Time-varying fiscal multipliers in an agent based model with credit-rationing

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Abstract
The authors build a simple agent-based model populated by households with heterogenous and time-varying financial conditions in order to study how fiscal multipliers can change over the business cycle and are affected by the state of credit markets. They find that deficit-spending fiscal policy dampens the effect of bankruptcy shocks and lowers their persistence. Moreover, the size and dynamics of government spending multipliers are related to the degree and persistence of credit rationing in the economy. On the contrary, in presence of balanced-budget rules, output permanently falls below pre-shock levels and the ensuing multipliers fall below one and are much lower than the ones emerging from the deficit-spending policy. Finally, the authors show that different conditions in the credit market significantly affect the size and the evolution of fiscal multipliers.

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Keywords Fiscal multipliers; agent-based models; credit-rationing; balance-sheet recession; bankruptcy shocks

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1 Introduction

We develop an agent-based model populated by heterogenous households with time-varying financial conditions in order to study how financial constraints and more generally the state of credit markets affect output fluctuations and the size of government consumption multipliers under different fiscal rules.

The Great Recession has shown the increasing role of financial markets in macroeconomic dynamics. For instance, Ng and Wright (2013) find that in the last 30 years all the downturns occurring in the US economy originate in financial markets. In presence of strong financial frictions (see Brunnermeier et al., 2012, for a survey), credit markets diffuse shocks in a nonlinear way, increasing their magnitude and persistence (Bernanke et al., 1999; Gertler and Kiyotaki, 2010; Brunnermeier and Sannikov, 2014). Moreover, in presence of bankruptcy shocks, the economy can experience protracted balance-sheet recessions as agents cannot spend because of excessive debt levels (Koo, 2008, 2011).[1]

All this poses a new challenge to fiscal policies, as the size of fiscal multipliers may change over time (see Gechert and Rannenberg, 2014, for a survey). For instance, Auerbach and Gorodnichenko (2012) and Bachmann and Sims (2012) find that fiscal multipliers are higher than two during recessions but around one in periods of expansion. More recently, Ferraresi et al. (2014) find that the response of output to fiscal policy shocks is stronger and more persistent when the economy is in a "tight" credit regime (see also Canzoneri et al., 2016; Schleer and Semmler, 2014). Finally, Blanchard and Leigh (2013) have argued that the recent fiscal consolidation plans released by many advanced economies produced stronger recessionary effects than what forecasted, because the estimated fiscal multipliers did not take into account the dismal situation of the financial system (together with the zero lower bound constraining monetary policy and the deep slack in the economy).

The notion of state-dependent multipliers is reminiscent of Leijonhufvud (1973, 2009) 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. This is evocative of the idea of "dark corners" put forward by Blanchard

[1] On the strong link between tightening households' borrowing constraints and the Great Recession, see Hall (2011) and Mian and Sufi (2011).

(2014) and akin to the interplay between de-leveraging and balance-sheet recessions in Koo (2008, 2011).

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 the present paper, we build a simple agent-based model, populated by households with heterogeneous and time-varying financial conditions, where debt overhangs may endogenously emerge, paving the way to protracted recessions. Moreover, the size of fiscal multipliers is affected by fiscal policy as well as by structural conditions in the credit market.[2] Our approach considers the economy as a complex evolving system (Farmer and Foley, 2009; Kirman, 2010; Rosser, 2011; Dosi, 2012). In that, state-dependent fiscal multipliers are emergent disequilibrium phenomena stemming from the interaction among an ecology of heterogeneous agents.[3]

We find that in presence of small bankruptcy shocks, deep and persistent downturns emerge, as the fall in aggregate demand and credit supply increases the number of households which are credit rationed. In such a framework, deficit-spending fiscal policy dampens the negative effect of shocks and lowers their persistence. Moreover, the size of the multipliers is time-varying and is related to the evolution of credit rationing in the aftermath of the bankruptcy shock. Indeed, when households are credit constrained, surges in public expenditure sustain private consumption (in line Galí et al., 2007; Kaplan and Violante, 2011; Anderson et al., 2016; Parker et al., 2013). In addition public expenditure allows households to "repair" their balance sheets, by increasing their wealth and returning to normal consumption levels (Leijonhufvud, 2009; Koo, 2008).

In contrast to the foregoing results, balanced-budget fiscal rules lead to a permanent fall of output below the pre-crisis levels, in tune with Dosi et al. (2015). In presence of fiscal discipline, multipliers are still time varying, but they are lower and close to zero.

Finally, we study the impact of credit market conditions on the size of multipliers. We find that fiscal multipliers are higher in more leveraged economies and when sanctions on bankrupted households are stronger. In addition, lower credit multipliers or higher borrower spreads imply lower multipliers values. The interplay between banks balance sheet and frictions in the credit market is at the core of such results.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 discusses the steady state conditions of the model. Section 4 presents simulation results. Finally, Section 5 concludes.

[2]See also Seppecher and Salle (2015) and Raberto et al. (2012) for similar studies on the interplay between deleveraging crises and recessions in an agent-based framework.

[3]For a critical comparison of DSGE and agent-based models, see Fagiolo and Roventini (2012) and Gaffard and Napoletano (2012).

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. This assumption about households preferences is a simple idea to introduce the motivation for trade interaction the possibility of coordination failures in the model, and it is reminiscent of the works of Diamond (1982) and Howitt and Clower (2000). 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 $Y_{jt} = L_{jt}$, where L_{jt} is the amount of wheat purchased. This implies that total output is simply

$$Y_t = L_t. \tag{1}$$

Mills can buy the wheat from each households in proportion to the household's share of total available wheat. In addition, a mill can buy all the input good she needs at the price P_l up to to the total amount of input available (L^{max}). Each mills produces at zero profits 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 mills' output (and thus household incomes) will always be determined by the level of overall consumption demand unless 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, one can identify two classes of agents: savers and borrowers. Savers are households whose current liquid wealth W_{it} is larger than desired consumption (i.e. $Z_i \leq W_{it}$). 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 credit 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 (see e.g. Delli Gatti et al., 2005)

$$TS_t = kE_t^B, \quad k > 0 \tag{2}$$

where k is the credit multiplier. We assume an endogenous money framework (Lavoie, 2003), so that $k > 1$. Furthermore, credit is allocated to agents using a pecking order (see Dosi et al., 2013, 2015) that depends on the on ratio between household's wealth W_{it} and her credit demand CD_{it}.

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

Credit demand 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 higher than total credit supply. In such 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 and their actual consumption is equal to their liquid 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 ($0 < \mu^b < 1$). Likewise, the interest rate paid on deposits, r^s is determined by applying a mark-down μ^s on the central bank interest rate ($0 < \mu^s < 1$). We get

$$\begin{aligned} r^b &= r(1+\mu^b) \\ r^s &= r(1-\mu^s) \end{aligned} \tag{3}$$

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

$$L_t^B = kE_t^B - E_t^B = (k-1)E_t^B. \tag{4}$$

Bank profits, π_t^B are simply equal to:

$$\pi_t^B = r_t^b(kE_t^B) - r^s(k-1)E_t^B = [r^s + k(r^b - r^s)]E_t^B. \tag{5}$$

Households can go bankrupt. In such a case, the bad debt (BD_{it}) from bankrupted households negatively affects bank's net worth

$$E_t^B = E_{t-1}^B + \pi_t^B - \sum_{i=1}^{N} BD_{it} \tag{6}$$

Notice that the stock of bad debt negatively affects the supply of credit in the economy (via Eq. (2)). Finally, 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 describe fiscal policy. We assume that taxation is proportional to income so that disposable income of household i is simply $y_{it}^D = (1-\tau)y_{it}$, where $\tau > 0$

is the tax rate. The government sets its consumption level and the tax rate according to different fiscal rules (more on that in Section 4.1 below). Government debt (if any) is purchased by the central bank.

Aggregate demand AD_t is 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:

$$Y_t = AD_t = C_t + G_t + \pi_t^B \tag{7}$$

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

2.1 The balance sheet dynamics of households

Let us now discuss the balance sheet dynamics of households and how bankruptcies emerge in the model.

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 $\beta_{it} \leqslant 1$ 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

$$W_{it+1} = (1-\tau)y_{it} - (1+r_b)(\beta_{it}-1)W_{it}, \tag{8}$$

if the agent is a borrower, and

$$W_{it+1} = (1-\tau)y_{it} + (1+r_s)(1-\beta_{it})W_{it}, \tag{9}$$

if the agent is a saver.

Households who are unable to repay their debt go bankrupt. This occurs whenever 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 expression above can also be defined in terms of 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.

2.2 The timeline of events

In each time period the sequence of events is the following:

- Desired consumption and the ensuing households credit demand is determined
- Government consumption and the government balance are fixed.
- The bank sets the credit supply, which is allocated to consumers.
- Actual private consumption is determined
- Aggregate income of the period is computed and distributed between agents
- Taxes are collected
- Households repay their debt, compute their wealth, and bankruptcies occur.

3 Steady state conditions

Before carrying out simulation experiments we identify the steady state conditions of the model that we impose at beginning of each simulation run. In steady state, the levels of all micro (households wealth, households income, households consumption, debt, profits of the bank) and macro (aggregate consumption, government expenditure, income, tax revenues) variables are constant. Moreover, in steady states, credit rationing is absent. Notice that such a steady state is not unique. In particular, in Section 4 we show that the model has multiple steady states, also characterized by a positive share of credit rationed consumers.

Let us begin considering steady state conditions for households wealth, which plays a central role in the model, as it determines actual consumption, aggregate income, tax revenues (and thus government balance). In addition, by fixing the overall amount of consumption loans it affects bank's revenues and net worth. First, notice that the assumption that each mill buys wheat from households in proportion to their 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 mentioned in Section 2, 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. In absence of credit rationing, all borrowers are able to satisfy their consumption plans. Accordingly, the steady state level of wealth of household i is

$$w_i^* = \frac{\alpha_i(1-\tau)Y^{H*}}{[1-(1+r^b)(1-\beta_i^*)]} \tag{10}$$

if the agent is a borrower, and

$$w_i^* = \frac{\alpha_i(1-\tau)Y^{H*}}{[1-(1+r^s)(1-\beta_i^*)]} \tag{11}$$

if the agent is a saver. The above steady state levels are stable, if $|(1+r^b)(1-\beta_i^*)| < 1$ for a borrower, and $|(1+r^s)(1-\beta_i^*)| < 1$ for a saver.

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

$$C_i^* = \gamma_i^* C^*, \qquad \sum_{i=1}^{N} \gamma_i^* = 1 \tag{12}$$

Moreover, as $C_i^* = \beta_i^* w_i^*$ and $C^* = (1-\tau)Y^{H*}$, the relations between individual consumption shares γ_i^* and marginal propensity to consume β_i^* are:

$$\frac{\beta_i^* \alpha_i}{[1-(1+r_b)(1-\beta_i^*)]} = \gamma_i^* \tag{13}$$

$$\frac{\beta_i^* \alpha_i}{[1-(1+r_s)(1-\beta_i^*)]} = \gamma_i^* \tag{14}$$

for a borrower and a saver respectively. Solving the above equations for β_i^* we get:[4]

$$\beta_i^* = \frac{\gamma_i^* r^b}{[\gamma_i^* r^b + (\gamma_i^* - \alpha_i)]} \tag{15}$$

in the case of a borrower, and

$$\beta_i^* = \frac{\gamma_i^* r^s}{[\gamma_i^* r^s + (\gamma_i^* - \alpha_i)]} \tag{16}$$

for a saver. Finally, given Equations (15) and (16), we design 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 $0 < \eta^* < 1$. In Section 4.2 we also experiment with different values of $< \eta^*$, in order to

[4]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.

analyze how recession and multiplier dynamics change in economies which are initially more or less leveraged.

4 Simulation experiments

All simulation experiments are carried out according to the following scheme. We assume that the economy is initially in steady state (cf. Section 3) and we shock it by letting a fraction f of households go bankrupt. We then track the dynamics of aggregate output under different types of fiscal rules. We considered three types of fiscal rules:

- *Deficit-spending* rule. The government keeps the level government spending at the steady state level and deficit emerges whenever tax revenues fall below the steady state level
- *Balanced-budget I* rule. The government keeps the level of public spending at the steady state level, but tax rate is adjusted accordingly so that tax revenues are equal to government spending in every period.
- *Balanced-budget II* rule. Government spending is equal to tax revenues in every period.

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 the fiscal impulse in the model. In what follows we perform experiments with different intensities of the fiscal impulse.

In our analysis we mainly focus on government spending multipliers, which are computed as the variation in aggregate output between two different experiments characterized by different levels of government consumption. More precisely, let $Y_z^{fr}(t)$ and $G_z^{fr}(t)$ indicate respectively the paths of aggregate output and government spending associated with the fiscal rule "fr" (e.g. deficit-spending) and the baseline level of fiscal intensity z, in which government consumption correspond to 1% of steady state income. For different levels of fiscal intensity h (e.g. government spending equals to 2% of steady state output), the multiplier is calculated as follows (see Aruoba et al., 2013, for a very similar procedure applied in a DSGE framework)

$$m_h^{fr}(t) = \frac{Y_h^{fr}(t) - Y_z^{fr}(t)}{G_h^{fr}(t) - G_z^{fr}(t)}, \tag{17}$$

with $h \neq z$.[5]

[5] In the *balanced-budget II* rule the level of government spending corresponds initially to the baseline h, and it then evolves according to the tax revenues.

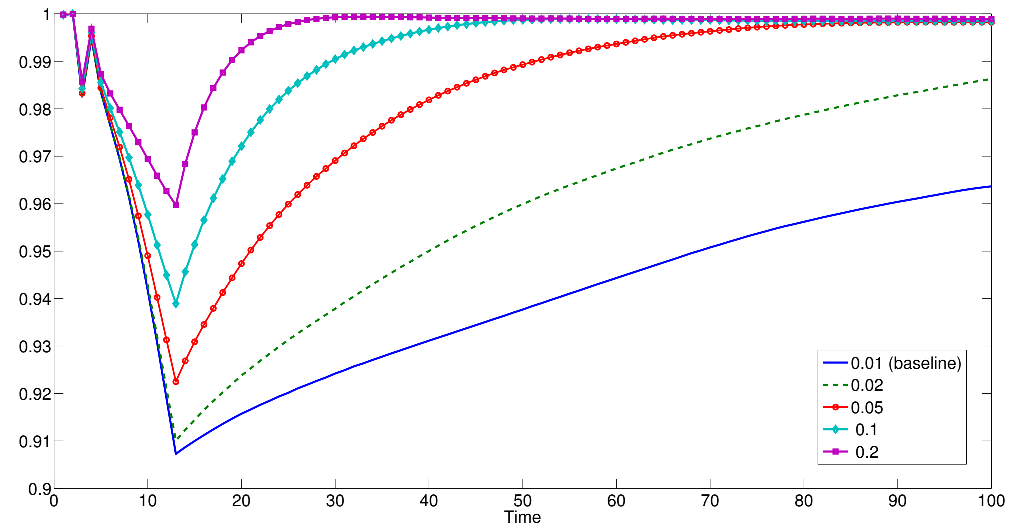

Figure 1: Evolution of aggregate income as a fraction of steady state income. Deficit-spending rule. The values in the legend correspond to different intensities of fiscal intensity. Each point of the graphs is an average of 50 independent Monte-Carlo simulations.

4.1 Fiscal rules, credit rationing and fiscal multipliers

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 shock where a fraction $f = 5\%$ of all borrowers go bankrupt. The plot shows two central results of the model. First, higher levels of government expenditures (expressed as fraction of steady state income) reduce the magnitude of the negative effects of the bankruptcy shock. In other words, higher levels of government consumption reduce the fall in aggregate output in the aftermath of the shock, a result in tune with recent works in the literature (see e.g. Galí et al., 2007; Kaplan and Violante, 2011; Anderson et al., 2016; Parker et al., 2013). Second, the size of government expenditures affects the speed of the recovery. More specifically, higher levels of government consumption decrease the persistence of the shock and favor a quicker recovery to the steady state level of income.[6]

The dynamics of fiscal multipliers after a bankruptcy shock for different intensities of government expenditure is shown in Figure 2. The values of fiscal multipliers follow an inverse U-shaped pattern, which is more pronounced for higher levels of fiscal intensity, and peak values are reached after the through of the recession (compare Figs. 2 and 1). Such results confirm the insights of the recent empirical works on state-dependent fiscal multipliers (e.g. Auerbach and Gorodnichenko, 2012; Ferraresi et al., 2014). Moreover, Figure 2 shows that the value of the peak multiplier is decreasing in the level of the

[6] As we explained in the previous section, the deficit associated with this budgetary rule is generated by the fact that on the one hand government spending is kept fixed at the steady state level, whereas tax revenues fall with income. As tax revenues are proportional to income, it follows that the deficit will eventually be absorbed whenever aggregate income returns to the steady state level, an outcome that occurs for a levels of fiscal intensity that are high enough (cf. Figure 1).

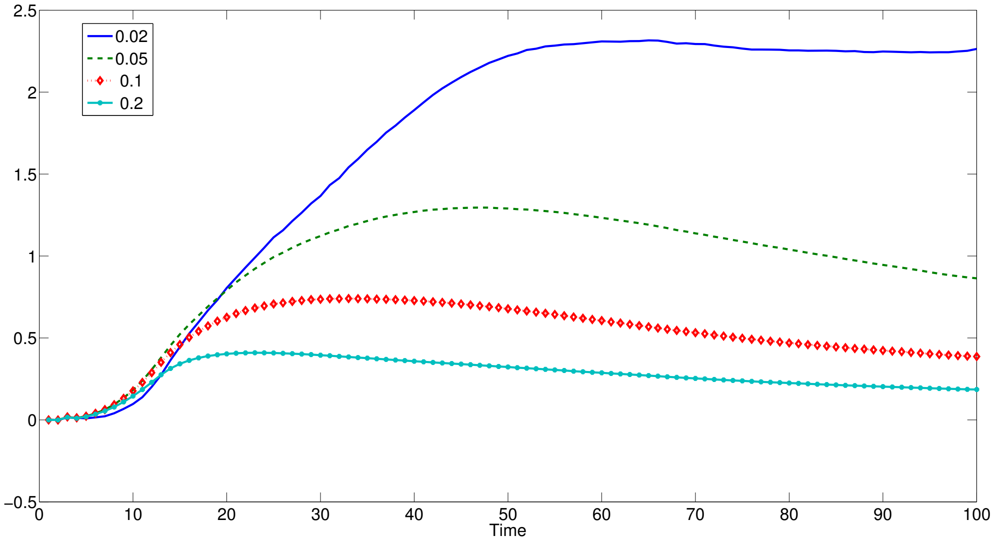

Figure 2: Evolution of fiscal multipliers. Deficit-spending rule. All multipliers are calculated in relation to the baseline fiscal intensity $k = 0.01$ (see also Eq. (17)). Each point of the graphs is an average of over 50 independent Monte-Carlo simulations.

government expenditure. In particular, peak values of the multipliers higher than one are associated with relatively low fiscal intensities (e.g. government spending equal to 2% or 5% of steady state income), while higher levels of government expenditures have peak values lower than one.

To shed more light on the mechanics of recessions and multipliers, we study the evolution of credit rationing in the aftermath of a bankruptcy shock. Figure 3 shows the evolution of the fraction of credit-constrained borrowers for different levels of fiscal intensity. First, the figure shows that the through of the recession coincides with the peak in credit rationing. Second, the fraction of constrained borrowers decreases with the level of fiscal intensity. Third, also the persistence in credit rationing decreases with higher levels of government spending.

The rise in the fraction of constrained borrowers after the shock is in line with the insights in Koo (2008, 2011), and it is explained by the fact that households disposable income falls following a bankruptcy shock, because of the lower consumption demand of bankrupted households. Accordingly, an increasing number of households are forced to borrow funds in order to keep their desired level of consumption unchanged. At the same time, bank net worth is depleted by the accumulation of bad debt of bankrupted households and total credit supply plunges accordingly (see Equation 2). Furthermore, as household income is proportional to aggregate income and aggregate demand (cf. Equation 7), the reduction in household income is inversely proportional to the level of government expenditure. It follows that government spending acts as a parachute against the general fall in incomes and the increase in credit rationing. This explains why the number

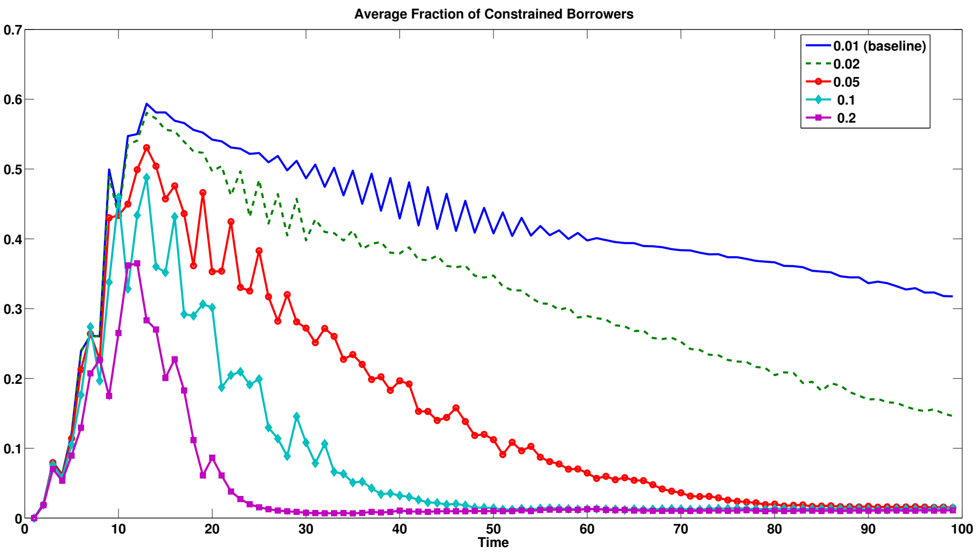

Figure 3: Evolution of the fraction of constrained borrowers. Deficit-spending rule. The values in the legend correspond to different intensities of fiscal intensity. Each point of the graphs is an average of over 50 independent Monte-Carlo simulations.

of constrained borrowers is lower for high levels of fiscal intensities, and the recovery from the credit rationing trap is faster.

The dynamics of credit rationing in the model also explains the behaviour of multipliers. By construction the consumption of credit constrained borrowers is equal to the level of their wealth, which closely tracks their income. It follows that a higher and more persistent credit rationing - as it occurs at low level of fiscal intensity - also generates a larger fiscal space, where government spending can have larger effects. This explains why in the model the size of the fiscal multiplier decreases with the level of government consumption. Interestingly, notice that in the model the dynamics of fiscal multipliers is lagging the one of credit rationing (compare Figure 1 and Figure 2). Thus, differently to standard Keynesian income-expenditure models but in line with the insights of Koo (2008) and Leijonhufvud (2009), in our model fiscal expenditure doers not bring immediate large increases in output. This is because the consumption of credit constrained consumers is bound by their wealth, which is low in the aftermath of the shock. However, by increasing income levels, fiscal expenditure also allows constrained borrowers to repair their balance sheets and to get back to effective consumption levels compatible with their desired plans. Such a process of "re-leveraging" explains why higher values of the multiplier are always observed with significant lags, in correspondence of decreases in the fraction of constrained borrowers (compare Figures 2 and 3).

The above discussion relates to experiments with the deficit-spending rule. How do results change if we allow for *balanced-budget* rules? Figure 4 shows the evolution of aggregate income (as a fraction of steady state income) in the case where the *balanced*

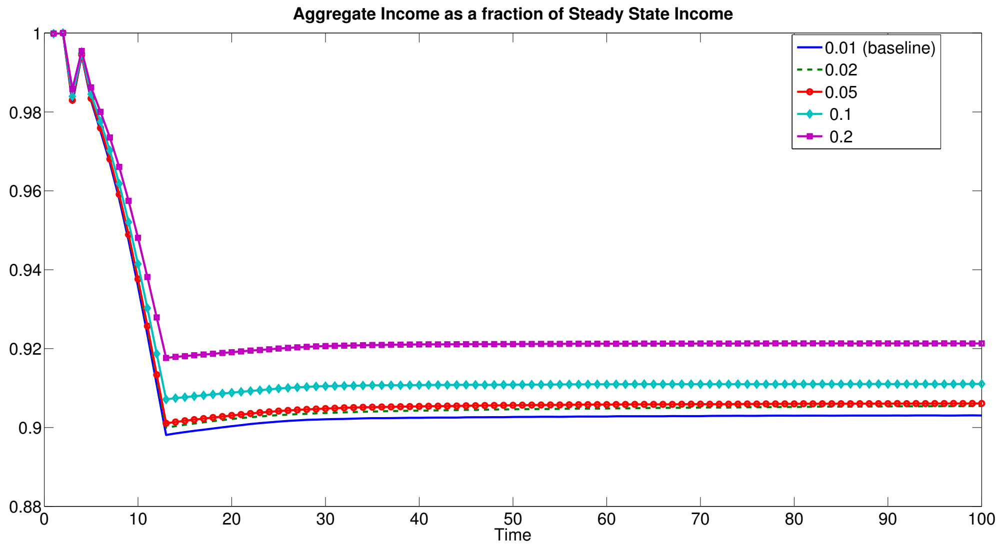

Figure 4: Evolution of aggregate income as a fraction of steady state income. Balance budget I rule. The values in the legend correspond to different intensities of fiscal intensity. Each point of the graphs is an average of over 50 independent Monte-Carlo simulations.

Fiscal Intensity	Deficit Spending	Balanced Budget I	Balanced Budget II
0.02	2.689	0.788	1.014
	(0.105)	(0.166)	(0.154)
0.05	1.331	0.272	0.294
	(0.028)	(0.051)	(0.049)
0.1	0.769	0.148	0.178
	(0.014)	(0.021)	(0.023)
0.2	0.425	0.109	0.109
	(0.007)	(0.012)	(0.012)

Table 1: Peak multipliers across different fiscal rules. Standard errors in parentheses. Values are averages across 50 independent Monte-Carlo simulations.

budget I rule (with endogenous tax rate) is adopted. Results are the same also for the other type of balanced budget rule (*balanced budget II* rule, with endogenous government expenditure). As the plot shows quite starkly, balanced-budget rules prevent the recovery of the economy from the initial bankruptcy shock. For any level of fiscal intensity, the economy moves to a new equilibrium characterized a level of income which is lower than the initial one (cf. Figure 4).

Let us now consider the peak multipliers obtained under the three different fiscal rules considered (see Table 1). Balanced-budget fiscal multipliers are always lower than the ones associated with the deficit-spending rule and they are never significantly higher than one.

These results can be understood by looking at the evolution of credit rationing with

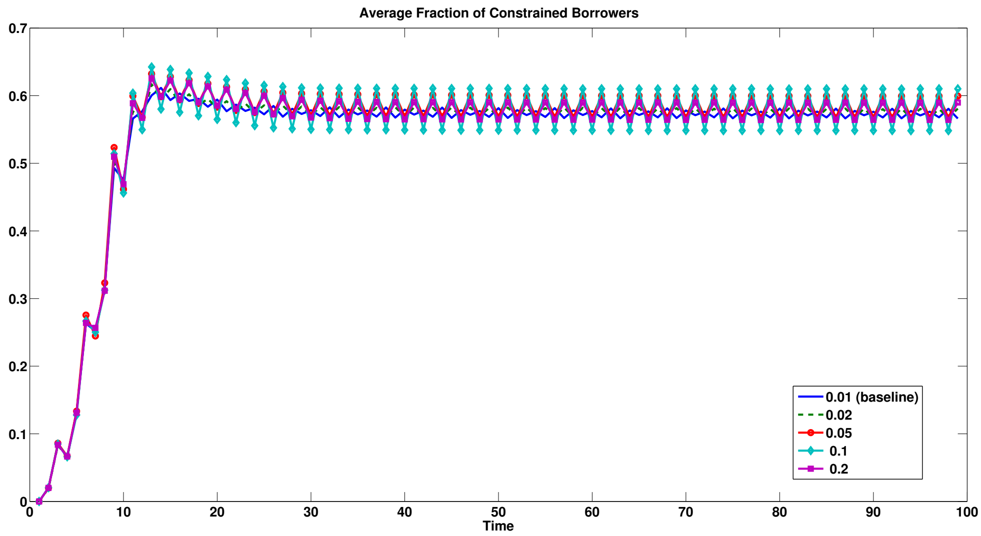

Figure 5: Evolution of the fraction of constrained borrowers. Balanced-budget I rule. The values in the legend correspond to different intensities of fiscal intensity. Each point of the graphs is an average of over 50 independent Monte-Carlo simulations.

balanced budget rules (cf. Figure 5). With both balanced budget rules the fraction of credit constrained borrowers becomes very high at any level of fiscal intensity. In addition, this fraction does not decrease over time, as in Figure 3. On the one hand, rising the tax rate to fully balance government expenditure (as in the balanced budget rule I) further depresses household disposable incomes that are already falling after the bankruptcy shock and it reinforces credit rationing and de-leveraging in the economy. On the other hand, decreasing government expenditure (as in the balanced-budget rule II), does not trigger the re-leveraging process necessary to restore the pre-shock output levels observed under the deficit spending rule.

4.2 Credit conditions and fiscal multipliers

In the previous section we have shown how the dynamics of recessions and fiscal multipliers strongly interplays with the dynamics of credit rationing. We now turn to study how different variables affecting credit conditions influence the size of the fiscal multiplier. More specifically, we focus on the deficit spending rule and we experiment both with variables affecting the cost of credit (e.g. the spread on borrowers interest rate, μ^b), as well as with variables affecting the supply of credit (e.g. the credit multiplier k), or the persistence of credit rationing (e.g. the duration of the credit embargo on bankrupted households, $T_{default}$). Finally, we also analyze deficit-spending fiscal multiplier in economies characterized by different levels of leverage, captured by the initial fraction of borrowers in the economy (the paramater η^*).

Let us begin with the effects of the spread on borrowers interest rate. Figure 6

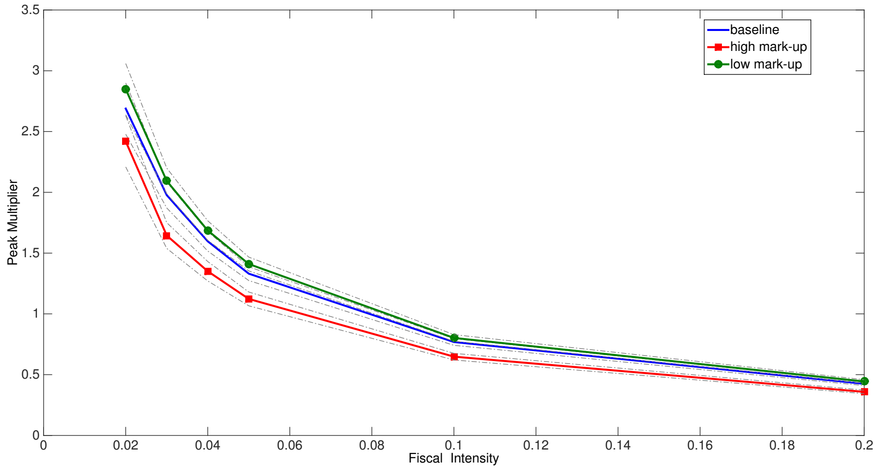

Figure 6: Peak fiscal multipliers as a function of the fiscal intensity and for different mark-ups on borrower interest rate. 95% confidence bands in gray. Deficit-spending rule. Values are averages over 50 independent Monte-Carlo simulations.

compares the peak fiscal multiplier as a function of fiscal intensity in the baseline case ($\mu^b = 0.1$) as to the cases of high ($\mu^b = 0.5$) and low ($\mu^b = 0.01$) mark-ups. Reducing mark-up rates does not significantly impact on multiplier values. However, higher spreads result into lower fiscal multipliers. By implying higher interests on household debt, higher mark-up rates boost bank profits thus enhancing a faster recovery of bank's net worth after the bankruptcy shock. As a consequence, the process of recovery from credit rationing is faster and multiplier values are lower (see Dosi et al., 2015, for a similar dynamics).

A mechanics similar to the one just described is at the root of the dynamics when the credit multiplier is changed. Figure 7 shows the effects on peak multipliers of the experiments where the credit multiplier is either increased ("high credit multiplier", $k = 4$) or decreased ("low credit multiplier", $k = 1$) with respect to the baseline ($k = 2$). Lowering credit multipliers produces peak multipliers which are statistically lower than the baseline, whereas this does not occur for high credit multiplier values. This is explained by the fact that lower credit multipliers also imply a lower bank's leverage and thus a lower impact of bankruptcy shocks on credit supply. As a consequence, the increase in credit rationing is smalle when the bankruptcy shock hits the economy, and the fiscal space and the ensuing fiscal multipliers are smaller.

The parameters discussed so far have only an indirect effect (via bank's net worth) on the dynamics of credit rationing in the economy. Figure 8 shows instead the results of the experiment where we tune up and down a parameter directly affecting the credit rationing of one class of agents, namely the duration of the credit embargo on bankrupted households ($T_{default}$). The figure shows that sanctioning more bankrupted households, by increasing the duration of the credit embargo (to 40 periods, from a baseline level of 10 periods) has a huge effect on the size of the multipliers. In contrast, fiscal multipliers

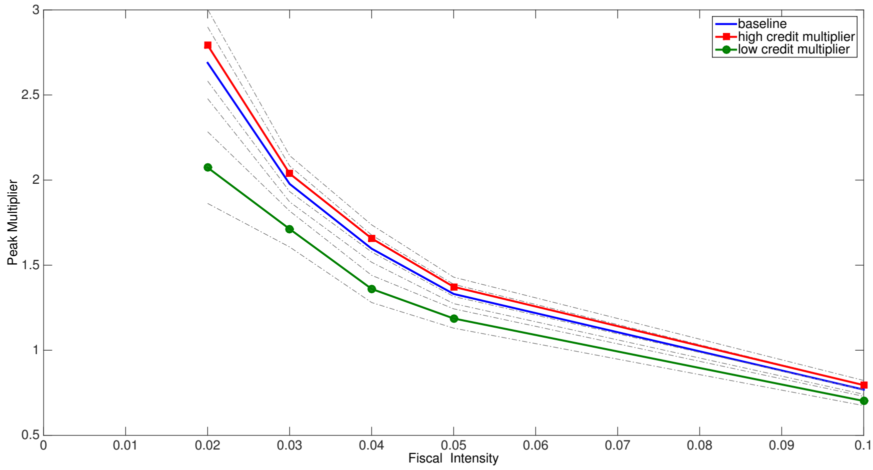

Figure 7: Peak fiscal multipliers as a function of the fiscal intensity and for different values of the credit multiplier. 95% confidence bands in gray. Deficit-spending rule. Values are averages over 50 independent Monte-Carlo simulations.

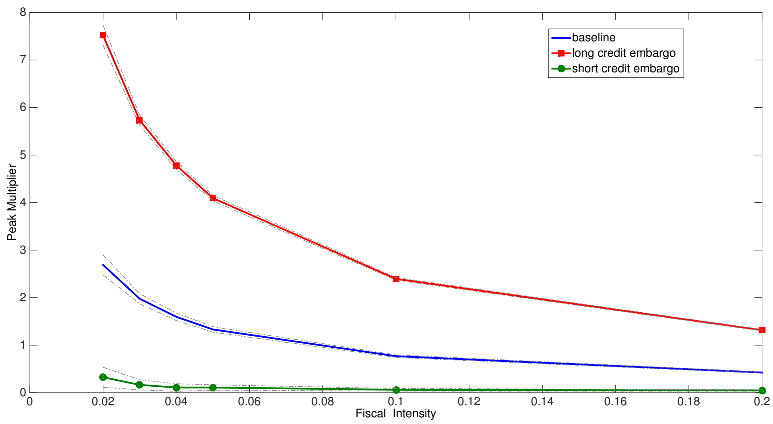

Figure 8: Peak fiscal multipliers as a function of the fiscal intensity and for different durations of the credit embargo on bankrupted households. 95% confidence bands in gray. Deficit-spending rule. Values are averages over 50 independent Monte-Carlo simulations.

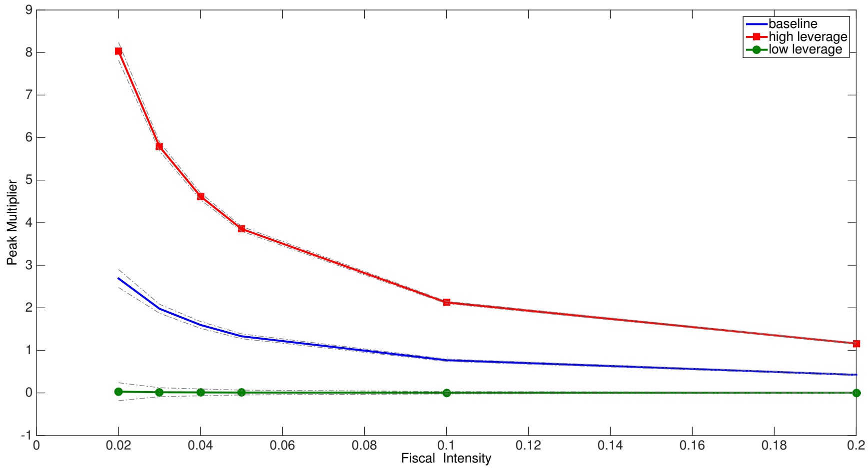

Figure 9: Peak fiscal multipliers as a function of the fiscal intensity and for different shares of borrowers in the economy. 95% confidence bands in gray. Deficit-spending rule. Values are averages over 50 independent Monte-Carlo simulations.

become basically zero when the duration of the credit embargo is very low (2 periods). Moreover, such effects are much stronger than those observed in the previous cases. Longer credit embargoes imply that bankrupted households are forced to keep their consumption expenditures below their desired levels for a longer period of time. As a consequence, the fall in aggregate demand is more persistent and credit rationing will be larger and more prolonged. In such a framework, the fiscal multipliers rise. In contrast, in the scenario where bankrupted households are quickly reabsorbed in the pool of borrowers, the fall in aggregate demand and the ensuing credit rationing are much less persistent and the multipliers fall almost to zero.

Similar results to those just mentioned are also observed when one changes the shares of borrowers in the economy. More precisely, Figure 9 compares the size of multipliers in the baseline scenario, where borrowers are half of household population, to the "high leverage" (share of borrowers equal to 80% of households) and "low leverage" (share of borrowers equal to 20% of households) scenarios. The figure shows that multipliers are much higher in more leveraged economies, whereas multipliers become zero in economies having small fractions of debt-dependent expenditures.

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. The credit supply of bank depends on its net worth and it is affected by bad debts resulting from the bankruptcy of households. Moreover, the government taxes agents and purchases goods following different fiscal rules. Finally, aggregate income is determined by aggregate demand.

Simulation results show that small bankruptcy shocks can trigger wide and persistent falls in output. This occurs because bankruptcy shocks trigger both a fall in aggregate demand and in households income, and a reduction in credit supply, thereby provoking a surge in credit rationing that magnifies the effects of the initial shock (in the spirit of the works of Koo, 2008, 2011).

In such a framework we analyze the effects of deficit spending vis-à-vis balanced-budget fiscal rules. We find that a deficit-spending rule is able to reduce the impact of the bankruptcy shock on the economy and to favor a fast recovery from the recession. In contrast, balanced-budget rules imply a permanent fall of output below the pre-shock levels (in line with Dosi et al., 2015). Government spending multipliers are typically much higher in the deficit-spending scenario that in the balanced-budget ones. Moreover, the size of the multiplier is time-varying and is determined by the degree and persistence of credit rationing in the economy. In particular, the largest values are observed with significant lags during a recession. This is because, differently from a standard keynesian income-expenditure channel, the effects of fiscal expenditure in our model are initially dampened by the presence of credit rationing and by the low-levels of constrained borrowers' wealth. At the same time, by increasing households income, fiscal expenditure allows households to repair their balance sheets and allows them to return to normal consumption levels, in line with the insights of Koo (2008) about the effects of fiscal policy in the Japanese recession, and with the ones of Leijonhufvud (2009) about the post-war experience in the US.

Finally, we study the impact of credit market conditions on the size of multipliers. We find that higher borrower interest rates and lower credit multipliers induce a reduction in the value of the fiscal multipliers, as they improve banks' balance sheets, thus reducing the level of credit rationing. Moreover, fiscal multipliers are higher in more leverage economies and when credit markets are "tighter", i.e. when bankrupted borrowers do not have access to credit for longer period of times. This occurs because bankruptcy shocks are likely to have stronger and more persistent impact on the credit rationing of such economies.

The model can be extended in several directions. First, we only focused on government spending multipliers. However, one could also analyze whether the above results generalize to different types of tax multipliers. Second, one can explore the possible role that price dynamics may play in strengthening or weakening the credit rationing dynamics and thus the size of the multiplier. Third, fiscal multipliers could be studied when households change their desired consumption over time. Fourth, one could study the possible interplay between inequality, credit rationing and macroeconomic dynamics (see e.g. Dosi et al., 2013, 2015). Finally, the model could be extended by introducing multiple consumption goods in order to study how the size of the multiplier differs according to which sectors of the economy government spending is directed to.

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