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Institute of Economics
Scuola Superiore Sant'Anna

Piazza Martiri della Libertà, 33 - 56127 Pisa, Italy
ph. +39 050 88.33.43
institute.economics@sssup.it

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Inequality, Redistributive Policies and Multiplier Dynamics in an Agent-Based Model with Credit Rationing

Elisa Palagi °
Mauro Napoletano §°*
Andrea Roventini °§
Jean-Luc Gaffard °*

° Institute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy
§ OFCE, Science-Po, Sophia Antipolis, France
* Universite' Cote d'Azur, SKEMA, CNRS, GREDEG, Nice, France

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Inequality, Redistributive Policies and Multiplier Dynamics in an Agent-Based Model with Credit Rationing

Elisa Palagi* Mauro Napoletano† Andrea Roventini‡
Jean-Luc Gaffard§

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Abstract

We build an agent-based model populated by households with heterogenous and time-varying financial conditions in order to study how different inequality shocks affect income dynamics and the effects of different types of fiscal policy responses. We show that inequality shocks generate persistent falls in aggregate income by increasing the fraction of credit-constrained households and by lowering aggregate consumption. Furthermore, we experiment with different types of fiscal policies to counter the effects of inequality-generated recessions, namely deficit-spending direct government consumption and redistributive subsidies financed by different types of taxes. We find that subsidies are in general associated with higher fiscal multipliers than direct government expenditure, as they appear to be better suited to sustain consumption of lower income households after the shock. In addition, we show that the effectiveness of redistributive subsidies increases if they are financed by taxing financial incomes or savings.

Keywords: income inequality, fiscal multipliers, redistributive policies, credit-rationing, agent-based models

JEL classification: E63, E21, C63

*Scuola Superiore Sant'Anna, Pisa (Italy); E-mail address: elisa.palagi@sssup.it

†Corresponding Author. Observatoire Français des Conjonctures Economiques (OFCE), France, and Université Côte d'Azur, SKEMA, CNRS, GREDEG, France, and Scuola Superiore Sant'Anna, Pisa (Italy); E-mail address: mauro.napoletano@sciencespo.fr

‡Scuola Superiore Sant'Anna, Pisa (Italy), and OFCE, Sophia-Antipolis (France); E-mail address: aroventini@sssup.it

§Observatoire Français des Conjonctures Economiques (OFCE), France, and Université Côte d'Azur, SKEMA, CNRS, GREDEG, France; E-mail address: jeanluc.gaffard@sciencespo.fr

1 Introduction

This work investigates how income inequality affects aggregate output in presence of financial market imperfections, and, relatedly, which type of fiscal policy is better suited to cope with increases in income inequality.

Two major trends have accompanied the eruption of the Great Recession in 2008: (i) a spectacular long-term increase in both income and wealth inequality (see Piketty, 2014), (ii) a surge in the fraction of debt-leveraged agents in the economy (see Mian and Sufi, 2015). The possible causal link between inequality and crises is still highly debated in the empirical literature (see Atkinson and Morelli, 2011; Bordo and Meissner, 2012). Nevertheless, some recent studies have stressed the presence of an empirical relation between inequality and the debt dynamics of households (see e.g. Coibion et al., 2014; Kumhof, Rancière, and Winant, 2015). Building on this insight, a number of theoretical works both in the DSGE (e.g. Iacoviello, 2008; Kumhof, Rancière, and Winant, 2015) and in the agent-based camps (see e.g. Caiani, Russo, and Gallegati, 2016; Cardaci, Saraceno, et al., 2015; Ciarli et al., 2012; Dosi et al., 2013, 2015, 2016a,b; Isaac, 2014; Russo, Riccetti, and Gallegati, 2016)[1] have proposed models where high inequality can indeed lead to recessions by producing excessive household leverage of low-income households.

In this work we link the latter strand of literature to the one that has empirically investigated the state-dependent nature of fiscal multipliers (e.g. Auerbach and Gorodnichenko, 2012) and the influence of credit regimes on fiscal policy effectiveness (e.g. Ferraresi, Roventini, and Fagiolo, 2014). We do so by building an agent-based model where permanent inequality shocks produce large and persistent falls in aggregate output by generating a high fraction of credit-constrained consumers. Next, we use the model to study how the effectiveness of different types of fiscal policies (direct government consumption, redistributive policies) changes with the amplitude of the inequality shock hitting the economy.

More precisely, we extend the agent-based model (ABM henceforth) developed in Napoletano, Roventini, and Gaffard (2015) to study how time-varying multipliers may emerge in presence of financial market imperfections and credit rationing. In that work, we focused on recessions generated by bankruptcy shocks affecting households, and we focused on the dynamics of fiscal multipliers associated with direct government consumption under alternative fiscal rules (deficit-spending, balanced-budget). In this work, we turn to analyze recessions generated by shocks changing the income distribution of agents. In addition, we consider a broader spectrum of fiscal interventions (direct government spending vs. redistributive policies), and of possible alternative methods of financing government subsidies (taxes on financial incomes or on savings). In the model households' income is proportional to aggregate income, and income shares vary across households, which, in

[1] For a survey on macroeconomic agent-based models, see Fagiolo and Roventini (2012, 2017).

turn, are heterogenous in desired levels of consumption. In the model, there are two classes of households/consumers: savers, who have enough resources to finance their desired consumption plans, and borrowers, who need credit to satisfy their desired consumption plans. Credit is provided by a bank, which gathers deposits from savers, pays interest on them and, finally, supplies credit to borrowers. The bank sets the supply of credit as a multiple of its net-worth and allocates it to borrowers using a pecking-order based on their financial fragility. As in Napoletano, Roventini, and Gaffard (2015) we identify a steady state in the model corresponding to a situation of full utilization of resources and no credit rationing. In that framework we then introduce shocks that permanently change the inequality in households' income shares.

Extensive Monte-Carlo simulations show that inequality shocks produce a permanent fall in output, by generating a large share of borrowers in the population, and a permanent increase in the fraction of credit-rationed households. Moreover, we find that direct government deficit-spending fiscal policy lowers the fall in income generated by the increase in inequality, thereby acting as a parachute against shocks.

As in Napoletano, Roventini, and Gaffard (2015), we find that fiscal multipliers associated with direct government spending are always larger than one. However, the size of the multiplier decreases with the intensity of the government intervention. The latter result reflects the fact that, at lower degrees of fiscal intensity, the fall in aggregate income resulting from a shock is larger (due to the lower "parachute" effect) and this generates a larger "fiscal space". Likewise we find that the multipliers associated for a given level of fiscal intensity decreases with the magnitude of the inequality shock. The latter result is explained by the fact that a stronger rise in inequality also generates a large redistribution in favor of the rich households, who save most of their income. In presence of credit rationing, this increases the leakage in aggregate expenditure, thereby reducing the size of the multipliers.

Furthermore, we compare the effectiveness of direct government spending vis-à-vis a redistributive policy providing subsidies to low-income households. As we assume that public budget is balances, total expenditures for subsidies are entirely financed by additional taxes. Our results show that, in general, subsidies are more effective than direct government spending in dampening the effects of the inequality shocks, and they are associated with larger fiscal multipliers. This difference is explained by the distributional consequences of the two fiscal policies. Government consumption affects directly aggregate demand and the benefits of this policy accrues to households in proportion to their share of aggregate income, and thus in higher proportion to richer households. This, in turns, generates additional saving and thus increases leakages in aggregate expenditure. In contrast, subsidies are specifically targeted to low-income households. This generates additional consumption and injections in aggregate expenditure.

Finally, we also experiment with different ways of financing subsidies, considering taxes on (i) profits and wage income related to the real economic activity (productive income henceforth); (ii) financial income (i.e. interests on deposits), (iii) deposit savings. We find that a redistributive policy financed by either taxes on financial incomes or on savings is more effective than one financed via taxes on productive income. The reason of this difference is explained by the fact that the latter type of tax reduces the income of all households in the economy, and of low income households in particular, thereby dampening the effects of subsidies. The other two types of taxes, instead, target directly the sources of leakage in the aggregate expenditure, thereby contributing to increase the effectiveness of the subsidies policy.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 presents the simulation results, starting with the effect of inequality shocks, and then turning to analyze the effectiveness of different types of fiscal policies. Finally, Section 4 concludes.

2 The model

In the model there are N heterogeneous households. Each household i owns a fixed amount of an homogeneous input good, "wheat", that cannot be used for consumption and which is sold in order to gather resources for consumption. The input good is purchased by j homogeneous firms, the "mills", that use it to produce an output good, "flour". Households consume the homogeneous output good produced by firms.

Firms use a constant returns to scale technology. Firm j's production function is

$$Y_{jt} = L_{jt} \tag{1}$$

where L_{jt} is the amount of wheat purchased by the firm. Total output is simply

$$Y_t = L_t \tag{2}$$

The price at which the wheat is purchased is P_l. The firms gets zero profits out of the consumable good production so that $P_0 = P_l$. Finally, in this model overall consumption demand determines the level of mills' output up to the maximum level of available wheat L^{max}.

Each household has a constant desired level of consumption Z_i such that if $Z_i \leq W_{it}$, where W_{it} is households' i liquid wealth at time t, the household is a saver and her consumption equal to her desired level. Otherwise, if $Z_i > W_{it}$, household i is a borrower. Savers can always finance their consumption with their own liquid 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. Later on we insert the possibility of credit rationing: borrowers who do not get credit will not be able to satisfy their desired consumption plans, and they will be forced to rely only on their liquid wealth for consumption.

In the economy there is a representative bank whose total credit supply is a multiple of the net worth of the bank E_t^B (Delli Gatti et al., 2005)

$$TS_t = kE_t^B \tag{3}$$

where $k > 0$ is the credit multiplier and, since we are in an endogenous money framework (Lavoie, 2003), $k > 1$. Credit supply depends on the bank's net worth at time t, E_t^B, such that the healthier is the bank from a financial viewpoint, the higher is the credit supply in the economy. Credit is allocated to agents using a pecking order (Dosi et al., 2013, 2015) depending on the ratio between a household's wealth and credit demand, W_{it}/CD_{it}. Credit demand is given by $CD_{it} = Z_{it} - W_{it}$. If total credit demand is higher than total credit supply some borrowers are partially or totally credit rationed. In the case credit is denied to some agents, their consumption is equal to their current net liquid wealth, W_{it}.

The bank sets the interest rate on loans by applying a mark-up μ 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 baseline interest rate $(0 < \mu^s < 1)$. Therefore, interest rates on loans and deposits are respectively

$$r^b = r(1 + \mu^b) \tag{4}$$

$$r^s = r(1 - \mu^s) \tag{5}$$

Bank liabilities, L_t^B, are defined as the difference between the assets of the bank (the credit supply) and its net worth:

$$L_t^B = kE_t^B - E_t^B = (k-1)E_t^B \tag{6}$$

Bank profits π_t^B are given by:

$$\pi_t^B = r_t^b(kE_t^B) - r^s(k-1)E_t^B = [r^s + k(r^b - r^s)]E_t^B \tag{7}$$

If some households go bankrupt, their bad debt, BD_{it}, negatively affects the bank's net worth and, thus, credit supply. Finally, we assume that there is a target level of net worth $\bar{E}_t^B$ such that if $E_t^B \geq \bar{E}_t^B$ bank profits are distributed to a homogeneous class of agents, the bankers, who entirely consume their income. If instead $E_t^B < \bar{E}_t^B$ then the bank does not distribute the profits, which are instead added to the bank's reserves. The law of motion for the bank's net-worth thus reads:

$$E_t^B = \begin{cases} E_{t-1}^B - \Sigma_{i=1}^N BD_{it}, & \text{if } E_t^B \geq \bar{E}_t^B \\ E_{t-1}^B + \pi_t^B - \Sigma_{i=1}^N BD_{it}, & \text{if } E_t^B < \bar{E}_t^B \end{cases} \tag{8}$$

Concerning fiscal policy, there is a proportional tax on income, such that households' disposable income is given by:

$$y_{it}^D = (1 - \tau)y_{it} \tag{9}$$

with $i = 1, ..., N$ and $\tau > 0$ being the tax rate.

The government sets its consumption level and the tax rate according to a deficit-spending fiscal rule. This means that the government keeps the level of government spending at the steady state level and deficit emerges whenever tax revenues fall below the steady state level. Government debt (if any) is purchased by the central bank.

Aggregate demand is given by

$$Y_t = AD_t = C_t + G_t + \pi_t^B \tag{10}$$

such that it is defined as the sum of households and government consumption, respectively C_t and G_t, plus the consumption of bankers, π_t^B, if any. As long as the constraint L^{max} is not binding aggregate income is determined by aggregate demand.

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 define $\beta_{it} = Z_i/W_{it}$ as household's i marginal propensity to consume out of wealth at time t. In particular, $\beta_{it} > 1$ if the household is a borrower, while $\beta_{it} \leq 1$ if the household is a saver.

It is assumed that consumption loans are fully repaid at the end of each period. The same occurs for the remuneration of savings.

The law of motion of agents' wealth is thus

$$W_{it+1} = (1 - \tau)y_t - (1 + r_b)(\beta_{it} - 1)W_{it} \tag{11}$$

if the agent is a borrower, and

$$W_{it+1} = (1 - \tau)y_t + (1 + r_s)(1 - \beta_{it})W_{it} \tag{12}$$

if the agent is a saver.

Households go bankrupt if they are unable to repay their debt. This occurs if household's resources at the beginning of the period are lower than debt plus interests, so if:

$$(1-\tau)y_{it} < (1+r_b)(\beta_{it}-1)W_{it} \tag{13}$$

In terms of consumption levels:

$$(1-\tau)y_{it} < (1+r_b)(C_{it}-W_{it}) \tag{14}$$

If a households goes bankrupt, his wealth is set equal to zero and the bank gets a credit loss equal to:

$$BD_{it} = (1+r_b)(C_{it}-W_{it}) - (1-\tau)y_{it} \tag{15}$$

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

Moreover, in some scenarios we consider later on, savers may face either a flat tax on financial income, ϕ, or a flat tax on deposits, η after an inequality shock is introduced. In the first case, savers' wealth is updated in the following way:

$$W_{it+1} = (1-\tau)y_t + \left[1+(1-\phi)r_s\right](1-\beta_{it})W_{it} \tag{16}$$

When, instead, a tax on deposits is applied, savers' wealth evolves according to:

$$W_{it+1} = (1-\tau)y_t + (1+r_s)(1-\eta)(1-\beta_{it})W_{it} \tag{17}$$

Furthermore, in some scenarios the government distributes a subsidy to low-income households after the inequality shock. This subsidy is directly added to the income of the household who receives it, and it is financed either by the proportional tax on income, or by the tax on financial income or, finally, by the tax on deposits.

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 are 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 to agents

- Taxes are collected
- Households repay their debt, compute their wealth, and bankruptcies occur

2.3 Steady state conditions

At the beginning of each simulation run the economy is in steady state. 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 state, credit rationing is absent and all resources are fully utilized. Notice that steady states are not unique in the model. In particular, in Section 3 we show that the model has multiple steady states, also characterized by a positive share of credit rationed consumers.

Each household is assigned a time-invariant share of total household income. Disposable income of each household i at time t can be therefore written as:

$$y_{it} = \alpha_i(1-\tau)Y_t^H \tag{18}$$

where Y_t^H is total household income.

The steady-state level of wealth, considering that in absence of credit-rationing all borrowers are able to satisfy their consumption plans, is

$$w_i^* = \frac{\alpha_i(1-\tau)Y_t^{H*}}{[1-(1+r^b)(1-\beta_i^*)]} \tag{19}$$

if the agent is a borrower, and

$$w_i^* = \frac{\alpha_i(1-\tau)Y_t^{H*}}{[1-(1+r^s)(1-\beta_i^*)]} \tag{20}$$

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 if $|(1+r^s)(1-\beta_i^*) < 1|$ for a saver.

Aggregate consumption is constant in steady state and each agent consumes a fraction of total consumption: equal to:

$$C_i^* = \gamma_i^* C_i^* \tag{21}$$

where $\Sigma_i^N \gamma_i^* = 1$.

Furthermore, as $C_i^* = \beta_i^* w_i^*$ and $C^* = (1-\tau)Y^{H*}$,

$$\frac{\beta_i^* \alpha_i}{[1-(1+r_b)(1-\beta_i^*)]} = \gamma_i^* \tag{22}$$

for a borrower;

$$\frac{\beta_i^* \alpha_i}{[1 - (1 + r_s)(1 - \beta_i^*)]} = \gamma_i^* \tag{23}$$

for a saver.

Finally, we can write agents' marginal propensity to consume in steady state for borrowers and savers respectively as

$$\beta_i^* = \frac{\gamma_i^* r^b}{[\gamma_i^* r^b + (\gamma_i^* - \alpha_i)]} \tag{24}$$

$$\beta_i^* = \frac{\gamma_i^* r^s}{[\gamma_i^* r^s + (\gamma_i^* - \alpha_i)]} \tag{25}$$

For a given distribution of income shares, consumption weights are randomly assigned to households and values of β_i^* are computed, so that the fraction of borrowers in the population is $0 < \eta^* < 1$.

3 Simulation results

In this analysis, each simulation experiment includes 50 independent Monte-Carlo simulations [2]. In each Monte-Carlo repetition, we run simulations for a series of 6 fiscal intensity parameters, which define government expenditures as percentages of steady state income. The same parameters also determine the proportional tax rate.

In addition to a proportional tax on income, households face either a tax on financial income or a tax on deposits.

Moreover, we consider two different scenarios for government expenditure. In the first one government consumption directly enters in aggregate income, using a deficit-spending fiscal rule. The government keeps the level of government spending at the steady state level and deficit emerges whenever tax revenues fall below the steady state level. In the second scenario, a subsidy is introduced after the inequality shock. The subsidy is targeted towards low-income households. This is a balanced-budget policy: total expenditure for subsidies is equal to the taxes collected by the government in the previous period.

In the initial steady state, income is assigned to households by using an algorithm generating shares that are comprehended within a small range of values[3]. This implies that the initial income distribution is quite egalitarian. Next, at time $t = 3$ the economy is shocked such that the distribution of income shares becomes considerably more unequal,

[2] As pointed out by Fagiolo and Roventini (2012, 2017), this method permits to have a distribution of a given statistics computed on simulated variables. In fact, given the stochastic nature of the process, each Monte-Carlo run will give a different value of such statistics. By analyzing how this statistics depends on some initial parameters, one can get descriptive knowledge of the dynamics in the system.

[3] See Napoletano, Roventini, and Gaffard (2015) for more details about the algorithm generating income shares

and we then track the dynamics of the economy resulting from the above shock. The analysis is performed for different magnitudes of the inequality shock that map different fractions of the income earned by the lower and middle classes. Three different inequality shocks are considered: a "low inequality shock", in which 98% of the population get 80% of total income, a "medium inequality shock", which is the one analyzed in detail in the subsequent section, in which the bottom 98% of the population get 60% of total income, and a "high inequality shock", in which the bottom 97% of the population get 40% of total income. Finally, we repeat the above described experiments with inequality shocks for the following policy scenarios:

- direct government expenditure, proportional tax on income and flat tax on financial income (Scenario I);
- direct government expenditure, proportional tax on income and flat tax on deposits (Scenario II);
- subsidy and proportional tax on income (Scenario III);
- subsidy and flat tax on financial income (Scenario IV);
- subsidy and flat tax on deposits (Scenario V).

3.1 Scenarios I and II: Medium inequality shock

Let us begin by discussing the case of a medium inequality shock introduced in the scenarios where government consumption enters directly in aggregate income (scenarios I and II). In both scenarios, aggregate income as a fraction of steady state income falls considerably after the inequality shock is introduced. This is revealed by Figure 1. When the distribution becomes more unequal, many households lack the internal resources necessary to finance desired consumption and there is a decline in aggregate demand that spurs a trend of plunging aggregate income, with the economy entering a recession, in line with Dosi et al. (2013, 2015) and Cardaci, Saraceno, et al. (2015).

The figure also shows the evolution of aggregate income over time for different fiscal intensity parameters, which set the level of (constant) government expenditure as a fraction of steady state income. First, the smaller is the fiscal intensity, the deeper is the downturn, suggesting that a more active government dampens the negative effects triggered by the switch to a regime of highly skewed income distribution.

Furthermore, Figure 1 also reveals that - for any fiscal intensity - the shock has permanent effect on aggregate income, which converges to a lower steady-state level. This is true for every fiscal intensity parameter considered. Let us turn to analyze the behavior of fiscal multipliers in the direct government expenditure scenarios. Multipliers are calculated as a ratio between the variation in aggregate output in two scenarios with different fiscal

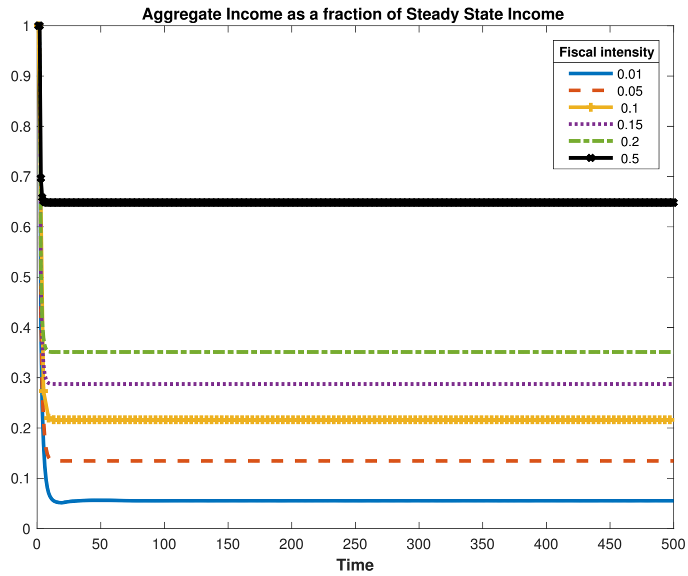

Figure 1: Evolution of aggregate income as a fraction of steady state income. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

intensities and the variation in government consumption in these two different cases. The baseline level of fiscal intensity z is the one in which government consumption corresponds to 1% of steady state income.

$$m_h^{fr}(t) = \frac{Y_h^{fr}(t) - Y_z^{fr}(t)}{G_h^{fr}(t) - G_z^{fr}(t)} \quad \text{with } h \neq z \tag{26}$$

The dynamics of fiscal multipliers is plotted in Figure 2. The figure shows that fiscal multipliers are state-dependent and time-varying. In addition, they are higher for lower levels of aggregate income. When aggregate income reaches extremely low levels after the inequality shock, active government expenditures can provide a stimulus to the economy and may, thus, have a stronger impact on the evolution of aggregate income. In other words, there is a bigger "fiscal space" in the cases where the crisis is more evident. Furthermore, Figure 2 reveals that - for all levels of fiscal intensity - peak multipliers are significantly higher than one. This is in line with Auerbach and Gorodnichenko's (2012) empirical findings about the high levels of multipliers during recessions.

To shed light on the drivers of high fiscal multipliers in the model, let us analyze the evolution of the fraction of constrained borrowers after the shock (cf. Figure 3). The share of credit-constrained borrowers rises after the inequality shock and stays permanently high. The introduction of an inequality shock leads to a situation in which many households find themselves with a lower income share than in steady state, such that their desired level of consumption, which is assumed to be constant over time, can now be higher than the resources at their disposal. In other words, following the inequality shock households' realized marginal propensities to consume become very high for agents

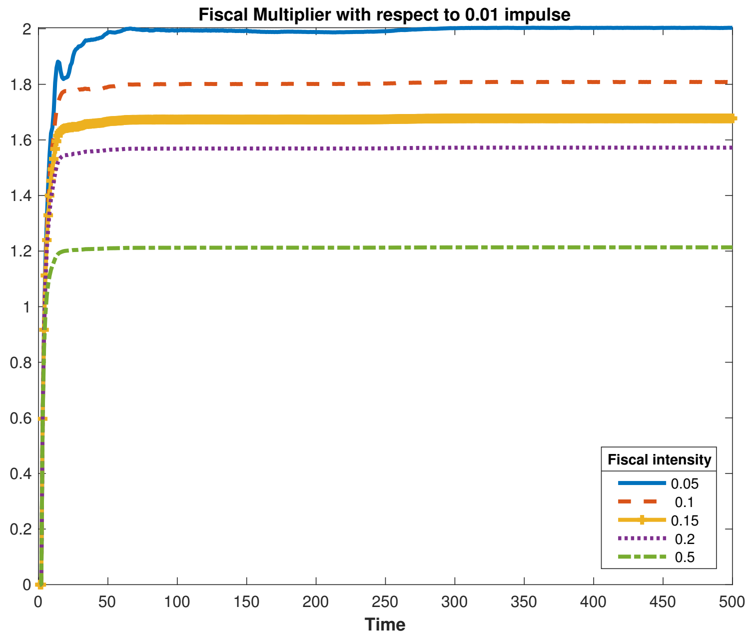

Figure 2: Evolution of fiscal multipliers with respect to 0.01 fiscal impulse. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

who cannot satisfy their consumption plans. These households are the ones who after the shock get a lower income share than in steady state [4]. This implies that a larger number of households has to take up debt in order to finance the same level of desired consumption. The pool of borrowers thus widens. In such a situation, credit supply is not sufficient to cover all credit demand, and credit rationing arises (Stiglitz and Weiss, 1981), and leads to a fall in aggregate consumption and in aggregate income. These above dynamics are in line with recent empirical findings (e.g. Ferraresi, Roventini, and Fagiolo, 2014), that suggest the fact that fiscal policy is more effective in tighter credit regimes. Again, government consumption can dampen the perverse dynamics triggered by a rise in inequality, and this is why we observe a lower fraction of constrained borrowers for higher fiscal intensity parameters.

3.2 Scenarios I and II: Comparison among different inequality shocks

The results of the previous section concern only the case of a medium inequality shock. In this section we move to compare the dynamics of the economy under alternative sizes of the shock.

Table 1 reports the minimum level of aggregate income (as a fraction of steady state income) that is obtained for different inequality shocks and different fiscal intensities.

[4] This is in line with the work of Caiani, Russo, and Gallegati (2016).

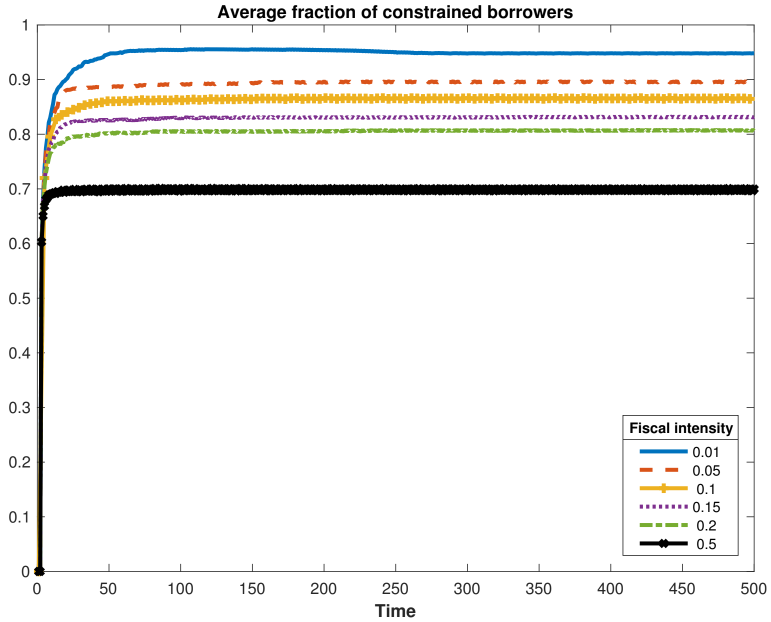

Figure 3: Evolution of the average fraction of constrained borrowers. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

Notice that the lower such a level of income is, the more severe are the consequences of a given shock. First, the results in the table indicate that more inequality generates larger falls in aggregate income. At any fiscal intensity, minimum income is lower in the case of the high inequality shock. Second, for any inequality shock the fall in income is lower if the level of fiscal intensity is higher. This confirms that government spending acts as a parachute against the fall in household incomes for whatever shape of the distribution of income.

Fiscal intensity	Low inequality	Medium inequality	High inequality
5%	18%	13%	11%
10%	27%	21%	18%
15%	34%	28%	25%
50%	68%	65%	61%

Table 1: Minimum aggregate income as a fraction of steady state income for low, medium and high inequality

These dynamics can be explained by looking at the average fraction of constrained borrowers in the different inequality scenarios. Figure 4 compares the dynamics of the share of credit constrained borrowers across the low and high inequality shock, and it clearly reveals that the average fraction of constrained borrowers is higher in the case in which the level of inequality becomes higher.

Finally, Table 2 compares the evolution of multipliers for different inequality scenarios. The results in the table indicate that a less skewed distribution of income is associated

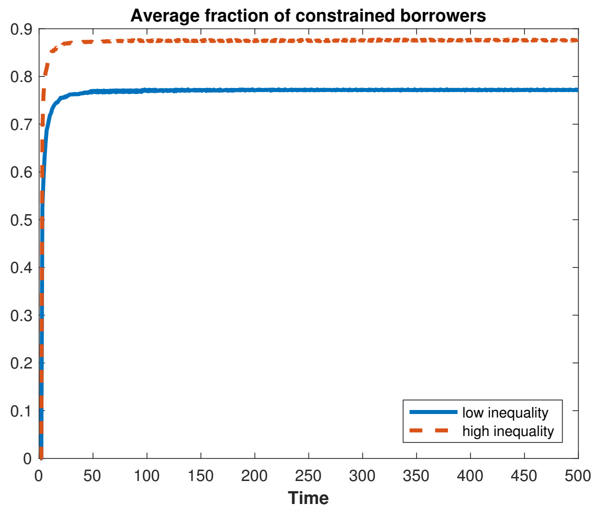

Figure 4: Average fraction of constrained households for 15% fiscal intensity parameter, low inequality vs. high inequality

with higher multipliers. This may at first glance sound counter-intuitive because higher inequality is associated with higher aggregate income falls, and thus one would expect a larger fiscal space as well. However, it becomes more clear if one thinks more carefully about the distributional consequences of inequality shocks. A stronger inequality shock generates a larger distribution of income in favor of the rich, who save most of their income. In presence of credit rationing, this increases the leakage in aggregate expenditure and the multiplier is therefore reduced. This sheer effect of the rise of inequality is further reinforced by the fact that, when government consumption affects directly aggregate demand, the benefits of fiscal policy accrue to households in proportion to their share of aggregate income, and thus in higher proportion to rich households, who save instead of generating additional expenditure.[5]

Fiscal intensity	Low inequality	Medium inequality	High inequality
5%	2.36	1.97	1.51
10%	2.02	1.80	1.46
15%	1.81	1.67	1.39
50%	1.21	1.21	1.14

Table 2: Peak multipliers with respect to 1% fiscal intensity.

3.3 Redistributive fiscal policies

This section analyzes the effects of the introduction of redistributive policies in the economy. We first analyze the case where the subsidy is financed by a proportional tax on

[5]Notice however that, in a genuine Keynesian fashion, aggregate saving falls with aggregate income following the inequality shock.

income (Scenario III). Next, we turn to study the cases where the subsidy is financed by a tax on financial income (Scenario IV) and, finally, by a tax on deposits (Scenario V).

3.3.1 Scenario III

Let us focus again on the scenario with medium inequality shock. The introduction of a subsidy financed by a proportional tax on income, implies a less severe downturn compared to the case of direct government spending (compare Figures 5 and 1). This confirms empirical findings about positive effects of redistribution on the evolution of output (e.g. Ostry, Berg, and Tsangarides, 2014) and theoretical findings that posit that the introduction of subsidies stabilizes macroeconomic dynamics (e.g. Caiani, Russo, and Gallegati, 2016; Dosi, Fagiolo, and Roventini, 2010; Dosi et al., 2013). Consider for instance the case where the fiscal intensity parameter is equal to 15%. What emerges from Table 3 is that the minimum aggregate income, measured as a fraction of steady state income, is of 34%, compared to a minimum income of 28% in a scenario without subsidy. In fact, when a subsidy is introduced after the inequality shock, poorer households are able to increase more their consumption, thereby contributing to dampen the adverse effects of the rise of inequality and to increase the resilience of the economy.

The effects of the introduction of a subsidy widely differ depending on the fiscal intensity parameter. In fact, as emerges from Figure 5, for the highest value of the parameter, the fall in aggregate income is quite limited and, after some periods, the subsidy allows the economy to attain a level of aggregate income which is close to the initial one, given by the more egalitarian distribution of income. This is because the government has a higher amount of resources at its disposal to be used for redistributive purposes. Therefore, in this scenario with 50% fiscal intensity, a high government expenditure in the first periods reduces the fall in aggregate output, and, combined with the introduction of the subsidy after the inequality shock, it allows the economy to quickly recover from the crisis, almost fully. However, for all fiscal intensity parameters, the economy reaches a steady state which is lower than the initial one.

Fiscal intensity	Direct government expenditure	With subsidy
5%	13%	14%
10%	21%	24%
15%	28%	34%

Table 3: Minimum aggregate income as a fraction of SS income, medium inequality shock. Direct government expenditure vs. subsidy.

Comparing multipliers for the cases with subsidy and with direct public expenditure, it turns out that peak multipliers are higher in the former case. Taking again as example the case with a fiscal intensity of 15 percent, Table 4 shows that the value of the multiplier

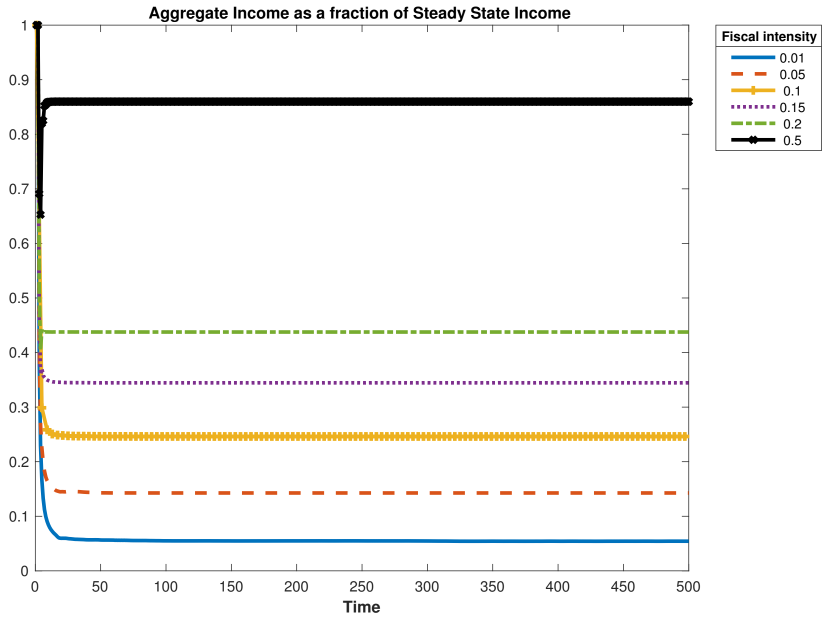

Figure 5: Evolution of aggregate income as a fraction of steady state income. Scenario III, medium inequality shock.

Fiscal intensity	Direct government expenditure	With subsidy
5%	1.97	2.19
10%	1.80	2.23
15%	1.67	2.08

Table 4: Peak multipliers with respect to 0.01 fiscal impulse. Medium inequality. Direct government expenditure vs. subsidy.

is equal to 2.08 with subsidy, while it is equal to 1.67 in the scenario without this redistributive policy. In other words, the subsidy has a bigger effect on aggregate income than direct public expenditure. This is because the subsidy increases directly poor households' disposable income. This dampens the increase in leakage resulting from the inequality shock (see previous section), thus generating a higher multiplier compared to the case of direct government expenditure.

Summing up, the introduction of a redistributive policy, such as a subsidy, not only attenuates the fall in aggregate income due to an inequality shock, by functioning as an automatic stabilizer. It also triggers larger variation in incomes than direct government consumption. The higher effectiveness of redistributive fiscal policies is also evident across different inequality shocks. Table 5 shows the effects of introducing the subsidy in different inequality scenarios. What emerges is that the subsidy limits the fall in aggregate income for each of the three scenarios and for each fiscal intensity parameter (compare Table 5 to Table 1).

Finally, Figure 6 tracks the evolution of fiscal multipliers associated with the introduc-

Inequality shock	Direct government expenditure	With subsidy
Low	34%	43%
Medium	29%	34%
High	25%	29%

Table 5: Minimum aggregate income as a fraction of steady state income for low, medium and high inequality. Direct government expenditure vs. subsidy. 15 percent fiscal intensity.

tion of a subsidy, respectively for the low and high inequality shocks. Similarly to the case of direct government spending, fiscal multipliers are higher when inequality is lower. This is again explained by the dynamics of the model, that implies a higher leakage associated with stronger inequality shocks (see discussion in the previous section). Nevertheless, for any magnitude of the inequality shock, the subsidy allows a higher fiscal multiplier effect than direct. This is revealed by Table 6, that compares peak multipliers for the different policy scenarios considered so far (and for a fiscal intensity of 15%). Let us now turn to analyze whether the effects of redistributive policies are affected by the way the subsidy is financed.

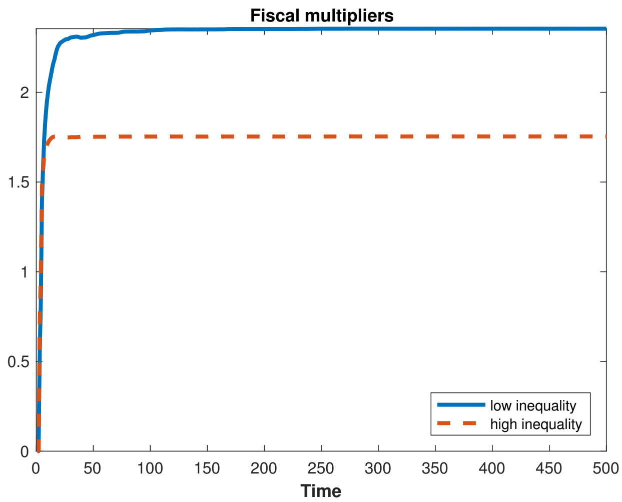

Figure 6: Evolution of fiscal multipliers for 0.15 fiscal intensity with respect to 0.01 fiscal impulse in the scenario with subsidy. Low and high inequality shock.

Inequality shock	Direct government expenditure	With subsidy
Low inequality	1.88	2.24
Medium inequality	1.63	2.12
High inequality	1.39	1.74

Table 6: Maximum multiplier for 0.15 fiscal intensity parameter with respect to 0.01 fiscal impulse. Direct government expenditure vs. subsidy (Scenario III).

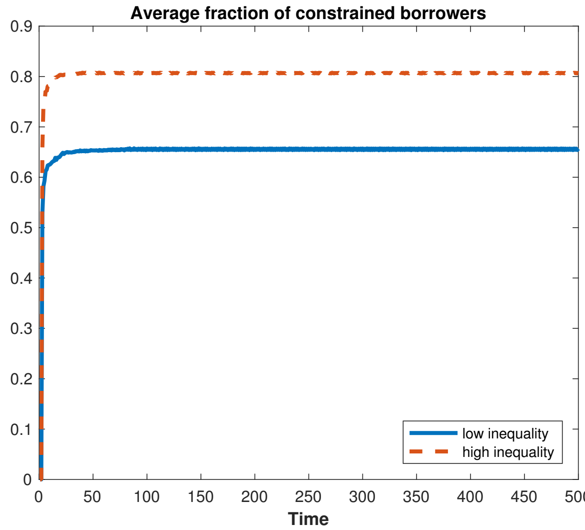

Figure 7: Evolution of average fraction of constrained borrowers in the scenario with subsidy, low and high inequality shock. 15% fiscal intensity parameter.

3.3.2 Scenario IV

Consider first the case in which the subsidy is financed with a tax on financial income instead of a flat tax on income. Our simulations show that the magnitude of the fall in aggregate income is basically the same as in the previous case. What significantly changes is the dynamics after the crisis. In fact, for any fiscal intensity parameters, aggregate income does not get stuck at a lower level of income, but it returns to the initial steady state level.

Furthermore, and in line with previous results, a high fiscal intensity parameter limits the fall in aggregate income. When the subsidy is introduced after the crisis, aggregate income increases faster in cases where the fall is less severe. The dynamics underlying the initial fall in aggregate income and the subsequent increase are analogous to the ones presented in previous sections. Scenario IV, by taxing financial income, allows a higher degree of redistribution in the population. This allows households to repair their balance sheets throughout the time span considered, and gradually increase their consumption.

A comparison of the different inequality cases shows that the fall in aggregate income is more pronounced for higher levels of inequality, as visible from Table 7. Moreover, the subsequent recovery is faster when inequality is low. In fact, low inequality is associated with a lower fraction of constrained borrowers in the population, as shown in Figure 9. This means that when inequality is high a higher fraction of households are not able to satisfy consumption plans. In this case, the recovery is slower.

Let us now analyze fiscal multipliers and compare their evolution in the low and high inequality cases. At the beginning, for several periods, these are higher when the system is characterized by a low concentration of income, as shown in Figure 10. By increasing income levels, subsidies allow borrowers to repair their balance sheets. However,

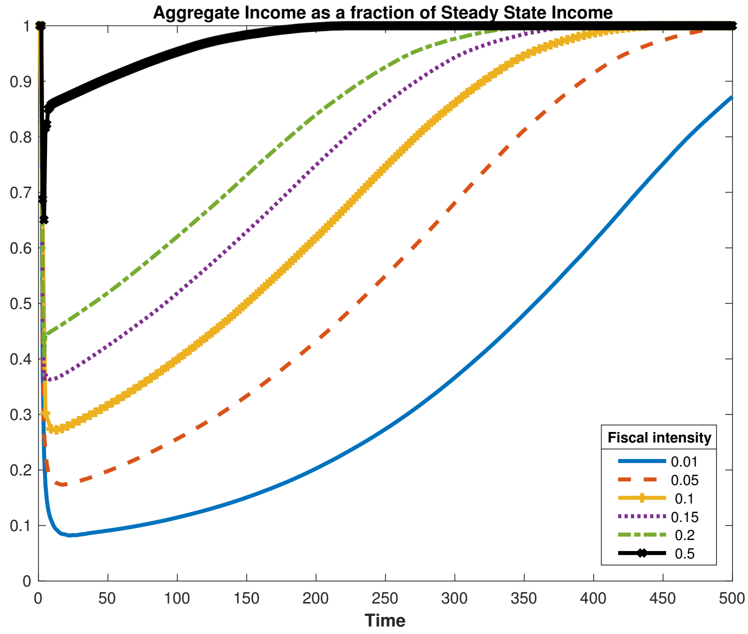

Figure 8: Evolution of aggregate income as a fraction of steady state income. Scenario IV, medium inequality shock.

Inequality shock	Max multiplier	Minimum aggregate income
Low inequality	3.87	44%
Medium inequality	4.28	37%
High inequality	4.53	30%

Table 7: Peak multipliers and minimum aggregate income in Scenario IV for different inequality shocks. 15% fiscal intensity.

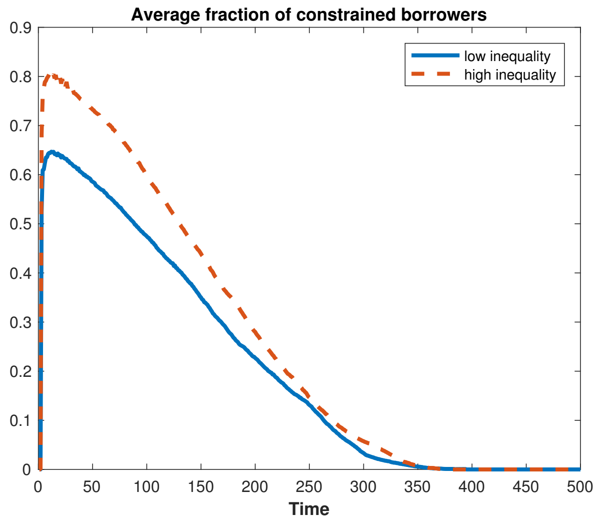

Figure 9: Evolution of average fraction of constrained borrowers. Low vs. high inequality shock. Scenario IV, 15% fiscal intensity.

in Scenario IV it takes time for indebted or credit constrained households to get back to desired consumption levels. This process explains why in a 100 periods time span the highest peak multipliers are observed in the low inequality scenario. In fact, for the high inequality case, it takes even more time than in the low inequality case. In a wider time span, from Figure 10 we observe that, when the steady state level is reached again, the highest level of peak multipliers over 500 periods is observed in the high inequality scenario. This is because there is a wider fiscal space in this case [6].

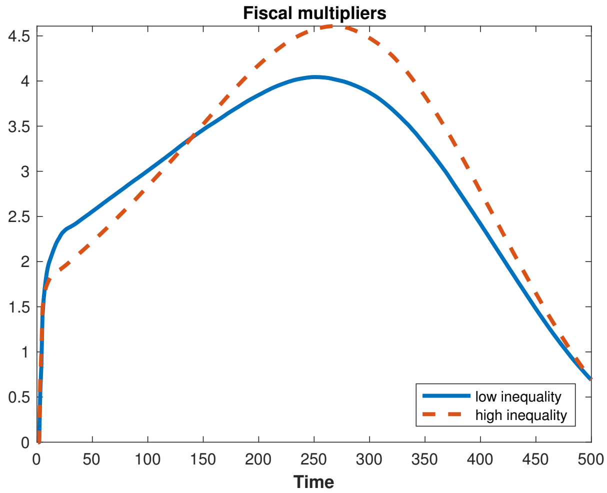

Figure 10: Evolution of fiscal multipliers. Scenario IV, 15% fiscal intensity. Low vs. high inequality shock.

3.3.3 Scenario V

Let us now consider the case in which subsidies are financed with a tax on savers' deposits. This time, the return to steady state is much faster with respect to the previous case, as visible from Figure 11. The higher is the initial fiscal intensity parameter, the less pronounced is the fall in aggregate income and the faster is the process of recovery. Similarly to Scenario IV, the combination of subsidies given to low-income households and a tax on deposits grants a high degree of redistribution across households. In this scenario, the positive effects of such a redistribution are even more visible.

The different inequality scenarios differ in the magnitude of the fall (Table 8) and, thus, in the speed of recovery.

In fact, higher inequality is associated with a higher fraction of constrained borrowers in the population, as shown in Figure 12. As subsidies are distributed to households, their income increases, such that they can increase consumption. As the average frac-

[6] In scenario III, aggregate income persistently stayed at lower levels in the high inequality case with respect to the low inequality case. Lower peak multipliers were associated with high inequality. In fact, when resources used for redistributive aims are not sufficient to significantly change low-income households' situation, a more skewed distribution seems to act as an impediment for the recovery.

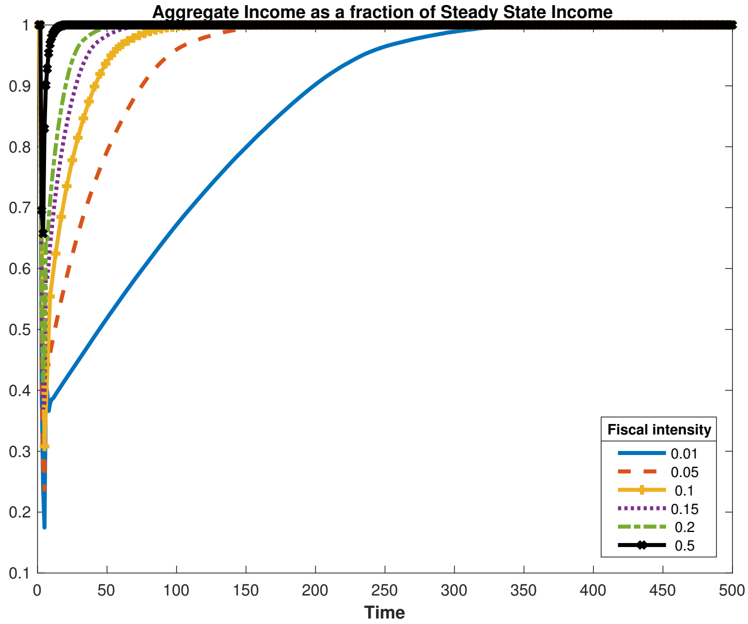

Figure 11: Evolution of aggregate income as a fraction of steady state income. Scenario V, medium inequality shock.

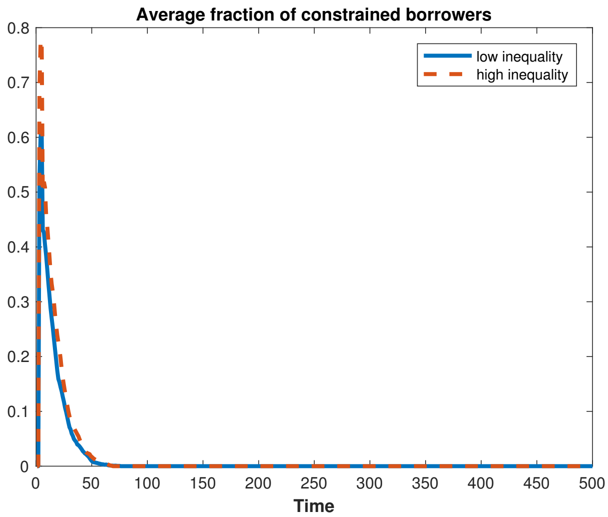

Figure 12: Evolution of average fraction of constrained borrowers. Scenario V, 15% fiscal intensity. Low vs. high inequality shock.

tion of constrained borrowers decreases, income increases, fostering a positive spiral of diminishing fraction of constrained borrowers and increasing income through increased consumption. When the average fraction of constrained borrowers approaches zero, the economy is back to the initial steady state.

Peak multipliers are decreasing with the value of fiscal intensity parameters, as shown in Table 9. Moreover, peak multipliers are higher for higher levels of inequality (Table 8). With the economy getting back to steady state in all inequality scenarios, a more concentrated income distribution is associated with a more pronounced fall in aggregate income and, thus, with a wider fiscal space. Finally, Table 9 makes a comparison among the different scenarios with subsidy, for what concerns fiscal multipliers. The highest multipliers are associated to the ones observed in Scenario IV, as it takes more time for aggregate income to return to steady state. This implies a larger fiscal space.

Inequality shock	Max multiplier	Minimum aggregate income
Low inequality	3.2	44%
Medium inequality	3.44	36%
High inequality	3.68	30%

Table 8: Peak multipliers and minimum aggregate income for different inequality shocks. Scenario V. 15% fiscal intensity.

Fiscal intensity	Scenario III	Scenario IV	Scenario V
5%	2.19	8.30	7.54
10%	2.23	5.58	4.67
15%	2.08	4.28	3.44

Table 9: Comparison among peak multipliers in scenarios with subsidy. Medium inequality shock. 15% fiscal intensity.

4 Conclusions

We built a simple agent-based model to study the impact of inequality shocks on income dynamics in presence of financial imperfection and to analyze the effectiveness of different types of fiscal policies.

We find that permanent inequality shocks produce large and persistent falls in output by generating large pools of credit-constrained consumers. Simulation results show that fiscal policy always dampens the effects of the inequality shock on aggregate output and the emerging fiscal multipliers are larger than one. At the same time, redistributive fiscal policy providing subsidies to low-income households is more effective than direct government spending. This is explained by the different distributional effects associated with such policies. Direct government spending has a regressive impact, as it benefits more households with larger income shares. In contrast, redistributive subsidies directly benefit low income households, generating larger injections in aggregate expenditure and higher fiscal multipliers. We also find that the financing of subsidies also matters: fiscal transfers to low income households are more effective if they are financed via taxes on financial income and savings instead of productive income ones. This is because taxes on financial income and savings reduce the leakage in aggregate expenditures, thereby boosting the positive impact of fiscal policy on income.

Our model could be extended in several ways. First, one could study policies that affect the balance sheet of the bank and its propensity to provide credit to households (e.g. unconventional monetary policies). Likewise, we have only considered exogenous changes to income inequality. One could instead extend the model in order to account for endogenous and time evolving-inequality, and then study how different types of fiscal and monetary policies can affect the latter.

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References

Atkinson, Anthony B and Salvatore Morelli (2011). "Economic crises and Inequality". In: *UNDP-HDRO Occasional Papers*(2011/6).

Auerbach, Alan J. and Yuriy Gorodnichenko (2012). "Measuring the Output Responses to Fiscal Policy". In: *American Economic Journal: Economic Policy* 4(2), pp. 1–27.

Bordo, Michael D and Christopher M Meissner (2012). "Does inequality lead to a financial crisis?" In: *Journal of International Money and Finance* 31(8), pp. 2147–2161.

Caiani, Alessandro, Alberto Russo, and Mauro Gallegati (2016). "Does Inequality Hamper Innovation and Growth?" In: *Available at SSRN 2790911*.

Cardaci, Alberto, Francesco Saraceno, et al. (2015). *Inequality, Financialisation and Economic Crisis: an Agent-Based Model*. Tech. rep. Observatoire Francais des Conjonctures Economiques (OFCE).

Ciarli, Tommaso et al. (2012). "The role of technology, organisation, and demand in growth and income distribution". In:

Coibion, Olivier et al. (2014). *Does greater inequality lead to more household borrowing? New evidence from household data*. Tech. rep. National Bureau of Economic Research.

Delli Gatti, Domenico et al. (2005). "A new approach to business fluctuations: heterogeneous interacting agents, scaling laws and financial fragility". In: *Journal of Economic behavior & organization* 56(4), pp. 489–512.

Dosi, Giovanni, Giorgio Fagiolo, and Andrea Roventini (2010). "Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles". In: *Journal of Economic Dynamics and Control* 34(9), pp. 1748–1767.

Dosi, Giovanni et al. (2013). "Income distribution, credit and fiscal policies in an agent-based Keynesian model". In: *Journal of Economic Dynamics and Control* 37(8), pp. 1598–1625.

Dosi, Giovanni et al. (2015). "Fiscal and monetary policies in complex evolving economies". In: *Journal of Economic Dynamics and Control* 52, pp. 166–189.

Dosi, Giovanni et al. (2016a). *The Effects of Labour Market Reforms upon Unemployment and Income Inequalities: An Agent Based Model.* LEM working paper 2016/27. Scuola Superiore Sant'Anna.

Dosi, Giovanni et al. (2016b). *When more flexibility yields more fragility: the microfoundations of keynesian aggregate unemployment.* LEM working paper 2016/06. Scuola Superiore Sant'Anna.

Fagiolo, Giorgio and Andrea Roventini (2012). "Macroeconomic Policy in Agent-Based and DSGE Models". In: *Revue de l'OFCE* 124(5), pp. 67–116.

Fagiolo, Giorgio and Andrea Roventini (2017). "Macroeconomic policy in DSGE and agent-based models redux: New developments and challenges ahead". In: *Journal of Artificial Societies and Social Simulation* 20(1).

Ferraresi, T., Andrea Roventini, and Giorgio Fagiolo (2014). "Fiscal Policies and Credit Regimes: A TVAR Approach". In: *Journal of Applied Econometrics* DOI: 10.1002/jae.2420.

Iacoviello, Matteo (2008). "Household debt and income inequality, 1963–2003". In: *Journal of Money, Credit and Banking* 40(5), pp. 929–965.

Isaac, Alan G (2014). "The intergenerational propagation of wealth inequality". In: *Metroeconomica* 65(4), pp. 571–584.

Kumhof, Michael, Romain Rancière, and Pablo Winant (2015). "Inequality, leverage, and crises". In: *The American Economic Review* 105(3), pp. 1217–1245.

Lavoie, Marc (2003). "A primer on endogenous credit-money". In: *Modern Theories of Money*, pp. 506–543.

Mian, Atif and Amir Sufi (2015). *House of debt: How they (and you) caused the Great Recession, and how we can prevent it from happening again.* University of Chicago Press.

Napoletano, Mauro, Andrea Roventini, and Jean-Luc Gaffard (2015). "Time-varying fiscal multipliers in an agent-based model with credit rationing". In: *Laboratory of Economics and Management (LEM) Working Paper Series (19).*

Ostry, Mr Jonathan David, Mr Andrew Berg, and Mr Charalambos G Tsangarides (2014). *Redistribution, inequality, and growth.* Tech. rep. 14/02. International Monetary Fund Staff Papers.

Piketty, Thomas (2014). "Capital in the 21st Century". In: *Cambridge: Harvard University Press.*

Russo, Alberto, Luca Riccetti, and Mauro Gallegati (2016). "Increasing inequality, consumer credit and financial fragility in an agent based macroeconomic model". In: *Journal of Evolutionary Economics* 26(1), pp. 25–47.

Stiglitz, Joseph E and Andrew Weiss (1981). "Credit rationing in markets with imperfect information". In: *The American economic review* 71(3), pp. 393–410.