherwise.

Our model results crucially depend on how different households respond to changes in taxes. Heterogeneous households models endogenously generate a distribution of wealth, and thus a distribution of marginal propensities to consume and of labor supply elasticities. Importantly, in our model, marginal propensity to consume, as well as labor supply elasticity, is higher for poor households. Thus, an increase in government spending financed with taxes on poor households, generates a strong decline in consumption and labor supply, and consequently an economic contraction. On the other hand, if more progressive taxes are used, the contraction is less severe. To the best of our knowledge, this intuitive finding is new in the literature.

Since Baxter and King (1993), it is known that the effects of government spending do depend on the taxes used to finance it. In this paper, we focus on a particular dimension of taxes, namely, their distribution across households. The discussion above points out the importance of changes in progressivity, both theoretically and empirically. Although we are primarily interested in understanding how progressivity shapes the effects of government spending, we also isolate the effects of a temporary change in tax progressivity, assuming constant government spending. We find that changes in progressivity are a powerful tool for inducing output and consumption expansion. This suggests directions for future research, as we discuss at the end of the paper.

1.1 Breaking the Crowding-Out of Public on Private Consumption

Typically, empirical work measures the effects of government spending by means of a multiplier: the amount of dollars that consumption or output increase by after a $1 increase in government spending. Table 1 summarizes multipliers found in previous work. Output multipliers range from 0.3 to unity, while consumption multipliers are closer to zero - typically not larger than 0.1.[5] These inconclusive findings are already puzzling: as we argue next, 'standard' models in macroeconomics

[5]Except for Blanchard and Perotti (2002) who find large positive consumption multipliers.

Table 1: Output and Consumption Multipliers: Summary of the Empirical Literature

Multipliers (on impact)	Output	Consumption
Blanchard and Perotti (2002)	0.90 (0.30)	0.5 (0.21)
Gali, Lopez-Salido, and Valles (2007)	0.41 (0.16)	0.1 (0.10)
Barro and Redlick (2011)	0.45 (0.07)	0.005 (0.09)
Mountford and Uhlig (2009)	0.65 (0.39)	0.001 (0.0003)
Ramey (2011b)	0.30 (0.10)	0.02 (0.001)

Notes: *All numbers are obtained from the original papers. Numbers in parenthesis stand for standard deviations.*

predict a crowding-out of private consumption after an increase in public consumption.[6]

Consider a real business cycle model with a representative household, competitive labor markets, and preferences over consumption c and hours worked h given by:

$$U(c,h) = \frac{c^{1-\sigma}}{1-\sigma} - \frac{h^{1+\varphi}}{1+\varphi}$$

As described in Hall (2009), the key equation for understanding the impact of government spending on private consumption is the *intra-temporal* Euler equation. If lump-sum taxes are used by the government, this equation reads as follows

$$\downarrow \log mph_t = \downarrow \sigma \log c_t + \uparrow \varphi \log h_t, \tag{1}$$

where mph is the marginal product of labor. This equation defines a very tight link between hours worked and consumption: if, as typically found in the data, households work more after an increase in government spending, the marginal product of labor falls and private consumption has to drop for equation (1) to hold. In addition, if government expenditures are financed with labor income

[6] By 'standard' we have in mind the two workhorse models in macroeconomics: the neoclassical growth model and the benchmark New Keynesian model.

taxes τ, these taxes must increase to finance the increase in public consumption.[7] Thus, as shown in equation (2), consumption drops even further, as initially remarked by Baxter and King (1993):

$$\downarrow \log(1-\tau_t) + \downarrow \log mph_t = \downarrow\downarrow \sigma \log c_t + \uparrow \varphi \log h_t, \tag{2}$$

This crowding-out effect of government spending on private consumption is typically seen as puzzling since it is not in line with many empirical findings.

We break equation (2) in two dimensions. First, we assume an indivisible labor supply, as in Hansen (1985), Rogerson (1988), or Chang and Kim (2007) more recently. Then, equation (2) holds with inequality at the individual level, breaking the tight link between government spending, consumption and labor. As pointed out by Chang and Kim (2007), the indivisibility of labor choice generates a countercyclical labor wedge. We show that this effect will help us deliver larger output multipliers, but will not be enough to obtain positive consumption multipliers. The second, and more important, way in which we break equation (2) is by assuming labor income taxes that depend on households' heterogeneous characteristics. As a consequence, at the moment of an increase in government spending, some households may face larger taxes while others may see a reduction in their taxes. The distribution of the tax burden towards wealthier households generates a positive consumption multiplier. This is the key new force that we analyze in this paper.

The rest of the paper is organized as follows. Section 2 contains the empirical analysis. In Section 3 we layout the model, and Section 4 computes the effect of government spending for different tax progressivity schemes. Section 5 isolates the effect of temporary increases in tax progressivity, and Section 6 concludes.

2 Evidence

In this section, we provide evidence that the effect of government spending on output and private consumption crucially depends on tax progressivity. In particular, we argue that spending induces a (cumulative) expansion in output only when accompanied with an increase in tax progressivity,

[7] We are implicitly assuming a balanced budget.

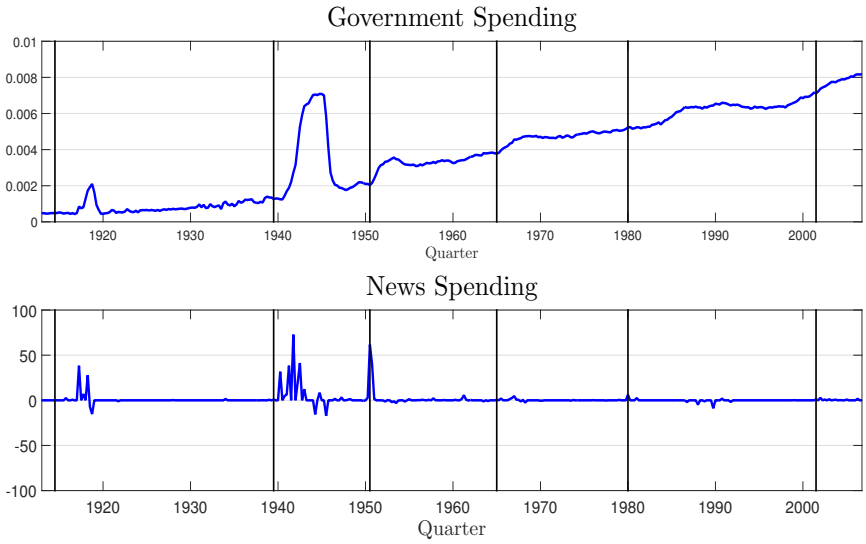


Figure 1: Defense Spending and Ramey Defense News

Notes: Vertical lines correspond to major military events: 1914:q3 (WWI), 1939:q3 (WWII), 1950:q3 (Korean War), 1965:q1 (Vietnam War), 1980:q1 (Soviet Invasion to Afghanistan), 2001:q3 (9/11).

while the long-run multiplier is virtually zero when progressivity does not increase. In order to show this, we use two commonly used empirical approaches: first, a local projection method as developed by Jorda (2005) and recently used by Ramey and Zubairy (2014) for estimating spending multipliers; and second, an agnostic VAR estimation as developed by Uhlig (2005a). These methodologies allow us to estimate the effect of government spending conditioning on the path of tax progressivity; and they deliver similar responses.

As documented before, most large changes in military spending over the last century occurred before the sixties. Figure 1 shows how large military spending for WWI, WWII and the Korean War were relative to other periods of military build-up. Thus, before showing estimations using local projection in Section 2.2 and agnostic VAR in Section 2.3, we first we develop and compute a novel measure of tax progressivity for the US for the period 1913-2012. Details on this measure are presented in Section 2.1.

2.1 A Tax Progressivity Measure: 1913-2012

Our new measure for tax progressivity γ of the federal income and social security tax in the US between 1913 and 2012 is plotted Figure 2. This measure relies on a fundamental assumption: that the individual income tax system is well approximated by a loglinear function, which is characterized by two parameters, (λ, γ), where λ captures the level of the tax system and γ its curvature. In particular, we assume that, for a given income y, the after-tax income is equal to $\tilde{y} \equiv \lambda y^{1-\gamma}$.[8] Using the IRS Public Files for the period 1960-2008, Feenberg, Ferriere, and Navarro (2014) argue that such a tax system fits very accurately the US tax system; similar results are found in Heathcote, Storesletten, and Violante (2014) using PSID data (2000-2006).[9] We provide robustness check of this assumption below.

Under this assumption, γ, the parameter that captures the curvature of the tax system, is equal to the ratio of the marginal minus the average tax rate, over unity minus the average tax rate:[10]

$$\gamma \equiv (AMTR - ATR)/(1 - ATR)$$

where $AMTR$ is the annual average marginal tax rate from 1913 to 2012 and ATR is the annual average tax rate from 1913 to 2012.[11] As a robustness check, we verify that our measure γ is highly correlated with the elasticity of the US federal personal income tax, as computed by Dan Feenberg using TAXSIM data over available years (1960-2012).[12] The correlation is of .85 in levels and .43 in growth rates. Finally, we transform this annual measure of progressivity into a quarterly one by repeating four times the annual measure. The rest of the data set is presented in Appendix A.2.

[8] Equivalently, the tax rate $\tau(\cdot)$ for an income level y is given by $\tau(y) = 1 - \lambda y^{-\gamma}$.

[9] See Section 3.2 for a more detailed explanation of this tax function.

[10] See Appendix A.1 for more details on this measure.

[11] The average marginal tax rate AMTR provides from Barro and Redlick (2011) and Mertens (2015). The average tax rate is based on our own computations using IRS Statistics of Income data and Piketty and Saez (2003). See Appendix A.2 for details.

[12] See Daniel's measure here: http://users.nber.org/~taxsim/elas/.

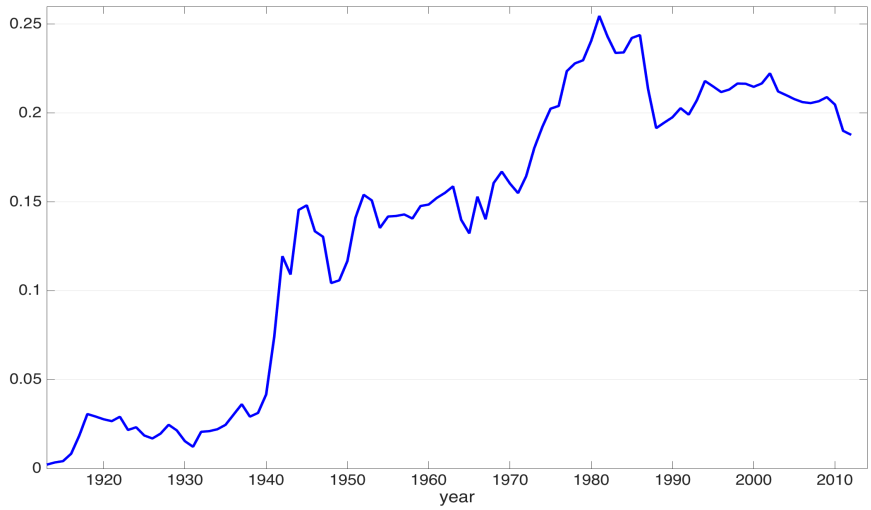


Figure 2: US Federal Tax Progressivity.

Notes: Souce: Authors' calculations.

2.2 Evidence from a Local Projection Method

We use Jorda (2005) local projection method to estimate impulse responses and multipliers. This methodology has increasingly being used for applied work, including the recent works by Auerbach and Gorodnichenko (2012) and Ramey and Zubairy (2014) who apply this method to estimate state-dependent fiscal policy multipliers. A linear version of Jorda (2005) method is as follows

$$x_{t+h} = \alpha_h + A_h(L)Z_t + \beta_h shock_t + \varepsilon_{t+h} \qquad \text{for } h = 0, 1, 2, \ldots, H \tag{3}$$

where x_{t+h} is a vector of variables of interest, Z_t is a set of controls, $A_h(L)$ is a polynomial in the lag operator, and $shock_t$ is the shock identified shock of interest. In our case, $shock_t$ is the defense news variable constructed by Ramey (2011b), and updated by Owyang, Ramey, and Zubairy (2013). For different horizons h, equation (3) can simply be estimated by ordinary least squares.

The coefficients β_h measure the h-periods ahead response of vector x_t to an innovation in $shock_t$ at time t. Thus, a plot of the sequence $\{\beta_h\}_h$ is interpreted as an impulse response function. Similarly, cumulative responses for different horizons h can be constructed as functions of $\{\beta_h\}$,

although the precision of the estimates tends to declines with the horizon length.

The local projection method in equation (3) can be adjusted to accommodate non-linear relations as follows

$$\begin{aligned} x_{t+h} &= \mathbb{I}\left(s_{t-1}=\mathrm{P}\right)\left\{\alpha_{P,h}+A_{P,H}Z_{t-1}+\beta_{P,h}g_t^*\right\} \\ &+ \mathbb{I}\left(s_{t-1}=\mathrm{R}\right)\left\{\alpha_{R,h}+A_{R,H}Z_{t-1}+\beta_{R,h}g_t^*\right\}+\phi_1 t+\phi_2 t^2+\varepsilon_{t+h} \end{aligned} \tag{4}$$

where s_t is a variable determining whether if tax progressivity is increasing ($s_t = P$) or if it's not increasing ($s_t = R$), $\mathbb{I}(\cdot)$ is an indicator function, and g_t^* is the military defense news variable.

Key to our empirical implementation is the selection criteria for the value of s_t. We define a quarter t as having an increasing path in progressivity, if our tax progressivity measure γ_t increases on average during the following Δ quarters: $\left\{s_t = P : \frac{1}{\Delta}\sum_{j=1}^{\Delta+1}\gamma_{t+j} > \gamma_t\right\}$. The forward looking nature of our identification relies on the assumption that households have some predictive capacity on the future path of taxes. This is a reasonable assumption because the tax codes in the US has always changed sluggishly, with long periods of political discussion before the actual implementation of the tax change. In practice, we use $\Delta = 12$ and perform robustness exercises.

Notice that $\{\beta_{s,h}\}$ depends on the state of tax progressivity, and we can thus compute impulse response functions and multipliers as a function of the state s_t. This is a key advantage of the local projection methodology, which allows to estimate state-dependent responses as the outcome of an ordinary least squares procedure.

The vector x_{t+h} contains two variables: the growth rate of GDP $\Delta^h y_{t+h} = \frac{Y_{t+h}-Y_{t-1}}{Y_{t-1}}$; and the adjusted by GDP increase in government spending $\Delta^h g_{t+h} = \frac{G_{t+h}-G_{t-1}}{Y_{t-1}}$. We use this adjusted measure of spending growth because, as initially pointed out by Hall (2009), it facilitates the multiplier computations to be interpreted as the dollar change in output after one dollar change in government spending (see equation (5) below). The control Z_t includes two lags of GDP and government spending, as well as two lags of the news variable g_t^*. Data is quarterly, and covers the period 1913-2010.

We compute multipliers following Ramey and Zubairy (2014). Let $\beta_{s,h}^y$ and $\beta_{s,h}^g$ be the response

of $\Delta^h y_{t+h}$ and $\Delta^h g_{t+h}$ to g_t^* if $s_{t-1} = s$, respectively. Then, the cumulative multipliers at horizon h as

$$m_{s,h} = \frac{\sum_{j=0}^{h} \beta_{s,h}^{y}}{\sum_{j=0}^{h} \beta_{s,h}^{g}} \qquad \forall h = 0, 1, 2 \ldots, H \tag{5}$$

We estimate equation (4) by ordinary least squares, and use the Newey-West correction for our standard errors (Newey and West, 1987). The confidence interval of the cumulative multiplier m_h is computed using delta method, see Appendix B for details.

The effect of government spending on output is significantly higher during periods of increasing progressivity. Figure 3 shows this by plotting the cumulative responses $m_{s,h}$ for different horizons and each state $s = \{P, R\}$. Although similar on impact ($h = 0$), the cumulative multipliers on output after one year are statistically different, being about twice smaller in the decreasing progressivity states. After two years, the cumulative multiplier is statistically equal to zero during periods of decreasing progressivity, while it remains around significantly positive -around 0.7- after three years for increasing progressivity periods. This is key evidence that tax progressivity matters for the effects of government spending.[13]

For completeness, Figure 3 also shows the implied multiplier without differentiating across progressivity states.

2.3 Evidence from an Agnostic VAR

To gather further evidence, we use Uhlig (2005b) agnostic VAR method to estimate impulse responses to government spending shocks for different paths of tax progressivity. We also find this method provides more precise estimates, and allows us to include private consumption in the estimations.[14]

As with standard structural VAR, the goal is to estimate

$$\mathcal{Y}_t = B(L)\mathcal{Y}_{t-1} + Av_t \tag{6}$$

[13] In Appendix B, we provide several robustness checks of our estimates.
[14] The local projection method, albeit simple, becomes very noisy for longer horizons.

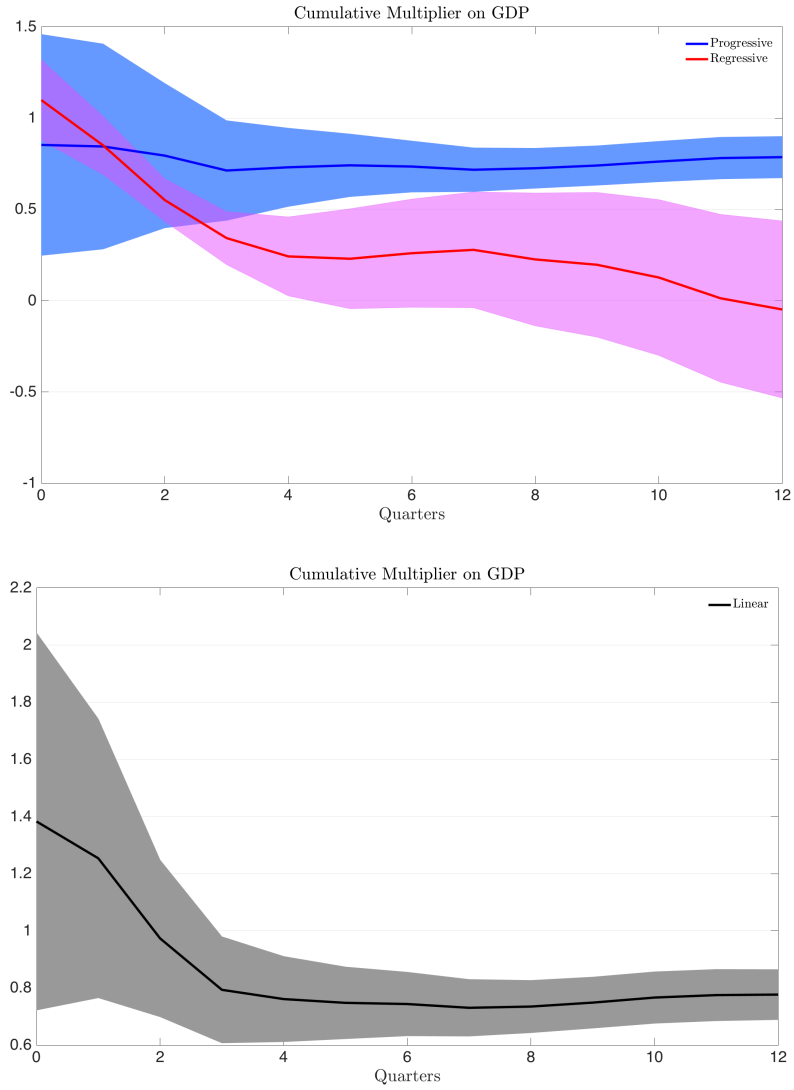


Figure 3: Cumulative multipliers on GDP

Notes: linear (top), progressive and regressive states (bottom). Local projection; data 1913-2010; confidence intervals: 68%; window: 12 quarters.

This methodology differentiates from preexisting literature regarding restrictions imposed on A to achieve identification: for each shock of interest, the agnostic identification imposes a set of sign restrictions on *one* column of the matrix A, based on the definition of that shock. Starting with Uhlig (2005b), the typical goal of agnostic VAR has been to estimate monetary and fiscal shocks: see for instance Arias, Caldara, and Rubio-Ramirez (2015) and Caldara and Kamps (2012) for recent work on monetary and fiscal shocks, respectively. For estimation, we follow the algorithm described in Arias, Rubio-Ramirez, and Waggoner (2015).

We use this method to estimate the effects of military spending shocks, depending on the progressivity of taxes. In our benchmark specification, we use quarterly data from 1919 to 2010 to build a vector $\mathcal{Y}_t \equiv [g_t^\star \ \gamma_t \ \log(Y_t) \ \log(G_t) \ \log(C_t)]$, with a lag of four quarters, where C_t denotes private consumption in non-durables and services. We define the three following shocks: (1) a *linear* shock, defined as: a positive response of $g_t^\star$ on impact, together with a positive response of G_t for four periods; (2) a *progressive* shock, defined as a linear shock with the additional restriction that γ_t reacts positively for four quarters and increasingly for three periods; and (3) a *regressive* shock, defined as a linear shock with the additional restriction that γ_t reacts negatively for four quarters and decreasingly for three periods.[15]

As shown in Figure 4, the response of output and consumption are strikingly different depending on how progressivity changes after the spending shock. Output increases only if progressivity does, and the spending shock actually induces an output contraction if a less progressive tax system is used. Similarly, private consumption contracts after an increase in spending if less progressive taxes are used, and the multiplier is virtually zero otherwise. A battery of robustness checks is presented in Appendix C: the result is robust to several specifications, including adding fiscal surpluses in the vector $\mathcal{Y}_t$, or using military spending rather than total spending, as well as using two lags rather than four for the matrix B.

[15]The additional "acceleration" assumption for γ_t, common in this literature, is made to ensure a symmetric reaction of progressivity in the progressive and regressive case.

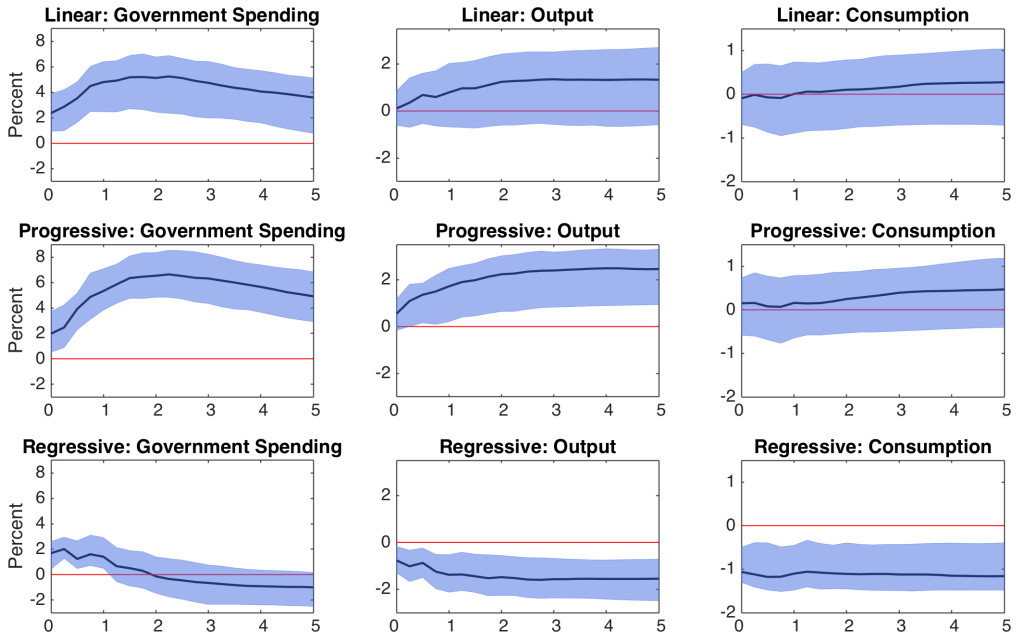


Figure 4: Agnostic VAR: Impulse responses

Notes: linear, progressive, and regressive shocks. Agnostic VAR; data 1913-2010; confidence intervals: 68%.

3 A Model with Progressive Taxes

In this section, we develop a model that can account for the empirical findings described in Section 2. In particular, we show that an increase in spending induces an expansion in output only if financed with an increase in tax progressivity. Key to out result is the distribution of the tax burden towards households with lower elasticity of labor and consumption (i.e.: lower marginal propensity to consume). We first describe the steady state of the economy when government spending and taxes are constant, as well as the calibration strategy. In the following sections, we investigate the effects of government spending shocks in this economy.

3.1 Environment

Time is discrete and indexed by $t = 0, 1, 2, \ldots$. The economy is populated by a continuum of households, a representative firm, and a government. The firm has access to a constant return to scale technology in labor and capital given by $Y = K^{1-\alpha}L^{\alpha}$, where K, L and Y stand for capital, labor, and output, respectively. Both factor inputs are supplied by households. We assume constant total factor productivity.

Households: Households have preferences over sequences of consumption and hours worked given as follows:

$$\mathbb{E}_o \sum_{t=0}^{\infty} \beta^t \left[\log c_t - B \frac{h_t^{1+1/\varphi}}{1+1/\varphi} \right]$$

where c_t and h_t stand for consumption and hours worked in period t. Households have access to a one period risk-free bond, subject to a borrowing limit $\underline{a}$. They face an indivisible labor supply decision: during any given period, they can either work $\bar{h}$ hours or zero.[16] Their idiosyncratic labor productivity x follows a Markov process with transition probabilities $\pi_x(x', x)$.

Let $V(a, x)$ be the value function of a worker with level of assets a and idiosyncratic productivity

[16] With indivisible labor, it is redundant to have two parameters B and φ. We keep this structure to ease the comparison with an environment with divisible labor in a later section.

x. Then,

$$V(a,x) = \max\{V^E(a,x), V^N(a,x)\} \tag{7}$$

where $V^E(a,x)$ and $V^N(a,x)$ stand for the value of being employed and non-employed, respectively. The value of being employed is given by

$$\begin{aligned} V^E(a,x) &= \max_{c,a'} \left\{ \log(c) - B\frac{\bar{h}^{1+1/\varphi}}{1+1/\varphi} + \beta\mathbb{E}_{x'}\left[V(a',x')|x\right] \right\} \\ \text{subject to} & \\ c + a' &\leq wx\bar{h} + (1+r)a - \tau(wx\bar{h}, ra) \\ a' &\geq \underline{a} \end{aligned} \tag{8}$$

where w stands for wages, r for the interest rate and $\underline{a}$ is an exogenous borrowing limit. Note that households face a distortionary tax $\tau(wxh, ra)$, which depends on labor income wxh and capital earnings ra. The function $\tau(\cdot)$ could accommodate different tax specifications, including affine taxes, and we will use to introduce different progressive tax schemes.

Analogously, the value for a non-employed household is given by

$$\begin{aligned} V^N(a,x) &= \max_{c,a'} \left\{ \log(c) + \beta\mathbb{E}_{x'}\left[V(a',x')|x\right] \right\} \\ \text{subject to} & \\ c + a' &\leq (1+r)a - \tau(0, ra) \\ a' &\geq \underline{a} \end{aligned} \tag{9}$$

If the household decides not to work, he does not obtain any labor earnings, but does not experience disutility of working. Every period, each household compares value functions (8) and (9) and makes labor, consumption and savings decisions accordingly. Let $h(a,x), c(a,x)$ and $a'(a,x)$ denote his optimal policies.

Firms: Every period, the firm chooses labor and capital demand in order to maximize current profits,

$$\Pi = \max_{K,L} \left\{ K^{1-\alpha} L^{\alpha} - wL - (r+\delta)K \right\} \tag{10}$$

where δ is the depreciation rate of capital. Optimality conditions for the firm are standard: marginal productivities are equalized to the cost of each factor.

Government: The government's budget constraint is given by:

$$G + (1+r)D = D + \int \tau(wxh, ra) d\mu(a,x) \tag{11}$$

where D is government's debt and $\mu(a,x)$ is the measure of households with state (a,x) in the economy. Notice that in steady state, government spending G as well as the fiscal policies $\tau(\cdot)$ and D are kept constant. In the next section, we will change this budget constraint in different ways and analyze its consequences.

Equilibrium: Let A be the space for assets and X the space for productivities. Define the state space $S = A \times X$ and $\mathcal{B}$ the Borel $\sigma-$algebra induced by S. A formal definition of the competitive equilibrium for this economy is provided below.

Definition 1 *A **recursive competitive equilibrium** for this economy is given by: value functions $\left\{V^E(a,x), V^N(a,x), V(a,x)\right\}$ and policies $\{h(a,x), c(a,x), a'(a,x)\}$ for the household; policies for the firm $\{L,K\}$; government decisions $\{G,B,\tau\}$; a measure μ over $\mathcal{B}$; and prices $\{r,w\}$ such that, given prices and government decisions: (i) Household's policies solve his problem and achieve value $V(a,x)$, (ii) Firm's policies solve his static problem, (iii) Government's budget constraint is satisfied, (iv) Capital market clears: $K + D = \int_{\mathcal{B}} a'(a,x) d\mu(a,x)$, (v) Labor market clears: $L = \int_{\mathcal{B}} xh(a,x) d\mu(a,x)$, (vi) Goods market clears: $Y = \int_{\mathcal{B}} c(a,x) d\mu(a,x) + \delta K + G$, (vii) The measure μ is consistent with household's policies: $\mu(\mathcal{B}) = \int_{\mathcal{B}} Q((a,x),\mathcal{B}) d\mu(a,x)$ where Q is a transition function between any two periods defined by: $Q((a,x),\mathcal{B}) = \mathbb{I}_{\{a'(a,x)\in\mathcal{B}\}} \sum_{x'\in\mathcal{B}} \pi_x(x',x)$.*

3.2 A Non-linear Tax Scheme

We assume a linear tax on capital income $\tau^K ra$, and a non-linear tax function τ^L on labor income wxh.[17] We borrow the function τ^L from Heathcote, Storesletten, and Violante (2014), which is indexed by two parameters, γ and λ: $\tau^L(y) = 1-\lambda y^{-\gamma}$. The parameter γ measures the progressivity of the taxation scheme. When $\gamma = 0$, the tax function implies an affine tax: $\tau^L(y) = 1 - \lambda$. When $\gamma = 1$, the tax function implies complete redistribution: after-tax income $\left[1 - \tau^L(y)\right] y = \lambda$ for any pre-tax income y. A positive (negative) γ describes a progressive (regressive) taxation scheme. The second parameter, λ, measures the level of the taxation scheme: one can think of $1 - \lambda$ as a quantitatively-close measure of the average labor tax.[18] Thus, an increase in $1 - \lambda$ captures an increase in the level of the taxation scheme (it shifts the entire tax function up), while an increase in γ captures an increase in progressivity. It turns the entire tax function counter-clockwise. Figure 5 shows how the tax function changes for different values of γ and λ.

3.3 Calibration

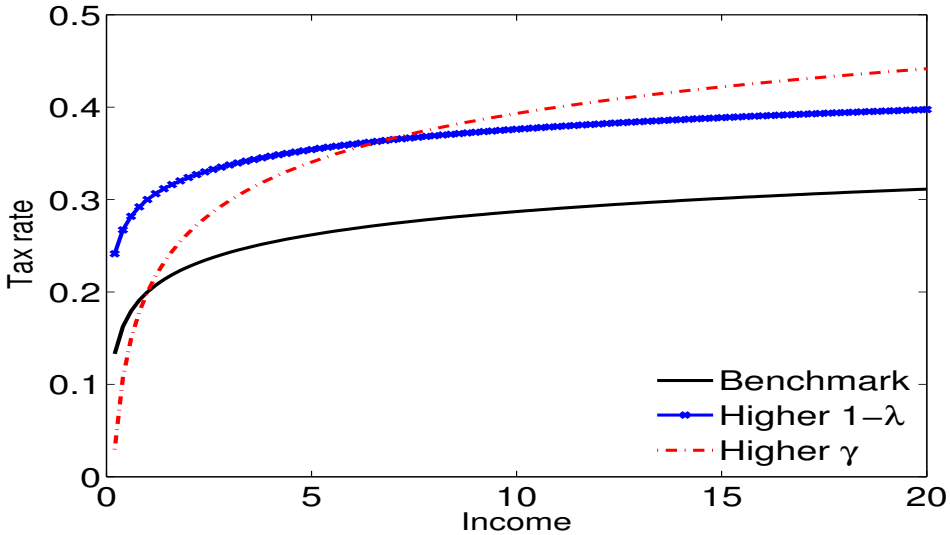
Some of the model's parameters are standard and we calibrate them to values typically used in the literature. A period in the model is a quarter. We set the exponent of labor in the production function to $\alpha = 0.64$, the depreciation rate of capital to $\delta = 0.025$, and the level of hours worked when employed to $\bar{h} = 1/3$. We follow Chang and Kim (2007) and set the idiosyncratic labor productivity x shock to follow an AR(1) process in logs: $\log(x') = \rho_x \log(x) + \varepsilon'_x$, where $\varepsilon_x \sim \mathcal{N}(0, \sigma_x)$. Using PSID data on wages from 1979 to 1992, they estimate $\sigma_x = 0.287$ and $\rho_x = 0.989$. To obtain the transition probability function $\pi_x(x', x)$, we use the Tauchen (1986) method. The borrowing limit is set to $\underline{a} = -2$, which is approximately equal to a wage payment and delivers a reasonable distribution of wealth (see Table 3 below).

For the tax function $\tau(wxh, ra)$, as discussed in Section 3.2, we assume affine capital taxes and non-linear labor income taxes: $\tau(wxh, ra) = \tau_L(wxh)wxh + \tau_K ra$. We set capital taxes to

[17] The choice of a progressive labor tax together with a flat capital tax is somehow arbitrary. However, Feenberg, Ferriere, and Navarro (2014) finde that capital taxes are well approximated by a afine tax function, while labor taxes exhibit more concavity.

[18] When $\gamma = 0$, $1 - \lambda$ is exactly the labor tax. In our calibration with $\gamma = 0.1$, the average labor tax is 0.211 while $1 - \lambda \approx 0.204$.

Figure 5: Non-linear tax as a function of two parameters (λ, γ).



Notes: Plots for the tax function $\tau(y) = 1 - \lambda y^{-\gamma}$, for different values (λ, γ). The parameter γ measures progressivity, while $1 - \lambda$ measures the level of the tax function.

$\tau_K = 0.35$, following Chen, Imrohoroglu, and Imrohoroglu (2007). For labor taxes, we select the progressivity parameter γ as follows: by using PSID data on labor income for the years 2001 to 2005, Heathcote, Storesletten, and Violante (2014) find a value of $\gamma = 0.15$; with IRS data on total income for the year 2000, Guner, Kaygusuz, and Ventura (2012) find a value of $\gamma = 0.065$. We set $\gamma = 0.1$, an intermediate value between these two estimates. The value of λ is computed so that the government's budget constraint is met in equilibrium. Finally, we jointly calibrate preference parameters β and B, and policy parameters G and D to match an interest rate of 0.01, a government spending over output ratio of 0.15, a government debt-to-output ratio of 2.4, and an employment rate of 60 percent, which is the average of the Current Population Survey (CPS) from 1964 to 2003.[19] Table 2 summarizes the parameter values.

Table 3 shows wealth and employment distribution in the model, compared to the PSID data for the total population over 18 years old in the 1984 survey.[20] As often in this class of models,

[19]We target an average 60% participation rate as observed in the CPS. As a robustness check, we compare the distribution of participation in our model with PSID data for the 1984 survey. The average participation rate in PSID is 65%, which is close to our target.

[20]We keep all households where the head of household is 18 or above, and where labor participation is known for both the head and the spouse, if the head has a spouse. An individual is counted as participating in the labor market

Table 2: Parameter Calibration

$\beta = 0.987$	$B = 144$	$G = 0.21$	$D = 3.41$	$(\tau_k, \gamma, \lambda) = (0.35, 0.1, .85)$
$\alpha = 0.64$	$\varphi = 0.40$	$\delta = 0.025$	$\bar{h} = 1/3$	$\underline{a} = -2$
		$(\rho_x, \sigma_x) = (0.989, 0.287)$		

Table 3: Wealth and employment distribution in model and data

Quintiles	1st	2nd	3rd	4th	5th
Share of Wealth					
- *Model*	−0.01	0.04	0.12	0.25	0.61
- *Data (PSID)*	−0.00	0.02	0.07	0.15	0.77
Participation Rate					
- *Model*	0.83	0.63	0.57	0.52	0.45
- *Data (PSID)*	0.65	0.75	0.69	0.60	0.57

Notes: We keep all households where the head of household is 18 or above, and where labor participation is known for both the head and the spouse, if the head has a spouse. An individual is counted as participating in the labor market if he has worked or been looking for a job in 1983. Financial wealth includes housing.

the steady-state underestimate the right tail of the wealth distribution although it roughly matches the left part of the distribution.[21] For the labor force participation, the model predicts a strongly decreasing profile of participation rates with respect to wealth, which is only mildly observed in the data.[22] Overall, albeit simple, the model makes a reasonable fit with data. We show next that matching the wealth distribution is crucial for the key mechanism in the paper.

3.4 A Distribution of Labor Supply Elasticities and MPCs

An increase in taxes implies a negative wealth effect, to which households respond by cutting down consumption. Furthermore, an increase in labor taxes typically induces households to work less. This is why an increase in spending financed higher taxes induces a contraction. However, the size of the contraction crucially depends on the elasticity of households' labor supply and consumption

if he has worked or been looking for a job in 1983. Financial wealth includes housing.

[21] See Cagetti and De Nardi (2008) for details on wealth concentration in bond economies with heterogeneous households.

[22] Matching the distribution of employment participation rate is also a hard task for bond economies with heterogeneous households. See Mustre-del Rio (2012) who allows for heterogeneity in households preferences to match the distribution of participation rates.

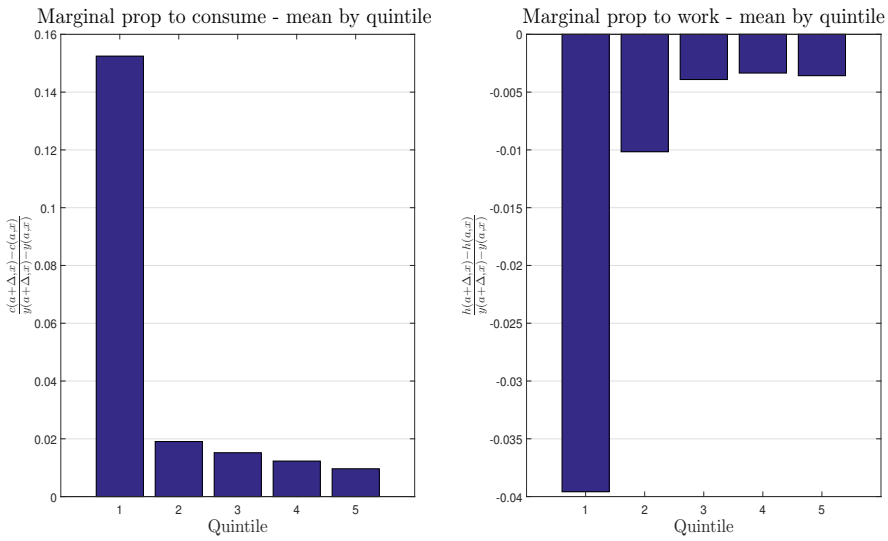


Figure 6: Labor supply elasticity and marginal propensity to consume by households wealth

Notes: Income is defined as $y(a,x) = wxh(a,x) + (1+r)a - \tau(wxh, ar)$

to the tax change. The smaller these elasticities are, the smaller the contraction generated.

In an economy with heterogeneous households, the individual responses to tax changes depend on the households' wealth. Figure 6 shows that poorer households have both a larger marginal propensity to consume, as well as a higher elasticity of labor supply. Accordingly, a tax increase on wealthier households will induce a smaller contraction that if taxes were increased for poor households.

The logic just described is the reason why tax progressivity shapes the effects of government spending. If the increase in spending is financed with higher tax progressivity, the response of aggregate consumption and hours will only mildly decline. However, the recession will be larger if less progressive taxes are used. This is the exercise we perform in next section.

4 Government Spending with Progressive Taxes

The discussion in Section 3.4 suggests that changes in the distribution of taxes can be a key driver of household's responses after a shock in government spending. In this section we analyze

the effect of government spending, and how it depends on tax progressivity. We assume that at $t = 0$ the government unexpectedly and temporarily raises government spending G by one percent. Simultaneously, the government announces the taxation scheme that will be used to finance the increase in expenditures. In particular, it announces a path for the labor tax progressivity $\{\gamma_t\}$ that will be implemented jointly with the increase in spending. Capital tax and government's debt are kept at their steady-state value, and the sequence for $\{\lambda_t\}$ adjusts such that the government's budget constraint (11) is satisfied every period.

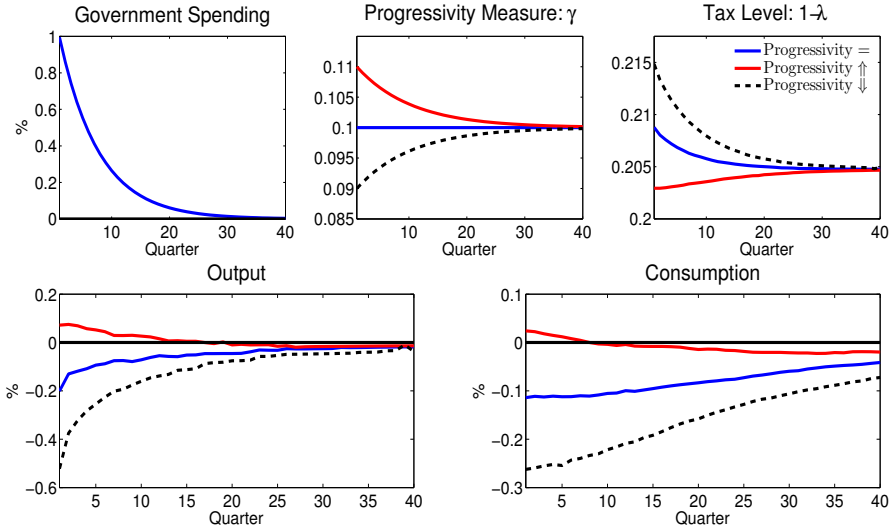
We explore the implications of three different taxation schemes: (1) **Constant Progressivity**: γ is kept at its steady state level; (2) **Higher Progressivity**: γ temporarily increases from 0.1 to 0.11; (3) **Smaller Progressivity**: γ temporarily decreases from 0.1 to 0.09. Note that the tax scheme used in every case is progressive (γ is always positive); only the level of progressivity changes. Also, all experiments generate the same revenues per period for the government. Finally, households have perfect foresight about the future paths of spending and taxes in all cases.

The top right panel of Figure 7 shows the path implied for $1 - \lambda$. When γ is constant, the level of the tax scheme has to increase since the government needs to raise more revenues: the average labor tax increases. However, when progressivity γ increases, the government can afford a mild decrease in the tax level since it is taxing higher income at a higher rate. On the contrary, a decrease in γ requires a large increase in the tax level $1 - \lambda$ to finance the new spending.

The bottom panel of Figure 7 plots the economy's responses for output and aggregate consumption in these three experiments. Our findings are threefold. First, output and consumption multipliers to a spending shock depend crucially on the taxation scheme used: not only their magnitude, but even their sign, can change. Second, with constant (or smaller) progressivity, the shock in spending results in a contraction of both output and consumption. The reason is that average tax rates, as measured by $1 - \lambda$, must increase to balance the government's budget constraint, which is contractionary.[23] Third, when government spending is financed with a *more progressive* taxation scheme, the model can generate a joint increase in public and private consumption. The

[23]Our experiment with fixed γ is qualitatively similar to the result of Baxter and King (1993): in a standard real business cycle model with a representative agent, an increase in government spending financed through a larger income tax is contractionary.

Figure 7: Responses to a government spending shock financed with different tax systems.



Notes: Model impulse response to a government spending shock financed with progressive labor taxes. Impulse functions are computed for different choices of progressivity $\{\gamma_t\}$.

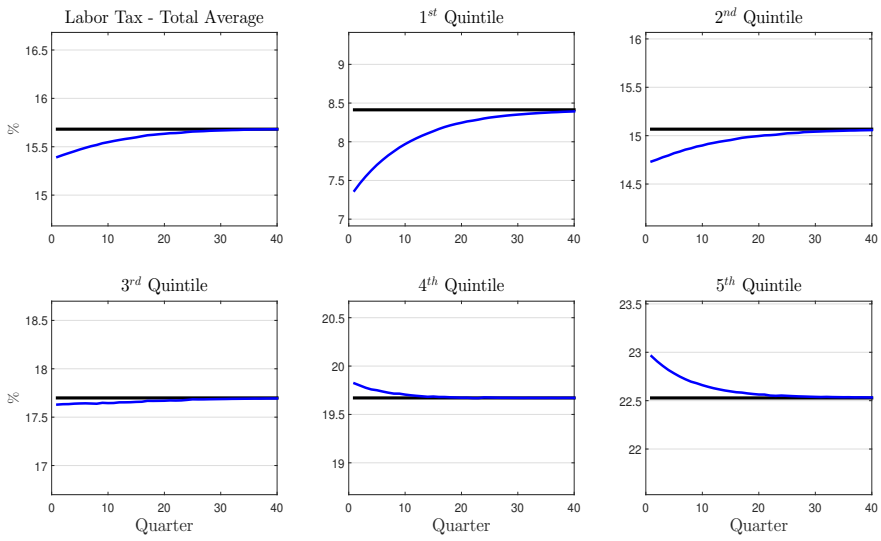
key difference is that progressive taxes distribute the tax burden towards wealthy agents. In turn, wealthy agents partly use their buffer savings to absorb the shock, thus responding only mildly to the spending shock. Furthermore, with the increase in progressivity, some less wealthy households actually experience a decrease in taxes, as seen in Figure 8. This induces them to consume and work more, generating an expansion. Notice also in Figure 8 that the changes in labor taxes induced by the increase in tax progressivity are of limited magnitude.

It is worth emphasizing that all the taxation schemes described above generate the *same* amount of revenues for the government (balanced budget). Different multipliers are obtained as a result of different levels of progressivity: the key mechanism analyzed here is how the burden of taxes is distributed across households, not over time. To the best of our knowledge, this intuitive finding is new in the literature.[24]

To conclude, notice that responses at the individual and at the aggregate level crucially depend

[24]On a related note, we provide in Appendix D robustness checks regarding the balanced budget assumption, as with heterogeneous agents and distortionary taxes, the Ricardian Equivalence does not hold. Using Uhlig (2010) formulation for debt-financed government spending, we argue that the response of tax progressivity is quantitatively of much larger importance for multipliers than the response of debt.

Figure 8: Labor tax response to a government spending shock financed with more progressive taxes.



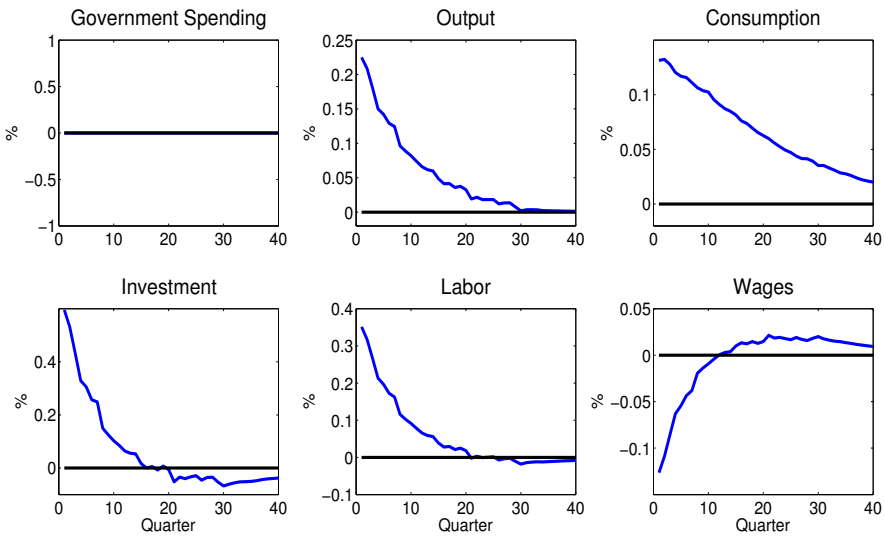
Notes: Impulse response, average and per quintile, to a government spending shock financed with more progressive labor taxes.

on the taxation scheme used by the government; the heterogeneity across households does not wash out at the aggregate level. Modeling heterogeneous agents is key: in a model with a representative household, all experiments would collapse to a unique increase in the labor-tax rate faced by the representative household. In addition, the expansionary effect of government spending occurs because of the increase in tax progressivity and despite the increase in government spending. The expansion would be larger if, for the same increase in progressivity, government spending were kept constant. We show this explicitly in Section 5.

5 Transfers

As discussed earlier, private consumption and output in our model increases after a government spending shock because of the rise in progressivity, but despite the increase in public consumption. In other words, the economic expansion would be larger if, given the same change in progressivity, there were no increase in government spending. Indeed, if public consumption is kept constant, then revenues levied through taxes are also constant. Thus, when progressivity temporarily increases,

Figure 9: More progressive taxes, constant government spending



Notes: Impulse response to a temporary increase in labor tax progressivity. Government spending is kept constant.

the level of the labor tax function, $1 - \lambda$, can decrease more, resulting in a larger boom in output and consumption. Figure 9 shows the economy's response to an increase in progressivity γ as in Section 4, but with no increase in government spending.[25] Output and consumption increase by 0.22 percent and 0.14 percent respectively, versus 0.1 percent and 0.05 percent in Section 4. In other words, a temporary shock in progressivity is a powerful tool in generating expansions.

The exercise in this section suggest that changes in progressivity could have large effects on aggregate output and consumption. This finding opens a large set of new questions, for instance, how a temporary change in progressivity differs from a permanent one, or whether a change in capital tax progressivity would have the same aggregate effects. A formal analysis of these topics is a priority for future work.

6 Conclusion

The aim of this paper is to solve the existing gap between evidence and model predictions, regarding the effects of government spending on output and private consumption. We develop a model where

[25] One may think of this experiment as measuring the effects of transfers: for a revenue-neutral budget, the government redistributes wealth from the wealthier to the least-wealthy households through rise and reductions of taxes.

agents are heterogeneous in wealth and productivity, and labor is indivisible, and find that the distribution of the tax burden across households is crucial to determine the response of aggregate variables: a rise in government spending can be expansionary, both for output and consumption, only if financed with more progressive labor taxes. Key to our results is the model endogenous heterogeneity in households marginal propensities to consume and labor supply elasticities.

Our empirical work provides evidence that tax progressivity has significantly moved in the US over the last century. This is important to discipline the somewhat old question of the macroeconomic effect of government spending. It also opens an avenue for future research on the aggregate and distributional effects of dynamic changes in tax progressivity.

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A Data Sources and Definitions

A.1 Progressivity

A novel time series [P] is built to measure the progressivity of the federal income tax (including social security taxes and tax credits) since 1913, using a measure of average tax rate [ATR] and a measure of average marginal tax rate [AMTR]. The Average Tax Rate [ATR] is computed as Total Tax Liability over Total Income:

- Total Tax Liability (federal income and social security taxes, including tax credits); Source: Statistic Of Income (SOI), IRS; 1913-2014 (annual); Data, Table: "All Individual Income Tax Returns: Sources of Income and Tax Items". From 2006 to 2013, the time series are built by the SOI using another sampling; tax rates are the same until the third digit.

- Total income: Source: Piketty and Saez (2003), 1913-2014 (annual), Data, Table A0.

For the Average Marginal Tax Rate [AMTR], we use the time series of Barro and Redlick (2011) (Federal, Social Security, Data) for years 1912-1945 and Mertens (2015) (Federal, Social Security; Data) for 1946-2012; over the overlapping period, the two measures are almost undistinguishable (correlation, both in level and in growth rates: .99). Finally, the elasticity of the US federal personal income tax under fixed (1995) income distribution is computed by Daniel Feenberg using TAXSIM, 1960-2013 (annual), Data.

Finally, we construct an annual measure of federal personal income tax progressivity P as follows:

$$P = (AMTR - ATR)/(1 - ATR)$$

Should the tax system be exactly loglinear, this measure would be equal to γ. To see this, recall that under a loglinear tax system, given some income y, the after-tax income is $\lambda y^{1-\gamma}$; we define $T(y) \equiv y - \lambda y^{1-\gamma}$ the amount of taxes paid for income y, and $\tau(y) \equiv 1 - \lambda y^{-\gamma}$ the tax rate; the marginal tax rate is equal to $T'(y) = 1 - \lambda(1-\gamma)y^{-\gamma}$ and then:

$$\frac{T'(y) - \tau(y)}{1 - \tau(y)} = \frac{(1 - \lambda(1-\gamma)y^{-\gamma}) - (1 - \lambda y^{-\gamma})}{1 - (1 - \lambda y^{-\gamma})} = \gamma$$

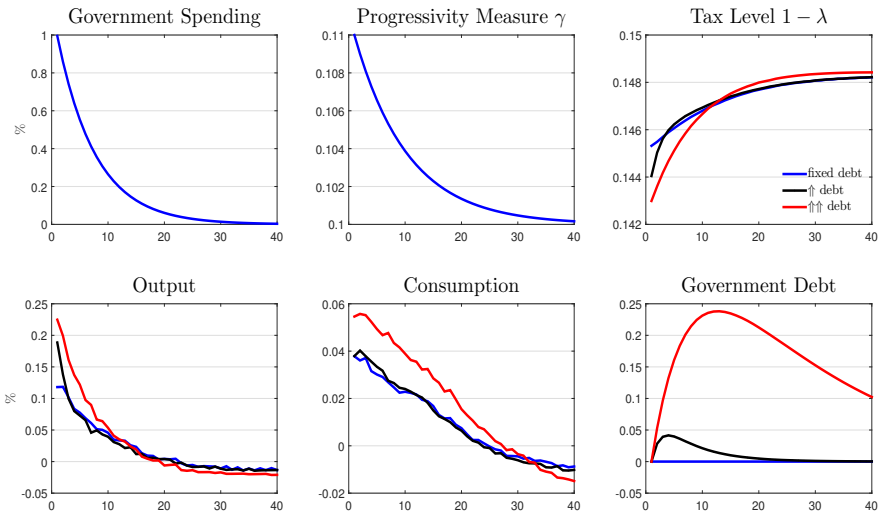
Thus, our measure P gives us an approximation of the progressivity of the tax system, reasonably well correlated with the measure [GAMMA] computed using TAXSIM data.

A.2 Other variables

Fiscal data The measure for military news, borrowed from **?**, is available quarterly from 1913 to 2013 (Data). The measure for total government spending (including federal, state, and local purchases, but excluding transfer payments) is borrowed from Owyang, Ramey, and Zubairy (2013). As a robustness check, we use the quarterly measure of federal defense spending built by Ramey (2011b) (1939-2008), and the (interpolated) annual measure of federal defense spending from Barro and Redlick (2011) (1913-2006). Finally, we build a measure of federal surplus as percent of gross domestic product, as the ratio of nominal federal surplus (Source: FRED, 1913-2013, annual, interpolated per fiscal year) over nominal quarterly GDP (see below).

Business cycle data Quarterly measures for GDP, GDP deflator, and population, from 1913 to 2013, are borrowed from **?**. For consumption data, we merge the Gordon measure for real non-durable consumption (source: American Business Cycles), in real terms in \$1972, 1919-1941 and 1947-1983, quarterly), with the measure built by Ramey (2011b) (1939-2008, quarterly, in real terms, normalized to 100 in 2005). The correlation between the two variables over overlapping years is of 1.00 in levels and 0.95 in growth rates.

Figure 10: Output and Consumption responses to a government spending shock financed with different levels of debt.



Notes: Impulse response to a government spending shock financed with more progressive labor taxes. No additional debt ($\varphi = 1$), some additional debt ($\varphi = .5$), mostly debt ($\varphi = .05$).

B Local Projection Method: Estimation and Inference

Table for robustness to be added

C Agnostic VAR

Robustness to be added

D The role of debt

Details on Uhlig (2010) to be added.