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Mauro Napoletano, Jean-Luc Gaffard, Andrea Roventini

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OUTSIDE THE CORRIDOR: FISCAL MULTIPLIERS AND BUSINESS CYCLES INTO AN AGENT-BASED MODEL WITH LIQUIDITY CONSTRAINTS

Mauro Napoletano
OFCE and Skema Business School,
Scuola Superiore Sant'Anna

Jean-Luc Gaffard
OFCE and Skema Business School

Andrea Roventini
Università di Verona, Scuola Superiore Sant'Anna,
OFCE and Skema Business School

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Mauro Napoletano[*] Jean-Luc Gaffard[†] Andrea Roventini[‡]

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Abstract

We build an agent-based model to study how fiscal multipliers can change over the business cycle. Our approach considers the economy as a complex evolving system. In that, fiscal state-dependent multipliers are emergent disequilibrium phenomenon stemming from the interaction among an ecology of heterogeneous agents. We study fiscal multipliers in response to different microeconomic shocks hitting the economy. We show that deficit-spending fiscal policy dampens the effect of a shock and lowers its persistence. Moreover, we show that the size and dynamics of the fiscal multiplier is inversely related to the evolution of credit rationing in the aftermath of the shock. We also investigate the effects of two different balanced budget rules. In the first type of such experiments, government expenditure is constrained to be equal to tax revenues of each period. In the second one the tax rate is eventually raised to balance a given level of government expenditure. We show that fiscal multipliers are very low with both balanced-budget rules. Finally, we show that fiscal multipliers are higher into more leveraged economies.

Keywords: Keynesian economics, Fiscal Multipliers, Corridor Effects, Agent-based models, Liquidity constraints
JEL classification: E63, E21, C63

1 Introduction

In the economics of Keynes, agents who are unable to sell as much as they would like at prevailing prices restrict demands in other markets. Unemployed workers cut their consumption demand. Demand-constrained firms restrict their demand for labor. Then supplies and demands depend on the current income and and multiplier effects matter.

[*]OFCE and Skema Business School, Sophia-Antipolis (France), and Scuola Superiore Sant'Anna, Pisa (Italy); E-mail address: mauro.napoletano@sciencespo.fr
[†]OFCE and Skema Business School, Sophia-Antipolis (France) ; E-mail address: jeanluc.gaffard@sciencespo.fr
[‡]Università di Verona (Italy), Scuola Superiore Sant'Anna, Pisa (Italy), and OFCE, Sophia-Antipolis (France); E-mail address: andrea.roventini@univr.it

The recent crisis has revealed that multiplier values can be significantly higher in economic downturns than in normal times. For instance, in 2009 the IMF had estimated that multipliers in developed countries averaged about 0.5, while it now calculates that they range from 0.9 to 1.7 during the Great Recession (see Blanchard and Leigh, 2013). The notion of state-dependent multipliers, corroborated by a growing body of recent empirical research (see e.g. Auerbach and Gorodnichenko, 2012; Bachmann and Sims, 2012), is reminiscent of Leijonhufvud (1973) corridor theory. According to Leijonhufvud, "inside the corridor, multiplier-repercussions are weak and dominated by neoclassical market adjustments, while outside the corridor, they should be strong enough for effects of shocks to the prevailing state to be endogenously amplified" (Leijonhufvud, 1973). One explanation for the corridor effect is the tightness of the liquidity constraints faced by households. During booms liquidity constraints are non-binding, and households engage into standard permanent-income consumption smoothing. Consequently, aggregate consumption depend less on current income and the size of the fiscal multiplier is low. In contrast, during economic downturns liquidity constraints are binding, and consumption is more sensitive to current income variations. Recent DSGE models (e.g. Eggertsson and Krugman, 2012) have modeled consumers debt overhangs as exogenous, or have investigated corridor effects in frameworks with limited agent heterogeneity. In our model agents have heterogeneous financial conditions and debt overhangs may emerge endogenously. Moreover, the size of fiscal multipliers affected by monetary policy as well as by structural conditions (e.g. distribution of household leverage). Our approach considers the economy as a complex evolving system. In that, fiscal state-dependent multipliers are emergent disequilibrium phenomenon stemming from the interaction among an ecology of heterogeneous agents. We study fiscal multipliers in response to different microeconomic shocks hitting the economy. We show that deficit-spending fiscal policy dampens the effect of a shock and lowers its persistence. Moreover, we show that the size and dynamics of the fiscal multiplier is inversely related to the evolution of credit rationing in the aftermath of the shock. We also investigate the effects of two different balanced budget rules. In the first type of such experiments, government expenditure is constrained to be equal to tax revenues of each period. We find, that fiscal multipliers are still time varying, but they are lower and converge towards a zero value. Similar results are observed under the second type of balanced budget rule, according to which the tax rate is eventually raised to balance a given level of government expenditure. The paper is organized as follows. Section 2 describes the model. Section 3 discusses the steady state conditions of the model. Section 4 presents some preliminary simulation results. Finally, Section 5 concludes.

2 A simple endowment economy

There are N heterogeneous households. Each household i has access to a given amount of a homogeneous input good ('wheat') that she can gather at no cost, but that she cannot use for consumption . In order to consume, each household has to sell her endowment good to homogeneous firms ('the mills') that use it to produce an output good ('flour'). The output good is purchased by households and used for their consumption

Each mill produces the consumption good on demand by using a constant returns to scale technology. The production function of a mill j is $Y_{jt} = L_{jt}$. This implies that total output is simply

$$Y_t = L_t$$

where L_t is the amount of wheat purchased. Mills always buys the wheat from each households in proportion to the household share of total wheat available. In addition, each firm can buy all the input good she needs at the price P_l up to to the total amount of input available (L^{max}). Furthermore, the mill produces at zero profit so that the final price of the output is simply $P_o = P_l$. Finally, notice that the above assumptions imply that the level of output of the mill will (and thus household incomes) will be determined by the level of overall consumption demand (up to the level where the input constraint L^{max} becomes binding).

Each household has a desired level of consumption Z_i, that we assume to be constant over time Once desired consumption is determined it is possible to identify two classes of agents: savers and borrowers. Savers are households whose current liquid wealth W_{it} is larger than desired consumption (i.e. $Z_i \leq W_{it}$). At the other extreme, borrowers have liquid wealth W_{it} that is lower than desired consumption Z_{it} (i.e. $Z_i > W_{it}$). Savers can always finance their consumption with their own wealth. Accordingly, consumption of this class of agents is always equal to their desired level. In contrast, borrowers need financing from the credit sector to satisfy their consumption plans.

In the credit sector there is a representative bank that stocks the wealth of *all* agents and grants credit to borrowers. Total credit supply is set as a multiple of the net worth of the bank E_t^B (e.g. Delli Gatti et al., 2005)

$$TS_t = kE_t^B, \quad k > 0 \tag{1}$$

where k is the credit multiplier. We assume an endogenous money framework, so that $\rightarrow k > 1$. Furthermore, credit is allocated to agents using a pecking order (see Dosi et al., 2013) that depends on the on the ratio between household's wealth W_{it} and her credit demand CD_{it}.

$$\frac{W_{it}}{CD_{it}}$$

where CD_{it} is equal to the difference between the borrower's desired consumption and her wealth

$$CD_{it} = Z_{it} - W_{it}$$

The above assumptions imply that total credit demand can be lower or higher than total credit supply. In the former case all borrowers are able to get credit from the bank. In the latter case some borrowers are partially or totally rationed in the credit market. The lower is the position of the household in the pecking order, the higher is her probability of being credit-rationed. Borrowers who are denied credit are not able to satisfy their consumption plan. Their actual consumption is equal to their wealth W_{it}.

The bank sets the interest rate on loans r^b by applying a mark-up μ^b on the baseline interest rate r set by the central bank. Likewise, the interest rate paid on deposits, r^s is determined by applying a mark-down μ^s on the central bank interest rate. We get

$$\begin{aligned} r^b &= r(1+\mu^b) \\ r^s &= r(1+\mu^s) \end{aligned} \tag{2}$$

Bank liabilities, L_t^B are determined as the difference between assets (equal to total credit supply) and net-worth of the bank

$$L_t^B = kE_t^B - E_t^B = (k-1)E_t^B$$

Bank profits, π_t^B are simply equal to

$$\pi_t^B = r_t^b(kE_t^B) - r^s(k-1)E_t^B = [r^s + k(r^b - r^s)]E_t^B \tag{3}$$

The law of motion of bank's net worth is

$$E_t^B = E_{t-1}^B + \pi_t^B - \sum_{i=1}^{N} BD_{it}$$

Bank profits are distributed to a homogeneous class of agents ("the bankers") if bad debt is zero and are not distributed otherwise. The bankers fully consume their income.

Let us now turn to describing fiscal policy. We assume that taxation is proportional to income at the tax rate t so that disposable income of household i is simply $y_{it}^D = (1-\tau)y_{it}$. The government sets consumption level and the tax rate according to different fiscal rules. Government debt (if any) is purchased by the central bank. Aggregate demand AD_t determined as the sum of households and government consumption, respectively C_t and G_t, plus the consumption of bankers if any (and equal to bank profits π_t^B). As long as the constraint L^{max} is not binding aggregate income is determined by aggregate demand. Formally, we get:

$$Y_t = AD_t = C_t + G_t + \pi_t^B$$

Total households income Y_t^H is total income minus the income of bankers, i.e. $Y_t^H = Y - \pi_t^B$.

Finally, let us discuss households' balance sheet dynamics. Let define $\beta_{it} = Z_i/W_{it}$ as the propensity to consume out of wealth of agent i at time t. It follows that, $\beta_{it} > 1$ if the household is a borrower and $\beta_{it} <= 1$ if she is a saver. We assume that consumption loans must be fully repaid at the end of each period. The same occurs for the remuneration of savings. It follows that the law of motion of agent's wealth is

$$W_{it+1} = (1 - \tau)y_{it} - (1 + r_b)(\beta_{it} - 1)W_{it} \tag{4}$$

if the agent is a borrower, and

$$W_{it+1} = (1 - \tau)y_{it} + (1 + r_s)(1 - \beta_{it})W_{it} \tag{5}$$

if the agent is a saver. In the above equations r_b and r_s (with $r_b \geq r_s$) are respectively the borrowers' and lenders' interest rate. Households who are unable to repay their debt go bankrupt. From 4 one gets that the condition for bankruptcy is simply that household's resources at the beginning of the period are lower than debt plus interests, i.e.

$$(1 - \tau)y_{it} < (1 + r_b)(\beta_{it} - 1)W_{it}$$

The above can also be re-expressed using consumption levels

$$(1 - \tau)y_{it} < (1 + r_b)(C_{it} - W_{it})$$

Once bankruptcy occurs the wealth of the household is reset to zero and the bank gets a credit loss equal to

$$BD_{it} = (1 + r_b)(C_{it} - W_{it}) - (1 - \tau)y_{it}$$

Bankrupted households are denied access to the credit market for $T_{default}$ periods.

The sequence of events unfolding in each period is the following

- Desired consumption of the period is determined. Households credit demand is determined
- Government consumption and the government balance is determined
- Total credit supply is determined. Credit is allocated to consumers. Actual private consumption is determined

- Aggregate income of the period is determined and distributed
- Taxes are collected
- Debt is repaid. Household's wealth is determined. Household bankruptcy is determined

3 Steady State Conditions

Before carrying simulation experiments we identify the steady state conditions of the model. By steady state here, we mean a state of the economy where levels of all microeconomic variables (households wealth, households income, households consumption, debt, profits of the bank) are constant and where levels of all macroeconomic variables (aggregate consumption, aggregate government expenditure, tax revenues, aggregate income) are also constant.

To find the steady state conditions of the model described in the previous section we focus on steady state conditions for households wealth. Indeed, household wealth plays a central role in the model, as it determines actual consumption, aggregate income, tax revenues (and thus government balance). In addition, by determining the overall amount of consumption loans it affects banks' revenues and net worth. First, notice that the assumption that each mill buys wheat from a household in proportion to the household's share of total wheat implies that each household is entitled a time-invariant share of total household income. Let us label this share by α_i. If Y_t^H is total household income of the period, then disposable income of each household; y_{it} is equal to

$$y_{it} = \alpha_i(1-\tau)Y_t^H$$

As we said in the previous section, households whose marginal propensity to consume out of wealth is lower or equal to 1 always satisfy their consumption plans. In contrast, agents with $\beta_i > 1$ need to borrow to achieve their desired consumption. We focus on steady states of the model where credit rationing is absent. Accordingly, all borrowers are able to get their desired consumption level. Using this fact, we get that the steady state level of wealth household i is

$$w_i^* = \frac{\alpha_i(1-\tau)Y^{H*}}{[1-(1+r^b)(1-\beta_i^*)]} \quad (6)$$

if the agent is a borrower and

$$w_i^* = \frac{\alpha_i(1-\tau)Y^{H*}}{[1-(1+r^s)(1-\beta_i^*)]} \quad (7)$$

if the agent is a saver. Also, notice that the above steady state levels are stable if the following conditions are satisfied

$$| (1 + r^b)(1 - \beta_i^*) |< 1$$

for a borrower

$$| (1 + r^s)(1 - \beta_i^*) |< 1$$

for a saver.

Aggregate consumption must be constant in steady state. Thus, we can express steady state individual consumption, C_i^* as a fraction of steady state aggregate consumption C^*

$$C_i^* = \gamma_i^* C^*, \quad \sum_{i=1}^{N} \gamma_i^* = 1 \tag{8}$$

Moreover, by exploiting the fact that, by definition, $C_i^* = \beta_i^* w_i^*$ and that $C^* = (1-\tau)Y^{H*}$ we get the following relations between individual consumption shares γ_i^* and individual marginal propensity to consume β_i^*

$$\frac{\beta_i^* \alpha_i}{[1 - (1 + r_b)(1 - \beta_i^*)]} = \gamma_i^* \tag{9}$$

for a borrower and

$$\frac{\beta_i^* \alpha_i}{[1 - (1 + r_s)(1 - \beta_i^*)]} = \gamma_i^* \tag{10}$$

for a saver. Solving for the above equations for β_i^* we get

$$\beta_i^* = \frac{\gamma_i^* r^b}{[\gamma_i^* r^b + (\gamma_i^* - \alpha_i)]} \tag{11}$$

and

$$\beta_i^* = \frac{\gamma_i^* r^s}{[\gamma_i^* r^s + (\gamma_i^* - \alpha_i)]} \tag{12}$$

for a saver.[1]. Furthermore, by exploiting Equations 11 and 12 we designed an algorithm that, for a given distributions of income shares $\{\alpha_i\}$, randomly assigns consumption weights to households and computes the values of β_i^* so that the fraction of borrowers in the population is $0 < \eta^* < 1$ (and the one of savers is $1 - \eta^*$).

[1]Incidentally, notice that the above functions are increasing in α_i^* and decreasing in γ_i^*. It follows that, if we impose that all agents have the same consumption share in steady state ($\gamma_i = 1/N, \forall i$) then borrowers should be concentrated in the upper part of the income distribution.

4 Simulation Experiments

We now discuss the results of the simulation experiments using different fiscal rules in the framework of the model described in Section 2. In these simulation experiments we assumed that the economy was initially in the steady state described in Section 3. We then shocked the steady state by assuming that a given fraction of households goes bankrupt and tracking the dynamics of output under different types of fiscal rules. In particular, we considered three types of fiscal rules:

- *deficit-spending rule*. The government keeps the level government spending at the steady state level, and it is allowed to create a deficit if tax revenues fall below the steady state level
- *balanced-budget rule I*. Government spending is equal to tax revenues in every period
- *balanced-budget rule II*. The government keeps the level government spending at the steady state level. The tax rate is adjusted accordingly so that tax revenues are equal to government spending in every period.

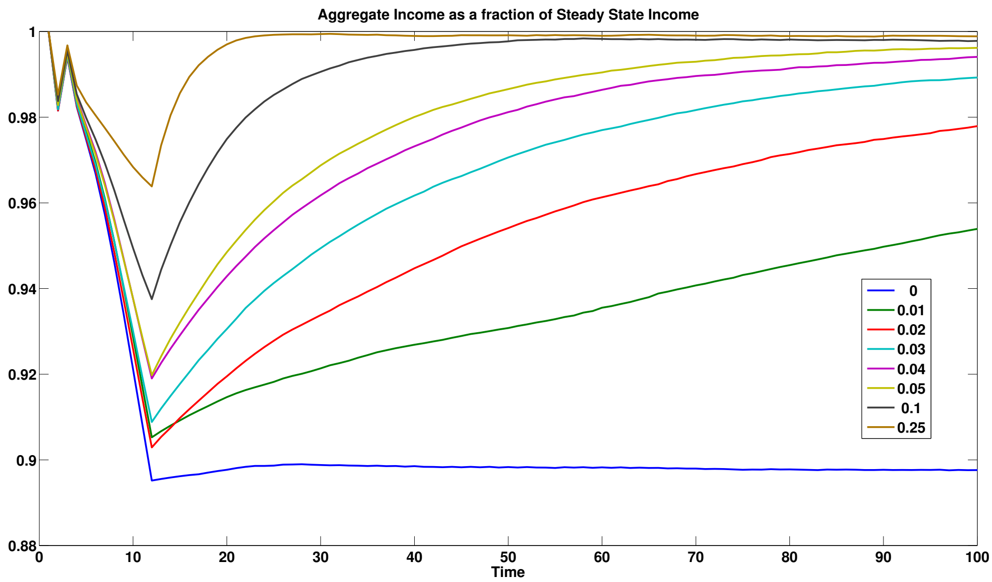

Figure 1: Evolution of aggregate income as a fraction of steady state income. Deficit-spending rule. The values in the legend correspond to different intensities of government expenditures and tax rates.

In each of the above experiment the level of government expenditure (and the tax rate when required) is set as a fraction of the steady state income level, according to a coefficient that captures the "intensity" of fiscal policy in the model. We then repeat each experiment for different intensities of fiscal policy.

Let us begin with the analysis of the deficit-spending rule. Figure 1 shows the evolution of aggregate income as a fraction of steady state income in the aftermath of a bankruptcy shocks. The plot shows two results of the model. First, higher levels of government expenditures (corresponding to higher fiscal policies intensities in the figure) reduce the magnitude of the effects of the shocks. In other words the higher the level of government expenditure the lower is the fall in aggregate output in the aftermath of a shock. Moreover, higher levels of government expenditure lower the persistence of the shock and favors a quicker recovery to the steady state level of income.

In light of the above results we now proceed to calculate fiscal multipliers corresponding to different levels of fiscal policy intensity. More precisely, we calculate fiscal impact multipliers as follows

$$k_{ki}(t) = \frac{Y_k(t) - Y_i(t)}{G_k(t) - G_i(t)} \tag{13}$$

In the above expression $k_{ki}(t)$ is the fiscal multiplier at time t corresponding to the experiment with govt. expenditure intensity k in relation to the experiment govt. expenditure intensity i.

Figure 2 shows the dynamics of fiscal impact multipliers for different intensities of government expenditure and following a bankruptcy shock. First, the values of fiscal multipliers follow an inverse U-shaped pattern, and peak values are reached after the through of the recession (compare Fig. 2 to Figure 1). Moreover, many fiscal multipliers have peak values that are significantly higher than one. In particular, the value of the peak multiplier is decreasing in the level of the government expenditure. This latter result can be understood by noticing that the impact multipliers are calculated as a ratio between the variation in aggregate income and the variation in government expenditure. As after-shock fall in output is at most of 10% (check the blue line in Figure 1, corresponding to the case where fiscal policy is absent), and given that aggregate output is bounded above by the capacity constraint L^{max} it comes to no surprise that government intensities values equal or higher than 10% are associated with peak multipliers that are lower than one.

Let us now turn to analyse the evolution of fiscal multipliers in relation to the degree of credit rationing in the economy. Figure 3 compares the evolution of fiscal multipliers to the one of the ratio between actual and desired consumption. A value of the latter lower than one indicates the presence of credit rationing because it implies that some borrowers are unable to satisfy their desired consumption plans and their consumption is limited by their current liquid wealth. Figure 3 shows that the evolution of fiscal multipliers is inversely related to the evolution of actual-to-desired consumption ratio, and thus to credit rationing in the economy. However, the dynamics of fiscal multipliers appears to be lagging the one of credit rationing. This delivers an important results of the model, namely government expenditure is able to trigger variation in output insofar as it is able to let borrowers escape from the credit rationing trap and to get back to effective consumption

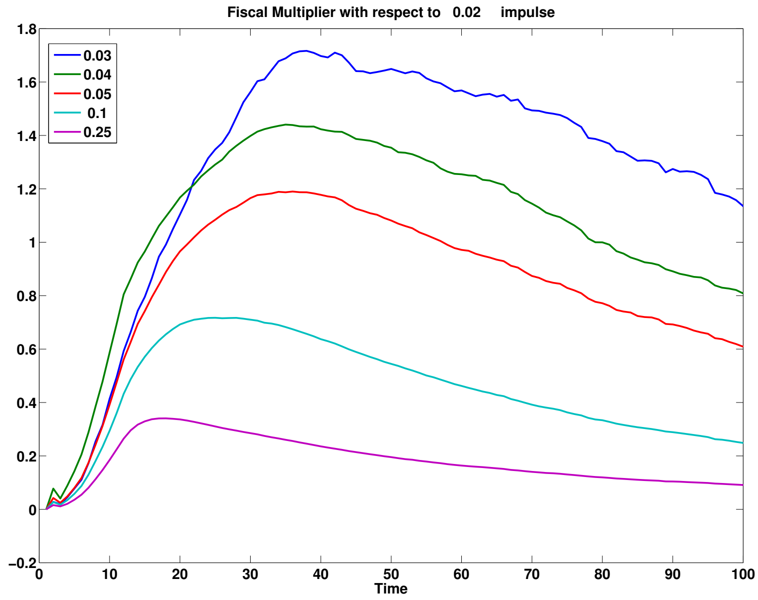

Figure 2: Evolution of fiscal multipliers. Deficit-spending rule. All multipliers are calculated in relation to an intensity $i = 0.02$ of government expenditure (see also Eq. 13).

levels compatible with their desired plans. Moreover, such a process of "re-leveraging" is faster the stronger is the level of government expenditure in the economy. This is showed by the fact that the peak multiplier is reached much faster for higher levels of government expenditure (see Figure 2).

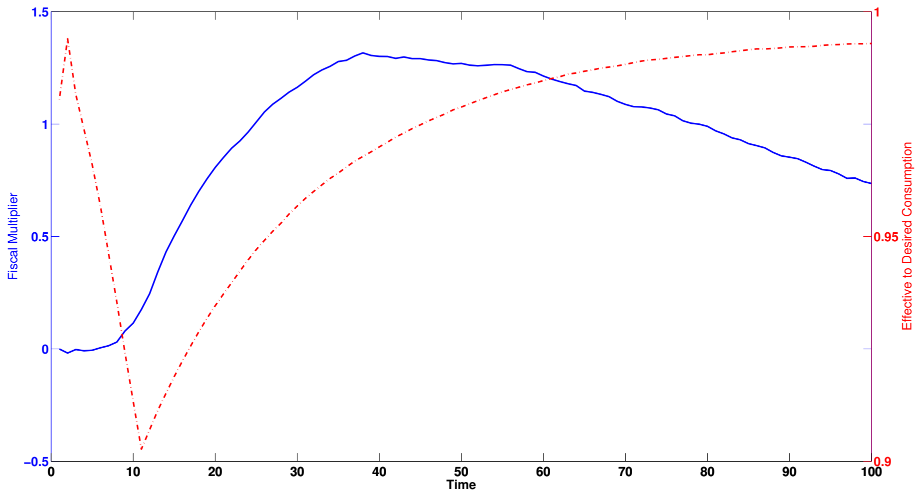

Figure 3: Evolution of fiscal multipliers (left scale) and ratio between actual and desired consumption (right scale). Deficit-spending rule.

All the above discussion related to experiments with the deficit-spending rule. How do the above results change if we allow for balanced-budget rules? Figure 4 compare the evolution of fiscal multipliers across different fiscal rules. As the plot shows quite

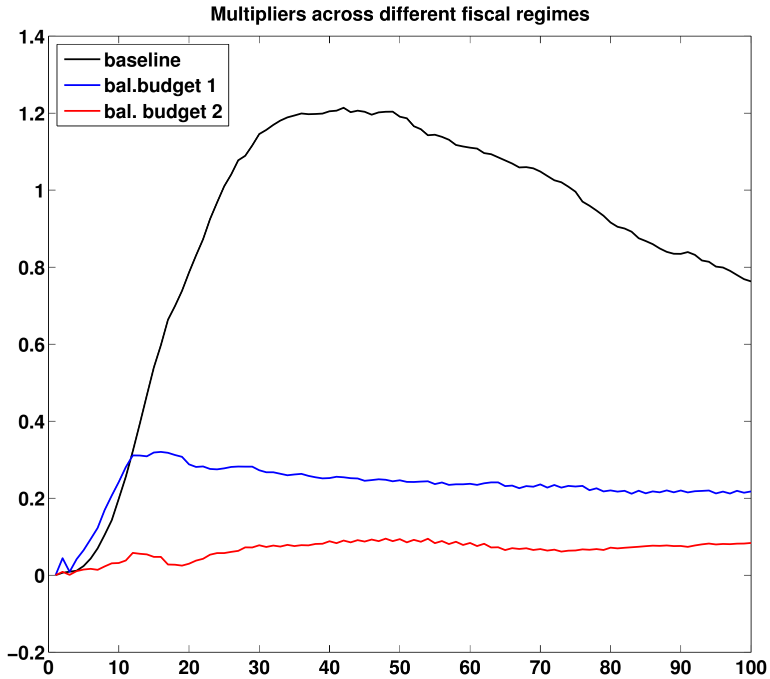

Figure 4: Deficit-spending vs. balanced-budget multipliers. In the plot "baseline" refers to the deficit-spending rule, "bal. budget 1" refers to the balanced-budget rule with endogenous government expenditure, "bal. budget 2" to the balanced budget rule with endogenous tax rate.

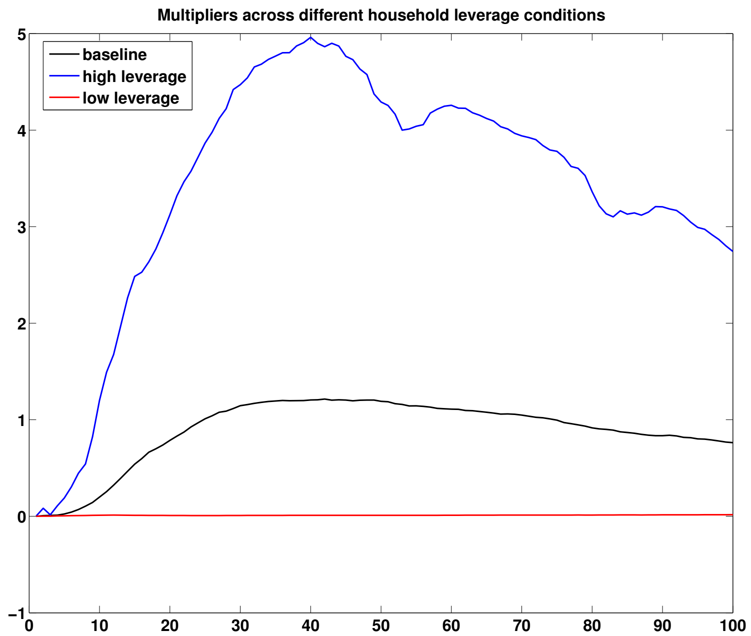

Figure 5: Fiscal multipliers for different initial fractions of borrowers in the economy. Deficit-spending rule

starkly balanced-budget fiscal multipliers are always very low. On one hand, decreasing government expenditure to adapt it to falling tax revenues (as it is implied by the balanced-budget rule with endogenous government expenditure), does not help in triggering the re-leveraging process discussed before and restore pre-shock output levels. On the other hand rising the tax rate to fully balance government expenditure (as it is implied by the balanced budget rule with endogenous tax rate) further depresses household disposable incomes that are already falling after the shock and further reinforce credit rationing and de-leveraging in the economy.

To conclude, Figure 5 compares the evolution of fiscal multipliers (with the deficit-spending rule) for different initial shares of borrowers in the households population. The latter is a measure of the degree of leverage in the economy as it captures the extent to which total consumption in the economy depends on consumption loans. The plot in the figure clearly shows that fiscal multipliers are growing in the degree of debt leverage in the economy. The same is observed for the magnitude and persistence of the effects of a bankruptcy shock (not shown). The result that multipliers are higher in more leveraged economy is explained by the fact that - to repeat - a greater share of consumption depends on bank loans in such economies and that bankruptcy shocks are going to generate higher degrees of credit rationing. It follows that the re-leveraging process triggered by deficit-spending fiscal policy is going to be more pervasive in such economies and, thus, able to lead to higher increases in output in the aftermath of the shock.

5 Conclusions

We built a simple agent-based model to study how fiscal multipliers are affected by liquidity constraints in the economy. The model features two classes of heterogenous agents: savers, who can finance desired consumption with their liquid wealth, and borrowers who need bank's loans to satisfy their desired consumption plans. In the model bank's credit supply depends on bank's net worth that is affected by bad debt (if any). Moreover, the government taxes agents and purchases goods according to different fiscal rules. Finally, aggregate income is determined by aggregate demand. In such a framework we showed that small bankruptcy shocks can trigger wide and persistent falls in output. The magnitude and persistence of the shock is inversely related to the intensity of government expenditure in the economy. Moreover, we showed that fiscal multipliers can be significantly higher than one during recessions, and that the value of the multiplier is inversely related to the degree of credit rationing in the economy. Finally, we studied fiscal multipliers across different fiscal regimes and degrees of debt leverage in the economy. We showed that fiscal multipliers associated with balanced budget rules are very low compared to the ones associated with deficit-spending rules. Moreover, fiscal multipliers are higher in more leveraged economies. We plan to extend the model in several directions, by exploring further fiscal rules, and to investigate the robustness of results under different consumption behaviors.

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