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

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Abstract

We investigate how government spending multipliers depend on the distribution of taxes across households used to finance the spending. We exploit the U.S. historical variations in the financing of spending since 1913 to show that multipliers are positive only when financed with more progressive taxes, and zero otherwise. We rationalize this finding by using a heterogeneous household model with indivisible labor supply. The model results in a lower labor responsiveness to tax changes for top-income earners and, in turn, spending financed with more progressive taxes induces a smaller crowding-out and thus larger multipliers, as empirically found.

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

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

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1 Introduction

Government spending is frequently used to mitigate the effect of recessions. Two recent examples are the *European Economic Recovery Plan*, proposed by the European Commission in 2008, and its American counterpart, the *American Recovery and Reinvestment Act*, authorized by the U.S. Congress in 2009. The unusual scale of these fiscal interventions has renewed the interest in understanding how expansionary government spending is. However, despite the recurrence of this question in policy debates, there is no consensus among economists on the size of spending multipliers – that is, on the response of output to a one-dollar increase in spending.

Some empirical work, notably using military events, suggests that multipliers are modest and typically below unity (Ramey and Shapiro, 1998; Burnside, Eichenbaum, and Fisher, 2004; Barro and Redlick, 2011; Ramey, 2011).[1] Other studies, often relying on a structural VAR approach, estimate larger multipliers (Blanchard and Perotti, 2002; Perotti, 2008; Mountford and Uhlig, 2009).[2] This disparity in empirical findings has its counterpart in theoretical work. Standard versions of the Neoclassical and New-Keynesian model generate small output multipliers, but their exact magnitude depends on details of the model specifications.[3] A crucial element in these models is the nature of the government's budget adjustment to finance the increase in spending (Ohanian, 1997; Uhlig, 2010). Multipliers are small but positive when financed with lump-sum taxes, but significantly smaller – and even negative – if more realistic income taxes are used, as first shown in the seminal work by Baxter and King (1993).[4]

In this debate though, an important dimension has been neglected: the distribution, across households, of the fiscal burden consequent to the stimulus. This is somewhat surprising, for at least two reasons. First, from a theoretical perspective, recent work has shown that the cross-sectional dimension of fiscal policy has significant aggregate implications.[5] However, most existing studies on government spending assume a representative-agent and thus cannot discuss how multipliers depend on the tax distribution.[6] Second, from a historical perspective, the U.S. has typically implemented substantial tax reforms to finance large changes

[1]See Fisher and Peters (2010) for larger multipliers on military spending.

[2]For instance, Romer and Bernstein (2009) use a multiplier of 1.5 when estimating the effects of *American Recovery and Reinvestment Act*.

[3]In the Neoclassical model, Edelberg, Eichenbaum, and Fisher (1999) and Burnside, Eichenbaum, and Fisher (2004), show how multipliers vary depending on assumptions about preferences and technology. In the New Keynesian environment, multipliers are larger if monetary policy does not strongly react to inflation (Christiano, Eichenbaum, and Rebelo, 2011; Eggertsson, 2011; Nakamura and Steinsson, 2014), or when there is a large fraction of non-Ricardian households and spending is initially debt-financed (Gali, Lopez-Salido, and Valles, 2007).

[4]Drautzburg and Uhlig (2015) also argue that, even in a New-Keynesian environment at the zero-lower-bound, spending multipliers are substantially lower when financed with distortionary taxes.

[5]See Heathcote (2005) and Bhandari, Evans, Golosov, and Sargent (2017), among many others.

[6]A few remarkable exceptions are Bilbiie and Straub (2004), Monacelli and Perotti (2011), Hagedorn, Manovskii, and Mitman (2017) and Brinca, Holter, Krusell, and Malafry (2016).

in spending, but these reforms have not been alike: in some cases –like WWI, WWII and the Korean War– the fiscal burden was tilted towards top-income earners; while in other cases –like Vietnam War and the Reagan military build-up– the burden was more evenly distributed.[7] Thus, the U.S. history of spending and taxation is particularly insightful to understand how the distribution of taxes shapes spending multipliers, which is the question tackled in this paper.

We first approach this question empirically. We exploit the historical variation in the financing of spending in the U.S. to estimate multipliers that depend on the progressivity of taxes used. We find that spending multipliers are larger when financed with more progressive taxes – that is, spending is more expansionary when the tax burden falls more heavily on top-income earners. We then develop a heterogeneous household model that can rationalize this finding. The key component in the model is an extensive labor supply decision, which results in lower labor responsiveness to tax changes for top-income earners. Consequently, financing spending in a more progressive fashion induces a smaller crowding-out and thus larger multipliers. Using tax revenue household data, we also provide evidence of the cross-section predictions of the model.

To assess empirically how spending multipliers depend on tax progressivity, we use local-projections method as recently done by Ramey and Zubairy (2014).[8] To do so, we build a novel measure of tax progressivity for the U.S. starting in 1913 with the creation of income taxation. A long time-series of progressivity is important for our purposes because the largest changes in spending, as well as many substantial tax reforms, occurred during the first half of the 20^{th} century. Albeit simple, we show that our measure of progressivity accurately reflects tax reforms. We then use this measure to estimate state-dependent multipliers, where the state depends on tax progressivity.

We find spending to be significantly more expansionary in progressive states, with a cumulative multiplier of between 0.8 and 1 after three years. Multipliers are roughly zero otherwise. In other words, a government can increase output by about 90 cents if it spends one more dollar and finances it by taxing mostly top-income earners, while there would be no effect on output if financed by taxing all households more evenly.

We then analyze these findings through the lens of a model. Theory tells us that spending multipliers crucially depend on the taxes used to finance the stimulus. The rationale is as follows: a government will have to raise taxes to finance the increase in spending; and higher taxes crowd-out the private sector, which ultimately limits how expansionary spending can be. The larger the crowding-out, the smaller the multiplier.

An *off-the-shelf* model of heterogeneous households with an extensive labor supply decision can account

[7]We briefly discuss the U.S. history of taxation in Section 2.2. See Brownlee (2016) and Brownlee (2000) for a more detailed discussion, as well as Scheve and Stasavage (2016).

[8]Similar methods are used in Auerbach and Gorodnichenko (2012b) and Fieldhouse, Mertens, and Ravn (2018), among others.

for our empirical findings, because of the rationale just discussed. In this environment, top-income earners have exceptional labor market prospects and thus face a large opportunity cost of exiting the labor market, which renders them less responsive to tax changes. Hence, an increase in spending financed with more progressive taxes induces a smaller crowding-out and, in turn, a larger spending multiplier, as empirically found. This effect is quantitatively large. In our benchmark model, a spending shock evenly financed across households generates a negative multiplier of about -0.4 during the first three years. However, if the bottom-10% of workers are exempted from higher taxes, the multiplier is raised by 0.3; and if only the top-35% workers finance the spending shock, multipliers are raised by an additional 0.3.

The heterogeneity of labor supply responses to tax changes is a central element in our model. Support for this heterogeneity can be found in several sources. In the micro-labor literature a consensus has emerged, that labor supply fluctuations are mostly driven by the extensive margin (Heckman, 1993), and that labor participation elasticities are significantly larger for lower-income earners (Blundell, 1995). Accordingly, labor participation elasticities that decrease with income has become a standard assumption in the public finance literature (Kleven and Kreiner, 2006; Immervoll, Kleven, Kreiner, and Saez, 2007). Further support for this heterogeneity comes from the recent work by Zidar (2017). This paper uses tax-revenue data to investigate how tax changes for different income groups affect aggregate economic activity. It finds that tax hikes to the bottom-90% are very detrimental for total employment, while the effect is negligible when taxing the top-10%. We show that our calibrated model is quantitatively consistent with the findings in Zidar (2017).

We also provide direct evidence on the cross-sectional effects of government spending using tax revenue data since 1960. We find that an increase in spending is moderately expansionary for low-income households in progressive states, and strongly contractionary otherwise; while top-income earners' responses are of much smaller magnitudes, and do not significantly depend on progressivity.[9] We see the lower responsiveness of top-income earners, together with the previous work discussed above, as compelling evidence of the mechanism explored in our paper.

Our work relates to the large literature on estimating spending multipliers, and more particularly to the small but growing literature on state-dependent multipliers. The recent work by Ramey and Zubairy (2014) and Auerbach and Gorodnichenko (2012a) discuss how spending multipliers may depend on the state of the economy (slack and/or zero-lower-bound). We build on their methodological contributions to estimate how the path of tax progressivity shapes multipliers. Importantly, as we discuss in Section 2.5, the state-dependence of multipliers we identify goes beyond the one discussed in these two previous papers: tax progressivity substantially affect multipliers regardless the amount of slack in the economy. Previous

[9] See Anderson, Inoue, and Rossi (2016) for a related discussion.

empirical work had also considered how the financing scheme affects spending multipliers, focusing on the intertemporal allocation of taxes (Gali, Lopez-Salido, and Valles, 2007; Broner, Clancy, Alberto, and Ercez, 2017). We add to this work by considering the intratemporal tax distribution, which is sensible from a theoretical perspective and shown to have substantial qualitative and quantitative consequences. We also contribute to the empirical work on fiscal policy more generally, by constructing a simple measure of tax progressivity for a long period that accurately reflects tax reforms in the U.S.

A recent line of research has stressed the importance of households' heterogeneity for the aggregate effects of fiscal and monetary policies (Kaplan, Moll, and Violante, 2018; Auclert, 2017).[10] This work typically incorporates Keynesian features and focus on how households' heterogeneity shapes aggregate demand in response to fiscal and monetary policies. The key element in these models is the distribution of marginal propensities to consume. In contrast, our mechanism relies primarily on heterogeneity in labor participation elasticities, and its effect on aggregate supply in response to fiscal shocks. Since aggregate demand channels are arguably an important component of the fiscal policies, we incorporate Keynesian features to our benchmark model for the quantitative evaluation of our model in Section 4.

The rest of the paper is organized as follows. Section 2 presents the evidence. Section 3 illustrates through simple experiments the effects of tax progressivity on spending multipliers in a model. Section 4 compares the model to the macro and micro data presented in Section 2. Section 5 concludes.

2 Government Spending and Tax Progressivity: Evidence

Most substantial fluctuations in government spending occurred during the first half of the past century, as shown in Figure 1. Consequently, to estimate spending multipliers as well as on how they depend on tax progressivity, it is important to use long time series. To achieve this, Section 2.1 describes a novel measure of tax progressivity for the U.S. starting in 1913, and Section 2.2 discusses how this measure accurately reflects the historical changes of the federal income tax code. This measure is then used to estimate state-dependent spending multipliers, where the state depends on the tax progressivity. Sections 2.3 and 2.4 describe the estimation and the progressivity states, while Section 2.5 presents the results. Finally, Section 2.6 analyzes the heterogeneous effects of government spending across households. These aggregate and cross-sectional findings are the core motivation for the model developed in Section 3.

[10]See also Kaplan and Violante (2014), McKay and Reis (2016), Debortoli and Gal (2012), and Gornemann, Kuester, and Nakajima (2016) among others.

2.1 A Tax Progressivity Measure: 1913-2012

We build a measure of tax progressivity for the U.S. since 1913. To do so, we assume that the federal tax code on personal income is well approximated by a log-linear tax function, where the tax rate on income level y is given by $\tau(y) = 1 - \lambda y^{-\gamma}$. The parameter γ measures the progressivity of the taxation scheme. When $\gamma = 0$, the tax rate is constant: $\tau(y) = 1 - \lambda$. When $\gamma = 1$, the tax function implies complete redistribution: after-tax income $(1 - \tau(y))\, y$ equals λ for any pre-tax income y. A positive (negative) γ describes a progressive (regressive) taxation scheme. The second parameter, λ, is as a quantitatively-close measure of the average income tax.[11] Thus, an increase in $1 - \lambda$ captures a rise in the overall level of the taxation, while an increase in γ captures a rise in progressivity: it decreases tax rates for low income levels and increases it for higher ones, as shown in Figure 2. Albeit simple, this tax function features a remarkably good fit to the U.S. federal income tax system.[12]

An advantage of this tax function is that the progressivity parameter γ can easily computed as:

$$\gamma \equiv (AMTR - ATR)/(1 - ATR) \tag{1}$$

where $AMTR$ is the average marginal tax rate and ATR the average tax rate. Importantly, measures of $AMTR$ and ATR can be constructed for the U.S. since 1913, and we can thus compute a long time series of the progressivity measure γ.[13] The measure of progressivity γ is plotted in Figure 3.

The computation of γ in (1) is exact when assuming the log-linear tax function, but is also an intuitive proxy for tax progressivity more generally. In particular, γ increases when marginal tax rates increase on average more than average tax rates, which often occurs when taxes increase at the top of the income distribution without largely affecting taxes at the bottom. As such, this measure accurately tracks changes in the U.S. federal income tax system since its creation in 1913, as we discuss next.

[11] Notice that when $\gamma = 0$, the tax-rate is exactly $1 - \lambda$.

[12] This tax function has been extensively used in recent work, for instance by Heathcote, Storesletten, and Violante (2014) and Guner, Kaygusuz, and Ventura (2014) among others. These papers argue that it fits particularly well the U.S. federal income tax code in recent years. In a companion paper (Feenberg, Ferriere, and Navarro, 2016), we use tax revenue data (from the TAXSIM program) to show that this log-linear approximation of the tax system has a very good fit since 1960 as well.

[13] We use the average marginal tax rates series constructed by Barro and Redlick (2011) and Mertens and Olea (2018), and IRS Statistics of Income data and the Piketty and Saez (2003) measures of income for constructing the average tax rate. See Appendix A.1 and Appendix A.2 for more details on the computations and data sources.

2.2 A Narrative of Tax Progressivity

We briefly discuss the main historical reforms in the U.S. federal income tax code. A more detailed description of the historical reforms to the tax code can be found in Appendix C.

The Sixteen Amendment to the United States Constitution, adopted on February 3rd of 1913, set the legal benchmark for Congress to tax individual as well as corporate income. The *Revenue Act* (*RA*) of *1913* determined personal income tax brackets for the first time, with a modest but progressive structure. Shortly after, the entry of the United States into World War I (WWI) greatly increased the need for tax revenues, which were largely obtained by expanding personal income taxes in a progressive fashion. The revenue acts during the Wilson administration drastically increased top marginal tax rates to a 60%–77% range, ten times more what they were three years ago.[14] The decade that followed WWI, with Andrew Mellon as a Secretary of the Treasury, observed a persistent decline in progressivity. However, this was substantially reversed by President Hoover who again increased top marginal tax rates to WWI levels with the *RA* of *1932*.

The most significant increase in tax progressivity occurred during the presidency of Franklin D. Roosevelt. The *RA* of *1935*, referred-to as the “Soak the Rich” tax at that time, already included increases in top marginal tax rates.[15] An even more drastic increase in progressivity came with the U.S. participation in WWII: after a sequence of tax reforms, top marginal tax rates reached a historical maximum range of 90%–94% with the *RA* of *1945*. Progressivity decreased after WWII, although higher top marginal tax rates were temporarily reinstated to finance Korean War.[16]

The next significant tax reform came more than ten years later with the Kennedy-Johnson *Tax Reduction Act* of 1964, which reverted progressivity by decreasing top marginal tax rates to a 60%-70% range. Although a temporary increase of taxes was implemented in 1968 to finance the Vietnam war, there were no substantial modifications to statutory rates in the last half of the 1960s nor the 1970s. Nevertheless, there were significant additions to tax deductions and credits during the 1970s which, together with a period of high inflation and non-indexed tax brackets, resulted in more progressive taxes.[17]

The most recent substantial decrease to tax progressivity occurred during the Reagan administration,

[14] Importantly, personal income taxes quickly became a substantial source of tax receipts, representing one third of total revenues by the end of WWI. The remaining two thirds of tax revenues were roughly evenly divided between corporate income taxes and tariffs.

[15] See Blakey and Blakey (1935).

[16] The *RA* of *1951* aimed to finance the war expenses without increasing deficits, and accordingly removed the tax cuts implemented after WWII. Nevertheless, the tax cuts were reinstated in the *RA* of *1954* once the Korean war was over. See more in Appendix C.

[17] During these years, the most important changes to the tax code took the form of increased tax expenses; typically tax deductions and tax credits (Brownlee, 2016, ch. 6). Inflation also raised progressivity as it increased effective marginal tax rates significantly more for top income earners – see Figure 2 in Mertens and Olea (2018).

with the the *Economic Recovery Tax Act* (ERTA) of *1981* and the *Tax Reform Act* (TRA) of *1986*, which initially lowered top marginal tax rates from 70% to 50%, and then further more to 28%.[18] Although the decrease in progressivity during the Reagan's presidency was never fully reverted, the subsequent administrations of Bush and Clinton implemented a partial recovery of it. The *Omnibus Budget Reconciliation Act* of 1990 and 1993 increased top marginal tax rates and expanded tax credits.[19]

Our simple tax progressivity measure, plotted in Figure 3, captures remarkably well the historical tax reforms since 1913 described in this section. Importantly, most variations in the measure γ are directly associated to tax reforms and political events, and do not correspond to changes in economic conditions.[20] Consequently, this new measure appears useful to estimate how government spending multipliers can depend on tax progressivity.

2.3 Local Projection Method

We use Jorda (2005) local projection method to estimate spending multipliers, with an instrumental variable procedure as recently done by Ramey and Zubairy (2014). This methodology has been increasingly used in applied work, and can easily be extended to estimate state-dependent multipliers.[21] A linear version of the method is as follows

$$\sum_{j=0}^{h} \Delta^j y_{t+j} = \alpha_h + A_h Z_{t-1} + m_h \sum_{j=0}^{h} \Delta^j g_{t+j} + \phi trend_t + \varepsilon_{t+h} \qquad \text{for } h = 0, 1, 2, \ldots, H \tag{2}$$

where $\Delta^h y_{t+h} = \frac{Y_{t+h} - Y_{t-1}}{Y_{t-1}}$ is GDP growth, $\Delta^h g_{t+h} = \frac{G_{t+h} - G_{t-1}}{Y_{t-1}}$ is the adjusted-by-GDP increase in government spending, and Z_t is a set of controls. For each horizon h, the coefficient m_h measures the cumulative response of output to a one-dollar increase in government spending.[22] Equation (2) is then estimated by a two-stage least squares procedure, where the cumulative spending growth is instrumented by

[18] The decrease in income taxes, added to the increased defense spending and the 1981 recession, resulted in large fiscal deficits, to which the Reagan administration responded by increasing other taxes, as with the Tax Equity and Fiscal Responsibility Act (TEFRA, 1982) and the Deficit Reduction Act (DEFRA, 1984). See Appendix C for more details.

[19] The *Tax Payer Relief Act* of *1997* did not affected tax rates, but included and expansion in Earned Income Tax Credit and the inclusion of new tax credits such as the child and education credits.

[20] With the notable exception of the 1970s, where changes in tax progressivity were partly driven by inflation. However, as we show below, there were no large shocks in spending during that time.

[21] See the recent work by Auerbach and Gorodnichenko (2013) and the survey by Ramey (2016), among others, who also use Jorda (2005) methods to estimate state-dependent multipliers.

[22] The GDP-adjusted measure of spending growth allows to interpret m_h as a multiplier without further transformation, as initially discussed by Hall (2009).

some identified spending shocks g_t^* to control for endogeneity.[23]

The local projection method in equation (2) can be adjusted to accommodate state-dependent relations as follows

$$\sum_{j=0}^{h} \Delta^j y_{t+j} = \mathbb{I}(s_t = \text{P}) \left\{ \alpha_{P,h} + A_{P,h} Z_{t-1} + m_{P,h} \sum_{j=0}^{h} \Delta^j g_{t+j} \right\} + \mathbb{I}(s_t = \text{R}) \left\{ \alpha_{R,h} + A_{R,h} Z_{t-1} + m_{R,h} \sum_{j=0}^{h} \Delta^j g_{t+j} \right\} + \phi \; trend_t + \varepsilon_{t+h} \tag{3}$$

where s_t is a variable that captures the state of tax progressivity –which we discuss below– and $\mathbb{I}(\cdot)$ is an indicator function. Notice that multipliers $\{m_{s,h}\}$ now depends on the state, $s_t = P$ in progressive periods and $s_t = R$ otherwise. This is a key advantage of the local projection method, which allows to estimate state-dependent responses as the outcome of an ordinary least squares procedure.

In the benchmark estimation, we use as instruments g_t^*, the two most common measures in the literature: the government spending innovation as identified by Blanchard and Perotti (2002) (*BP* shock henceforth), and the defense news variable constructed by Ramey (2011), and updated by Ramey and Zubairy (2014) (*RZ* shocks henceforth). The control Z_{t-1} includes eight lags of GDP, government spending, and the average marginal tax rate; the trend is quartic; and data is quarterly for 1913q1-2006q4.[24] We transform the annual measure of progressivity into a quarterly one by repeating four times the annual measure. The details of the construction of the data set are presented in Appendix A.2. We estimate equation (3) by ordinary least squares, and use the Newey-West correction for computing standard errors (Newey and West, 1987).

2.4 Progressive and Regressive States

Key to our empirical exercise is the selection criteria for the state s_t. We define a quarter t as more progressive if tax progressivity γ_t increases on average during the following Δ quarters: $\left\{s_t = P : \gamma_t^a > \gamma_{t-1}^b\right\}$, where $\gamma_t^a \equiv \frac{1}{\Delta_a} \sum_{j=0}^{\Delta_a} \gamma_{t+j}$ and $\gamma_{t-1}^b \equiv \frac{1}{\Delta_b} \sum_{j=1}^{\Delta_b+1} \gamma_{t-j}$. States which are not progressive are called regressive. Figure 4 shows the periods selected as progressive, together with the two measures of shocks.

Two points are worth discussing about our state definition. First, the state is forward-looking in nature,

[23] An alternative procedure to estimate spending multiplier is to project $\Delta^h y_{t+h}$ and $\Delta^h g_{t+h}$ on g_t^* separately, obtain coefficients β_h^y and β_h^g respectively, and finally compute cumulative multipliers as $m_h = \left(\sum_{j=0}^h \beta_j^y\right) / \left(\sum_{j=0}^h \beta_j^g\right)$. This alternative computation of the multiplier is numerically identical to the coefficient m_h obtained in equation (2). The advantage of estimating equation (2) directly is that it allows us to use more than one shock measure g_t^* as an instrument. See Ramey and Zubairy (2014) for a further discussion.

[24] We stop our sample on 2006q4 to avoid using data during the Great Recession, but Appendix B shows that results are robust to using alternative time periods.

to capture the (possibly sluggish) tax reforms subsequent to the increase in spending. Economically, this also presumes that households have some predictive capacity on the near-future path of taxes, an assumption justified by the long periods of political discussions typically observed before tax reforms, especially around military events.[25] In practice, we set $\Delta_a = 12$ and $\Delta_b = 8$, so that a state of increasing progressivity is a period where the average tax progressivity in the next three years is larger than the one during the two years before.[26]

Second, the state definition does not involve the level of tax progressivity, but its *change*. We focus on the change because it is the metric that captures whose households observe an increase in taxes, reflecting the distributional choice faced by governments to finance additional spending: as discussed above, the increased tax burden was distributed differently on alternative occasions in history.[27]

Our state definition categorizes spending shocks into progressive and regressive states. The outcome of this procedure is much in line with the narrative of Section 2.2. The WWI, WWII, and the Korean War – three wars for which the fiscal burden felt undoubtedly more on wealthier households – are all in progressive states. On the other hand, the Vietnam War, as well as the military build-ups during the Reagan and the G. W. Bush administrations, are in regressive states, again in line with the narrative evidence discussed above.[28] Thus, although a simple and uniform measure of progressivity for such a long period has clear limitations, our measure yields progressivity states which are largely consistent with the discussion in Section 2.2.[29]

2.5 Multipliers in Progressive and Regressive States

The effect of government spending on output is significantly higher during periods of increasing tax progressivity. Figure 5 plots the cumulative output multipliers $\{m_{s,h}\}$ when spending is instrumented by both BP and RZ shocks, for different horizons h and states $s = \{P, R\}$. For completeness, it also reports results for the non-state-dependent estimation, which are in line with previous work.

The cumulative multiplier on output is positive only in the progressive state. It is mildly positive on impact and steadily increases to about 0.85 after three years. In the regressive state, the multiplier is initially negative, and not statistically different from zero after two and three years. Finally, the p-value

[25]See Brownlee (2016) pg. xi.

[26]In Appendix B, we show that results are robust to small changes in Δ_a and Δ_b.

[27]In Section 3, we discuss more formally how changes in γ map to changes in the distribution of taxes.

[28]While the biggest RZ shocks mostly appear during progressive states, the more balanced BP shocks. We show in Appendix B that our results are robust to using each instrument separately.

[29]As a robustness check, we estimate γ using tax revenue administrative micro-data from 1960 onwards (TAXSIM, NBER), and obtain a state definition that is very similar to the one above on the overlapping period. See Appendix B.

for the difference in multipliers across states is always below 5% at all horizons plotted.[30] We take this as compelling evidence that tax progressivity shapes the effects of government spending.

In Appendix B, we provide several robustness checks of our estimates. In particular, we report multipliers using either RZ or BP shock separately as an instrument; we also check using alternative windows Δ for the progressive state definition, different lags and trend specifications, as well as different controls (adding government surplus, 3-month T-bill, removing the average marginal tax rate), and time periods (starting in 1953:q1, ending in 2008:q4). Our findings are robust: spending is found more expansionary when financed with more progressive taxes.

2.6 Cross-Sectional Effects of Government Spending

In this section, we consider the heterogeneous effect of government spending across households and how this depends on the progressivity of taxes. For this purpose, we estimate an equation similar to (3), but in this case we project the spending shock on households-level income. In particular, we estimate the following equation

$$\begin{aligned}\ln y_{i,t+h} &= \sum_{q\in\text{quantiles}} \sum_{s=P,R} d^q_{i,t+h}\mathbb{I}(s_t = s)\left\{\alpha^q_{s,h} + A^q_{s,h}Z_{t-1} + \delta^q_{s,h}\ln\left(\frac{G_{t+h}}{G_{t-1}}\right)\right\} \\ &+ \sum_{q\in\text{quantiles}} d^q_{i,t+h}\ \phi^q\ trend_t + \varepsilon_{i,t+h}\end{aligned} \qquad (4)$$

where $y_{i,t+h}$ is income of household i in year $t+h$, $d^q_{i,t+h}$ is a dummy indicating the household's quantile in year $t+h$, and G_t is government spending. As before, we instrument spending using the RZ and BP shocks. Thus, $\delta^q_{s,h}$ measures the average response (elasticity) of income in quantile q to a spending shock, h periods ahead.

For households' income, we use tax-revenue data from the NBER's TAXSIM program. The data is annual from 1960 to 2008, not top-coded, and with an average of 83,000 observations per year. A drawback of this data is that we cannot keep track of household's over time, and thus we must rely on a repeated cross-section over time and not a panel.[31] As controls we use two lags of (the log of) GDP and government spending. The time-trend is quadratic, and notice that we allow for quantile dependent time-trends. Finally, we divide observations into five quantiles (quintiles). We cluster errors by year t when computing standard errors.

[30] See Table 6 for p-values.

[31] We experimented constructing a synthetic panel by grouping households into percentiles, and obtained very similar results.

We find very heterogeneous responses across households to a spending shock, as shown in Figure 6. For low-income households, spending is found expansionary in periods of higher progressivity, and strongly contractionary otherwise. As income increases, responses are of much smaller magnitudes and do not significantly depend on progressivity. This profile of lower responsiveness as income increases is a key element in the model of next section and, as we discuss, in line with previous studies.

3 A Model with Government Spending and Progressive Taxes

We develop a heterogeneous household model that can rationalize the empirical findings of Section 2. The central implication of the model is that higher-income earners are less responsive to tax changes than lower-income ones. Consequently, a spending increase financed with more progressive taxes induces a smaller crowding-out, and thus larger multipliers. We start by describing the model environment and its calibration, and then discuss the model-implied distribution of labor supply elasticities. Since these elasticities are key to the model, we carefully discuss how they compare to previous empirical work. Finally, we present two simple experiments to understand the aggregate and cross-sectional effects of government spending under alternative paths for the distribution of taxes. Section 4 contains a more quantitative evaluation of the mechanism.

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 first present a steady-state without aggregate uncertainty, and later analyze transition dynamics as a result of a temporary spending shock.

Households. Households value consumption and leisure. Labor supply is indivisible: during any given period, households can either work $\bar{h}$ hours or zero. Their idiosyncratic labor productivity x follows a Markov process with transition probabilities $\pi_x(x', x)$. Labor productivity shocks are uninsurable: households can only trade a one period risk-free bond to self-insure, subject to a borrowing limit $\underline{a}$.

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

$$\begin{aligned} V(a,x) &= \max_{c,h,a'} \left\{ \log(c) - Bh + \beta \mathbb{E}_{x'} \left[V(a',x') | x \right] \right\} \qquad (5) \\ \text{subject to} & \\ c + a' &\leq wxh + (1+r)a - \mathcal{T}(wxh, ra) + T \\ h &\in \left\{ 0, \bar{h} \right\}, \qquad a' \geq \underline{a} \end{aligned}$$

where c and h denote consumption and hours worked, and w and r denote wage and the interest rate. Households face a distortionary tax $\mathcal{T}(wxh, ra)$, which depends on labor income wxh and capital earnings ra, and receive a lump-sum transfer T. Let $h(a,x)$, $c(a,x)$ and $a'(a,x)$ denote a household's optimal policies.

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

$$\Pi = \max_{K,L} \left\{ K^{1-\alpha} L^{\alpha} - wL - (r+\delta)K \right\} \qquad (6)$$

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:

$$G + (1+r)D + T = D + \int \mathcal{T}(wxh, ra) d\mu(a,x) \qquad (7)$$

where D is government's debt and $\mu(a,x)$ is the measure of households with state (a,x) in the economy. In steady-state, government spending G is kept constant. Later in this section, we will change G and adjust the budget constraint in different ways to analyze their implications.

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: a value function $V(a,x)$ and policies $\{h(a,x), c(a,x), a'(a,x)\}$ for the household; policies for the firm $\{L, K\}$; government decisions $\{G, D, T, \mathcal{T}\}$; 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 its 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 Calibration

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 $\varepsilon_x \sim \mathcal{N}(0, \sigma_x)$, with $\sigma_x = 0.287$ and $\rho_x = 0.939$.[32] 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 delivers a reasonable distribution of wealth (see Table 2 below).

We assume that the tax function $\mathcal{T}(wxh, ra)$ has two components: a flat tax on capital income τ_k, and a non-linear tax-rate $\tau_L(\cdot)$ on labor income wxh; thus $\mathcal{T}(wxh, ra) = \tau_k ra + \tau_L(wxh)wxh$. The capital tax-rate τ_k is set to 35%, following Chen, Imrohoroglu, and Imrohoroglu (2007). This number primarily reflects two flat taxes in the tax code: corporate income taxes and property taxes.[33] For the labor tax, we assume the tax function described in Section 2.1: $\tau_L(wxh) = 1 - \lambda(wxh)^{-\gamma}$. As discussed before, this simple tax function fits very well the U.S. tax code, and the parameter γ can be clearly interpreted as the progressivity of the tax system. We set $\gamma = 0.10$, which is a value in line with the estimates in Feenberg, Ferriere, and Navarro (2016), as well as Heathcote, Storesletten, and Violante (2014) and Guner, Kaygusuz, and Ventura (2012). 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, T and D to match: an interest rate of 1%, a government spending-to-output ratio of 15%, a transfers-to-output ratio of 5%, an annual government debt-to-output ratio of 60%, and an employment rate of 60% – which is the average of the Current Population Survey (CPS) from 1964 to 2003.[34] Table 1 summarizes the parameter values.

Table 2 reports wealth and employment distributions in the model and in the data (PSID, 1983). Overall, the model fits the data reasonably well: it generates a wealth distribution and a labor participation profile

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[32] These numbers are estimated using the whole sample of PSID ages 18 to 65 from 1979 to 1992. See Chang and Kim (2007).

[33] The capital income taxed at a progressive rate –i.e, as ordinary income in federal tax code– represents only a small fraction of the fiscal revenues raised on capital income. See Joines (1981).

[34] The average participation rate in PSID for 1983, year that we use for comparison with our model below, is 65% –close to our target. Adding lump-sum transfers has little impact on our results, but implies a reasonable average labor tax in the model (around 15.75% in steady-state).

that are comparable with the observed ones.[35] We next document how the model matches the distributions of labor participation elasticities and marginal propensities to consume, two central statistics to the mechanism evaluation.

3.3 Heterogeneous Elasticities

The model-implied labor participation elasticity (*lpe*) declines substantially with income. Table 3 reports two measures of *lpe*: with respect to the wage and the labor tax rate; and for three income groups: the total population, the top-10%, and the bottom-90%.[36] A 1%-increase in labor taxes induces a 0.43%-decrease in participation for the bottom-90% of earners, while the decline is only 0.03% for the top-10%. Although larger in size, the same decreasing pattern for *lpe* is found with respect to the wage.[37]

Since the distribution of *lpe* is central to our results, it is worthwhile to compare it with previous empirical findings. A large body of work has measured labor supply elasticities across different demographic and income groups.[38] A consensus has emerged, that labor supply responsiveness to tax changes is mostly due to the extensive margin (Heckman, 1993), and that *lpe* are significantly larger for lower-income earners (Blundell, 1995). We briefly review some of the evidence supporting this view.

Using reforms to 'in-work' tax credits in the U.S., Eissa and Liebman (1996) estimate an elasticity of labor participation of 1.2 for lone mothers; and Brewer, Duncan, Shephard, and Surez (2006) find similar numbers for the U.K.[39] Estimates for males are on average lower than for women, but they are also found larger for lower income groups. Using data for the U.K., Meghir and Phillips (2010) find a *lpe* of 0.32 for prime age males with low education levels, while the elasticity is only 0.03 for households with the highest education.[40] Similarly, in the U.S., Moffit and Wilhelm (2000) find an elasticity of 0.2 for medium income households and essentially zero for top-income earners.[41]

[35] As common with heterogeneous household environments, the model underestimates wealth and labor participation for households at the right tail of the wealth distribution (Cagetti and De Nardi, 2008, Mustre-del Rio, 2012).

[36] Elasticities are computed after a one-period unexpected 1% decrease in wage, or a one-period unexpected 1% increase in the labor tax rate. The latter corresponds to the average tax rate paid by a household. These figures should be understood as uncompensated elasticities. The computation is performed in partial equilibrium.

[37] The model average *lpe* with respect to the wage is large compared to standard micro estimates, which are typically below unity. This discrepancy reflects the well-known gap between macro and micro labor elasticities.

[38] Two recent outstanding surveys of the literature are Meghir and Phillips (2010) and Keane (2011).

[39] In line with these findings, Meyer and Rosenbaum (2001) argue that 62% of the increase in lone mother labor participation between 1984 and 1996 in the U.S. is due to changes tax credits.

[40] Meghir and Phillips (2010) use their estimated model to simulate the outcome of a tax reform, and find mute labor supply responses for top-income earners and substantial ones for bottom-income earners (see pages 248-251). For Italy, Aaberge, Colombino, and Strøm (1999) also find that *lpe* decreases with income, especially for women.

[41] The estimates of Moffit and Wilhelm (2000) should be understood as a combination of the intensive and extensive labor elasticities.

Based on this evidence, the public finance literature has used *lpe* that substantially decrease with income. For instance, Kleven and Kreiner (2006) and Immervoll, Kleven, Kreiner, and Saez (2007) assume a *lpe* between 0.4 and 0.8 for the lowest income-deciles, and an elasticity of zero for the highest deciles. Our model-implied elasticities are well within this range.

While we excluded an intensive labor supply margin from our model, the elasticity of hours worked is typically seen as small and homogeneous across workers (Mroz, 1987). As such, the intensive margin would not interact in interesting ways with tax progressivity.[42]

Our model does not generate higher elasticity of taxable income for top-income earners, as found in the U.S. (Saez, 2004). However, the higher elasticity of taxable income largely concerns the top 1%, and thus the implications on aggregate labor supply responses would likely be contained in our model. Furthermore, evidence shows that the higher elasticity of taxable income at the top is a short-run effect, and the result of income-shifting rather than hours worked (Goolsbee, 2000).[43]

Additional support for the model-implied distribution of *lpe* can be found in the recent work by Zidar (2017). This paper combines tax reforms and tax-return data (TAXSIM) to construct a yearly measure of *tax shocks* for two income groups: the bottom-90% and the top-10%. An increase in taxes – equivalent to 1% of GDP– to the top-10% is found to have no effect on total employment nor output. On the contrary, a tax shock of the same magnitude supported by the bottom-90%, contracts employment by about 2% per year on average over a three year period.

The experiments in Zidar (2017) are very informative about the distribution of *lpe*. In particular, we compute the employment response to different tax shocks in our model, which are reported in Table 4. Our results are in line with Zidar's ones: a tax increase on the bottom-90% roughly equivalent to 0.1% of GDP, induces a 0.23% contraction in employment (compared to the 0.24% in data); while a tax shock on the top-10% has virtually no effect on employment. Appendix X provides a complete description of the experiment in the model, together with many robustness checks.

Finally, the model also generates heterogeneity in marginal propensities to consume (*mpc*), as shown in Table 5. Households closer to their borrowing constraint feature a larger *mpc*, implying a larger consumption

[42]For instance, when considering the intensive margin in addition to the extensive one, Kleven and Kreiner (2006) and Immervoll, Kleven, Kreiner, and Saez (2007) assume an elasticity of hours worked equal to at most 0.1, and constant across households. An homogenous intensive labor supply elasticity across households is also assumed by Diamond (1998) and Saez (2001) among others. See also Triest (1990) for an empirical evaluation of this assumption. For completeness, we report the results of the model with divisible labor in Section 3.4.

[43]Using detailed data on executives compensations, Goolsbee (2000) finds a short-run elasticity of taxable income larger than one, but at most 0.4 and probably closer to zero after one year. Furthermore, the large short-run responses comes from highest-income executives exercising stock options in anticipation of the rate increases, while more conventional forms of taxable compensation (such as salary and bonuses) show little responsiveness to tax changes.

response to a tax change. Of a rebate equal to 1% of the average labor income in a quarter, the bottom-10% of the wealth distribution exhibit an *mpc* of 0.2, five times larger than the average *mpc*.[44] However, the *mpc* heterogeneity in the model is rather conservative relative to data: *mpc* are estimated to be as high as 0.5 for the liquidity constrained households (Kaplan and Violante, 2014).[45] Overall, this second aspect only plays a minor quantitative role to the mechanism described next.

We see these previous findings as compelling support of the model-implied distribution of *lpe*, which is a key statistic behind our mechanism. For completeness, we also explore the implications of divisible labor supply in the next section and argue that it fails to generate heterogeneity in labor supply elasticities as observed in data; and consequently cannot account for the empirical results of Section 2.

3.4 Spending and Tax Progressivity: Two Illustrative Experiments

We turn next to the effect of government spending in our model. We present two simple experiments to illustrate how the effect of spending depends on tax progressivity. A more comprehensive quantitative evaluation of the model is presented Section 4.

The experiments are as follows. At $t = 0$, while the economy is at steady-state, the government unexpectedly announces a temporary increase in government spending that follows a path $\{G_t\}$, which eventually returns to its steady-state.[46] To focus on the role of the distribution of *lpe*, we assume that the increase in spending is financed through an increase in labor taxes only.[47] In particular, the government announces a path for the progressivity of labor taxes $\{\gamma_t\}$, and a sequence for the level of labor taxes $\{\lambda_t\}$ such that the government's budget constraint (7) is met every period. Thus, jointly with the spending increase, the government announces the distribution of taxes that it will implement to finance the stimulus. While the change in spending and taxes is unexpected at $t = 0$, households have perfect foresight for the paths $\{G_t, \gamma_t, \lambda_t\}$ after the announcements.

We explore the implications of two different tax schemes: (1) **Constant Progressivity**: γ is kept at its steady-state level; (2) **Higher Progressivity**: γ temporarily increases from 0.1 to 0.11. Note that the tax scheme used in every case is progressive (γ is always positive); but the level of progressivity changes. Importantly, both experiments generate the same fiscal revenues per period: only the distribution of the (labor) tax burden across household changes.

[44] A rebate of this size is comparable with the tax decrease described in Section 3.4. For larger shocks, *mpc* are smaller, reflecting the non-linearity of the model.

[45] See also Misra and Surico (2014), and citations therein

[46] We assume a 1% increase of spending on impact, and a return to steady-state at a rate $\rho_G = 0.98$.

[47] We explore the role of debt in Section 4.

Figure 7 shows the output response to the spending shock under the two taxation schemes. When progressivity is constant (red line), output contracts by more than 0.05%, which is reminiscent of Baxter and King (1993): in a standard real business cycle (RBC) model with a representative agent, an increase in government spending financed through a larger income tax results in a contraction. Thus, if progressivity is kept constant, our model roughly behaves as an RBC. On the other hand, when the government uses more progressive taxes to finance a spending shock, output expands by almost 0.2%. Hence, shifting the distribution of labor taxes across households changes not only the size but also the sign of the output response.[48]

This striking difference in output responses at the aggregate level comes from two reasons: first, tax changes across households are very different under the two tax schemes; and second, households respond heterogeneously to tax changes. Thus, depending on who pays more taxes, the aggregate responses differ. We discuss this next by showing the hours and consumption responses across the distribution for each taxation scheme.

We first analyze the case when progressivity γ is kept constant, and only the level of the tax scheme adjusts. The top three panels of Figure 8 show the average labor tax for three income-subgroups of the population: the bottom-50, the 50-to-90, and the top-10. The steady-state level of labor taxes is different across groups, reflecting the progressivity of the tax system. However, when progressivity is kept constant, the tax increase subsequent to the spending shock is roughly equal across households – about 25 basis points for all groups. Top-income households, who have low *lpe* and *mpc*, respond very little to the tax increase, both in terms of hours and consumption. On the other hand, the bottom-50 of the distribution, who have larger *lpe*, reduces hours worked sharply by almost 0.5%. In aggregate, output contracts.

Results are very different when higher progressivity is used to finance a spending shock. In this case, as Figure 9 shows, the tax increase to the top-10% is more than twice the increase they faced in the constant progressivity case. Nevertheless, there reaction is roughly the same as before and top-income households barely respond to the tax increase. On the other hand, the increase in γ tilts the tax function counter-clockwise, such that the lower part of the distribution experience a tax decrease.[49] Poor households, who react more strongly to a tax change, provide substantially more hours. As a result, output expands.

It is worth emphasizing that both cases described generate the *same* amount of tax revenues every period. Different output responses result of different levels of progressivity because households exhibit heterogeneous

[48]We also explored the case when the government uses less progressive taxes to finance a spending shock. In this case, the output contraction is even more severe than in the case with constant progressivity. Results are available in Online Appendix.

[49]In Section 4, we adjust the tax function so that an increase in taxes for top-income earners doesn't necessarily involve a decrease of taxes for bottom-income earners.

responses to tax changes. Consequently, the distribution of the tax burden is crucial to the aggregate effects of spending. Output increases more when spending is financed with more progressive taxes, as empirically found.

Why indivisible labor? A key ingredient in our model is the indivisible labor supply assumption. If we instead assume a divisible labor supply model, the labor supply elasticity slightly increases with income (see Table 3), which is inconsistent with the evidence discussed in Section 3.3.[50] More importantly, as Figure 10 shows, the divisible labor supply model implies that government spending is less expansionary when using more progressive taxes. This is in contrast to our empirical findings on Section 2. We conclude that matching the empirical pattern of *lpe* as a function of income is essential to account for how tax progressivity shapes government spending multipliers, as our model does.

4 Spending and Tax Progressivity: A Quantitative Exploration

The previous section used an *off-the-shelf* model of heterogeneous households to argue that government spending multipliers crucially depend on the distribution of taxes used to finance the spending. However, the model abstracted of some features typically deem as important in the spending literature. In this section, we add two of these features, namely: public debt, to initially smooth the effects of distortionary taxation; and New-Keynesian features, to add a "demand channel" in the model.

Another simplification in the model of previous section was that an increase in progressivity simultaneously implied higher taxes at the top jointly with lower taxes at the bottom of the income distribution. Arguably, as documented in Section 2.2, taxes often increased at different rates across households to finance large spending shocks (wars); but seldom decreased for anyone during these periods. To incorporate a more realistic taxation scheme, we slightly modified the tax function used in previous section so that taxes can increase for top-income earners without affecting the rest of the tax distribution.

We briefly explain next the additions to the model, and then evaluate how spending multipliers depends on tax progressivity in the augmented model.

[50] For the divisible labor supply model we assume household preferences as: $u(c, h) = \log(c) - B\frac{h^{1-\varphi}}{1-\varphi}$. We set $\varphi = 2.5$ and target the same moments as the indivisible labor supply model when calibration parameters. The Online Appendix contains a more detailed explanation for the divisible labor supply model.

4.1 A modified tax function

Same as before, the government decides a path for progressivity $\{\gamma_t\}$ to finance a spending shock. However, we now assume that households pay a tax-rate on labor income that is at least as large the one faced in steady-state. In particular, labor income y is taxed at rate $\hat{\tau}_t(y) = \max\{\tau_{ss}(y), \tau_t(y)\}$, where $\tau_t(y) = 1 - \lambda_t y^{1-\gamma_t}$, and $\tau_{ss}(y) = 1 - \lambda_{ss} y^{1-\gamma_{ss}}$ is the steady-state tax rate. Thus, for a particular level of (γ_t, λ_t), the actual tax-rate is the upper-envelope of the steady-state tax-function and $\tau_t(y)$. An example of the new tax scheme is plotted in Figure 11.

Interestingly, as the government needs to increase tax revenues to finance the shock, selecting the level of tax progressivity γ_t along the transition boils down to selecting the fraction of households who will face higher taxes. In particular, if γ_t is constant, all households will face higher taxes than in steady-state as revenues must increase – and $\hat{\tau}_t(y) = \tau_t(y)$. On the contrary, as γ increases, only households with higher income will face an increased tax rate. The higher γ, the more of the fiscal burden that is shifted towards top-income earners.

We will consider three cases for the path of progressivity. First, the "constant progressivity" case of Section 3, where all working households finance the spending shock. Second, a case where the government increases progressivity slightly (from $\gamma = 0.1$ to $\gamma = 0.105$ on impact) and only the top-90% of the workers support the fiscal effort – and the bottom 10% face constant taxes. Third, a case where the government increases progressivity more significantly ($\gamma = 0.11$ on impact) so that only the top-35% of workers finance the shock.[51]

4.2 Debt Financing

When spending is financed with distortionary taxes only, Ricardian Equivalence does not hold and debt financing can affect spending multipliers. Furthermore, debt financing has been shown to be empirically relevant for determining spending multipliers (Gali, Lopez-Salido, and Valles, 2007). To address this, we add debt financing after a spending shock in the model.

We follow Uhlig (2010) and assume that, after a spending shock, debt follows a rule as:

$$D_{t+1} - D_{ss} = (1-\theta)(d_t - d_{ss}) \qquad \theta \in (0,1], \tag{8}$$

where $d_t = G_t + r_t D_t - \tau^k r_t A_t + T_t$ represents the fiscal deficit before labor-tax revenues, and $A_t = \int a d\mu_t(a,x)$ is total asset holdings by households in period t. The quantities d_{ss} and D_{ss} are the steady-state values of

[51] Fractions are computed on impact.

d_t and D_t, respectively. Consequently, $(1-\theta)$ is the fraction of additional spending financed through debt, while the remaining fraction θ is financed with increased labor taxes. If $\theta = 1$, all additional spending is financed with labor taxes, as in Section 3.4. If $\theta = 0.1$, roughly 10% of the additional spending is financed with higher labor taxes.[52]

When analyzing the effects of government spending, we will consider two cases for debt financing: no debt ($\theta = 1$), and 90% of additional deficit financed with debt ($\theta = 0.1$).

4.3 New-Keynesian Features

The spending literature often uses models with nominal rigidities so that increases in government spending can affect output through a "demand channel". To have a quantitative benchmark similar to previous work, we add nominal rigidities to our model and asses the effect of progressivity on spending multipliers in this environment. Furthermore, because households have heterogeneous *mpc* in our model, there is a non-trivial interaction between the distribution of taxes used to finance spending and aggregate demand in the economy (Hagedorn, Manovskii, and Mitman, 2017).

We include a New-Keynesian dimension by adding intermediate goods producers under monopolistic competition, who can adjust prices only subject to a quadratic cost (Rotemberg, 1982).[53] Intermediate goods producers demand capital and labor from households in competitive markets, and sell their output to a final good producer who combines the intermediate goods into a final consumption bundle demanded by households. We assume that monetary policy follows a simple Taylor rule, that responds to deviations of inflation from zero with a coefficient of $\phi_{\Pi} = 1.5$, as commonly used in the literature. Because the New-Keynesian features we add are standard, we defer a detail explanation of the model and its calibration to Appendix X.[54]

4.4 Spending and Progressivity in a Quantitative Model

We analyze government spending multipliers in the augmented model. The experiment is similar to the one in Section 3.4. At $t = 0$, while the economy is at steady-state, the government unexpectedly announces a temporary increase in government spending that follows a path $\{G_t\}$, which eventually returns to its

[52]The only caveat in the interpretation of θ is that, when initially financing spending with debt, labor taxes will have to raise in the future to cover interest rate payments as well.

[53]We assume an elasticity of demand of $\epsilon = 6$, and a marginal cost of adjusting prices of $\theta_p = 200$. These parameter values are standard, and imply a reasonable slope of the Phillips curve of 0.03. We assume a fixed cost so that profits are zero in steady-state, and then fully taxed along the transition.

[54]The production side of the economy is the standard New-Keynesian environment as described in Galí (2015), chapter 3. The only differences are the inclusion of physical capital, and households' heterogeneity.

steady-state. Simultaneously, the government announces a path for the progressivity of taxes $\{\gamma_t\}$ which, as discussed above, pins down the fraction of households that will pay higher taxes – capital taxes are kept constant. Finally, the government announces the fraction $(1-\theta)$ of additional spending that will be financed with debt. While the change in spending, taxes and debt is unexpected at $t = 0$, households have perfect foresight from there onwards. In all cases, the increase in spending is of 1% and it returns to steady-state at rate $\rho_G = 0.98$.

We explore the implications of three different paths for progressivity: (1) **constant progressivity**: γ is kept constant at $\gamma = 0.1$ and all households face higher taxes; (2) **small increase in progressivity**: γ increases slightly to $\gamma = 0.1025$, which implies that the top-90% of income earners face higher taxes; (3) **larger increase in progressivity**: γ is increased to $\gamma = 0.11$, and only the top-35% of income earners face higher taxes. In all cases, γ returns to steady-state at a rate $\rho_\gamma = 0.9$.

As a benchmark, we start analyzing the case with no debt ($\theta = 1$). Figure 12 shows the cumulative multipliers for the first three years after shock, and for three paths for progressivity. Multipliers are negative at all horizons –around -0.4– when all households pay higher taxes (constant γ case). On the contrary, multipliers increase substantially when only the bottom-10% of workers are exempt of higher taxes (small increase in γ), being roughly zero on impact and about -0.1 during the first three years. Finally, when only the top-35% of income earners face higher taxes, multipliers become positive and about 0.2 during the first three years. Thus, progressivity strongly shapes the effects of government spending, and just avoiding higher taxation for the bottom-10% increases multipliers by about 0.3. The cumulative multipliers is 0.6 larger if only top-income earners are taxed.

Allowing for debt financing substantially increase multipliers, as shown in Figure 13. In this case, we assume that the government finances 90% of the additional spending with debt, and compute multipliers for the three cases of tax progressivity discussed above. Tax progressivity still crucially determines the effects of government spending, with a difference in the cumulative multiplier of almost 0.2 after three years when only the top-35% of households face higher taxes.

Our model captures that spending multipliers are substantially larger when financed with more progressive taxes, as empirically found. The key moment to achieve this result is the larger *lpe* for bottom income earners. It's worth emphasizing that, although the model falls short in replicating the estimates of Section 2 under the progressive state, the multipliers we obtain are substantial and typically hard to get in models with distortionary taxation only. As we show next, the cross-sectional implications of the model are also in line with the evidence.

4.5 Cross-sectional effects

We finalize this section by discussing the cross-sectional implications of the model. Figure 14 plots the response of income, across the distribution of households, to a spending shock under different paths for progressivity. For comparison, the figure also includes the estimates of Section 2.6 using the tax revenue data. Although a bit smaller in magnitude, the model cross-sectional implications are entirely in line with the evidence: an increase in spending is moderately expansionary for low-income households if more progressive taxes are used, but strongly contractionary otherwise; while top-income earners' responses are of much smaller magnitudes, and do not significantly depend on progressivity. We see this result as validation of the main mechanism in the model.

5 Conclusion

We argued that government spending is more expansionary if financed with an increase in the progressivity of taxes, while the effect is smaller if all households are taxed more evenly. We exploited the historical variation in the financing of spending in the U.S. to asses this point empirically, and used an *off-the-shelf* model of heterogeneous households to rationalize the finding. The key element in the model is a lower responsiveness of labor supply to tax changes for top-income earners, for which we provided ample evidence.

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Table 1: Parameter Calibration

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

Table 2: 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. We measure participation of individuals, where 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.

Table 3: Labor participation elasticity.

Elasticities	w.r.t. wage	w.r.t. labor tax
Average	1.33	-0.36
Top-10	0.06	-0.03
Bottom-90	1.59	-0.43

Notes: Elasticities are computed after an one-period unexpected 1% decrease in wage, or 1% increase in the labor tax. Households are sorted by income.

Table 4: Aggregate responses to tax shocks .

	Tax shock	Top-10	Bottom-90	Model response	*Data*
Tax on the top-10	0.071%	0.065%	0.006%	0.002%	*0.004%*
Tax on the bottom-90	0.127%	0.004%	0.122%	-0.232%	*-0.264%*

Notes: Case (a) reports a fiscal shock financed with more progressive taxes ($\gamma = 0.11$). Case (b) reports a fiscal shock financed with less progressive taxes ($\gamma = 0.09$). In both cases, the tax shock is computed as in Zidar (2017), and reported as a percentage of annual GDP; a quarterly persistence of 0.5 is assumed. The employment and output model responses report the average percentage change in employment and output, on the year of the shock and the two years following the shock. The data responses are imputed from Zidar (2017).

Table 5: Marginal propensities to consume.

MPCs	Rebate: 1% wage	Rebate: 10% wage	Rebate: 100% wage
Bottom-10	0.20	0.06	0.04
Top-90	0.02	0.03	0.02
Average	0.04	0.03	0.02

Notes: Marginal propensities to consume, for the bottom-10, top-90, and total population; households are sorted by wealth. Column (a) reports results for a rebate equal to 1% of the mean quarterly wage, column (b) for a rebate of 10% of the mean quarterly wage, and column (c) for a rebate of one mean quarterly wage.

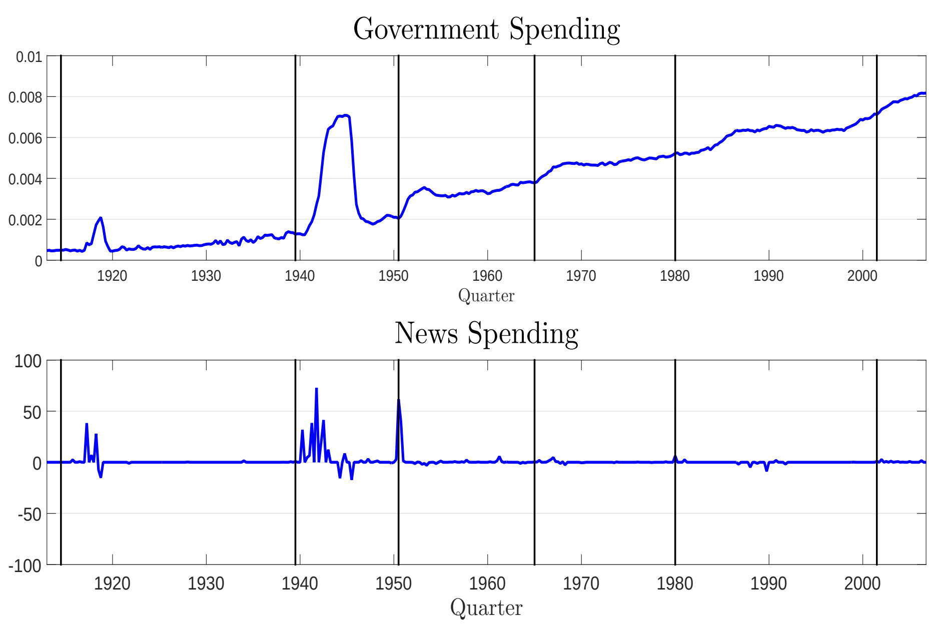

Figure 1: Defense Spending and Ramey Defense News

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).

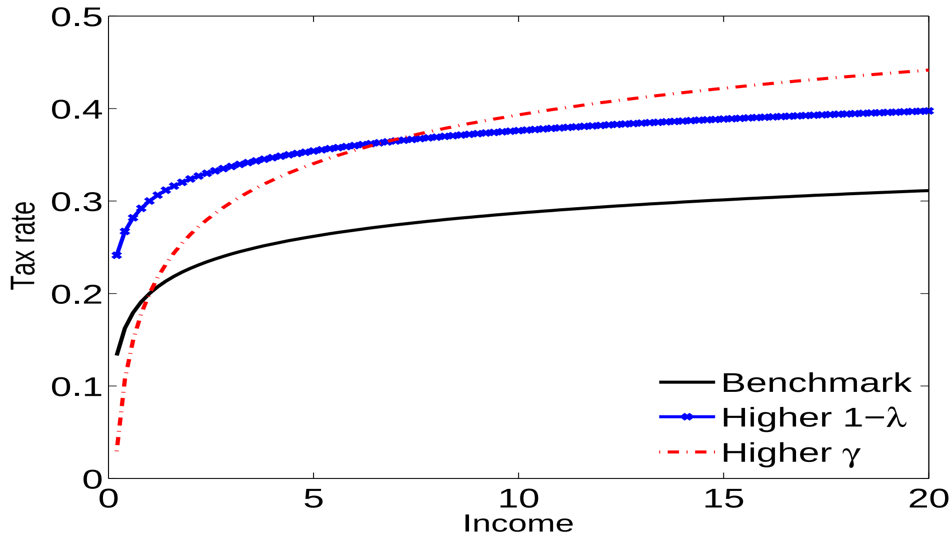

Figure 2: Non-linear tax as a function of two parameters (λ, γ).

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.

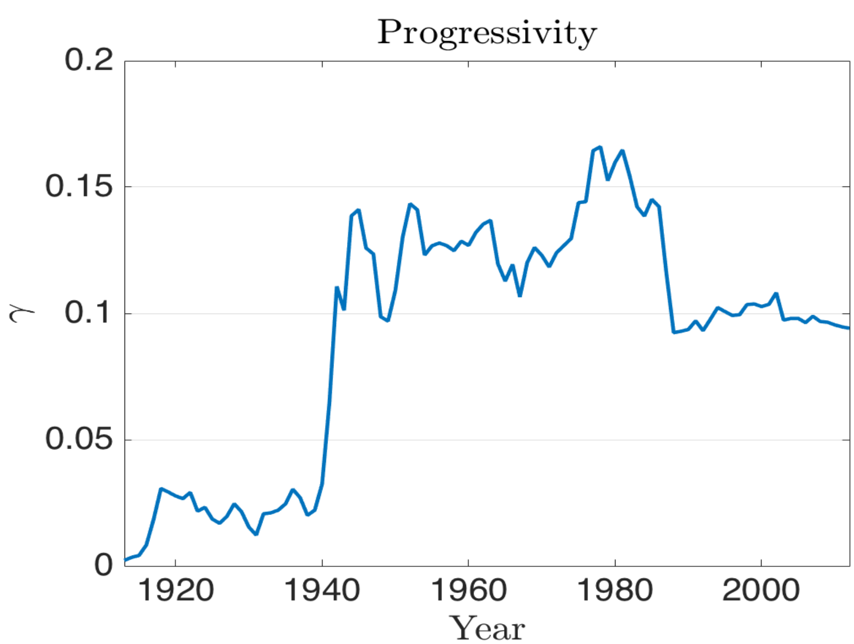

Figure 3: US Federal Tax Progressivity.

Notes: Souce: Authors' calculations.

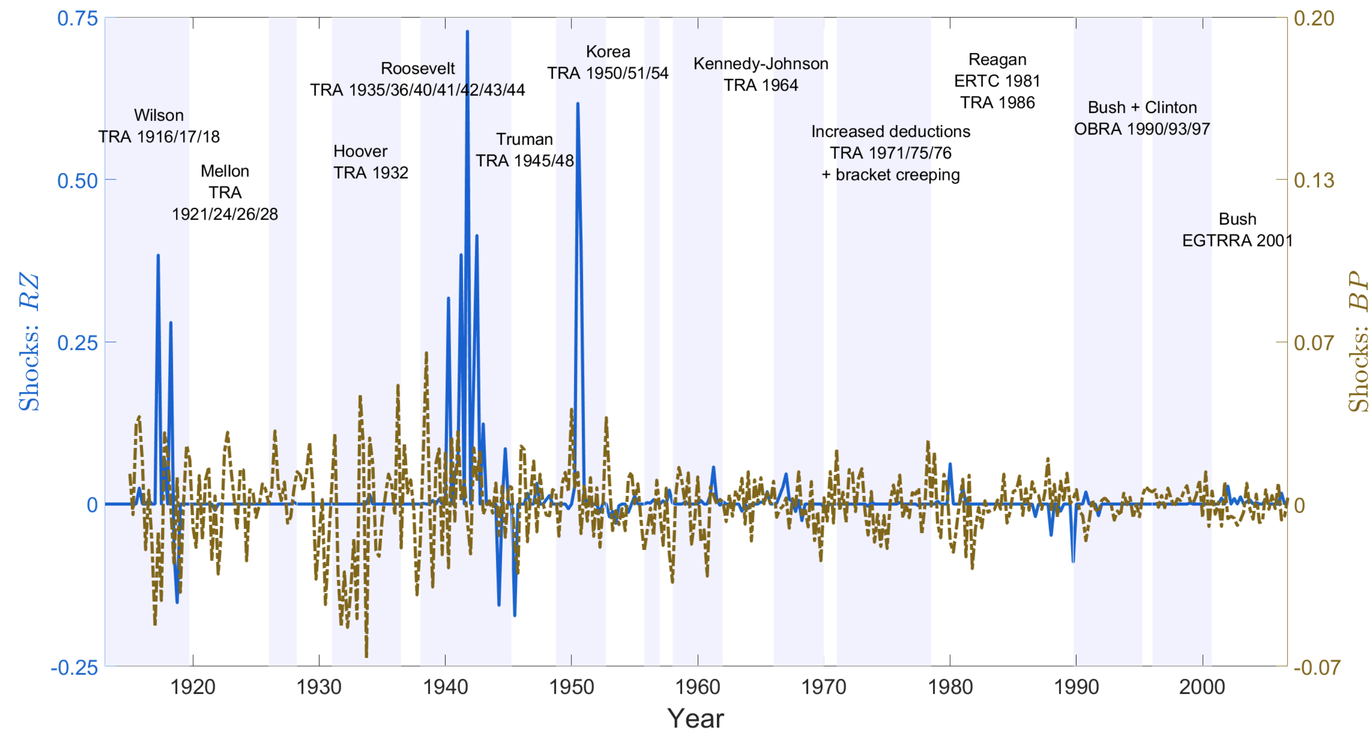

Figure 4: Progressive States and Spending Shocks

Notes: *Shaded areas correspond to periods of increased progressivity,* $s_t = P$. *The blue and green lines correspond to the* RZ *and* BP *shocks respectively.*

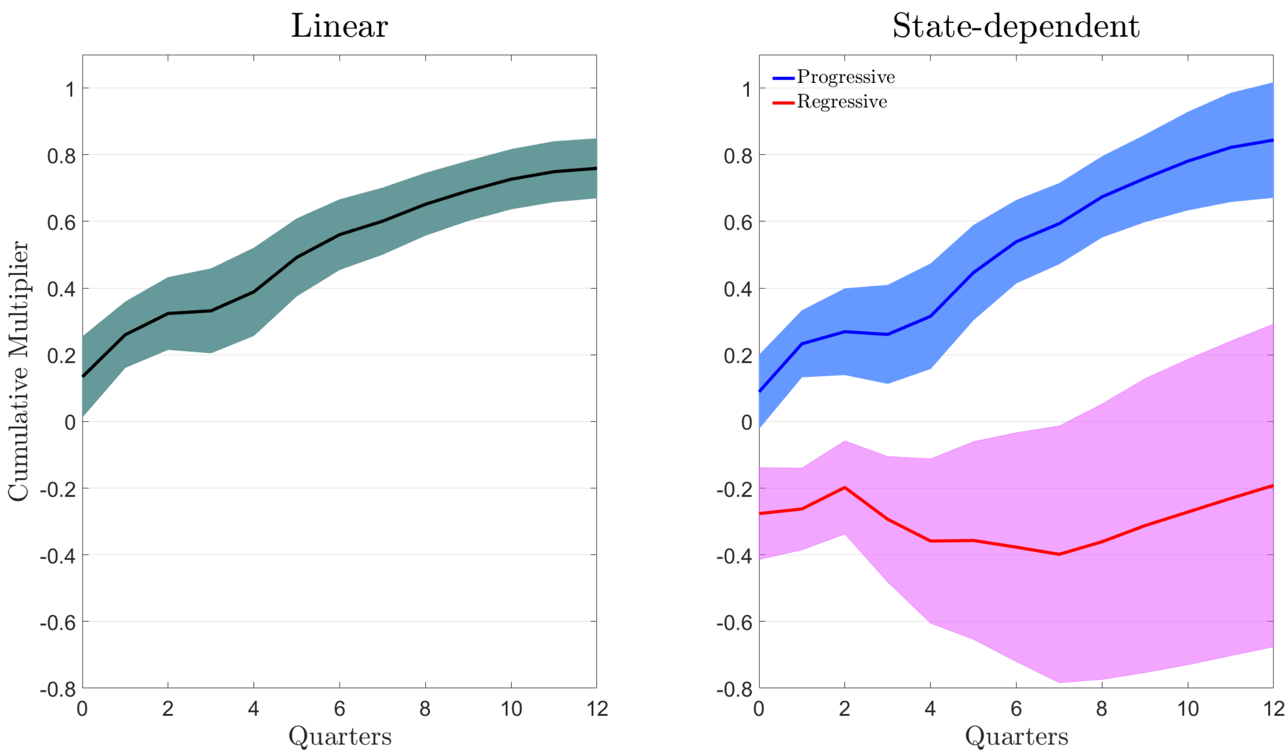

Figure 5: Cumulative multipliers on GDP

Notes: *Cumulative spending multipliers; linear (left), progressive and regressive states (right). Local projection; data 1913-2006; confidence intervals: 68%.*

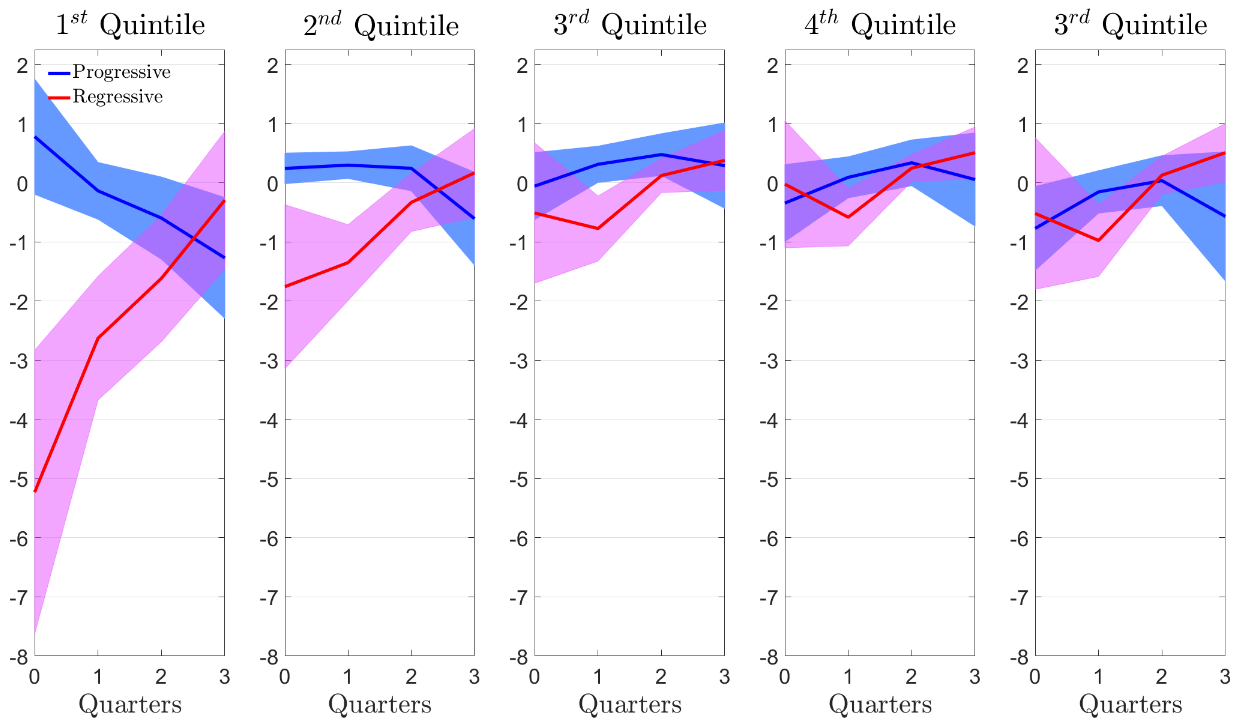

Figure 6: Income Response to a Spending Shock - by Quintlie

Notes: *Income elasticiy by quintile to a spending shock; progressive and regressive states. Local projection; data 1960-2006; confidence intervals: 68%.*

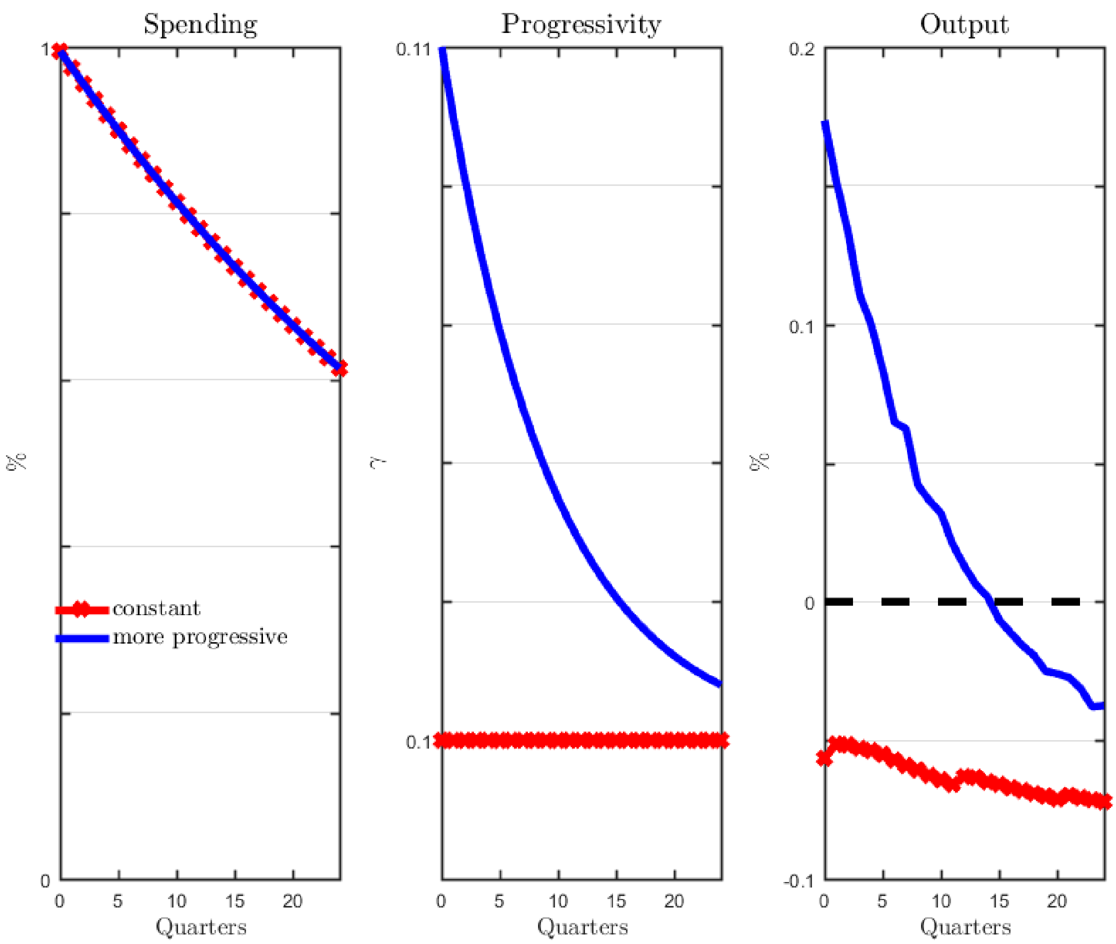

Figure 7: Responses to a government spending shock financed with different tax systems.

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

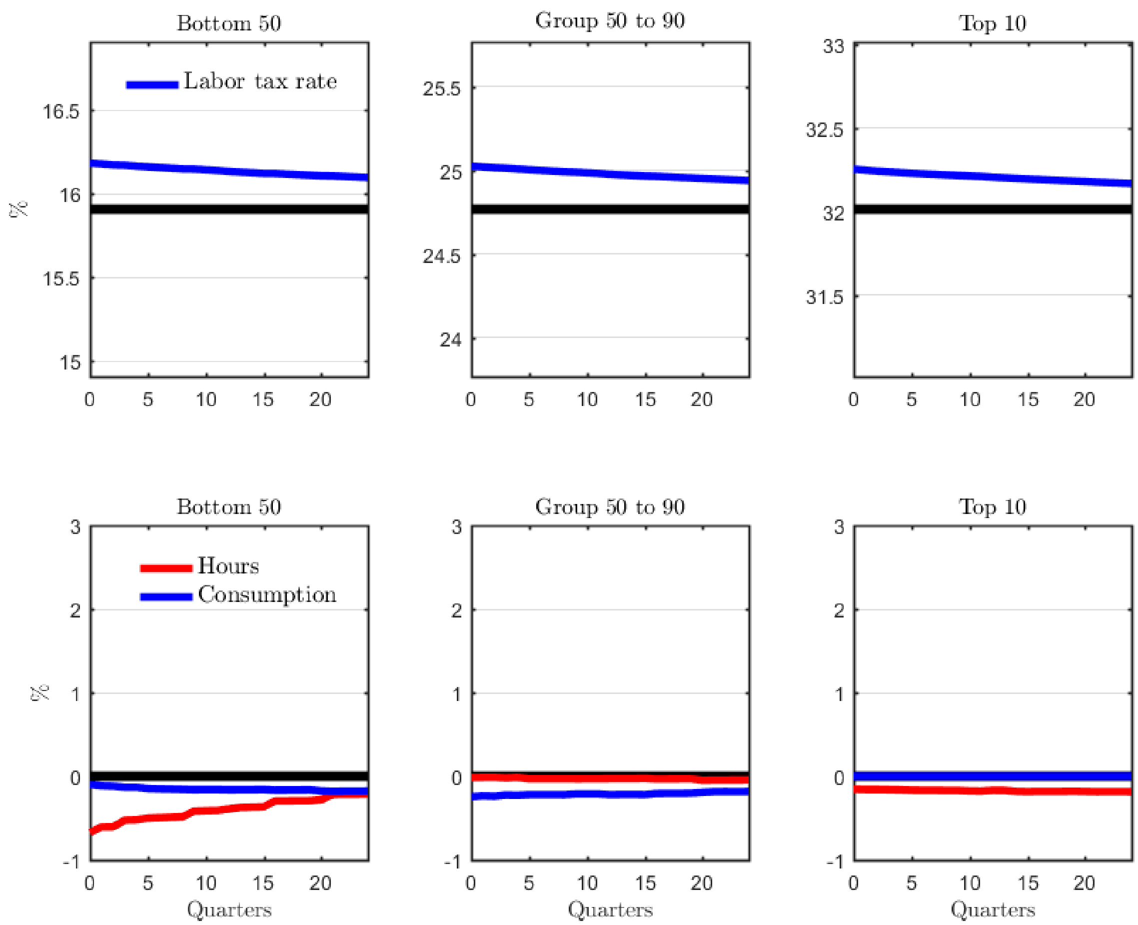

Figure 8: Responses to a government spending shock financed with different tax systems.

Notes: Impulse responses of average labor taxes (top panels) and hours and consumption (bottom panels), per income-quantile, to a government spending shock financed with labor taxes, keeping labor tax progressivity constant.

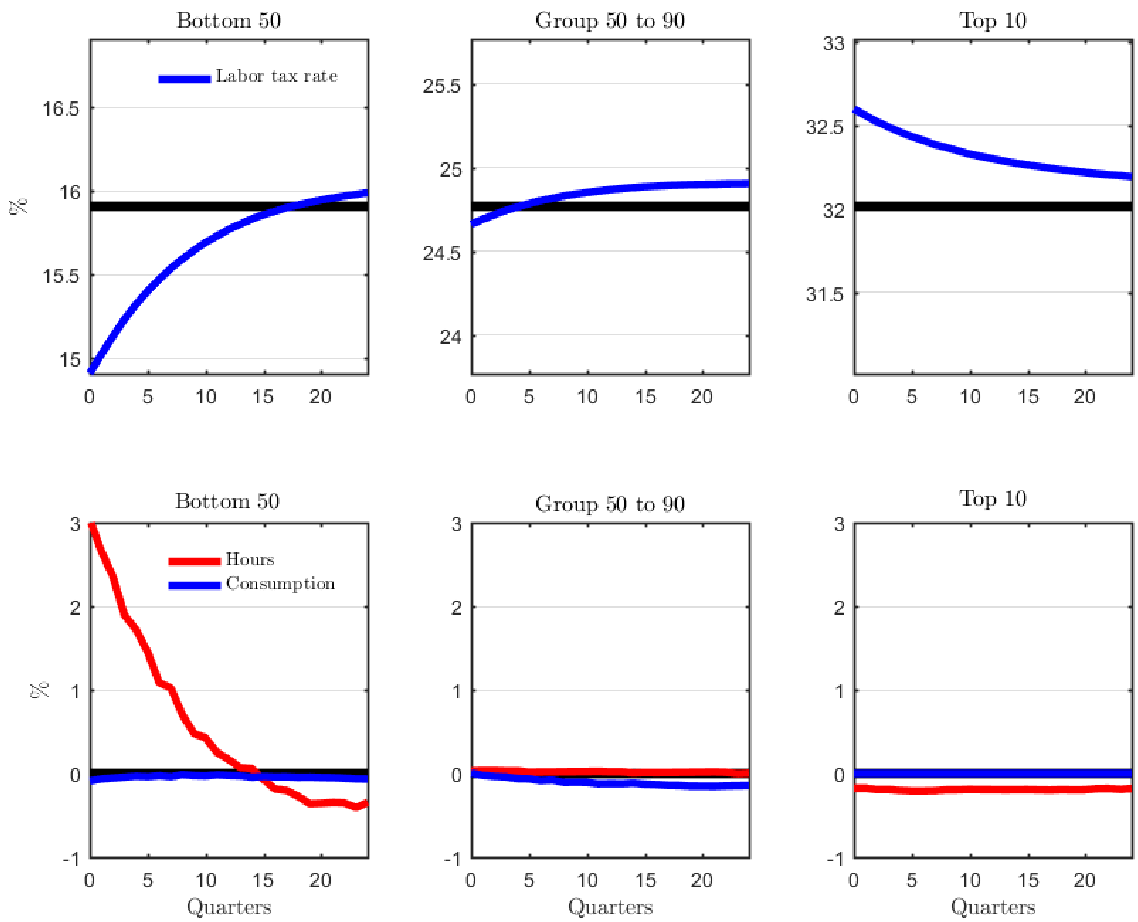

Figure 9: Responses to a government spending shock financed with different tax systems.

Notes: Impulse responses of average labor taxes (top panels) and hours and consumption (bottom panels), per income-quantile, to a government spending shock financed with more progressive labor taxes.

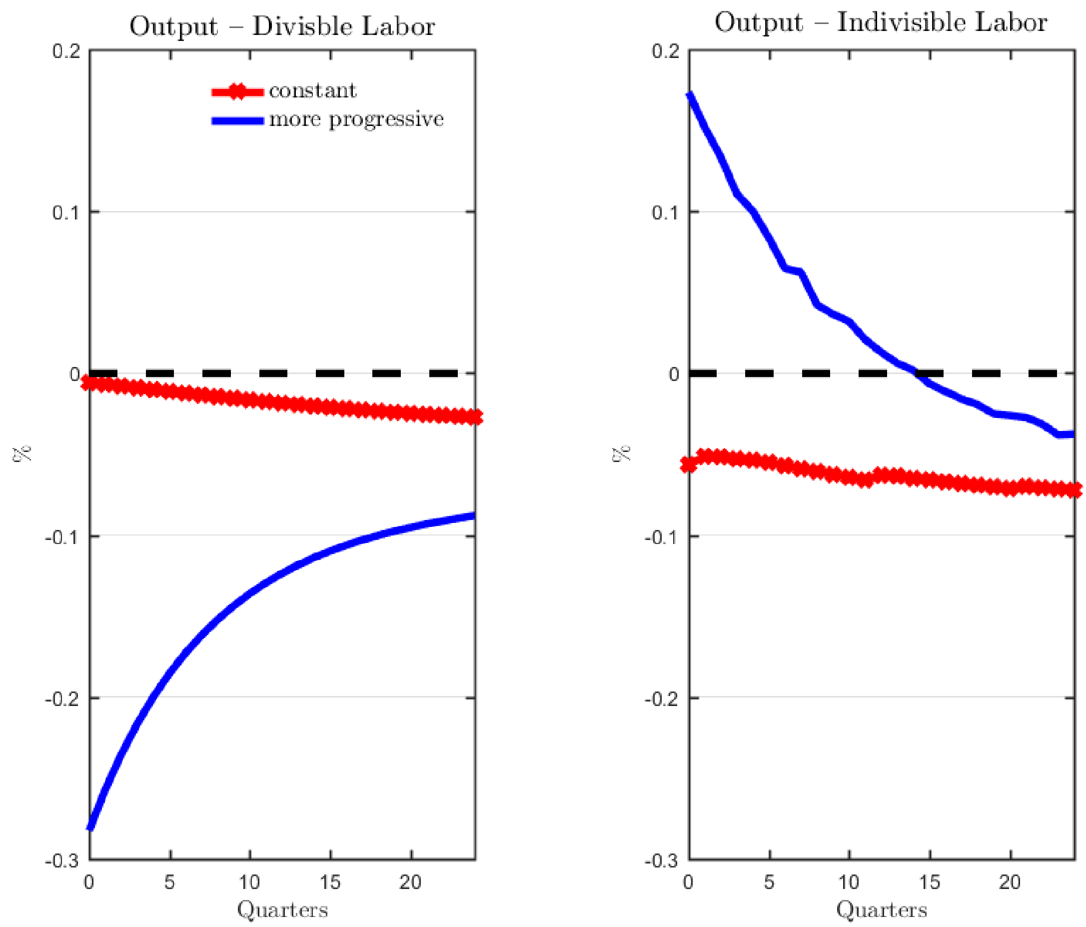

Figure 10: Output responses to a government spending shock financed with different tax systems - Divisible and Indivisible labor supply models.

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

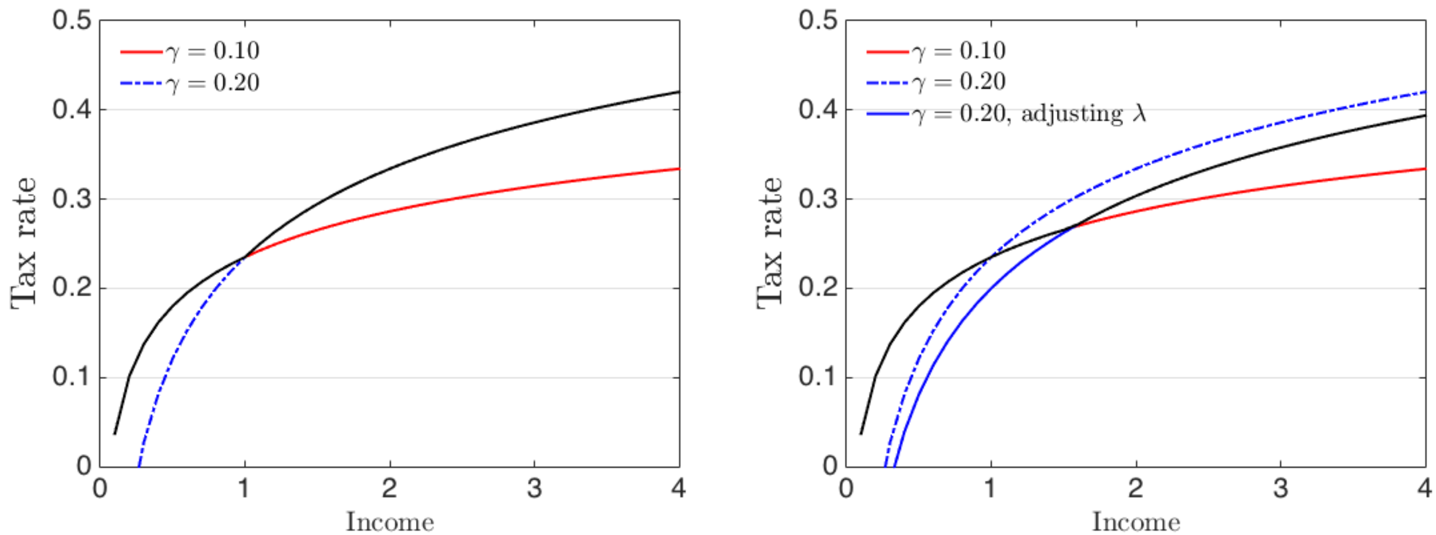

Figure 11: Modified Tax Function.

Notes:

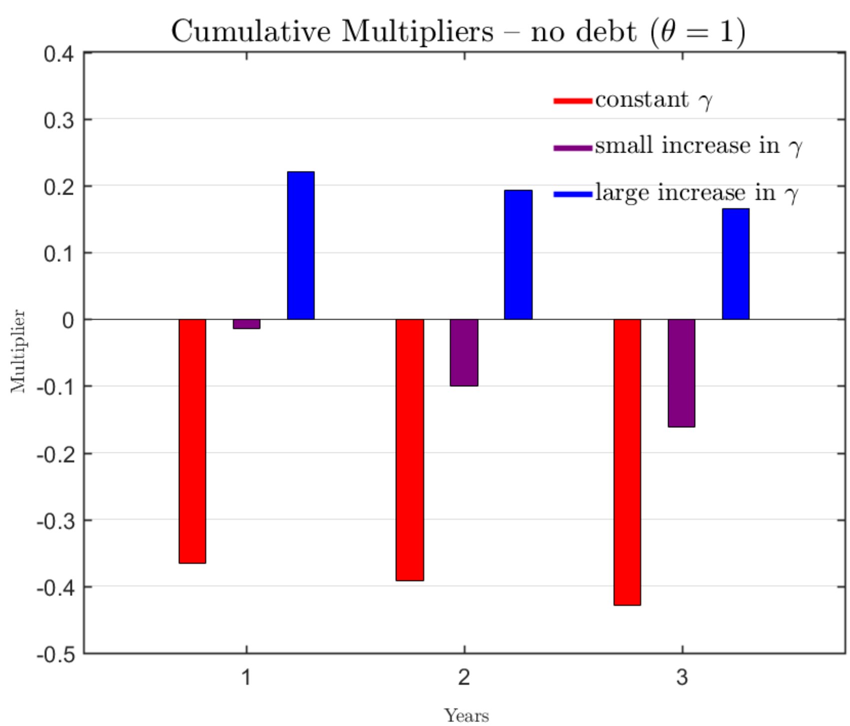

Figure 12: Output cummulative multipliers under different progressivity paths.

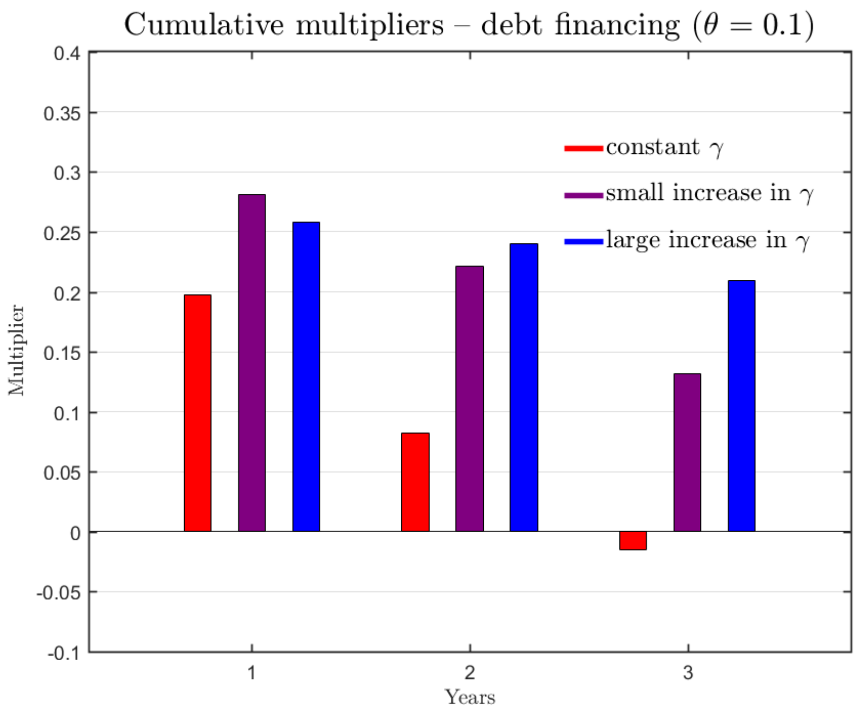

Figure 13: Output cummulative multipliers under different progressivity paths.

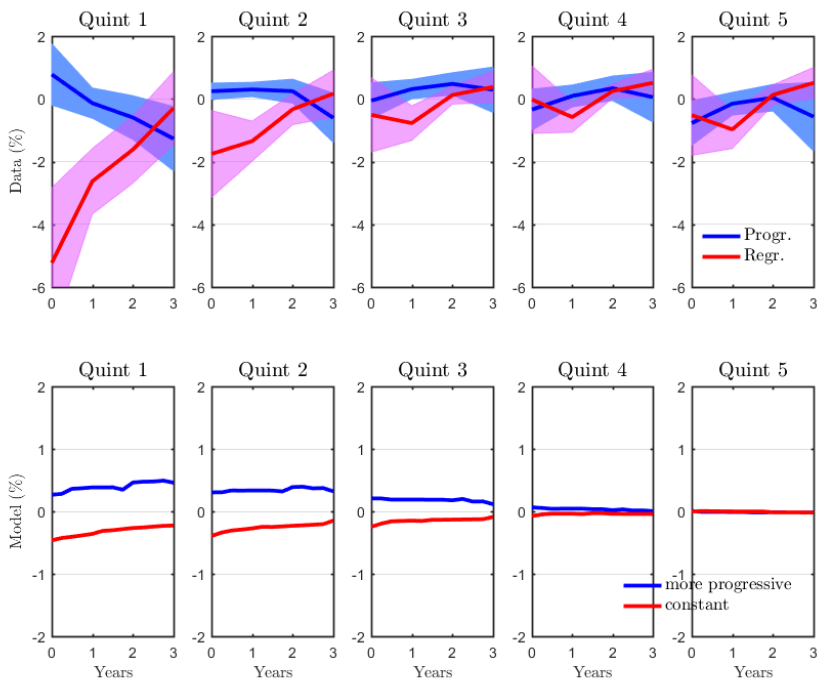

Figure 14: Income response across households to a spending shock under different progressivity paths – Model and Data.

A Data Sources and Definitions

A.1 Progressivity

A novel time series s built to measure the progressivity [P] of the federal income tax since 1913, using measures of average tax rate [ATR] and average marginal tax rate [AMTR]. The Average Tax Rate [ATR] is computed as Total Tax Liability over Total Income, where Total Tax Liability is computed for federal taxes including tax credits (Source: Statistic Of Income (SOI), IRS; 1913-2014 (annual), current dollars; data: SOI Bulletin article - Ninety Years of Individual Income and Tax Statistics, 1916-2005, Table 1, Col. L, for years 1913-2005; data: Individual Complete Report (Publication 1304), Table A, line 189, for 2006 onwards), and the measure for Total Income is borrowed from Piketty and Saez (2003) (data: Table A0, years 1913-2014). For the Average Marginal Tax Rate [AMTR], we use the time series of Barro and Redlick (2011) (data: federal, until 1945) and Mertens and Olea (2018) (data: federal, years 1946-2012).[55]

The measure [P] is constructed 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:

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

Of course, one could be worried that our measure, based on effective tax rates, reflect changes in the distribution rather than changes in the tax code itself. The TAXSIM program of the NBER, which we describe in more details in Appendix A.3, provides an annual measure of marginal and average tax rates over all taxpayers, using a *fixed* sample of taxpayers (data: years 1960-2008, fixed distribution of 1984). We compute the P implied by their tax rates, and find a correlation to our measure of progressivity of 0.79 in levels and 0.80 in growth rate on overlapping periods.

A.2 Other macro variables

Fiscal data. We use the measure of Ramey and Zubairy (2014) for military news (data: quarterly, 1913-2013), and the measure of Owyang, Ramey, and Zubairy (2013) for total government spending (including

[55]Over the overlapping period, these two measures are almost undistinguishable (correlation, both in level and in growth rates: 0.99).

federal, state, and local purchases, but excluding transfer payments). 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 Ramey and Zubairy (2014). 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 (2011) (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.

A.3 Micro data

Details on the micro data and interpolation to be added.

B Local Projection Method: Robustness

The benchmark estimation is as follows: spending is instrumented by two shocks, RZ and BP; the control Z_t includes eight lags of $\log GDP$, $\log G_t$, and $AMTR_t$; the trend is quartic; the time period is 1913:q1-2006:q4; the state is defined with $\Delta_a = 12$ and $\Delta_b = 8$.

Figure 15 depicts the two measures of shocks, together with the states. Table 6 shows robustness with respect to the definition of the state, Δ_a and Δ_b. Whether tax progressivity is higher in the two, three, or four years after the shock, than in the one, two, or three years before the shock, the result holds, and p-values are below 5% in all but one configuration. In this table, we also present the results with four lags and quadratic trend; again, p-values are always below 5%, except for the 1-year integral with four lags.

Table 7 explores robustness with respect to the time period, the controls, and the shocks. Case 1 shows multipliers when using a shorter sample (starting in 1953:q1). All multipliers increase, but again, multipliers are significantly larger in progressive states: p-values are below 5% at one and two years. Thus, our results are not driven only by the second war. In Cases 2, 3, and 4, we test the controls: removing the tax rate measure, adding a measure of fiscal tightness (surpluses) or monetary tightness (T-bill, ?) do not alter the main result. Finally, we estimate multipliers using one shock at a time. With BP shocks, multipliers are significantly different, whether we use the whole sample or only recent data. With RZ shocks, multipliers are significantly different when using the whole sample; however, on a shorter sample starting in 1953, the

	1-year integral				2-year integral				3-year integral			
	Lin.	Prog	Regr.	p-val	Lin.	Prog	Regr.	p-val	Lin.	Prog	Regr.	p-val
Benchmark	0.36	0.31	-0.30		0.51	0.70	-0.17		0.48	0.88	0.08	
	(.08)	(.08)	(.17)	.00	(.09)	(.10)	(.24)	.00	(.13)	(.09)	(.24)	.00
Case 1		0.20	-0.13			0.58	0.02			0.75	0.23	
$\Delta_a = 08$		(.11)	(.16)	.05		(.11)	(.21)	.00		(.08)	(.24)	.03
Case 2		0.38	-0.13			0.75	-0.06			0.91	0.00	
$\Delta_a = 16$		(.09)	(.21)	.02		(.10)	(.25)	.00		(.09)	(.26)	.00
Case 3		0.39	0.22			0.60	0.33			0.73	0.40	
$\Delta_b = 04$		(.10)	(.16)	.36		(.10)	(.19)	.15		(.08)	(.19)	.09
Case 4		0.32	-0.26			0.7	-0.19			0.89	0.03	
$\Delta_b = 12$		(.08)	(.17)	.01		(.10)	(.22)	.00		(.08)	(.21)	.00
Case 5	0.36	0.35	0.05		0.58	0.71	0.11		0.67	0.88	0.26	
lag = 4	(.07)	(.08)	(.18)	.11	(.07)	(.07)	(.23)	.01	(.08)	(.08)	(.22)	.01
Case 6	0.38	0.3	-0.07		0.59	0.68	-0.02		0.63	0.85	0.12	
trend = 2	(.08)	(.10)	(.17)	.04	(.08)	(.09)	(.22)	.00	(.10)	(.09)	(.23)	.00

Table 6: Local Projection Methods: Robustness checks on the state (cases 1-4), the lags (case 5), the trend (case 6).

result disappears; the limited amount of *RZ* shocks on that sample is a reasonable explanation of why this happens.

C US Tax Progressivity: A Brief Historical Discussion

C.1 Income Taxes 1913-1932: Wilson and WWI, then Andrew Mellon and Hoover

In this section, we discuss the main changes in the US federal income tax code since its creation in 1913. We argue that our simple tax progressivity measure tracks remarkably these changes, as well as that it's quantitatively close to the estimates one could obtain using micro-level data. Importantly, we argue that virtually all changes to the tax code are the result of political events and emergencies, predominantly wars.

The Sixteen Amendment to the United States Constitution, adopted on February 3rd of 1913, set the legal benchmark for Congress to tax individual as well as corporate income.[56] The *Revenue Act of 1913*

[56] The amendment specifies: "The Congress shall have power to lay and collect taxes on incomes, from whatever source derived, without apportionment among the several States, and without regard to any census or enumeration".

	1-year integral				2-year integral				3-year integral			
	Lin.	Prog	Regr.	p-val	Lin.	Prog	Regr.	p-val	Lin.	Prog	Regr.	p-val
Benchmark	0.36	0.31	-0.30		0.51	0.70	-0.17		0.48	0.88	0.08	
	(.08)	(.08)	(.17)	.00	(.09)	(.10)	(.24)	.00	(.13)	(.09)	(.24)	.00
Case 1	0.87	2.14	0.17		1.15	2.78	0.48		1.48	2.46	1.06	
start 53:q1	(.48)	(.78)	(.50)	.04	(.56)	(.94)	(.47)	.03	(.43)	(.87)	(.45)	.17
Case 2	0.43	0.42	0.12		0.62	0.64	0.23		0.70	0.74	0.36	
no tax rate	(.08)	(.09)	(.16)	.05	(.07)	(.07)	(.20)	.03	(.06)	(.06)	(.19)	.05
Case 3	0.59	0.56	-0.09		0.64	0.82	-0.50		0.49	0.76	-0.61	
surpluses	(.09)	(.12)	(.23)	.01	(.10)	(.14)	(.32)	.00	(.15)	(.10)	(.38)	.00
Case 4	0.70	1.32	-0.95		0.86	1.48	-1.30		1.12	0.98	-1.57	
T-bill, start 53:q1	(.42)	(.69)	(.58)	.01	(.49)	(.81)	(.71)	.01	(.52)	(.93)	(1.04)	.06
Case 5	0.28	0.28	-0.36		0.36	0.75	-0.21		0.12	1.04	0.32	
BP	(.09)	(.09)	(.18)	.00	(.12)	(.10)	(.26)	.00	(.24)	(.10)	(0.24)	.00
Case 6	0.86	2.17	0.14		1.13	3.17	0.41		1.44	2.82	0.92	
BP, start 53:q1	(.48)	(.79)	(.51)	.03	(.56)	(1.01)	(.49)	.02	(.54)	(.93)	(49)	.08
Case 7	0.61	0.53	-0.28		0.47	0.60	-0.43		0.41	0.79	-0.51	
RZ	(.10)	(.12)	(.19)	.00	(.13)	(.11)	(.28)	.00	(.19)	(.08)	(.35)	.00
Case 8	-2.76	0.61	0.54		-2.89	1.68	3.21		-6.28	0.16	-1.42	
RZ, start 53:q1	(.91)	(.86)	(.49)	.95	(1.14)	(.87)	(.85)	.15	(2.19)	(1.04)	(1.17)	.27

Table 7: Local Projection Methods: Robustness checks on periods (case 1), controls (cases 2-4), and shocks (cases 5-8).

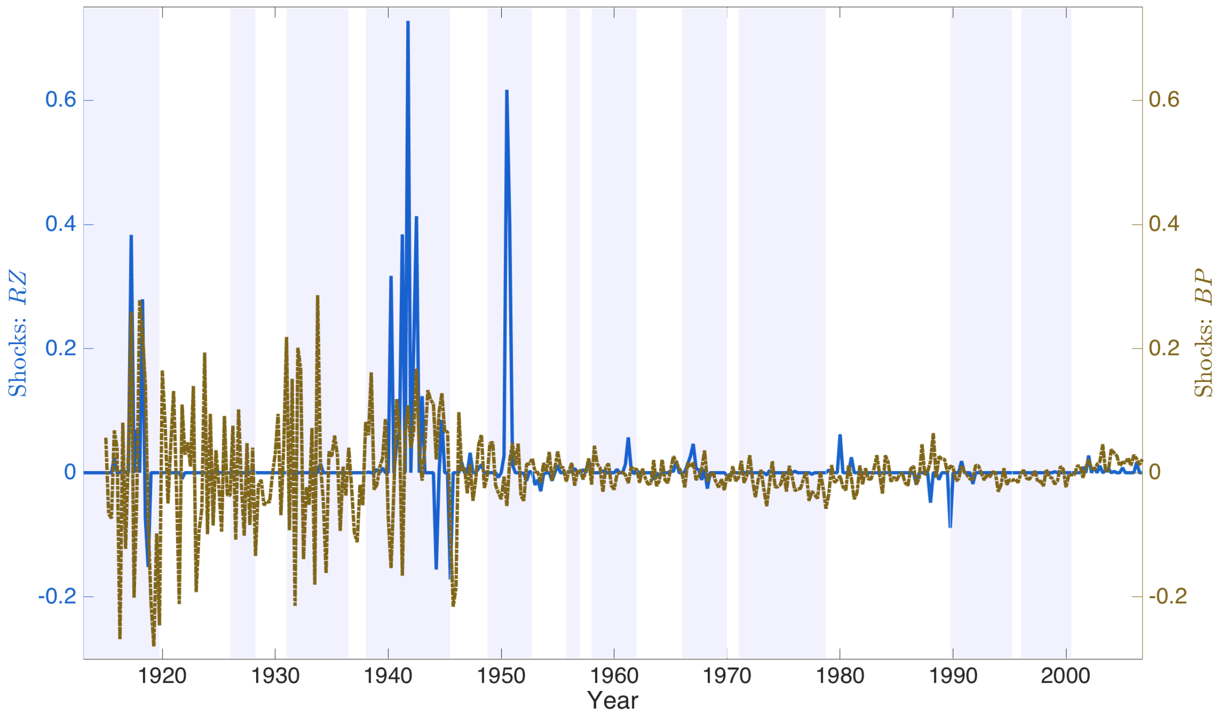

Figure 15: Spending shocks and tax progressivity states.

Notes: The blue line (left axis) depicts the RZ shocks, as a fraction of lagged nominal GDP. The brown line (right axis) plots the BP shocks. The shaded areas depict the progressive states ($s_t = P$).

determined personal income tax brackets for the first time, with a modest but progressive structure: the lowest marginal tax rate was 1% for income below \$20,000, and increased steadily reaching 7% marginal rate for income above \$500,000. The tax was progressive because of its structure, as well as because only wealthier households actually paid at the moment.

The entry of the United States into World War I (WWI) greatly increased the need for tax revenues, which were largely obtained by expanding income taxes in a progressive fashion. The *Revenue Acts* of *1916, 1917* and *1918* drastically increased top marginal tax rates to a 60% to 77% range, ten times more that they were three years ago. Although tax rates also increased at the bottom, including a temporary 4% tax for income over \$4,000 for years 1919 and 1920, the *Revenue Act of 1918* included exemptions that dampened the effect for poor income tax payers. By the end of WWI, individual income taxes were paid by about

The text is particularly vague on its definition of income, which opened the possibility several types of individual income. Previously, income taxes had temporarily been adopted during the Civil War, but a permanent legal framework hadn't been established. See Brownlee (2016)

15% of American households and represent one third of total tax revenues, with tariffs and corporate income taxes roughly equally contributing to the other two thirds.

The decade that followed WWI observed a decreased and recovery of tax progressivity. The end of WWI reduced the need for tax revenues, and with Republicans assuming control of both the presidency and the Congress, there was a partial reversal of tax progressivity. Under Secretary of Treasury Andrew Mellon, the *Revenue Acts* of *1921*, *1924*, *1926* and *1928* successively declined top marginal tax rates on individual income back to 25%, roughly one-third of what it was during war time.[57] However, under the belief that budget deficits was crowding-out the private sector, President Hoover promoted the *Revenue Act of 1932* which increased top marginal tax rates to a 56%-63%, restoring rates to WWI levels.

Our simple tax progressivity measure γ in Figure 3 captures remarkably well the above discussed increase, decline and recovery of tax progressivity during the first twenty years of the federal income tax system. The early increases are in 1917 and 1918, where the revenue acts drastically increased taxes at the top. Similarly, the decline in the early 1920s corresponds to the revenue acts of 1924 and 1926, where top marginal taxes were brought back to pre-WWI values. Finally, the increase in the early 1930s corresponds to Hoover's revenue act of 1932 where high top marginal tax rates were reinstated.

C.2 Income Taxes 1933-1945: Roosevelt Regimes

Tax progressivity increased significantly during the presidency of Franklin D. Roosevelt, initially as a continuation of President Hoover's last tax reform, and later because of the financial needs implied by World War II (WWII). The *Revenue Acts* of *1934*, *1935*, *1936* and *1938* were popularly known at the time as "Soak the Rich" tax.[58] The act of 1934 and 1936 kept top marginal tax rates fixed, but increased tax rates at the top by the lowering thresholds above which higher marginal tax rates brackets started. Furthermore, top marginal tax rates increased from 63% to 79% with the revenue act of 1936, which pushed top marginal tax rates to the 66% to 79% range.

A more drastic increase in progressivity came with the U.S. participation in WWII. The *Revenue Acts* of *1940*, *1941*, *1942*, *1943* and *1944* repeatedly increased top marginal tax rates, reaching an 90% to 94% range by 1945 which was slightly reduced with the *Reveue Act* of 1945. The revenue act of 1942 was perhaps the most important, because it broaden the base of taxpayers simultaneously with an increase in tax rates. Although taxes increase for all income levels, the reforms shift the burden of new revenues significantly towards top income households. Importantly, these changes established public expectations that

[57] However, corporate income tax rates did not declined as much.

[58] See Blakey and Blakey (1935) for instance.

any significant new taxes would be progressive.[59]

Again, our progressivty measure γ in Figure 3 captures well the changes discussed above. In particular, the last half of the 1930s exhibits a mild increase in progressivity which reflects the changes implemented in the revenue acts of *34-36*. Although these changes were not trivial, there were small relative to the tax modifications introduced by the revenue acts of *42* and *45*, a massive change which our γ measure clearly captures.

C.3 Income Taxes 1945-1980: The Era of Easy Finance

The tax regime that emerged of WWII proved more resilient than the one that emerged from WWI. Four basic ideas. 1) There were only few legislative changes on tax code during this period, especially when compared to the inter-wars period. 2) The Korean War, and partially the Vietnam War, were the only events that induced significant – albeit temporary– changes in the tax code. 3) Growth in a progressive tax system, as well as inflation in a non-indexed tax code, induced a steady increase of revenues. Without many drastic changes, debt to GDP decrease steadily and allowed the government to increase spending in other areas. This is why this period is often refer to as the "era of easy finance". 4) Part of this additional income was used to increased deductions and credits from tax liabilities.

With the end of WWII, individual income taxes decreased with the *Revenue Acts* of *1945* and *1948* by a range of 5% to 13%, with a higher decline at the top: the *Revenue Act* of *1948* imposed a 77% upper-bound to effective tax rates, which effectively was a decrease in tax progressivity. However, these adjustments didn't last long and were reinstated to finance the expenses associated with the Korean War: the *Revenue Acts* of *1950* and *1951* removed the tax acts of *1945* and *1948*, as well as temporary increased corporate taxes. By the end of the war, some of these measure were reverted with the *Internal Revenue Code* of *1954*. As a result of all these changes during the after war period, the effective tax rate on the top 1% was around 25% by the end 1950s, which was high relative to pre-WWII values but still lower than the peak observed during the war (Brownlee, 2000).

The next significant change came a decade later with the *Revenue Act* of *1964* from the Kennedy-Johnson administration, which was also known as the **Tax Reduction Act**. It essentially decreased marginal tax rates across the board and particularly at the top, pushing down top marginal tax rates to a 60% to 70% range – from the 80% to 91% previous range. Further tax cuts were probably prevented because of the increased participation of the U.S. in the Vietnam War.[60] In order to afford the war expenses, the *Revenue*

[59] See discussion in Brownlee (2016), pg. 142.

[60] U.S. involvement escalated following the 1964 Gulf of Tonkin incident, after which the U.S. president authorized to increase U.S. military presence. Regular U.S. combat units were deployed beginning in 1965.

and Expenditure Control Act of *1968* included a temporary 10% income tax surcharge on individuals and corporations for one year, as well as a decrease in domestic spending. By the end of the decade, a minor change was introduced by the *Tax Reform Act* of *1969* signed by President Nixon, which implemented a minimum tax rate level for certain incomes in order to avoid negative tax rates at the top because of the increased deductions and credits.

Although there were no legislative changes to tax rates for most of the 1970s, two important components affected personal income effective tax rates during the decade. First of all, because the tax system was progressive, (real) economic growth during these years effectively increased tax rates and thus tax revenues. At the same time, the economy experienced high inflation, and since the tax code was not indexed to inflation at the time, the resulting "bracket creep" also ended up generating higher tax rates and revenues. This *effortless* increase in tax revenues is the reason to label these years *the era of easy finance*.[61]

This abundance of resources allowed the government to substantially extend tax credits and deductions, which is the second component that affected effective tax rates during the 1970s.[62] Total tax exclusions (deductions and credits), as a fraction of taxable income, almost doubled from 11.8% in 1948 to 20.2 in 1978 (Bakija and Steuerle, 1991). Unfortunately, as we discuss in Appendix TBD, the effect of tax deductions on progressivty is not entirely captured by our γ measure.[63]

Again, our progressivty measure γ in Figure 3 captures well the changes discussed above. Progressivity decreases after WWII and recovers during the Korean War, reflecting the measures implemented during Truman and Eisenhower presidency respectively. Progressivity remains reasonably flat for almost a decade, and decreases in 1964 reflecting the **Tax Reduction Act** of the Kennedy-Johnson administration. Finally, progressivity increases in the 1970s because of growth and inflation.

C.4 Income Taxes 1980-1988: Reagan Tax Reform(s)

Three basic ideas. 1) The Economic Recovery Tax Act (ERTC, 1981) was the first significant reform to the tax code during Reagan administration. It decreased tax rates across the board, but especially at the top – so progressivity declined. 2) The second significant tax change was Tax Reform Act (TRA, 1986). The tax code was simplified, and taxes at the top declined again. This was even a more drastic change to the tax code. 3) Both the TRA, as well as TEFRA (1982) and DEFRA (1983) significantly cut tax expenses. This

[61] See discussion in Brownlee (2016), ch. 6.

[62] ADD example of mortgage credit and Freddie Mac and Fannie Mae.

[63] Nevertheless, to best of our knowledge, there is no quantitative assessment on how tax exclusions affect effective tax rates across distribution of households. While some deductions probably affect more poor households (like government transfers), others may benefit wealthier ones (like mortgage payments deductions).

was an important source of revenues, but not sure how it affected tax progressivity.

The latest significant changes to the U.S. tax code were implemented during the Reagan administration. The first of these changes was the *Economic Recovery Tax Act* (ERTA) of 1981, which reduced tax rates across the board. Top marginal tax rates where drastically reduced from 70% to 50%, which implied a significant drop in the overall progressivity of the tax system.[It also decreased taxes on capital gains] Importantly, for the first time, brackets started to be indexed by inflation. [ADD: what happened with corporate taxes]

The tax reduction of the ERTA, added to the increased defense spending and the 1981 recession, induce large fiscal deficits. The Reagan administration responded by increasing taxes. The *Tax Equity and Fiscal Responsibility Act* (TEFRA, 1982) and the *Deficit Reduction Act* (DEFRA, 1984) increased several taxes and reduced tax expenses, although didn't directly affect personal income taxes. The *Social Security Amendments* of 1983 also increased payroll taxes.

After a year long debate in Congress and public spaces alike, the *Tax Reform Act* (TRA) of 1986 was the second (and last) substantial change to federal income taxes during the Reagan administration. It essentially implemented changes along three lines. First of all, it massively simplified the tax code, reducing it to only five brackets (a 11%/15%/28%/35%/38.5% structure), which was further simplified to three brackets in 1988 (a 15%/28%/33% structure). It also eliminated many tax deductions and credits looking for more "horizontal equity". The second important change of TRA 1986 was a significant reduction in tax rates, especially at the top. Top marginal tax rates decreased from 50% to 28%, while taxes at the bottom virtually didn't change.[64] The third important change of the TRA 1986, was a notable expansion of the Earned Income Tax Credit (EITC), which effectively move many poor income households into negative tax rates.

The overall effect of the Reagan "tax cuts" into progressivity is not entirely obvious. On the one hand, both the ERTA of 1981 and the TRA of 1986, significantly decreased taxes at the top without affecting taxes at the bottom much. On the other hand, the increase in credits and reduction in deductions – the latter which typically benefited high income taxpayers – may have compensated for much of the decrease in top marginal tax rates. As a rough approximation, one could say that overall progressivity didn't change much during the 1980s.[65] Nevertheless, a clear group that benefited from Reagan tax reforms was the top 1%, whose effective tax rate declined from 28% to 23% during the Reagan administrations.[66]

[64] There was a 33% bubble marginal tax rates for intermediate levels of income. However, because there was maximum effective tax rate of 28%, the marginal tax rate returned to 28% after certain level of income.

[65] See Brownlee (2016), pg. 207, for a similar opinion. Also see Feenberg, Ferriere, and Navarro (2016) for a more quantitative evaluation of the change of progressivity during the 1980s.

[66] See Feenberg, Ferriere, and Navarro (2016).

C.5 Income Taxes 1988-2001: Bush and Clinton

"Read my lips, no new taxes", *George W. H. Bush*

"It's the economy, stupid", *Bill Clinton*

The decade that followed the Reagan administration, observed many changes to the tax code although all of much smaller magnitudes.[67] After fulfilling its promise of "no new taxes" (only) for a year, the Bush administration passed the *Omnibus Budget Reconciliation Act* (OBRA) of *1990*, which increased top marginal tax rates from 28% to 31%. It also substantially increased the EITC, which combined with the higher top marginal tax rates, implied a substantial increase of the progressivity of the tax system.

Two important tax reforms were implemented during the Clinton administration, both which simultaneously aimed to reduce fiscal deficits and increase tax progressivity. The first one was the *OBRA* of 1993, which added two higher tax brackets with marginal tax rates of 36% and 39.6% – relative the previous top marginal tax rate of 28%. It also the EITC, which made the system further more progressive. The second reform during the Clinton administration was the *Tax Payer Relief Act* of 1997, which didn't change tax rates but included new tax credits – such as the child and education credits.

Overall, the tax reforms implemented during the Bush and Clinton administration implied an increase in the progressivity of the tax system. Both, because of its increase in top marginal tax rates, but mostly because of the expansion in tax credits.

C.6 Income Taxes 2001-2010: Bush and Obama

[67] Actually, no tax change observed up to nowadays was as massive as the ones implemented by Reagan.