The Nonlinear Effects of Fiscal Policy*

Pedro Brinca[†] Miguel Faria-e-Castro[‡] Miguel H. Ferreira[§]
Hans A. Holter[¶] Valter Nóbrega[||]

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Abstract

We argue that the fiscal multiplier of government purchases is nonlinear in the size of the spending shock. In particular, the multiplier is increasing in the spending shock, with more expansionary government spending shocks generating larger multipliers and more contractionary shocks generating smaller multipliers. We document that empirically this holds true across time, countries and types of shocks. We then propose a neoclassical mechanism that hinges on the relationship between fiscal shocks, their form of financing, and the response of labor supply across the wealth distribution. A neoclassical incomplete markets model predicts that the aggregate labor supply elasticity is increasing in the spending shock, and this holds regardless of whether shocks are deficit- or balanced-budget financed. We show this mechanism to still be the driving force of the nonlinear effects of fiscal policy in the presence of nominal price rigidities. We find evidence for our mechanism using micro-data for the US.

Keywords: Fiscal Multipliers, Nonlinearity, Asymmetry, Heterogeneous Agents
JEL Classification: E21; E62

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[†]Nova School of Business and Economics
[‡]Federal Reserve Bank of St. Louis
[§]Queen Mary University of London and CEPR
[¶]University of Delaware, Nova School of Business and Economics and University of Oslo
[||]Nova School of Business and Economics

1 Introduction

During the 2008-2009 financial crisis, many OECD countries adopted expansionary fiscal policies to stimulate economic activity. These fiscal expansions were often followed by a period of austerity measures aimed at reducing the size of the resulting high levels of government debt (referred to as fiscal consolidations). This era of fiscal activism inspired the economic literature to revive the classical debate on the size of the fiscal multiplier and its determinants, such as the state of the economy, income and wealth inequality, demography, tax progressivity, and the stage of development, among others.[1] More recently, the Covid-19 crisis has forced many countries into unprecedented budget deficits. Thus, concerns about debt sustainability will likely spur consolidation programs of different sizes and forms of financing after the crisis.

Most of the literature on fiscal policy, however, treats the fiscal multiplier as one number: small and large shocks are assumed to have the same relative effects. In this paper, we argue that fiscal multipliers from government spending shocks are increasing in the the shock. That is, large negative shocks yield smaller multipliers, while large positive shocks yield larger multipliers. We first present empirical evidence of this pattern and then show that it can be generated by a standard calibrated neoclassical model with incomplete markets and heterogeneous agents. The key mechanism, which hinges on the differential response of labor supply across the income distribution, is robust to assumptions about the form of financing and survives the introduction of nominal rigidities in the context of a Heterogeneous Agents New Keynesian (HANK) model.

Applying the data and methodology from two well known empirical studies (Alesina et al. 2015a and Ramey and Zubairy 2018), we find evidence of the size dependence of fiscal multipliers across different time periods, countries, and types of shocks. In our first empirical exercise we adapt the methodology and data of Alesina et al. (2015a), who

[1] See for example Auerbach and Gorodnichenko (2012), Ramey and Zubairy (2018), Brinca et al. (2016), Brinca et al. (2021), Hagedorn et al. (2019), Krueger et al. (2016), Basso and Rachedi (2021), Ferrière and Navarro (2018), Ilzetzki et al. (2013), and Faria-e-Castro (2022).

use annual data on exogenous fiscal consolidation shocks (policies aimed at reducing government debt), identified via a narrative approach, across 15 OECD countries over the period 1981-2014. We find the multiplier to be significantly — both quantitatively and statistically — larger for smaller fiscal consolidation shocks, with the effect being stronger for unanticipated than for anticipated shocks. We also find the results to be similar across both spending- and tax-based consolidations.

In the second empirical exercise we borrow the data and methodology from Ramey and Zubairy (2018), who use quarterly data for the US economy going back to 1889 and an identification scheme for government spending shocks that combines news about forthcoming variations in military spending and the identification assumptions of Blanchard and Perotti (2002). Using the projection method of Jordà (2005), we find evidence that the fiscal multiplier is increasing in the size of the shock. This corroborates the finding that the multipliers of larger consolidations are smaller than those of smaller negative fiscal shocks.

Next, we show that these empirical findings can be rationalized in the context of a standard, neoclassical, heterogeneous agents model with incomplete markets, similar to Brinca et al. (2016) and Brinca et al. (2021) but with infinite time horizon. The model is calibrated to match key features of the US economy, such as the income and wealth distributions, hours worked, and taxes. In our model, agents face uninunsurable labor income risk that induces precautionary savings behavior. The equilibrium features a positive mass of agents who are borrowing constrained: as is well known, the elasticity of intertemporal substitution (EIS) is increasing in wealth, with constrained agents having the lowest EIS.[2] Thus the labor supply elasticity of constrained and low-wealth agents is higher and their work hours are more responsive to contemporaneous changes in income. On the opposite, the hours worked of constrained and low-wealth agents are less responsive to future income shocks. This model feature, combined with shifts of the

[2]See Domeij and Floden (2006) for the relationship between wealth and EIS of labor and Vissing-Jørgensen (2002) for the relationship between wealth and the EIS of consumption.

wealth distribution, is prevalent in driving the nonlinearity of fiscal policy, and we show that the mechanism survives even in the presence of nominal price rigidities.

We study how the economy responds to different types of government spending shocks: permanent or temporary, deficit-financed or balanced-budget financed. A decrease in government spending that leads to a reduction in government debt generates a positive future income effect, as capital crowds out government debt and increases real wages. This positive shock to future income induces agents to reduce savings today, raising the mass of agents at or close to the borrowing constraint. Since wealthier agents react more to shocks to future income, their labor supply falls by relatively more in response to this government spending shock. Combining these two forces delivers our result: larger debt consolidations leads to a larger increase in the mass of constrained agents, and these are the agents whose labor supply respond less to the shock. Therefore, larger fiscal consolidations (negative shocks to government spending) elicit a relatively smaller aggregate labor supply response, which results in a smaller fiscal multiplier. For increases in government spending financed by debt, the opposite is true: larger positive shocks induce larger labor supply responses and thus larger fiscal multipliers. We show that this mechanism holds for deficit-financed reductions in government spending, regardless of whether they are permanent or temporary.

We also show that balanced-budget government spending shocks result in the same pattern of size dependence thanks to the same mechanism. Consider the case of a fiscal contraction that is accompanied by a contemporary increase in transfers so that public debt is held constant: the contemporary positive income effect elicits a much larger labor supply response by constrained and low-wealth agents. This positive income effect increases agents' wealth and pushes some of them away from the borrowing limit. This rightward shift in the wealth distribution decreases the aggregate labor supply response, as agents further away from the constraint respond less than those at the constraint, resulting in a smaller response of output and a smaller fiscal multiplier. The larger the change in the transfer, the larger the shift in the wealth distribution and the larger the reduction in the aggregate labor supply elasticity and the fiscal multiplier. The opposite is true for fiscal expansions, contemporaneously financed by a decrease in lumpsum transfers: the negative income effect decreases agents' wealth and shifts the wealth distribution to the left, where agents have a stronger labor supply response, leading to a larger multiplier, the larger the size of the government spending shock.

Lastly, we show that our key mechanism, which relies on the differential response of labor supply across the wealth distribution and movements of the same distribution, survives the introduction of nominal rigidities. We repeat the same experiments in a state-of-the-art HANK model as in Auclert et al. (2021b), and find the same pattern of fiscal multipliers that are increasing in the size of the government spending shocks. The results and mechanism hold for both deficit and balanced budget fiscal experiments.

We conclude the paper by empirically testing the validity of our labor supply channel by inspecting micro-data. Using data from the Panel Study of Income Dynamics (PSID), we assess how the labor supply response to government spending shocks depends on wealth and how this relationship depends on the financing of the shock. We establish that for spending shocks that are financed through contemporary taxes/transfers, the labor supply response is strongest for poorer agents, while the response is stronger for wealthier agents when spending shocks are deficit-financed.

Our work is closely related to that of Krueger et al. (2016), Athreya et al. (2017), Ferrière and Navarro (2018), Auclert et al. (2021a), Andres et al. (2022), Basso and Rachedi (2021), Hagedorn et al. (2019), Brinca et al. (2016), Brinca et al. (2021) and Heathcote (2005) who also study the effects of fiscal policy in the context of incomplete markets models with heterogeneous agents. Our focus, however, is not on the state dependence of multipliers or on how different policies produce different multipliers, but rather on how the same type of policy — government spending — can generate fiscal multipliers that are size-dependent, regardless of the manner in which it is financed. Also related is the work of Cantore et al. (2022), who study how the effects of monetary policy interact with the labor supply of the left tail of the income distribution via a neoclassical mechanism that is based on wealth effects. Our study is complementary is theirs and focuses on a similar mechanism for fiscal policy.

The rest of the paper is organized as follows: Section 2 presents empirical evidence on nonlinear fiscal multipliers. Section 3 introduces the heterogeneous agents neoclassical model, and Section 4 describes our calibration strategy. Section 5 presents the results from the quantitative model. Section 6 introduces nominal prices rigidites in the neoclassical model and shows that the driving force of the nonlinear effects of fiscal policy is still the same. Section 7 empirically tests and validates the mechanism combining micro data from the PSID with data on government spending and debt. Section 8 concludes.

2 Empirical Evidence

In this section, we use two different empirical methodologies and datasets to document that larger fiscal shocks generate relatively larger effects on output, i.e. larger fiscal multipliers. We begin by presenting evidence from fiscal consolidation programs in 15 OECD countries, using the dataset from Alesina et al. (2015a). Second, we employ the methodology from Ramey and Zubairy (2018), who study fiscal multipliers using historical data for the US.

2.1 *Fiscal Consolidation Episodes*

Using the dataset of Alesina et al. (2015a), we illustrate that larger fiscal consolidations (reductions of government debt) generate smaller fiscal multipliers. This nonlinear effect is more evident for unanticipated fiscal shocks and applies to consolidations based both on revenue increases and on spending reductions (austerity).

The annual dataset of fiscal consolidation episodes includes 15 OECD countries and ranges from 1981 to 2014.[3] Alesina et al. (2015a) expand the original dataset of Pescatori et al. (2011) with exogenous fiscal consolidation episodes, known as IMF shocks. Pescatori et al. (2011) use the narrative approach of Romer and Romer (2010) to identify exogenous fiscal consolidations, i.e., consolidations driven uniquely by the desire to reduce budget deficits. The use of the narrative approach filters out all policy actions driven by the business cycle, guaranteeing that the identified consolidations are independent from the current state of the economy.

Besides expanding the dataset of Pescatori et al. (2011), Alesina et al. (2015a) use the methodological innovation introduced by Alesina et al. (2015b), who point out that a fiscal adjustment is a multi-year plan rather than an isolated change and consequently results in both unexpected policies and policies that are known in advance. Ignoring the link between both expected and unexpected policies may yield biased results.

Alesina et al. (2015a) define a fiscal consolidation as deviations of public expenditure relative to their level (in % of GDP) if no policy had been adopted plus expected revenue changes stemming from tax code revisions. Moreover, fiscal consolidations that were not implemented are not included in the dataset, and so all included fiscal consolidation episodes are assumed to be fully credible.

To formally investigate the nonlinear impact of consolidation shocks on GDP, we estimate the following specification to test for the existence of nonlinear effects of the consolidation shocks:

$$\Delta y_{i,t} = \beta_1 e_{i,t} + \beta_2 (e_{i,t})^2 + \alpha_i + \gamma_t + \epsilon_{it} \tag{1}$$

where $\Delta y_{i,t}$ and $e_{i,t}$ are the output growth rate and the fiscal consolidation shock in % of GDP, respectively, in country i and year t. α_i and γ_t are country- and time-level

[3] The dataset includes Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Japan, the United Kingdom, the US, Ireland, Italy, Portugal, and Sweden. As we only have data for Germany starting in 1991, we drop it from the baseline analysis. We then test and confirm that the results hold when including Germany, with the sample ranging from 1991 to 2014.

fixed effects, respectively. We include the squared term of the fiscal consolidation shocks $(e_{i,t})^2$ to capture the nonlinear effects of fiscal shocks. To account for simultaneous cross-country correlations of the residuals, we estimate equation (1) using the generalized least-squares method and controlling for heteroskedasticity. To control for the effects of outliers, we winsorize output variations at the 5th and 95th percentile.

The results are shown in Table 1, and they capture the negative effect of consolidation shocks on output, with β_1 being negative and statistically significant. β_2 is positive and significant, which illustrates the nonlinear effect of consolidation shocks on output: larger consolidations generate relatively smaller effects on output, i.e., smaller fiscal multipliers.[4] Not only is β_2 statistically significant but is also economically meaningful. An increase of one standard deviation of the fiscal consolidation shock is associated with a fiscal multiplier that is 78% smaller.

Table 1: Nonlinear effects of fiscal consolidation shocks.

Variable	(1) Benchmark
β_1	-0.908***
	(0.170)
β_2	0.261***
	(0.051)
Observations	510
Number of countries	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Unanticipated vs. Announced Shocks

We proceed by investigating whether it matters that fiscal shocks are unanticipated or announced in advance.[5] In order to test for nonlinear effects of both unanticipated and announced consolidations, we use the same methodology as in the previous section to

[4]Notice the fiscal multiplier is given by $\beta_1 + 2\beta_2 \times e_{it}$. If β_2 was zero, the multiplier would be constant and equal to β_1.

[5]Announced shocks are the sum of consolidation plans announced in the previous three years that are to be implemented in the current year t.

estimate the following specification,

$$\Delta y_{i,t} = \beta_1 e^u_{i,t} + \beta_2 (e^u_{i,t})^2 + \beta_3 e^a_{i,t} + \beta_4 (e^a_{i,t})^2 + \alpha_i + \gamma_t + \epsilon_{it}$$

where $e^u_{i,t}$ are the unanticipated shocks and $e^a_{i,t}$ are the announced shocks. The results are presented in Table 2: the nonlinear impacts of consolidations on output come from unanticipated shocks and not from announced consolidations. While β_4 is not statistically significant, β_2 is positive, statistically significant, and economically meaningful. An increase of one standard deviation of unanticipated consolidations reduces the size of the fiscal multiplier by 22%.

Table 2: Non-linear effects of fiscal unanticipated and announced consolidation shocks.

Variables	Benchmark
β_1	-0.465**
	(0.183)
β_2	0.150***
	(0.058)
β_3	-0.547**
	(0.215)
β_4	0.034
	(0.087)
Observations	510
Number of countries	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Our results are robust to the inclusion of further lags (for both types of shocks) as well as to the inclusion of consolidations announced in the current year to be implemented in the following three years. These results are presented in Tables 12 and 13 in Appendix A.1 and establish that the quadratic term β_2 is positive and statistically significant across specifications.

Financing Instrument

Lastly, we test if it matters whether consolidations are spending- or revenue-based. We estimate the following specification:

$$\Delta y_{i,t} = \sum_{i=0}^{3} \beta_{1,t-i} e^{u}_{i,t} + \sum_{i=0}^{3} \beta_{2,t-i} (e^{u}_{i,t})^2 + \sum_{i=0}^{3} \beta_{3,t-i} e^{a}_{i,t} + \sum_{i=0}^{3} \beta_{4,t-i} (e^{a}_{i,t})^2 + \sum_{i=0}^{3} \beta_{5,t-i} r^{u}_{i,t} + \sum_{i=0}^{3} \beta_{6,t-i} (r^{u}_{i,t})^2 + \sum_{i=0}^{3} \beta_{7,t-i} r^{a}_{i,t} + \sum_{i=0}^{3} \beta_{8,t-i} (r^{a}_{i,t})^2 + \alpha_i + \gamma_t + \epsilon_{it}$$

where $e^{u}_{i,t}$ and $e^{a}_{i,t}$ are the unanticipated and announced expenditure-based consolidation shocks and $r^{u}_{i,t}$ and $r^{a}_{i,t}$ are unanticipated and announced revenue-based consolidation shocks. We include lags to control for anticipation effects of fiscal shocks. The results are displayed in Table 3, and establish that the quadratic terms for both expenditure- and revenue-based (unanticipated) consolidations – β_2 and β_6, respectively – are positive and statistically significant on impact.[6][7] Moreover, both coefficients are economically meaningful on impact, with an increase by one standard deviation of a expenditure- and revenue-consolidation shocks lowering the respective multipliers by 26% and 20%.

Table 3: Non-linear effects of fiscal unanticipated expenditure and revenue consolidation shocks, including three lags of each shock.

	β_1	β_2	β_5	β_6
t	-0.580*	0.367*	-1.158***	0.571***
	(0.344)	(0.205)	(0.346)	(0.170)
$t-1$	-1.174***	0.487**	-1.074***	0.249
	(0.358)	(0.208)	(0.347)	(0.179)
$t-2$	-0.414	0.473**	-0.904***	0.249
	(0.354)	(0.207)	(0.330)	(0.188)
$t-3$	-1.209***	0.614***	-0.891***	0.578***
	(0.361)	(0.219)	(0.332)	(0.201)
Observations		510		
Number of countries		15		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14 in Appendix A.1 shows that our results are robust to the inclusion of future consolidation-plan announcements. Finally, Tables 15 to 17 show that our results are robust to (i) including Germany and (ii) restricting the sample to the 1991-2014 period.

[6] β_2 is significant for all time horizons, whereas β_6 is significant on impact as well as three years earlier.
[7] To simplify the presentation we do not report the announced consolidations parameters, which are not statistically significant.

2.2 *US Historical Data*

We continue to investigate the relationship between the fiscal multiplier and the size of the underlying fiscal shock by employing the methodology and the historical dataset constructed by Ramey and Zubairy (2018), which contains quarterly time series for the US economy ranging from 1951 to 2015.[8] The dataset includes real GDP, the GDP deflator, government purchases, federal government receipts, population, unemployment rates, interest rates, and defense news. Quarterly US historical data provides us with a long enough time series to compare the multipliers across fiscal shocks of different sizes, as well as many periods of expansion and recession, and different regimes for fiscal and monetary policy.

To identify exogenous government spending shocks, Ramey and Zubairy (2018) use two different approaches: (i) a defense news series proposed by Ramey (2011), which consists of exogenous variations in government spending linked to political and military events that are identified using a narrative approach and that are plausibly independent from the state of the economy, and (ii) shocks based on the identification hypothesis of Blanchard and Perotti (2002) that government spending does not react to changes in macroeconomic variables within the same quarter. Ramey and Zubairy (2018) argue that including both instruments simultaneously can bring advantages, as the Blanchard-Perotti shock is highly relevant in the short run (since it is the part of government spending not explained by lagged control variables), while defense news data are more relevant in the long run (as news happen several quarters before the spending actually occurs).

Figure 1 plots the quarterly observations of both shocks for the 1951-2016 sample. During this period we have shocks of different magnitudes and signs, with the values of the shocks ranging from -9% to 6% of GDP. This provides us with a significant amount of variation with which to test how the size of the shock affects the multiplier.

[8] We ignore data prior to 1951 to guarantee our results are not driven by the three outlier shocks that are WWI, WWII and the Korean war.

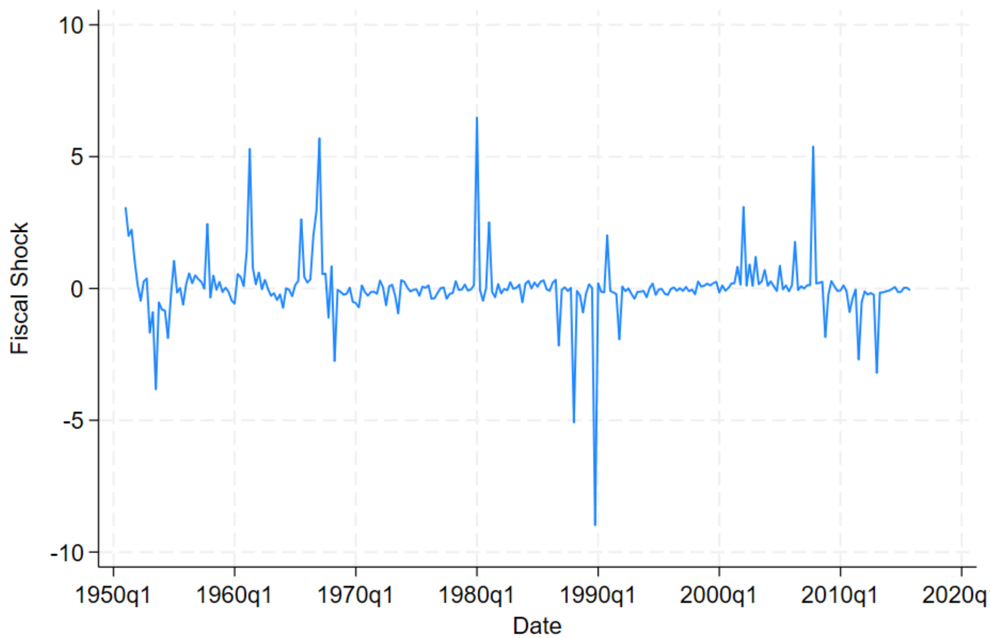

Figure 1: Government spending shocks as a percentage of real GDP.

Formally, we adapt the methodology as Ramey and Zubairy (2018), which is based on the local projection method of Jordà (2005). This method consists of estimating the following equation for different time horizons h:

$$y_{t+h} = \alpha_h + \Psi_h(L)z_{t-1} + \beta_h \text{shock}_t + \beta_{2,h}\left(\text{shock}_t\right)^2 + \epsilon_{t+h}, \text{ for } h = 0, 1, 2, ...$$

where y is real GDP per capita divided by trend GDP and z is a vector of lagged control variables, including real GDP per capita, government spending, and tax revenues (all divided by trend GDP). z also includes the defense news variable to control for serial correlation. Additionally, we include a quadratic time trend to control for any major trends in aggregate variables that may bias the results. $\Psi_h(L)$ is a polynomial of order four in the lag operator, and shock_t is a vector that includes both exogenous shock, the defense news variable and the Blanchard-Perotti spending shock.

Ramey and Zubairy (2018) follow a literature that highlights that, in a dynamic environment, the multiplier should not be calculated as the peak of the output response

Table 4: Linear and quadratic coefficients for impact, 1, 2, 3 and 4-year horizons. The specification includes both Blanchard-Perotti (BP) shocks and news shocks. Standard errors in parentheses.

	Linear	Quadratic
Impact	-2.188	3.546
	(0.839)	(0.850)
1-year	-6.051	3.051
	(1.583)	(0.700)
2-years	-10.567	2.820
	(2.699)	(0.680)
3-years	-13.813	2.547
	(2.001)	(0.359)
4-years	-17.127	2.424
	(4.245)	(0.571)
Observations	255	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

to the initial government spending variation but rather as the integral of the output variation to the integral of the government spending variation.[9] This method has the advantage of measuring all the GDP gains in response to government spending variations in a given period. Ramey and Zubairy (2018) propose to estimate the following instrumental variables specification that allows for the direct estimation of the integral multiplier:

$$\sum_{j=0}^{h} y_{t+j} = \delta_h + \phi_h(L)z_{t-1} + \beta_h \sum_{j=0}^{h} g_{t+j} + \beta_{2,h} \left(\sum_{j=0}^{h} g_{t+j} \right)^2 + \epsilon_{t+h}, \text{ for } h = 0, 1, 2, \ldots \quad (2)$$

where shock_t is used as an instrument to $\sum_{j=0}^{h} g_{t+j}$, which is the sum of government spending from t to $t+h$. We deviate from Ramey and Zubairy (2018) by adding the quadratic term, which allows us to test for the non-linear effects of fiscal policy. This way, the cumulative multiplier at horizon h can be directly interpreted as $\beta_h + 2 \times \beta_{2,h} \sum_{j=0}^{h} g_{t+j}$.

If the effects of fiscal policy are size dependent, the coefficient $m_{2,h}$ should be statistically different from zero. Table 4 reports the estimation results: the quadratic coefficient is positive and statistically significant, suggesting the multiplier to be increasing in the

[9] See Mountford and Uhlig (2009), Uhlig (2010), or Fisher and Peters (2010).

Table 5: Estimates for fiscal multipliers using the coefficients in Table 4. The first column reports the average minus one standard deviation, the second column reports the average, and the third column reports the average plus one standard deviation.

	-1 std	Average	+1 std
Impact	0.504	0.796	1.088
1-year	-0.265	0.355	0.974
2-years	-0.944	0.057	1.059
3-years	-1.280	0.001	1.283
4-years	-1.505	0.037	1.579
Observations		255	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

shock, in line with the evidence in section 2.1. Moreover, the result holds over different horizons, with the non-linearity still being prevalent 4 years after the shock.

In order to understand if the non-linearity, on top of being positive and statistically significant, is also economically meaningful we estimate its impact on the fiscal multiplier. Table 5 reports the average fiscal multiplier at different time horizons (middle column), as well as the multiplier when cumulative government spending $\sum_{j=0}^{h} g_{t+j}$ decreases or increases by 1 standard deviation. The table shows that the average multiplier on impact is 0.8. A one standard deviation reduction in cumulative government spending (around 4% of GDP on average) reduces the multiplier by 0.3, to 0.5. On the other hand, a one standard deviation increase in cumulative government spending raises the multiplier by 0.3, to 1.1.

Finally, we show in Appendix A.2 that our results are robust to changing several assumptions. First, we include one instrument at the time. Table 18 presents the results using only the Blanchard-Perotti instrument, while Table 19 shows the results when using only the news shocks. Second, we test for the exclusion of the quadratic time trend, to guarantee it is not affecting our results. Table 20 presents the results. Lastly, to guarantee that our results are robust to the number of lags selected, we test for the inclusion of 8 lags. The results can be found in Table 21.

3 Heterogeneous Agents Model

In this section, we develop a standard incomplete markets model that we will later calibrate to resemble the U.S. economy and use to study the nonlinear effects of fiscal policy.

Technology

The production sector is standard, with the representative firm having access to a Cobb-Douglas production function,

$$Y_t(K_t, L_t) = K_t^{\alpha} L_t^{1-\alpha}$$

where L_t is the labor input, measured in efficiency units, and K_t is the capital input. The law of motion for capital is

$$K_{t+1} = (1-\delta)K_t + I_t$$

where δ is the capital depreciation rate and I_t is the gross investment. Firms choose labor and capital inputs each period in order to maximize profits:

$$\Pi_t = Y_t - w_t L_t - (r_t + \delta)K_t.$$

In a competitive equilibrium, factor prices are paid their marginal products:

$$w_t = \frac{\partial Y_t}{\partial L_t} = (1-\alpha)\left(\frac{K_t}{L_t}\right)^{\alpha}$$
$$r_t = \frac{\partial Y_t}{\partial K_t} - \delta = \alpha\left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta$$

Demographics

The economy is populated by a continuum of infinitely lived households. Households differ with respect to their permanent ability levels assigned at birth, a, persistent idiosyncratic productivity shocks, u, asset holdings, k, and time discount factors that are uniformly distributed and can take three distinct values, $\beta \in \{\beta_1, \beta_2, \beta_3\}$. Agents choose how much to work, n, consume, c, and save, k', to maximize expected lifetime utility.

Labor Income

The hourly wage received by an individual depends on the wage per efficiency unit of labor, w, permanent ability $a \sim N(0, \sigma_a^2)$, and an idiosyncratic productivity shock u, which follows an AR(1) process:

$$u' = \rho u + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon^2).$$

The wage rate per hour worked by an individual i is given by

$$w_i(a, u) = we^{\gamma + a + u}$$

where γ is a constant used to normalize the average earnings in the economy to 1[10].

Preferences

Households' utility in a given period $U(c, n)$ is standard: time-additive, separable, and isoelastic, with $n \in (0, 1]$:

$$U(c, n) = \frac{c^{1-\sigma}}{1-\sigma} - \chi \frac{n^{1+\eta}}{1+\eta}$$

Each household maximizes their expected lifetime utility:

$$\max_{\{c_t, n_t, k_t\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t U(c, n)$$

Government

Government revenues include a distortionary labor tax τ_l. Tax revenues are used to finance public consumption of goods, G_t; lumpsum transfers, g_t; and interest expenses on public debt, rB_t. Denoting tax revenues as R, the government budget constraint is

[10]Normalizing average earnings to 1 is for example helpful when mapping an estimated nonlinear income tax code from the data to the model, like we do in Appendix C. We estimate the tax function on income normalized by Average Earnings in the data y/AE. Thus a person with average earnings in the data and model will have an income of 1.

defined as:

$$g \int \mathrm{d}\Phi + G + rB = R$$

Recursive Formulation of the Household Problem

In a given period, a household is defined by their asset position k, time discount factor β, permanent ability a, and persistent idiosyncratic productivity u. Given this set of states, the household chooses consumption, c; work hours, n; and future asset holdings, k', to maximize the present discounted value of expected utility. The problem can be written recursively as:

$$V(k,\beta,a,u) = \max_{c,k',n} \left[U\left(c,n\right) + \beta \mathbb{E}_{u'}\left[V(k',\beta,a,u')\right]\right]$$

$$\text{s.t.:}$$

$$c + k' = k\left(1+r\right) + g + nw\left(a,u\right)\left(1-\tau_l\right)$$

$$n \in [0,1], \quad k' \geq -b, \quad c > 0$$

where b is an exogenous borrowing limit.

Stationary Recursive Competitive Equilibrium

Let the measure of households with the corresponding characteristics be given by $\Phi(k,\beta,a,u)$. Then, we can define a stationary recursive competitive equilibrium (SRCE) as follows:

1. Taking the factor prices and the initial conditions as given, the value function $V(k,\beta,a,u,)$ and policy functions $c(k,\beta,a,u)$, $k'(k,\beta,a,u)$, $n(k,\beta,a,u)$ solve the households' optimization problems.

2. Markets clear:

$$K + B = \int k \mathrm{d}\Phi$$

$$L = \int n(k,\beta,a,u) \mathrm{d}\Phi$$

$$\int c \mathrm{d}\Phi + \delta K + G = K^{\alpha} L^{1-\alpha}.$$

3. Factor prices are paid their marginal products:

$$\begin{aligned} w &= (1-\alpha)\left(\frac{K}{L}\right)^{\alpha} \\ r &= \alpha\left(\frac{K}{L}\right)^{\alpha-1} - \delta. \end{aligned}$$

4. The government budget balances:

$$g \int \mathrm{d}\Phi + G + rB = \int \left[nw\left(a,u\right)\left(1-\tau_l\right)\right] \mathrm{d}\Phi.$$

Fiscal Experiments and Transition

Our fiscal experiments consist of changes in government spending G of different sizes (measured as a percentage of GDP) and under different financing regimes. This is important, as Ricardian equivalence does not hold in our model and therefore the type (and timing) of the financing of the shock can matter substantially for its effects on output.

1. Permanent debt consolidations and expansions. In the case of a consolidation, G decreases temporarily so as to allow public debt to fall. The economy then transitions to a new SRCE with lower public debt and G returns to its original level.

2. Temporary deficit-financed reductions and increases in G. Initially, the reduction in G leads to a fall in debt. Eventually, G returns to its original level and lumpsum transfers adjust so that debt also returns to its original level. The economy returns to the initial SRCE.

3. Temporary balanced-budget-financed reductions and increases in G. In the case of a reduction, lumpsum transfers increase to clear the government budget constraint

and maintain debt at a constant level. Eventually, the economy transitions back to the initial SRCE.

We delegate the formal definition of a transition equilibrium to Appendix B.

4 Calibration

We calibrate the starting SRCE of our model to the US economy. Some parameters are calibrated directly from empirical counterparts, while others are calibrated using the simulated method of moments (SMM) so that the model matches key features of the US economy. Section D in the appendix contains a table that summarizes the values for the parameters that are calibrated outside of the model.

Preferences

We set the Frisch elasticity of labor supply to 1, as in Trabandt and Uhlig (2011), a standard value in the literature. The disutility of work and the three values for the discount factor (χ, β_1, β_2, β_3) are among the parameters calibrated to match four data moments: the share of hours worked and the three quartiles of the wealth distribution, respectively.

Taxes and Government Spending

Following Hagedorn et al. (2019), we set transfers g to be 7% of GDP and government spending G to be 15% of GDP. The labor tax τ_l is then set so that total tax revenues clear the government budget.

Endogenously Calibrated Parameters

Some parameters that do not have any direct empirical counterparts are calibrated using SMM. These are the discount factors, borrowing limit, disutility from working, and variance of permanent ability. The SMM is set so that it minimizes the following loss function:

$$L(\beta_1, \beta_2, \beta_3, b, \chi, \sigma_a) = ||M_m - M_d|| \tag{3}$$

where M_m and M_d are the moments in the model and in the data, respectively.

We use six data moments to choose six parameters, so the system is exactly identified. The six moments we select in the data are (i) the share of hours worked, (ii-iv) the three quartiles of the wealth distribution, (v) the variance of log wages, and (vi) the capital-to-output ratio. Table 6 presents the calibrated parameters, and Table 7 presents the calibration fit.

Table 6: Parameters Calibrated Endogenously

Parameter	Value	Description
Preferences		
$\beta_1, \beta_2, \beta_3$	0.987, 0.988, 0.986	Discount factors
χ	11.5	Disutility of work
Technology		
b	1.70	Borrowing limit
σ_a	0.712	Variance of ability

Table 7: Calibration Fit

Data moment	Description	Source	Data value	Model value
K/Y	Capital-to-output ratio	PWT	12.292	12.292
$\text{Var}(\ln w)$	Yearly variance of log wages	LIS	0.509	0.509
$\bar{n}$	Fraction of hours worked	OECD	0.248	0.248
Q_{25}, Q_{50}, Q_{75}	Wealth quartiles	LWS	-0.014, 0.004, 0.120	-0.016, 0.002, 0.120

5 Quantitative Results

We now use the calibrated model as a laboratory to study the effects of government spending shocks of different sizes and under different financing regimes. We start by studying permanent debt consolidations: transitions where the debt level at the final steady state is different (lower or higher) than the debt level at the initial steady state. We then analyze temporary changes in G where the economy returns to the initial steady state. We consider both debt financing and balanced budget financing of the changes in G. In Appendix C we show that the results are robust to a more realistic tax structure, including labor tax progressivity, capital and consumption taxes.

5.1 *Permanent Debt Changes*

We start by considering permanent fiscal consolidations and expansions, the type of experiment that most closely resembles the policies that we empirically analyse in the first part of Section 2. The experiment consists of temporary changes in G that last for 30 quarters, with no changes in taxes or transfers. At the end of those 30 periods, debt reaches its new steady-state level and G returns to its initial level, while lump-sum transfers adjust to clear the government budget constraint given the new level of debt. The economy then takes 70 quarters to reach the new steady state with a new debt-to-GDP ratio and different lump-sum transfers.

Figure 2 plots the fiscal multiplier on impact (one quarter after the shock) depending on the size of the initial G variation. The multiplier is monotonically increasing in the shock: it is larger for larger increases in G and smaller for larger decreases in G. In other words, the effects of G on Y are nonlinear: the larger is the G shock, the larger the impact on output.

Figures 3 and 4 shed light on the mechanism at the heart of this paper that generates this nonlinearity. Figure 3 plots the % of agents with negative wealth one year after the shock, as a function of the size of the shock. The mass of agents with negative wealth is decreasing in the size of the shock: more negative shocks involve larger future reductions in public debt. This generates not only a positive wealth effect, as future lumpsum transfers will be higher, but also a future positive income (human wealth) effect, as debt is crowded out by capital and wages are increasing in the stock of capital. As agents internalize these positive wealth and income effects, they find it optimal to borrow more today. Thus more negative consolidations induce more agents to move towards the constraint in the short run. Figure 26 in Appendix E illustrates this point

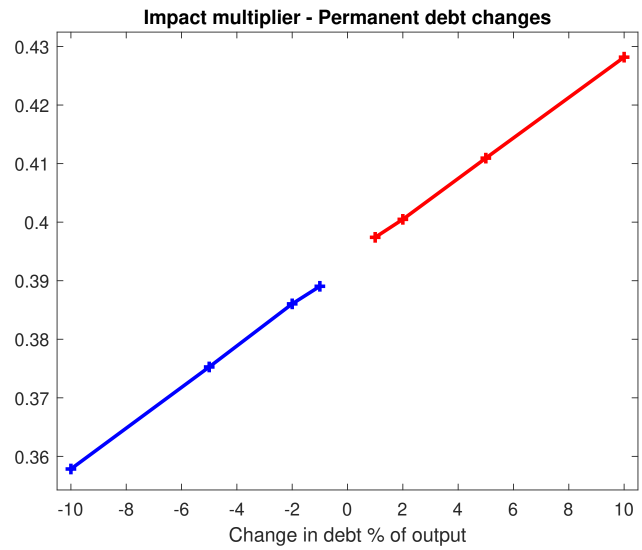

Figure 2: This figure plots the fiscal multiplier on impact (one quarter after the shock) for the permanent change in debt experiment as a function of the size of the variation in G (as a % of GDP). The blue line corresponds to G contractions, while the red line represents G expansions.

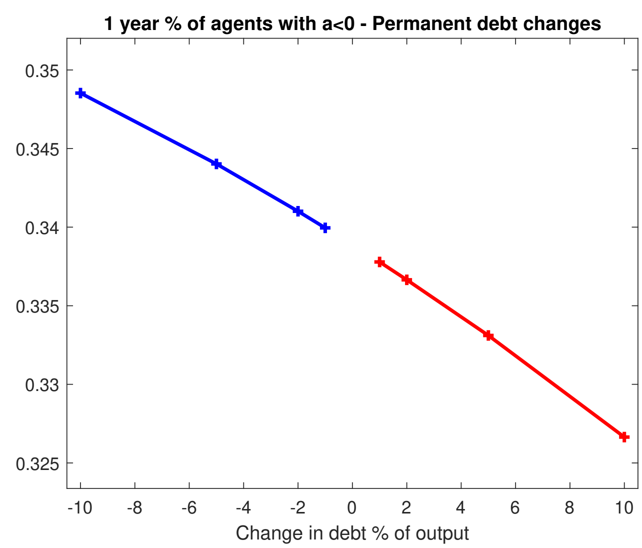

Figure 3: This figure plots the percentage of agents with negative wealth (one year after the shock) for the permanent change in debt experiment as a function of the size of the variation in G (as a % of GDP). The blue line corresponds to G contractions, while the red line represents G expansions.

by plotting the overall movement of the entire wealth distribution in response to the shocks of different sizes. More negative consolidations move agents from the middle of the wealth distribution to the bottom, while more positive consolidations induce the opposite movement of the distribution, thus explaining the larger multiplier.

Figure 4 illustrates why these changes in the percentage of constrained agents matter for aggregate dynamics. This figure plots the labor supply response across the wealth

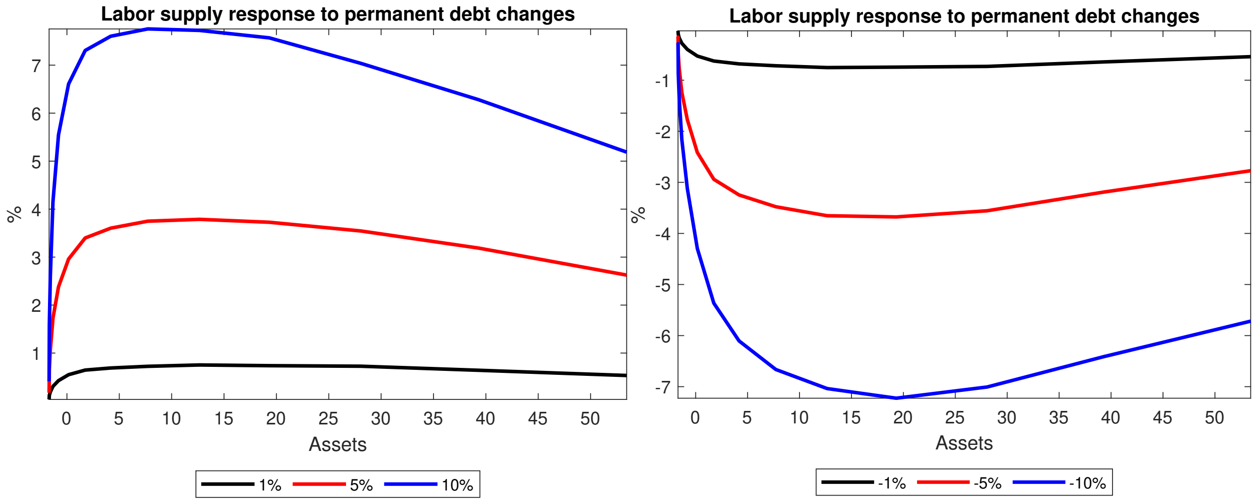

Figure 4: (Relative) labor supply response to different changes in G over the asset distribution, for the permanent change in debt experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

distribution for shocks of three different sizes (1%, 5%, and 10% of GDP). Notice that the labor supply of constrained and low-wealth agents is less responsive than that of agents in the middle of the distribution. These wealthier agents react strongly to changes in future income and wealth, while constrained agents respond only to changes in the current state (i.e., current taxes and transfers) and not to changes in future states. For this reason, constrained agents essentially do not react to government spending shocks in the short run, regardless of their size. These wealthier agents perceive larger wealth effects from larger spending shocks, hence reduce or increase their labor supply by more.

The mechanism can then be summarized as follows: negative spending shocks move the wealth distribution to the left. As more agents become net borrowers, the result is a smaller aggregate labor supply response and, consequently, a relatively smaller effect on GDP. The opposite is true for positive spending shocks, which move the wealth distribution to the right, to a region where labor supply is more responsive. In summary, the elasticity of aggregate labor supply to government spending shocks is increasing in the size of the fiscal consolidation shock. The same pattern translates to the fiscal multiplier as well.[11]

[11]Figures 17-19 in Appendix C show that the results are robust to a richer tax structure that includes

A permanent change in government spending that is financed by taxes (or lump-sum transfers) would generate qualitatively similar results. In an incomplete markets environment where the Ricardian Equivalence fails to hold, a permanent increase in G that is financed by increased taxes generates a negative wealth effect, shifting the wealth distribution to the left. Assuming that debt remains constant and thus taxes rise contemporaneously, this generates a negative current income effect to which low wealth agents react most strongly. The combination of the leftwards shift in the distribution with this differential response would cause the multiplier to be increasing in the size of the shock, just as in the experiment described above.

5.2 *Temporary Spending Shocks*

We now consider the case of temporary government spending shocks: sequences of shocks to G that result in the same original SRCE in the long run. We show that the same basic logic applies to this case. Additionally, we consider two types of financing regimes: (i) deficit financing, where the temporary shock is absorbed by changes in public debt until a certain point in time, after which transfers adjust to ensure that the economy returns to the initial (pre-shock) level of public debt, and (ii) balanced-budget financing, in which transfers adjust to keep public debt constant during the entire transition.

Path of the Shocks

We follow most literature on fiscal policy and assume that fiscal spending follows an AR(1) process in logs:

$$\log G_t = (1 - \rho_G) \log G_{SS} + \rho_G \log G_{t-1} + \varepsilon_t^G$$

where ρ_G is assumed to be 0.9 at a quarterly frequency, consistent with the estimates of Nakamura and Steinsson (2014) for military procurement spending.

both capital and consumption taxes, as well as labor tax progressivity.

Deficit Financing

Figure 5 plots the multiplier as a function of the size of the shock for the case of deficit financing. While the size of the multipliers is now slightly smaller since the shock is no longer permanent, the results are quantitatively similar and the overall pattern remains unchanged from the permanent debt change case.

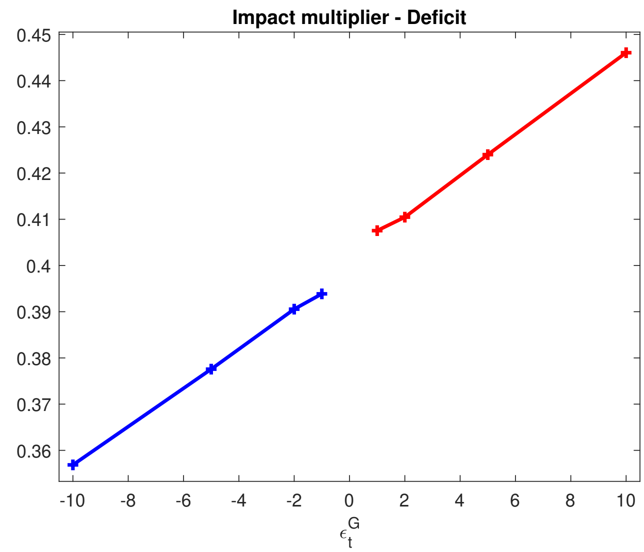

Figure 5: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ε_t^G (the initial impulse), for the deficit financing experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

Figures 6 and 7 confirm that the basic mechanism still applies. The mass of agents with negative wealth is decreasing on the size of the shock. As these shocks are deficit

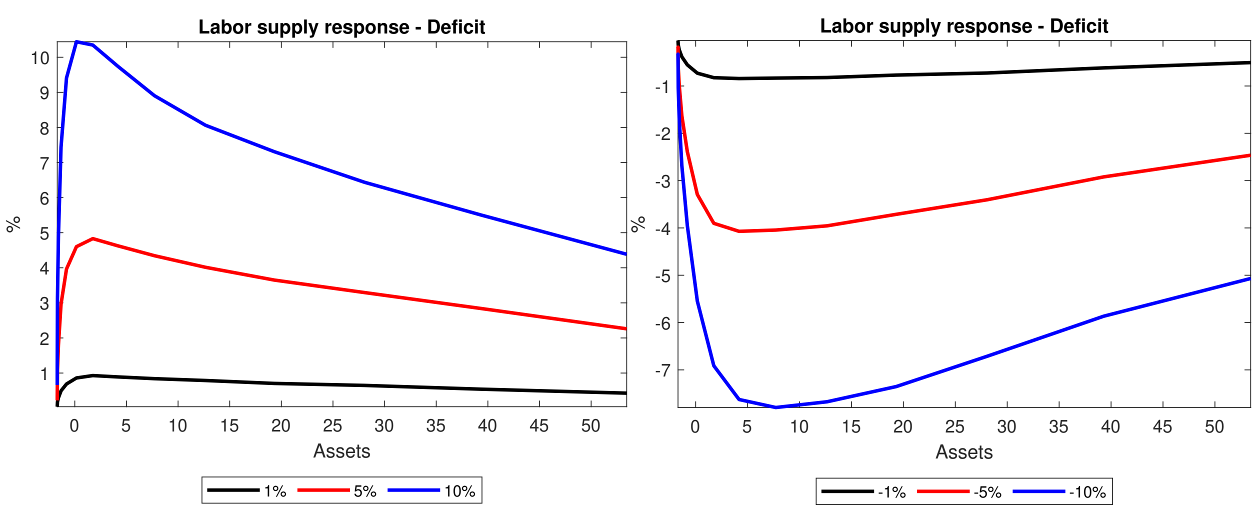

Figure 6: (Relative) labor supply response to different changes in G over the asset distribution, for the deficit financing experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

financed, they cause a future positive wealth effect to which only unconstrained agents respond. Therefore, the smaller the mass of agents that are constrained the larger the responses of the aggregate labor supply and GDP become. This explains why the multiplier is largest for large positive shocks and smallest for large negative shocks.[12] Figure 27 in Appendix E shows the overall movement of the wealth distribution, explaining the mechanism at play.

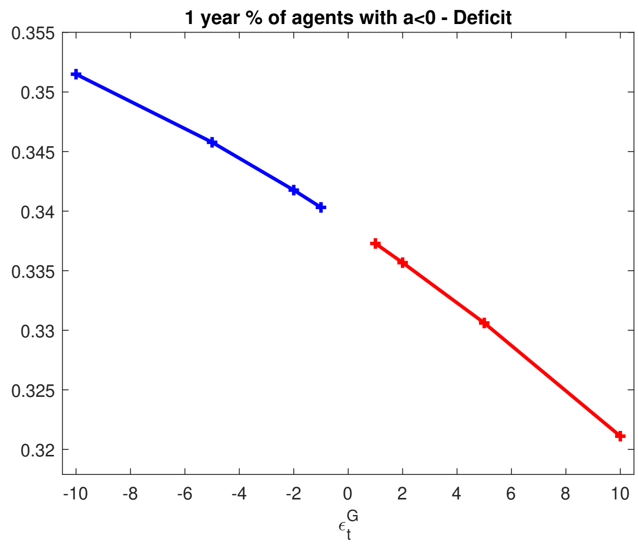

Figure 7: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ε_t^G (the initial impulse), for the deficit financing experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

Balanced-Budget

Figure 8 plots fiscal multipliers for the case where the government runs a balanced budget and thus decreases transfers when G increases so as to keep the level of debt constant. The qualitative results are identical, but the sizes of the multipliers are larger under this financing regime. While the core mechanism still revolves around differences in labor supply responses coupled with shifts in the wealth distribution, these now operate a bit differently. Due to contemporaneous changes in lumpsum transfers, constrained agents now display the largest labor supply responses. An increase in G is associated with a decline in lumpsum transfers, which elicits a much larger labor supply response by constrained and low-wealth agents.

[12]Figures 20-22 Appendix C present the results under a richer tax structure.

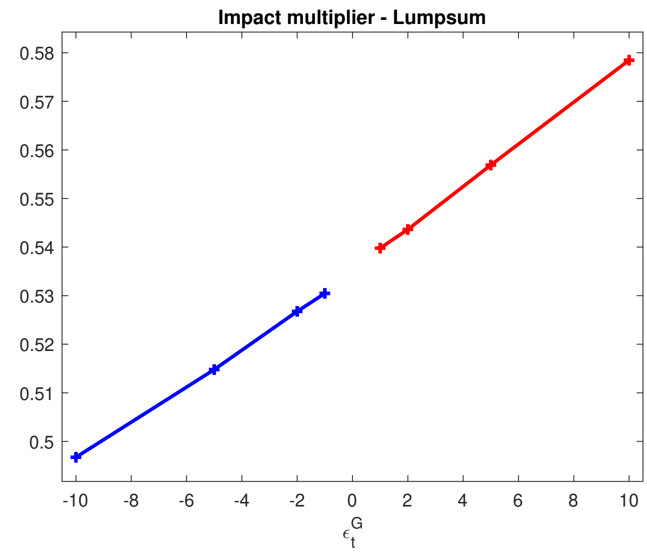

Figure 8: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ε_t^G (the initial impulse), for the balanced budget experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

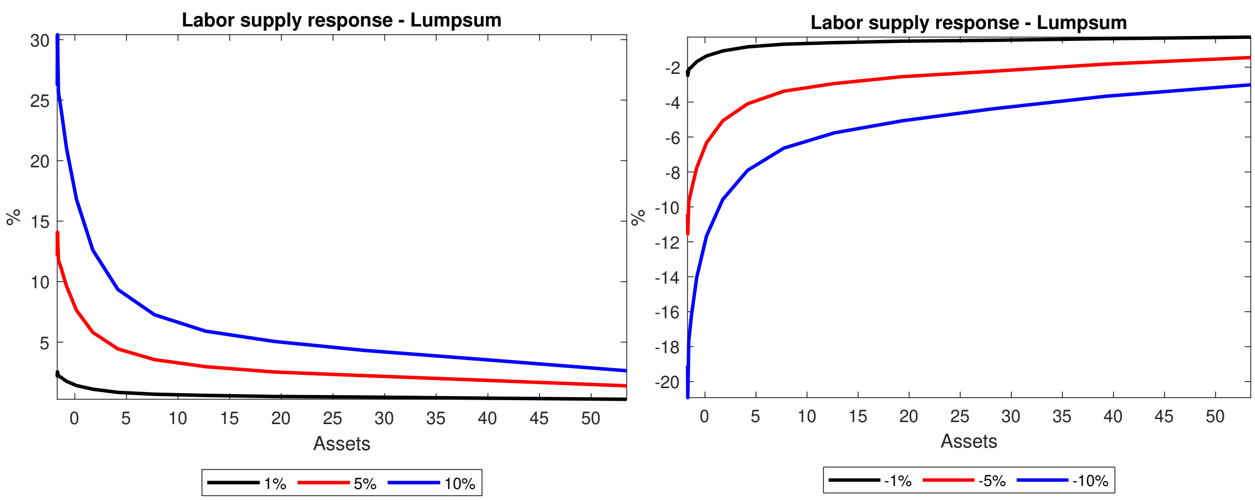

Figure 9: (Relative) labor supply response to different changes in G over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive goverbnment spending shocks while the right panel presents the results for negative shocks.

Figure 9 displays the labor supply responses by wealth and the size of the spending shock. These labor supply responses behave in the manner that we would expect, with constrained agents greatly expanding their labor supply in response to a positive shock that decreases transfers. These labor supply responses can be combined with the movements in the distribution presented in Figure 10 to deliver our result: the mass of agents with negative wealth is increasing in the size of the shock. A positive spending shock financed by a contemporary decrease in transfers moves agents towards the

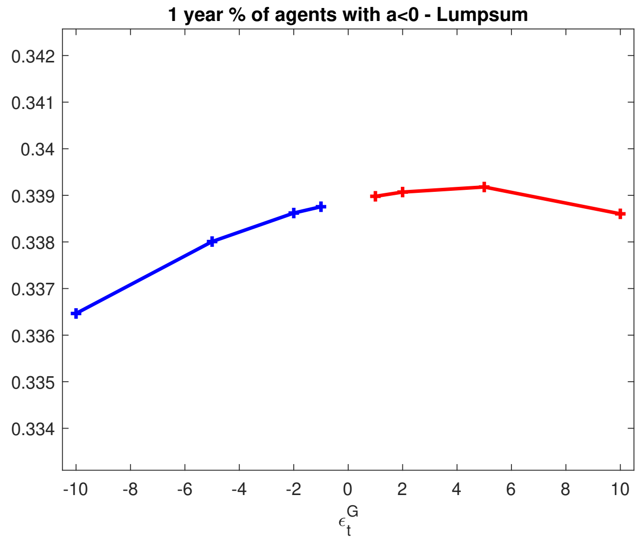

Figure 10: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ε_t^G (the initial impulse), for the balanced budget experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

constraint, where labor supply is more responsive. Conversely, a negative shock moves agents away from the constraint, where their labor supply is less responsive. The key mechanism again revolves around larger shocks shifting the distribution towards regions where the labor supply response is strongest. Figure 28 in Appendix E illustrates exactly this point.

One should note that the multipliers in this class of models tend to be lower than what is typically found in empirical exercises. Our case is no exception, for both the level and degree of nonlinearity of multipliers. Our results reinforce the need for future research to focus on amplification mechanisms that can bridge such a gap, especially in models with capital and empirically plausible monetary rules.[13] In the next section we take a first step in this direction by showing that the multipliers are larger and more non-linear in a HANK model.

[13]Figures 23-25 in Appendix C shows that the results are robust to the inclusion of capital and consumption taxes, as well as labor tax progressivity.

6 Heterogeneous Agents New Keynesian Model

The main source of nonlinearity for the multipliers that we discussed in the last sections is fundamentally a neoclassical mechanism that operates via differential changes in the labor supply of agents across the wealth distribution. As a form of robustness, we show that the main mechanism and result regarding the nonlinearity of multipliers survives in a state-of-the-art heterogeneous agents New Keynesian (HANK) model that closely follows the set up in Auclert et al. (2021b).

6.1 Setup

The setup follows closely that of the neoclassical model, with the main differences being (i) the addition of nominal rigidities in the form monopolistiocally competitive producers of differentiated varieties that are subject to quadratic costs of price adjustment, (ii) the addition of a central bank that follows a standard Taylor rule, and (iii) the exclusion of physical capital for computational tractability.

Households Households are ex-ante heterogeneous with respect to their discount factor $\beta_i \in \{\beta_1, \beta_2, \beta_3\}$ and choose how much to consume, c, work, n, and save, b', in order to maximize the same period utility function, subject to the same budget constraint as before. Note that savings are expressed in real terms. Additionally, since monopolistically competitive firms make positive profits at the stationary equilibrium, we assume that they are equally distributed across households in a lump-sum manner, d_t. The problem of the household can be written as:

$$\begin{aligned} V(b,\beta,u) &= \max_{c,n,b'} \left\{ \frac{c^{(1-\sigma)}}{1-\sigma} - \chi \frac{n^{(1+\eta)}}{1+\eta} + \beta \mathbf{E}_{u'} V(b',\beta,u') \right\} \\ c + b' &= (1+r)b + (1-\tau_l)wnu + g + d \\ b' &\geq \underline{b} \end{aligned} \tag{4}$$

Firms A competitive final goods firm aggregates a continuum of intermediate goods indexed by j with a constant elasticity of substitution $\mu/(\mu-1) > 1$. Intermediate goods are produced by monopolistically competitive firms with a linear production function:

$$y_i = F(n_j) \equiv n_j$$

Each firm sets the price of its product p'_j subject to quadratic adjustment costs, with κ moderating the extent of price rigidity. As $\kappa \to \infty$, we approach flexible prices:

$$\psi(p', p) = \frac{\mu}{\mu-1}\frac{1}{2\kappa}[\log(p'/p)]^2 Y$$

The firm's value function is given by

$$V(p) = \max_{p'} \left\{ \frac{p'}{p}y - wy - \frac{\mu}{\mu-1}\frac{1}{2\kappa}[\log(p'/p]^2 Y + \mathbb{E}\left[\frac{V(p')}{1+r'}\right] \right\}$$
$$\text{s.t.} \qquad y = \left(\frac{p'}{p}\right)^{-\frac{\mu}{\mu-1}} Y$$

The first-order condition of the firm's problem plus the assumption that firms adopt symmetric pricing strategies give rise to a New Keynesian Phillips curve that relates aggregate output to price inflation:

$$\log(1+\pi) + \kappa\left(\frac{1}{\mu} - w\right) = \mathbb{E}\left[\frac{1}{1+r'}\frac{Y'}{Y}\log(1+\pi')\right]$$

Households receive dividends from the ownership of firms, and dividends equal output net of labor and price adjustment costs: $d = Y - wL - \psi$

Fiscal and Monetary Policies For simplicity, we assume that government debt is denominated in real terms. The government budget constraint is given by

$$\tau_l wN + B = (1+r)B_{-1} + G + g$$

In the case of balanced budget experiments, we assume that lump-sum transfers adjust to keep the real stock of debt constant. In the case of deficit-financed changes in spending, we assume that lump-sum transfers follow a simple fiscal rule of the type

$$g = g_{ss} + \phi_T \left(\frac{B_{-1}}{B_{ss}} - 1 \right) \tag{5}$$

The monetary authority sets the nominal interest following a standard Taylor rule:

$$i = r^* + \phi_\pi \pi$$

where r^* is the real interest rate target, π_t is the inflation rate, and ϕ_π is the inflation Taylor rule coefficient. For simplicity, we assume that the central bank's inflation target is zero (and so the nominal and real rate targets coincide).

6.2 Equilibrium

The equilibrium is defined in a manner that is similar to that of the neoclassical model. Given a distribution of agents Φ, a competitive equilibrium with symmetric price-setting choices can be summarized as follows:

1. Taking a sequence of factor prices and initial conditions as given, households maximize the value function $V(b, \beta, u)$ with the respective policy functions being given by $c(b, \beta, u)$, $n(b, \beta, u)$, and $b'(b, \beta, u)$.

2. Firms optimally choose sequences of prices, production, and employment.

3. Fiscal and monetary authorities follow fiscal and interest rate rules.

4. Markets clear:

$$B = \int b \mathrm{d}\Phi$$
$$N = \int n(b, \beta, u) u \mathrm{d}\Phi$$
$$Y = \int c(b, \beta, u) \mathrm{d}\Phi + G + \psi$$

6.3 *Calibration*

The calibration of the HANK model is kept as close as possible to that of the neoclassical model. There are two sets of parameters that we change: the first set is parameters unique to the New Keynesian model, and the second set is parameters that are recalibrated to match certain targets.

New Keynesian parameters The NK features of the HANK model add a few parameters that are not present in the neoclassical model. We use similar parameter values to those of Auclert et al. (2021b): the degree of price rigidity is set to $\kappa = 0.1$ and the elasticity of substitution between varieties is set to target a steady state markup of 20%, $\mu = 1.2$. The central bank's sensitivity to deviations of inflation from its target is set to $\phi_\pi = 1.25$.

Internally calibrated parameters We internally recalibrate a series of parameters in order to match some of the same targets we consider in the neoclassical model at the stationary equilibrium: the discount factors $\{\beta_1, \beta_2, \beta_3\}$, the borrowing limit b, the disutility of labor χ, and the variance of the idiosyncratic component of log earnings σ_ϵ. These parameters are calibrated to match the three quartiles of the wealth distribution, the level of the real interest rate, the aggregate fraction of hours worked, and the annual variance of log wages. Table 8 summarizes the values for the endogenously calibrated parameters, and table 9 presents the model fit.

Parameter	Value	Description
$\beta_1, \beta_2, \beta_3$	0.9798, 0.9800, 0.9798	Discount factors
$\underline{b}$	0.163	Borrowing limit
σ_e	0.340	Cross-sectional std of log earnings
χ	12.463	Disutility of labor

Table 8: Internally calibrated parameters, HANK model

Data moment	Description	Source	Data	Model
$\text{Var}(\ln w)$	Yearly variance of log wages	LIS	0.509	0.509
$\bar{n}$	Fraction of hours worked	OECD	0.248	0.248
Q_{25}, Q_{50}, Q_{75}	Wealth quartiles	LWS	-0.014, 0.004, 0.120	-0.013, 0.004, 0.238
r	Real interest rate	Neoclassical model	0.0115	0.0115

Table 9: Model fit, HANK model

6.4 *Quantitative Results*

In this section, we repeat the main fiscal experiments that we conducted in the neoclassical model, and show that they, along with the core mechanism, are robust to the introduction of nominal rigidities.

Balanced Budget We assume again that government spending follows an AR(1) in logs, and consider a range of values for ϵ_t^G that correspond to changes from -10% to 10% of steady-state government spending on impact. Figure 11 plots the fiscal multipliers for the case where the government runs a balanced budget and adjusts lump-sum transfers so as to keep the level of debt constant. As expected, the HANK model generates larger multipliers than the neoclassical model. Additionally, the HANK model generates a larger nonlinearity, with the multipliers ranging from 0.60 to 0.68 in this experiment. Most importantly, the HANK model preserves the same pattern for the nonlinearity, with the multiplier increasing in the size of the government spending shock.

To confirm that this nonlinearity is driven by a similar mechanism, Figure 12 plots labor supply responses as a function of wealth for spending shocks of different sizes. As before, constrained agents at the bottom of the wealth distribution expand their labor supply response by more in response to positive spending shocks, i.e. a decrease in lump-sum transfers. Figure 13 shows that, just as in the neoclassical model, an increase

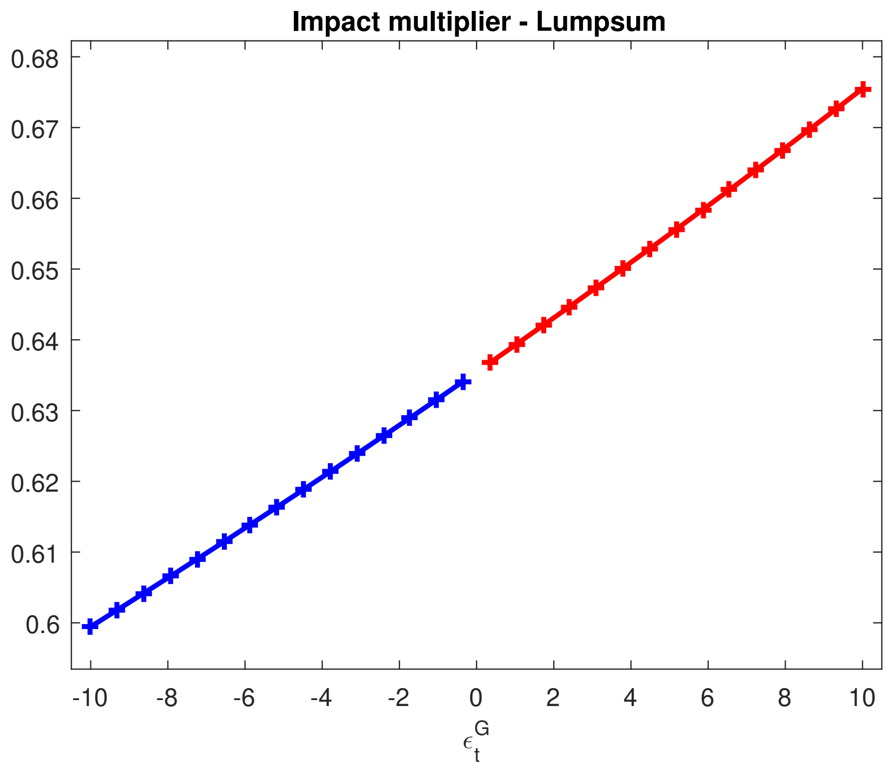

Figure 11: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ϵ_t^G (the initial impulse), for the balanced budget experiment.

in government spending is associated with more constrained agents. These two facts combined explain the nonlinearity, as a fiscal contraction reduces the mass of agents that are most responsive to the shock, while a fiscal expansion increases the mass of agents that are most responsive. A natural question is whether our result could be overturned by sufficiently strong aggregate demand externalities: a fiscal expansion leads to a reduction in transfers, which in turn reduces consumption and potentially moderates the increase in output. Our results show that, quantitatively, the neoclassical labor supply effect dominates given our calibration.

Deficit Financing Figure 14 presents the fiscal multiplier as a function of the shock for the case where the government lets debt clear its budget constraint and sets lump-sum transfers according to the fiscal rule in 5. As expected, deficit financing leads to larger multipliers in the HANK model, as well as to more variability, with multipliers ranging

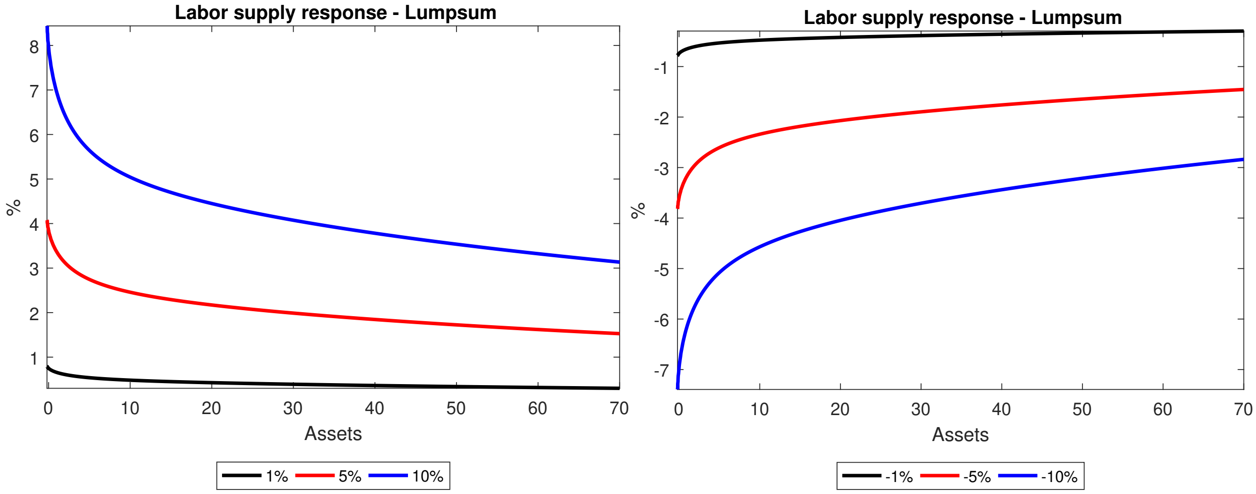

Figure 12: : (Relative) labor supply response to different changes in G over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

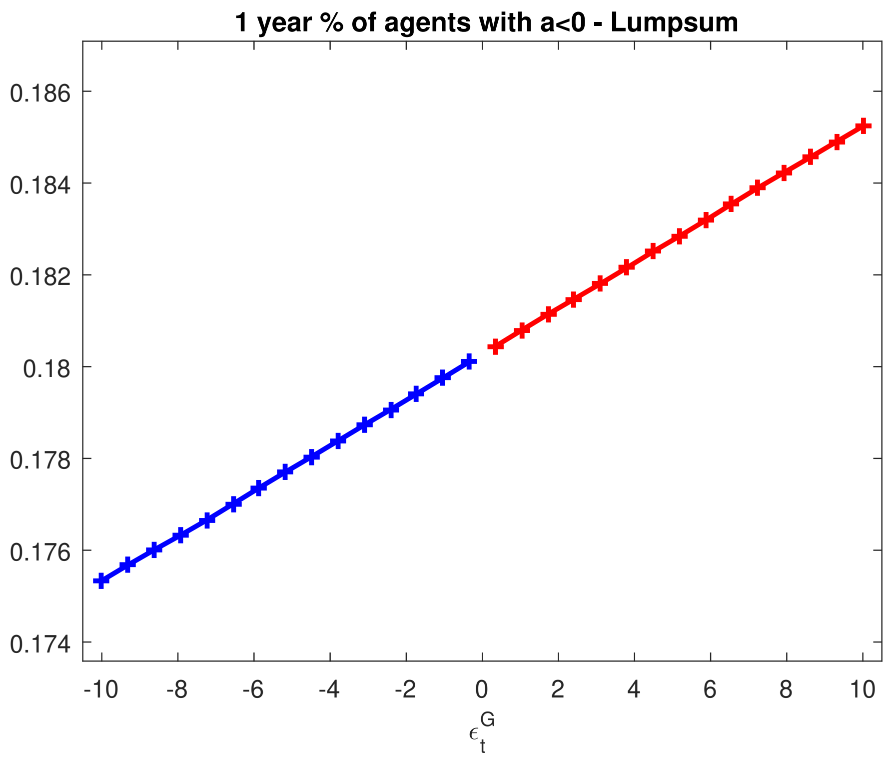

Figure 13: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ϵ_t^G (the initial impulse), for the balanced budget experiment.

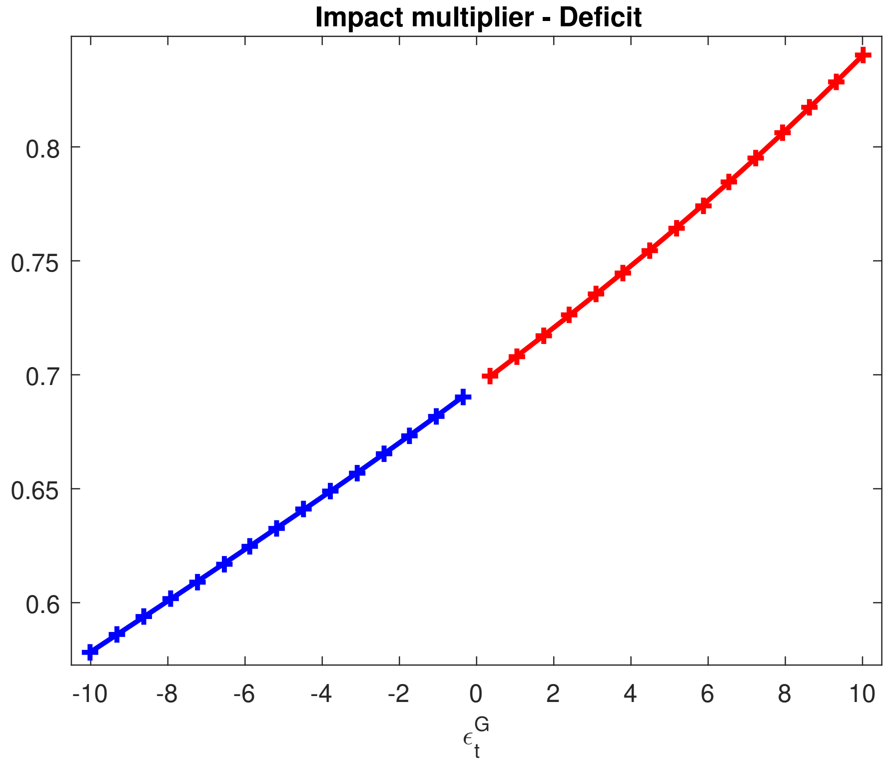

Figure 14: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ϵ_t^G (the initial impulse), for the balanced budget experiment.

between 0.58 and 0.84.

Figure 15 plots the labor supply responses by wealth and magnitude of the spending shock. Once again, the HANK model is able to replicate the same pattern as in the neoclassical model, with constrained the labor supply of constrained agents reacting by relatively less, and the mass of agents at the constraint decreasing in the size of the shock as shown in Figure 16.

7 Micro Evidence for the Mechanism

The mechanism we propose hinges on three key factors: (i) the elasticity of intertemporal substitution is increasing in wealth, (ii) there is a shift in the wealth distribution, and (iii) the financing regime for the fiscal shock. Intuitively, we propose that a positive tax-financed shock shifts the wealth distribution to the left. This, along with the fact that

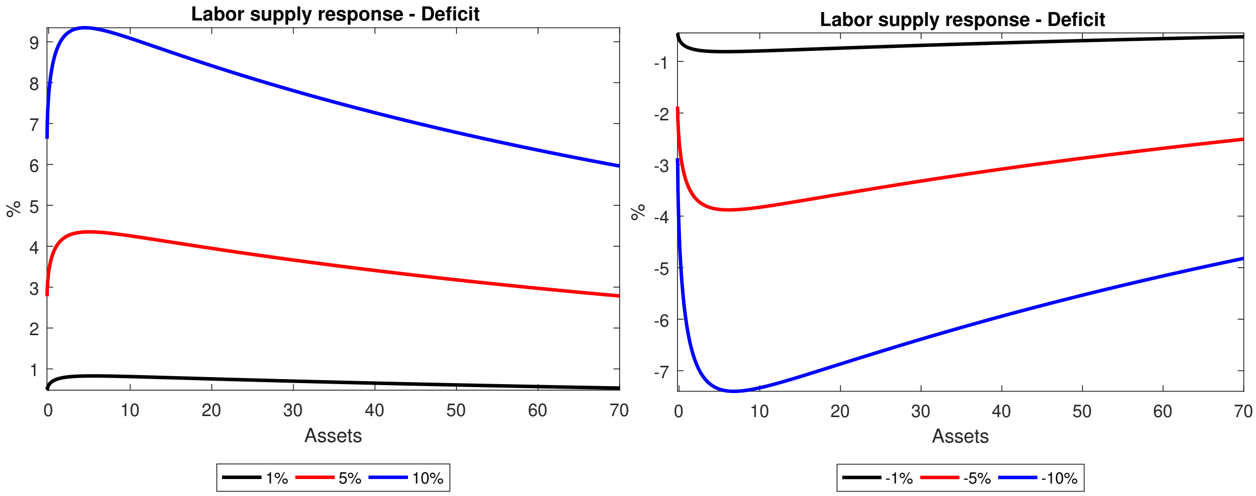

Figure 15: : (Relative) labor supply response to different changes in G over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

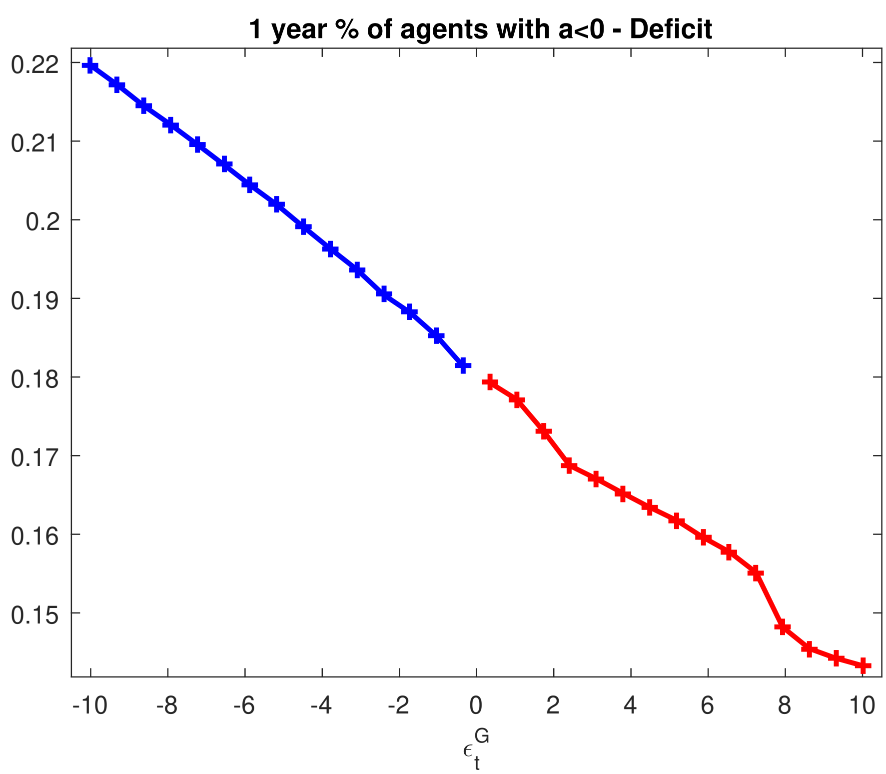

Figure 16: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ϵ_t^G (the initial impulse), for the balanced budget experiment.

the labor supply response to a current income shock is decreasing in wealth, generates a fiscal multiplier that is increasing in the shock. A positive debt-financed shock, on the other hand, shifts the distribution to the right, which combined with a labor supply response to a future income shock that is increasing in wealth, again leads to a fiscal multiplier that is increasing in the shock. Large positive shocks would have the largest multiplier and large negative shocks the smallest.

A number of papers have documented that the EIS is increasing in wealth, see Vissing-Jørgensen (2002) for example for the relationship between wealth and the EIS of consumption and, most notably in our context, Domeij and Floden (2006) for the relationship between wealth and the EIS of labor. Brinca et al. (2021) show that wealthier agents respond more to fiscal consolidation shocks. We here proceed to test for the dependence of the labor supply responses to fiscal shocks on wealth and whether they at all depend on the implied financing regime for the fiscal shocks. To do so we combine micro data from the PSID (1999-2015), which contains bi-annual data on wealth and hours worked, with the data on government spending shocks from Ramey and Zubairy (2018), which we use in Section 2.2.

We identify fiscal shocks as in Section 2.2 (using quarterly data) and then sum these shocks over a 2-year period, which coincides with the interval between wealth-data collection in the PSID.

Table (10) provides an overview of the dataset constructed. We report the aggregate statistics for the sum of the fiscal shock over a two year span, $\sum_{i=0}^{1} G_{t-i}$, and the

Table 10: Descriptive Statistics

	p25	p50	p75	sd
$\Delta \ln h_t$	-0.13	0.00	0.10	(1.96)
ΔB_t	-0.17	1.05	2.39	(4.42)
$\sum_{i=0}^{1} G_{t-i}$	-2.16	0.52	2.00	(4.98)
Net wealth$_t$	2,019	36,000	152,680	(512,553)

Table 11: *G* shock, labor supply response, total wealth, and financing regime

VARIABLES	(1) Total wealth <0	(2) Total wealth >0	(3) Total wealth < Wealth Q1	(4) Total wealth < Wealth Q2	(5) Total wealth > Wealth Q2	(6) Total wealth > Wealth Q3
β_1	1.060**	0.047	0.257**	0.095*	0.070*	0.058
	(0.477)	(0.037)	(0.109)	(0.058)	(0.040)	(0.047)
β_2	6.355**	0.750**	1.580*	1.035*	0.533	0.269
	(2.603)	(0.349)	(0.883)	(0.533)	(0.361)	(0.399)
β_3	-0.315**	-0.037**	-0.080*	-0.052**	-0.027	-0.014
	(0.129)	(0.017)	(0.043)	(0.026)	(0.017)	(0.019)
Observations	7,075	61,980	14,911	33,230	40,821	20,688
Number of ID	2,308	11,390	4,232	8,179	7,437	3,871

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

variations in debt from t-1 to t as percentage of GDP, ΔB_t, as well as statistics for the microdata on the change in hours worked, $\Delta \ln h_t$, and on net wealth, defined as the net value of all assets. We consider a household to be wealthy if it is in the top quartile of the distribution of net wealth. The median change in hours worked is zero, with the top quartile having increases above 10% and the bottom one decreases above 13%. Our sample includes wide variation in government debt, with a median change of 1% and a standard deviation above 4, which provides a good environment to test how different financing regimes affect the response of hours worked to fiscal shocks. To test this, we estimate the following equation:

$$\Delta \ln h_{it} = \beta_1 G_t + \beta_2 \Delta B_t + \beta_3 \Delta B_t \times G_t + \alpha_i + \epsilon_{it}$$

where ΔB_t is the change in government debt as a percentage of GDP, which we take as a proxy for whether fiscal shocks are deficit or tax financed.

The results for this specification are in Table 11 and are consistent with the predictions from our model. The marginal effect of a fiscal shock is given by $\beta_1 + \beta_3 \times \Delta B_t$. A balanced-budget fiscal shock has a marginal effect equal to β_1: our model predicts that this effect should be positive and larger for households at the bottom of the wealth distribution. The neoclassical version of our model also predicts that deficit-financed fiscal shocks generate smaller multipliers than balanced-budget ones, an effect that is consistent with $\beta_3 < 0$. Since wealthier households respond relatively more to deficit-financed fiscal shocks, this coefficient should be increasing in the wealth quantile (decreasing in absolute value, since it is negative). As the results in Table 11 show, all these predictions are borne by the data and for different sample splits. Appendix F shows that these results are robust to: (i) different splits of the sample by net wealth, (ii) using liquid wealth as opposed to wealth, which is defined as net wealth minus real estate assets, (iii) controlling for wages, and (iv) pooling all households in a single regression, and interacting the fiscal shock and debt terms with household wealth levels. The results for these robustness checks can be found in Tables 24- 27.

8 Conclusion

In this paper, we contribute to the analysis of the aggregate effects of government spending shocks by empirically documenting that fiscal multipliers are increasing in the size of the shock, contrary to what is commonly assumed in the literature. We show that the standard incomplete markets model can reproduce this fact, generating a multiplier that is nonlinear in the spending shock. Large negative shocks yield smaller multipliers, and large positive shocks yield larger multipliers. This holds both for debt-financed and balanced-budget-financed shocks.

We have shown that the response of labor supply across the wealth distribution, along with the response of this very same distribution, are crucial in generating this pattern of multipliers that are increasing in the shock. The EIS is increasing in wealth, which implies that low-wealth agents respond more to current income shocks and less to future income shocks. A positive tax-financed shock shifts the wealth distribution to the left. This, along with the fact that the labor supply response to a current income shock is decreasing in wealth, generates a fiscal multiplier that is increasing in the shock.

A positive debt-financed shock, on the other hand, shifts the wealth distribution to the right, which combined with a labor supply response to a future income shock that is increasing in wealth, leads again to a fiscal multiplier that is increasing in the shock. Using micro-data from the PSID, we validate the relationship between wealth, labor supply responses and fiscal shocks.

Recent events such as the Covid-19 crisis have led to large fiscal programs that will likely require some type of consolidation in the future. We believe our work is important to understand how the effects of these consolidation programs vary with their size.

We see this paper as a first step to understanding how the size of fiscal shocks can have different aggregate implications depending on the distributional features of the economy. The nonlinear effects we uncover in the benchmark model are quantitatively small: it is well-known that neoclassical incomplete market heterogeneous agent models generate fiscal multipliers that are smaller than those in the data. Adding nominal rigidities has the potential to raise not just the value of the multipliers but also the magnitude of the nonlinearities. Extending the model along other dimensions could further amplify these nonlinearities: for example, if wealthier consumers could be borrowing constrained as in Kaplan and Violante (2014). This would allow for larger masses of agents to be shifted to and from the constraint. Furthermore, in this paper we focused essentially on the role of heterogeneous marginal propensities to work in the transmission of fiscal policies. We leave for future research a more detailed investigation on how the joint distribution between marginal propensities to work and consume can affect the sign and size dependence of fiscal policy shocks.

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A Additional Empirical Evidence

A.1 IMF Shocks

$$\Delta y_{i,t} = \alpha_i + \sum_{i=0}^{3} \beta_{1,t-i} e^u_{i,t-i} + \sum_{i=0}^{3} \beta_{2,t-i} (e^u_{i,t-i})^2 + \sum_{i=0}^{3} \beta_{3,t-i} e^a_{i,t-i} + \sum_{i=0}^{3} \beta_{4,t-i} (e^a_{i,t-i})^2 + \alpha_i + \gamma_t + \epsilon_{it} \tag{6}$$

Table 12: Nonlinear effects of fiscal unanticipated and announced consolidation shocks, including three lags of each shock.

	β_1	β_2	β_3	β_4
t	-0.645***	0.186***	-0.109	-0.051
	(0.164)	(0.042)	(0.232)	(0.083)
$t-1$	-1.176***	0.163***	-0.561**	0.193
	(0.183)	(0.043)	(0.237)	(0.122)
$t-2$	-0.240	0.102**	0.257	-0.092
	(0.183)	(0.043)	(0.225)	(0.149)
$t-3$	-0.803***	0.255***	-0.122	-0.152
	(0.189)	(0.054)	(0.220)	(0.168)
Observations		510		
Number of countries		15		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

$$\begin{aligned}\Delta y_{i,t} =& \alpha_i + \sum_{i=0}^{3} \beta_{1,t-i} e^u_{i,t-i} + \sum_{i=0}^{3} \beta_{2,t-i} (e^u_{i,t-i})^2 + \sum_{i=0}^{3} \beta_{3,t-i} e^a_{i,t-i} \\ &+ \sum_{i=0}^{3} \beta_{4,t-i} (e^a_{i,t-i})^2 + \sum_{i=1}^{3} \delta_i e^a_{i,t+i,0} + \alpha_i + \gamma_t + \epsilon_{it}\end{aligned} \tag{7}$$

Table 13: Non-linear effects of fiscal unanticipated and announced consolidation shocks, including three lags of each shock and controlling for announced shocks at t that will be implemented over the next three years.

	β_1	β_2	β_3	β_4
t	-0.473***	0.148***	-0.130	-0.087
	(0.156)	(0.041)	(0.221)	(0.084)
$t-1$	-0.848***	0.126***	-0.306	0.158
	(0.159)	(0.042)	(0.233)	(0.117)
$t-2$	-0.347**	0.151***	0.284	-0.134
	(0.160)	(0.042)	(0.227)	(0.137)
$t-3$	-0.631***	0.189***	-0.234	-0.083
	(0.172)	(0.054)	(0.222)	(0.152)
Observations		510		
Number of countries		15		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

$$\Delta y_{i,t} = \sum_{i=0}^{3} \beta_{1,t-i} e^u_{i,t} + \sum_{i=0}^{3} \beta_{2,t-i} (e^u_{i,t})^2 + \sum_{i=0}^{3} \beta_{3,t-i} e^a_{i,t} + \sum_{i=0}^{3} \beta_{4,t-i} (e^a_{i,t})^2 + \sum_{i=0}^{3} \beta_{5,t-i} r^u_{i,t}$$
$$+ \sum_{i=0}^{3} \beta_{6,t-i} (r^u_{i,t})^2 + \sum_{i=0}^{3} \beta_{7,t-i} r^a_{i,t} + \sum_{i=0}^{3} \beta_{8,t-i} (r^a_{i,t})^2 + \sum_{i=1}^{3} \delta_i e^a_{i,t+i,0} + \alpha_i + \gamma_t + \epsilon_{it} \quad (8)$$

Table 14: Non-linear effects of fiscal unanticipated expenditure and revenue consolidation shocks, including three lags of each shock.

	β_1	β_2	β_5	β_6
t	-0.669*	0.178	-1.484***	0.731***
	(0.354)	(0.211)	(0.342)	(0.163)
$t-1$	-1.146***	0.452**	-1.592***	0.417**
	(0.365)	(0.212)	(0.339)	(0.172)
$t-2$	-0.081	0.204	1.022***	0.317*
	(0.355)	(0.204)	(0.321)	(0.177)
$t-3$	-1.600***	0.651***	-1.127***	0.626***
	(0.362)	(0.218)	(0.327)	(0.186)
Observations		510		
Number of countries		15		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A.1.1 1991-2014 period including Germany

Table 15: Non-linear effects of fiscal consolidation shocks.

VARIABLES	(1) Benchmark
β_1	-0.593***
	(0.106)
β_2	0.202***
	(0.033)
Observations	510
Number of countries	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 16: Non-linear effects of fiscal unanticipated and announced consolidation shocks.

Variables	Benchmark
β_1	-0.302**
	(0.125)
β_2	0.141***
	(0.031)
β_3	-0.163
	(0.126)
β_4	-0.017
	(0.052)
Observations	510
Number of country1	15

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 17: Non-linear effects of fiscal unanticipated expenditure and revenue consolidation shocks, including three lags of each shock.

	β_1	β_2	β_5	β_6
t	-0.177	-0.210	-1.347***	0.748***
	(0.183)	(0.128)	(0.190)	(0.094)
$t-1$	-1.203***	0.655***	-0.341	0.209
	(0.198)	(0.139)	(0.225)	(0.146)
$t-2$	-0.911***	0.024	-0.579***	0.911***
	(0.219)	(0.156)	(0.203)	(0.138)
$t-3$	-1.707***	0.875***	-0.043	0.356**
	(0.224)	(0.146)	(0.200)	(0.152)
Observations	510			
Number of countries	15			

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A.2 US Historical data

Table 18: Linear and quadratic coefficients for impact, 1, 2, 3 and 4-year horizons. The specification includes only Blanchard-Perotti (BP) shocks. Standard errors in parentheses.

	Linear	Quadratic
Impact	-2.180	3.542
	(0.840)	(0.849)
1-year	-6.050	3.055
	(1.582)	(0.700)
2-years	-10.648	2.850
	(2.720)	(0.690)
3-years	-14.094	2.612
	(1.511)	(0.283)
4-years	-17.506	2.481
	(4.346)	(0.588)
Observations	255	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 19: Linear and quadratic coefficients for impact, 1, 2, 3 and 4-year horizons. The specification includes only news shocks. Standard errors in parentheses.

	Linear	Quadratic
Impact	-8.855	10.368
	(8.928)	(11.074)
1-year	-19.045	8.470
	(14.323)	(6.197)
2-years	-55.049	13.503
	(51.781)	(12.259)
3-years	-85.377	14.358
	(94.499)	(15.425)
4-years	-252.852	32.966
	(758.902)	(97.868)
Observations	255	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 20: Linear and quadratic coefficients for impact, 1, 2, 3 and 4-year horizons. The specification includes both Blanchard-Perotti (BP) shocks and news shocks with no quadratic time. Standard errors in parentheses.

	Linear	Quadratic
Impact	-1.506	2.797
	(0.640)	(0.570)
1-year	-4.555	2.403
	(1.232)	(0.558)
2-years	-8.775	2.385
	(1.951)	(0.498)
3-years	-12.265	2.278
	(2.534)	(0.442)
4-years	-16.051	2.270
	(3.542)	(0.480)
Observations	255	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 21: Linear and quadratic coefficients for impact, 1, 2, 3 and 4-year horizons. The specification includes both Blanchard-Perotti (BP) shocks and news shocks and 8 lags of the control variables. Standard errors in parentheses.

	Linear	Quadratic
Impact	-2.059	3.401
	(0.914)	(0.971)
1-year	-5.846	2.941
	(1.726)	(0.779)
2-years	-9.659	2.570
	(2.433)	(0.639)
3-years	-11.838	2.166
	(3.288)	(0.585)
4-years	-14.753	2.080
	(4.112)	(0.560)
Observations	251	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

B Definition of a Transition Equilibrium During the Fiscal Experiments

We define the recursive competitive transition equilibrium as follows. For a given level of initial capital stock, initial distribution of households, and initial debt, respectively, K_0, Φ_0, and B_0, a competitive equilibrium is a sequence of individual functions for the household, $\{V_t, c_t, k_t', n_t\}_{t=1}^{t=\infty}$; production plans for the firm, $\{K_t, L_t\}_{t=1}^{t=\infty}$; factor prices, $\{r_t, w_t\}_{t=1}^{t=\infty}$; government transfers, $\{g_t, G_t\}_{t=1}^{t=\infty}$; government debt, $\{B_t\}_{t=1}^{t=\infty}$; and measures $\{\Phi_t\}_{t=1}^{t=\infty}$ such that the following hold for all t:

1. For given factor prices and initial conditions, the value functions $V_t(k, \beta, a, u)$ and the policy functions, $c_t(k, \beta, a, u)$, $k_t'(k, \beta, a, u)$, and $n_t(k, \beta, a, u)$ solve the consumers' optimization problem.

2. Markets clear:

$$K_{t+1} + B_t = \int k_t d\Phi_t$$

$$L_t = \int (n_t(k_t, \beta, a, u))\, d\Phi_t$$

$$\int c_t d\Phi_t + K_{t+1} + G_t = (1-\delta)K_t + K^\alpha L^{1-\alpha}.$$

3. The factor prices are paid their marginal productivity:

$$\begin{aligned} w_t &= (1-\alpha)\left(\frac{K_t}{L_t}\right)^\alpha \\ r_t &= \alpha\left(\frac{K_t}{L_t}\right)^{\alpha-1} - \delta \end{aligned}$$

4. The government budget balances:

$$g_t \int \mathrm{d}\Phi_t + G_t + rB_t = \int \left[\tau_k r_t k_t + \tau_c c_t + n_t w_t\,(a,u)\,(1-\tau_l\,(n_t w_t\,(a,u)))\right] \mathrm{d}\Phi_t.$$

5. The distribution follows an aggregate law of motion:

$$\Phi_{t+1} = \Upsilon_t(\Phi_t)$$

C Richer Tax Structure

Government

Government revenues include flat-rate taxes on consumption, τ_c, and capital income, τ_k. To model the nonlinear labor income tax, we use the functional form proposed in Benabou (2002) and recently used in Heathcote et al. (2017) and Holter et al. (2019):

$$\tau(y) = 1 - \theta_0 y^{-\theta_1} \tag{9}$$

where θ_0 and θ_1 define the level and progressivity of the tax schedule, respectively; y is the pre-tax labor income; and $y_a = [1 - \tau(y)]y$ is the after-tax labor income.

Tax revenues from consumption, capital, and labor income are used to finance public consumption of goods, G_t; interest expenses on public debt, rB_t; and lump-sum transfers to households, g_t. Denoting tax revenues as R and the measure of households by $\Phi(k, \beta, a, u)$, the government budget constraint is defined as:

$$\int g d\Phi + G + rB = R \tag{10}$$

Recursive Formulation of the Household Problem

In a given period, a household is defined by its asset position k, time discount factor β, permanent ability a, and persistent idiosyncratic productivity u. Given this set of states, household chooses consumption, c; work hours, n; and future asset holdings, k', to maximize the present discounted value of expected utility. The problem can be written recursively as

$$V(k,\beta,a,u) = \max_{c,k',n} \left[U(c,n) + \beta \mathbb{E}_{u'} \left[V(k',\beta,a,u') \right] \right]$$

$$\text{s.t.:}$$

$$c(1+\tau_c) + k' = k\left(1 + r(1-\tau_k)\right) + g + nw(a,u)\left(1 - \tau_l\left(nw(a,u)\right)\right)$$

$$n \in [0,1], \quad k' \geq -b, \quad c > 0 \tag{11}$$

where b is an exogenous borrowing limit.

Stationary Recursive Competitive Equilibrium

Let the measure of households with the corresponding characteristics be given by $\Phi(k,\beta,a,u)$. Then, we can define a stationary recursive competitive equilibrium (SRCE) as follows:

1. Taking the factor prices and the initial conditions as given, the value function $V(k,\beta,a,u,)$ and policy functions $c(k,\beta,a,u)$, $k'(k,\beta,a,u)$, $n(k,\beta,a,u)$ solve the households' optimization problems.

2. Markets clear:

$$K + B = \int k \mathrm{d}\Phi$$

$$L = \int n(k,\beta,a,u) \mathrm{d}\Phi$$

$$\int c \mathrm{d}\Phi + \delta K + G = K^{\alpha} L^{1-\alpha}.$$

3. Factor prices are paid their marginal productivity:

$$w = (1-\alpha)\left(\frac{K}{L}\right)^{\alpha}$$

$$r = \alpha \left(\frac{K}{L}\right)^{\alpha-1} - \delta.$$

4. The government budget balances:

$$g \int \mathrm{d}\Phi + G + rB = \int \left[\tau_k rk + \tau_c c + nw\left(a,u\right)\left(1 - \tau_l\left(nw\left(a,u\right)\right)\right)\right] \mathrm{d}\Phi.$$

Calibration

Taxes and Government Spending

We use the labor income tax function of Benabou (2002) to capture the progressivity of both the tax schedule and direct government transfers. We use the estimate of Holter et al. (2019), who estimate the parameter θ_1 for the US.[14] Consumption and capital tax rates are set to 5% and 36%, respectively, as in Trabandt and Uhlig (2011). Finally, following Hagedorn et al. (2019), we set transfers, g, to be 7% of GDP and government spending, G, to be 15% of GDP. θ_0 is then set so that total tax revenues clear the government budget.

Parameters Calibrated Endogenously

Some parameters that do not have any direct empirical counterparts are calibrated using the SMM. These are the discount factors, borrowing limit, disutility from working, and variance of permanent ability. The SMM is set so that it minimizes the following loss function:

$$L(\beta_1, \beta_2, \beta_3, b, \chi, \sigma_a) = ||M_m - M_d|| \tag{12}$$

where M_m and M_d are the moments in the model and in the data, respectively.

We use six data moments to choose six parameters, so the system is exactly identified. The six moments we select in the data are (i) the share of hours worked, (ii-iv) the three quartiles of the wealth distribution, (v) the variance of log wages, and (vi) the capital-to-output ratio. Table 23 presents the calibrated parameters, and Table 22 presents the calibration fit.

[14] They use OECD data on labor income taxes to estimate the function for different family types. They then weight the value of the parameter by the weight of each family type in the overall population to get an aggregate measures of tax progressivity.

Table 22: Calibration Fit

Data moment	Description	Source	Data value	Model value
K/Y	Capital-to-output ratio	PWT	12.292	12.292
$\mathrm{Var}(\ln w)$	Yearly variance of log wages	LIS	0.509	0.509
$\bar{n}$	Fraction of hours worked	OECD	0.248	0.248
Q_{25}, Q_{50}, Q_{75}	Wealth quartiles	LWS	-0.014, 0.004, 0.120	-0.018, 0.003, 0.121

Table 23: Parameters Calibrated Endogenously

Parameter	Value	Description
Preferences		
$\beta_1, \beta_2, \beta_3$	0.991, 0.993, 0.992	Discount factors
χ	11.1	Disutility of work
Technology		
b	1.99	Borrowing limit
σ_a	0.712	Variance of ability

Permanent Debt Consolidations

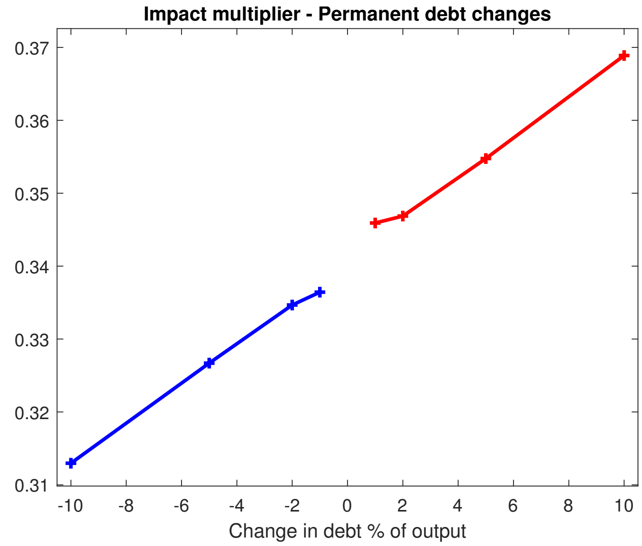

Figure 17: This figure plots the fiscal multiplier on impact (one quarter after the shock) for the permanent change in debt experiment as a function of the size of the variation in G (as a % of GDP). The blue line corresponds to G contractions, while the red line represents G expansions.

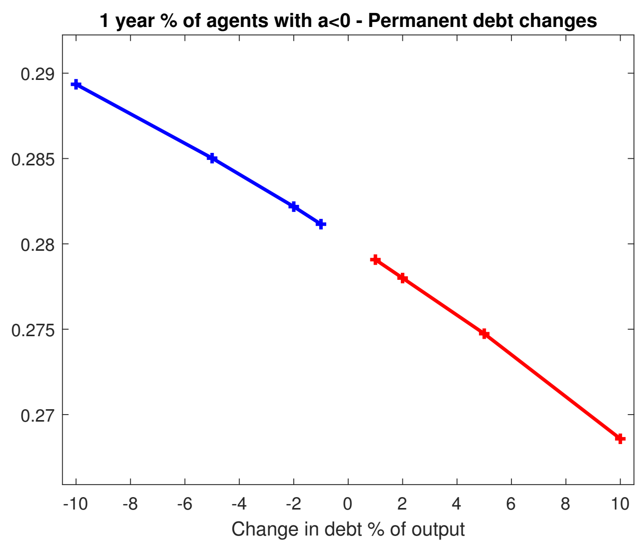

Figure 18: This figure plots the percentage of agents with negative wealth (one year after the shock) for the permanent change in debt experiment as a function of the size of the variation in G (as a % of GDP). The blue line corresponds to G contractions, while the red line represents G expansions.

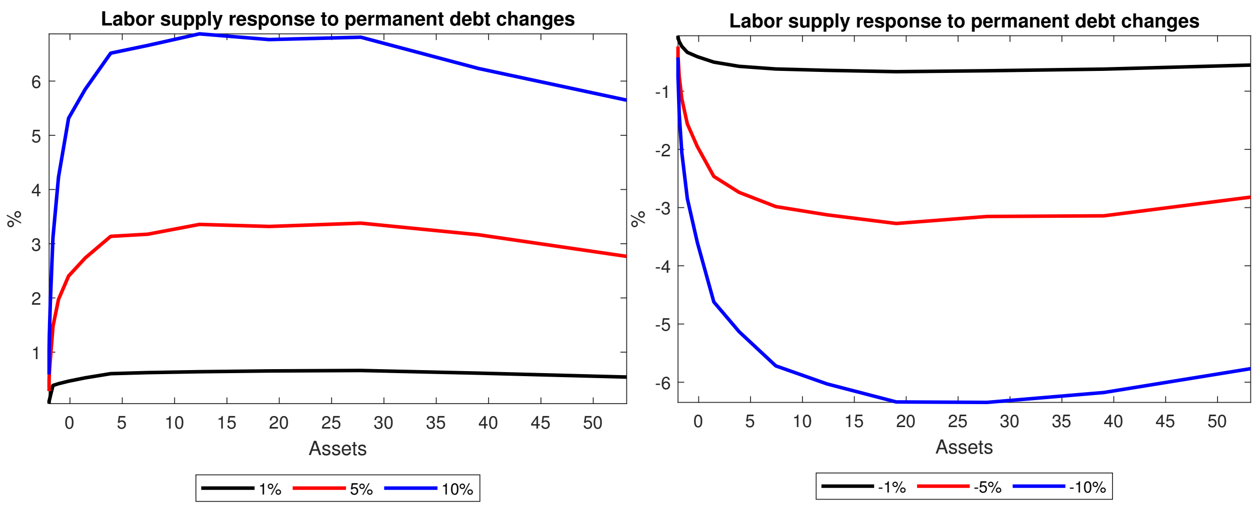

Figure 19: (Relative) labor supply response to different changes in G over the asset distribution, for the permanent change in debt experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

Deficit financing

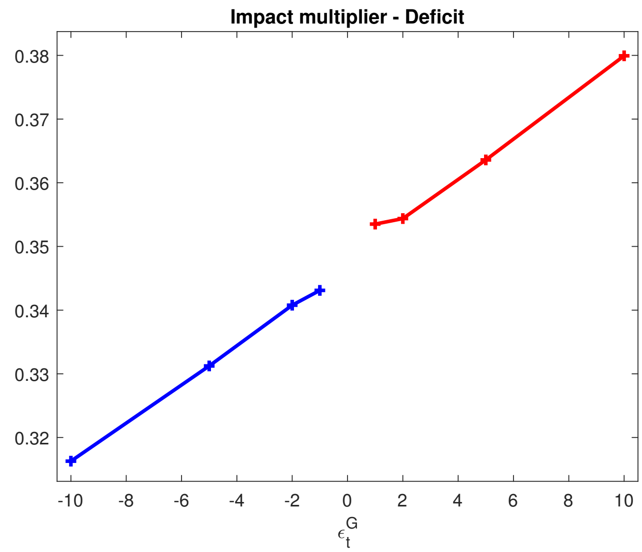

Figure 20: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ε_t^G (the initial impulse), for the deficit financing experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

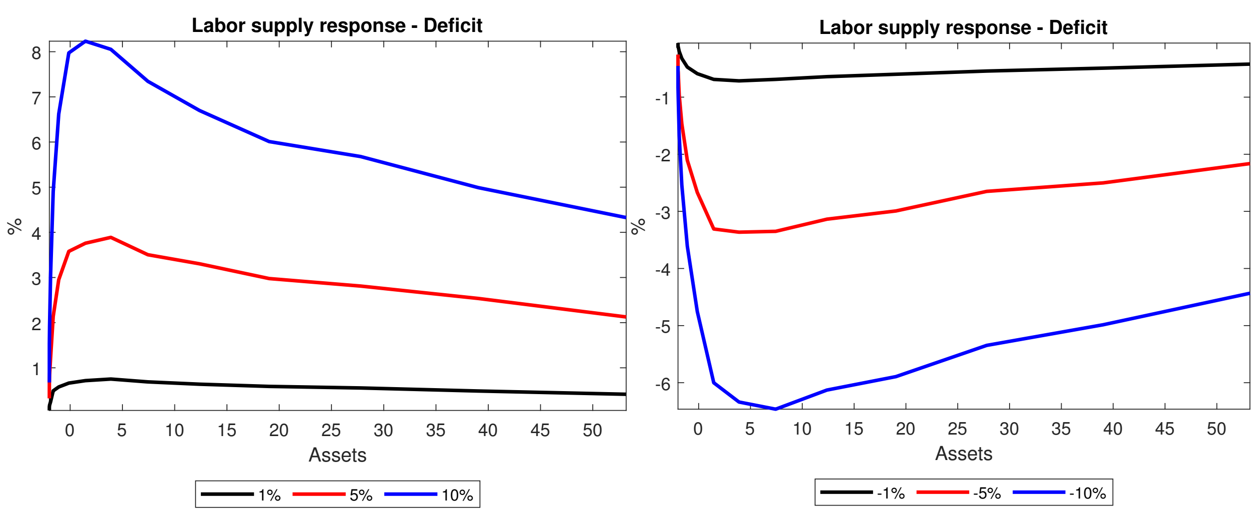

Figure 21: (Relative) labor supply response to different changes in G over the asset distribution, for the deficit financing experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

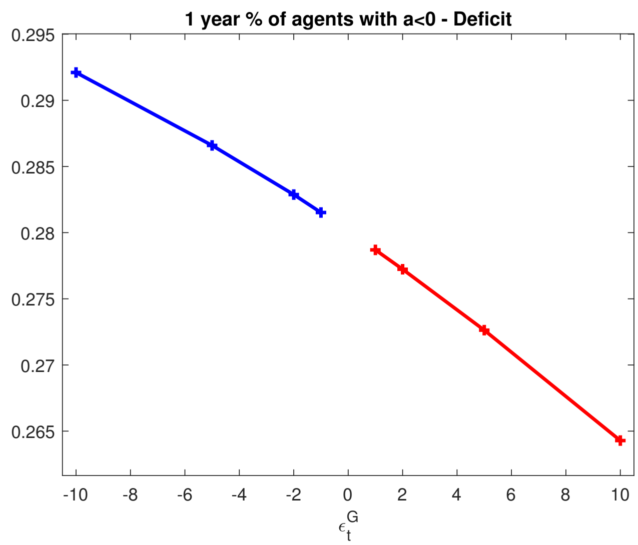

Figure 22: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ε_t^G (the initial impulse), for the deficit financing experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

Balanced budget

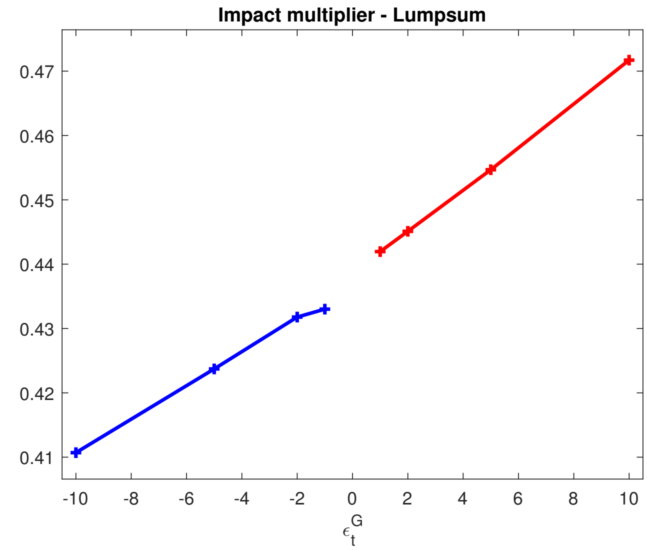

Figure 23: This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of ε_t^G (the initial impulse), for the balanced budget experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

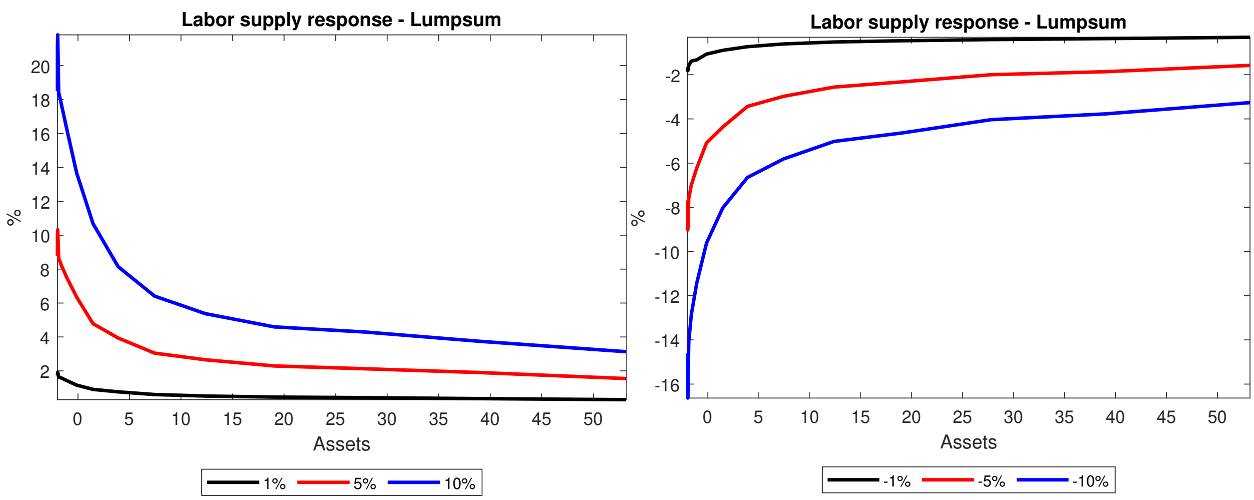

Figure 24: (Relative) labor supply response to different changes in G over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

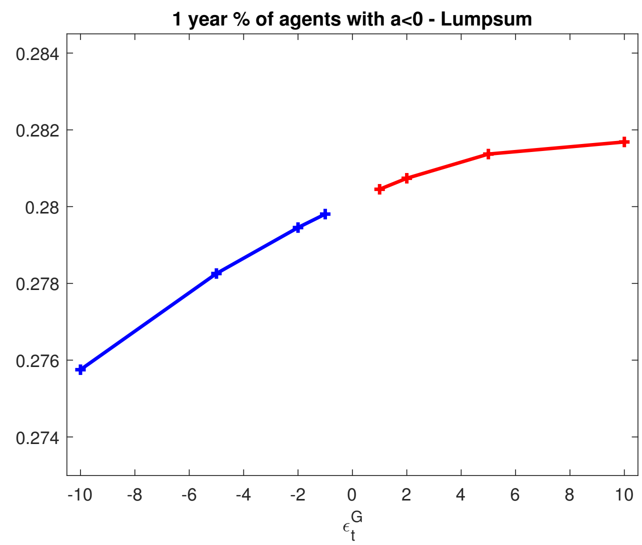

Figure 25: This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of ε_t^G (the initial impulse), for the balanced budget experiment. The blue line corresponds to G contractions, while the red line represents G expansions.

D Parameters Calibrated Outside of the Model

Parameter	Value	Description	Source
Preferences			
η	1	Inverse Frisch elasticity	Trabandt and Uhlig (2011)
σ	1.2	Risk aversion parameter	Consistent w. literature
Technology			
α	0.33	Capital share of output	Consistent w. literature
δ	0.015	Capital depreciation rate	Consistent w. literature
ρ	0.761	$u' = \rho u + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon^2)$	PSID 1968-1997
σ_ϵ	0.211	Variance of risk	PSID 1968-1997
Taxes			
θ_0	0.788	Income tax level	Holter et al. (2019)
θ_1	0.137	Income tax progressivity	Holter et al. (2019)
τ_c	0.047	Consumption tax	Trabandt and Uhlig (2011)
τ_k	0.364	Capital tax	Trabandt and Uhlig (2011)
Macro ratios			
B/Y	1.714	Debt-to-GDP ratio	U.S. Data
G/Y	0.15	Government spending-to-GDP ratio	Budget balance
g/Y	0.07	Transfers-to-GDP ratio	Hagedorn et al. (2019)

E Distribution

Permanent Shock: Permanent changes in debt

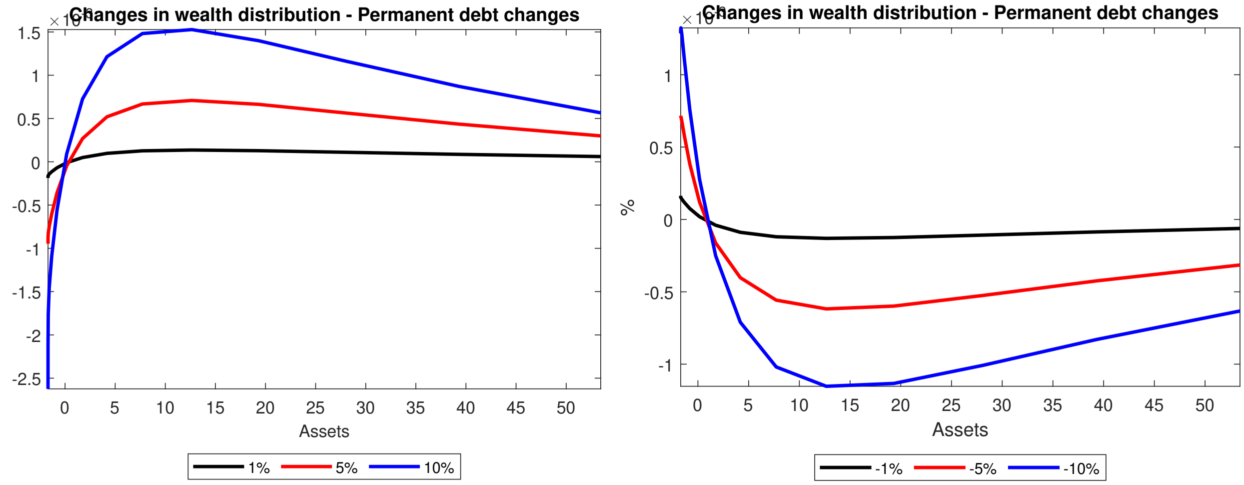

Figure 26: Changes in the distribution in response to a permanent change in G.

Temporary Shock: Deficit Financing

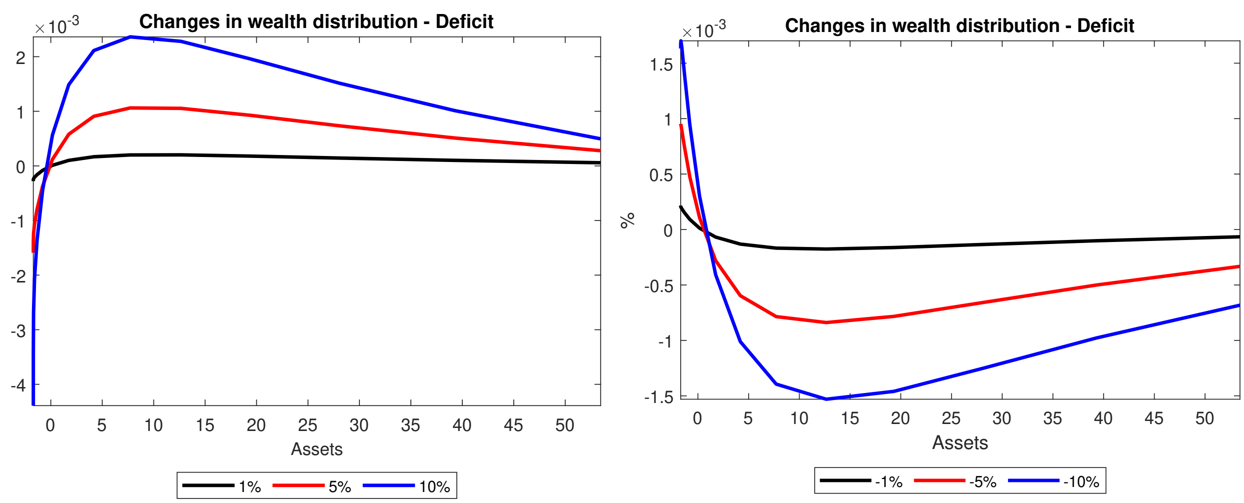

Figure 27: Changes in the distribution in response to a permanent change in G.

Temporary Shock: Balanced Budget

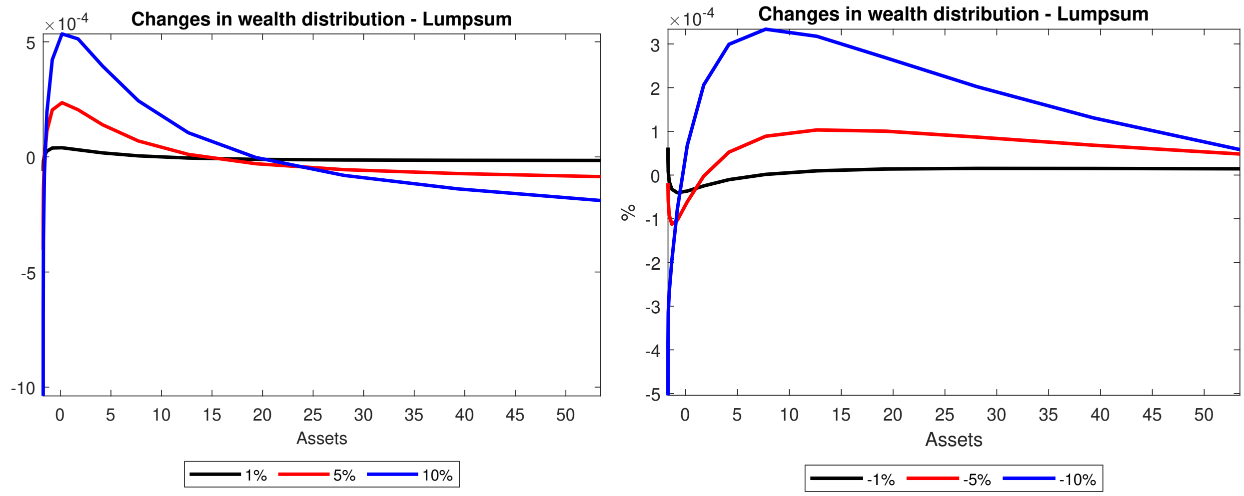

Figure 28: Changes in the distribution in response to a permanent change in G.

F Robustness: Micro Evidence of the Mechanism

Table 24: G shock, labor supply response and financing regime by total wealth. i^y is the annual income of the household.

VARIABLES	(1) Total wealth < 0	(2) Total wealth > 0	(3) Total wealth $> \$12000$	(4) Total wealth $< 1/2i^y$	(5) Total wealth $> 1/2i^y$	(6) Total wealth $> i^y$
β_1	1.060**	0.047	0.055	0.062	-0.030	0.012
	(0.477)	(0.037)	(0.039)	(0.057)	(0.034)	(0.036)
β_2	6.355**	0.750**	0.700**	1.548***	0.193	-0.282
	(2.603)	(0.349)	(0.357)	(0.519)	(0.306)	(0.328)
β_3	-0.315**	-0.037**	-0.035**	-0.076***	-0.009	0.014
	(0.129)	(0.017)	(0.017)	(0.025)	(0.015)	(0.016)
Observations	7,075	61,980	47,914	36,080	37,328	31,399
Number of ID	2,308	11,390	8,734	8,711	7,397	6,308

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 25: *G* shock, labor supply response, liquid wealth, and financing regime

VARIABLES	(1) Liquid wealth < 0	(2) Liquid wealth > 0	(3) Liquid wealth $<$ Wealth Q1	(4) Liquid wealth $<$ Wealth Q2	(5) Liquid wealth $>$ Wealth Q2	(6) Liquid wealth $>$ Wealth Q3
β_1	0.476**	0.055	0.476**	0.146***	0.028	0.034
	(0.185)	(0.038)	(0.185)	(0.056)	(0.041)	(0.052)
β_2	3.549***	0.575	3.549***	0.521	0.954***	0.458
	(1.214)	(0.356)	(1.214)	(0.566)	(0.357)	(0.425)
β_3	-0.176***	-0.029*	-0.176***	-0.027	-0.047***	-0.023
	(0.060)	(0.017)	(0.060)	(0.027)	(0.017)	(0.021)
Observations	9,478	57,981	9,478	33,851	39,471	20,133
Number of ID	2,968	10,929	2,968	8,311	7,568	3,910

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 26: *G* shock, labor supply response, total wealth, and financing regime while controlling for wages

VARIABLES	(1) Total wealth <0	(2) Total wealth >0	(3) Total wealth $<$ Wealth Q1	(4) Total wealth $<$ Wealth Q2	(5) Total wealth $>$ Wealth Q2	(6) Total wealth $>$ Wealth Q3
β_1	-0.005	-0.022	-0.149	-0.153***	0.012	0.008
	(0.267)	(0.028)	(0.103)	(0.049)	(0.029)	(0.032)
β_2	1.769	0.063	1.584**	1.211***	-0.260	-0.714**
	(1.539)	(0.258)	(0.753)	(0.406)	(0.258)	(0.289)
β_3	-0.086	-0.003	-0.076**	-0.058***	0.013	0.035**
	(0.076)	(0.012)	(0.037)	(0.020)	(0.012)	(0.014)
Observations	7,075	61,980	14,911	33,230	40,821	20,688
Number of ID	2,308	11,390	4,232	8,179	7,437	3,871

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

$$\begin{aligned}\ln h_{it} =& \beta_1 G_t + \beta_2 a_t + \beta_3 \Delta B_t + \beta_4 a_t G_t + \beta_5 \Delta B_t G_t + \beta_6 a_t \Delta B_t \\ & + \beta_7 a_t \Delta B_t G_t + \alpha_i + \gamma_t + \epsilon_{it}\end{aligned} \tag{13}$$

ΔB_t is the change of government debt as a percentage of GDP. Given that we are controlling for government debt changes and wealth, β_1 can be interpreted as the labor supply response of an agent with zero wealth when debt does not change. According to the model predictions, β_1 should be positive, as agents increase their labor supply in response to a positive fiscal shock. β_4 captures how the labor supply response depends on wealth, given that the public debt does not change. Our model predicts this term

Table 27: G shock, labor supply response, total wealth and financing regime

VARIABLES	(1) G Shock	(2) G Shock	(3) G Shock	(4) G Shock
β_1	0.327	0.068**	0.166	0.073**
	(0.232)	(0.031)	(0.180)	(0.032)
β_2			3.423	1.262
			(2.923)	(1.837)
β_3		0.873***		0.647*
		(0.304)		(0.347)
β_4			-0.173	-0.069
			(0.145)	(0.096)
β_5		-0.044***		-0.033*
		(0.015)		(0.017)
β_6				-0.650
				(0.919)
β_7				0.032
				(0.045)
Observations	81,678	81,678	81,678	81,678
Number of ID	17,670	17,670	17,670	17,670

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

will be negative because in a financing regime with a balanced budget, wealthier agents will respond the least to the shock. β_7 captures how the relation between wealth and the spending shock changes when the shock is financed with debt. To be in line with our model, this coefficient should be positive, as the labor supply of wealthier agents responds the most for deficit-financed shocks. Lastly, the coefficient β_5 tells us whether the financing regime affects the average labor supply response: deficit-financed shocks in the model generate smaller fiscal multipliers, due to a more muted labor supply response. This would be consistent with $\beta_5 < 0$.

Results in Table 27 show that the coefficient signs are all in line with what we would expect, thus validating the model's mechanism. For a 1% fiscal spending shock, when debt does not change, an increase in wealth by one standard deviation decreases the labor supply response by 94.5%. If debt increases by 1%, the response of a household with zero wealth decreases by 45.2%, while that for a household with wealth equal to one standard deviation increases by 800%.