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INEQUALITY, FINANCIALISATION AND ECONOMIC CRISES: AN AGENT-BASED MACRO MODEL

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Inequality, Financialisation and Economic Crises: an Agent-Based Macro Model*

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Abstract

By means of a macroeconomic model with an agent-based household sector and a stock-flow consistent structure, we analyse the impact of rising income inequality on the likelihood of a crisis for different institutional settings. In particular, we study how economic crises emerge in the presence of different credit conditions and policy reactions to rising income disparities. Our simulations show the relevance of the degree of financialisation of an economy. In fact, when inequality grows, a Scylla and Charybdis kind of dilemma seems to arise: on the one hand, low credit availability implies a drop in aggregate demand and output; on the other hand, relaxed credit constraints and a higher willingness to lend result in greater financial instability and a debt-driven boom and bust cycle. We also point out that policy reactions play a key role: a real structural reform that tackles inequality, by means of a more progressive tax system, actually compensates for the rise in income disparities thereby stabilising the economy. Results also show that this is a better solution compared to a stronger fiscal policy reaction, which, instead, only leads to a larger duration of the boom and bust cycle.

Keywords: Inequality, Household Debt, Credit Markets, Agent-Based Models, Stock-Flow Consistency

JEL Classification: C63, D31, E21, E62, G01

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1 Introduction: Inequality, Institutions and Financialisation

It is widely established that inequality increased substantially, both in developed and in emerging economies, starting from the late 1970s (Atkinson et al., 2011; IMF, 2007; Milanovic, 2010; OECD, 2008; Piketty and Saez, 2013). In particular, in Europe and in the United States those who have lost ground belong to the middle class, while in other areas of the world, such as China, the rise of inequality has hit the very poor. Nonetheless, in all cases the redistribution has benefited mainly the rich and the very rich (the top one percent of the population, see Figure 1), giving birth to what Dew-Becker and Gordon (2005) define as the "Superstar Economy".

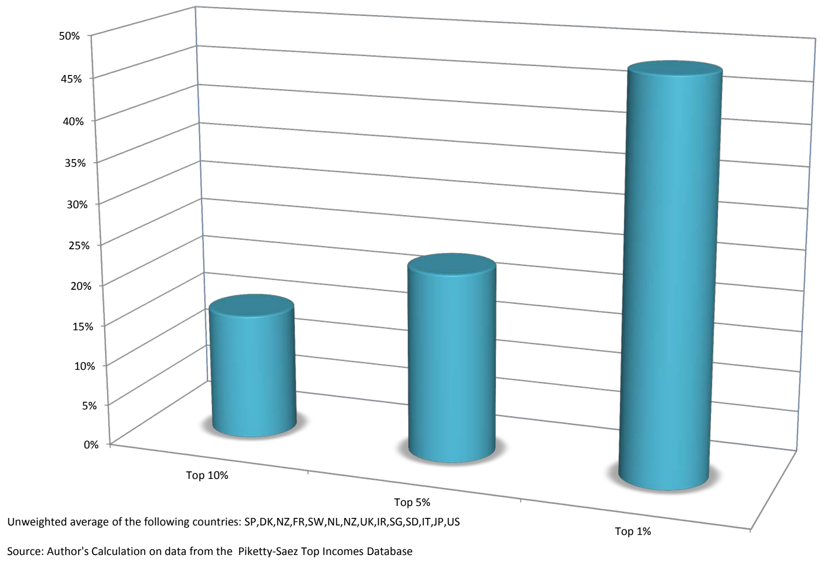

Figure 1: Average Change in Income Shares for Different Percentiles - 1980-2007.

Even though widening income inequality seems to be a widespread phenomenon in the recent years (Table 1), cross-country differences have emerged in terms of economic performance[1].

The American economy, for example, performed reasonably well with an average annual growth rate of 3.16% between 1981 and 2007. In particular, the United States have experienced an excess of demand over domestic production that resulted in an increasingly important trade deficit, which in 2006 peaked at almost 6% of GDP. This deficit was financed by the excess savings that, with different causes, characterised other regions of the world

[1]Among the selected countries, France is the only one where the Gini index has decreased in the selected time-span.

Country	*oldest*	*latest*
Canada	32.59 (1991)	33.68 (2010)
China	27.69 (1984)	42.06 (2010)
France	33.00 (1989)	31.69 (2005)
Germany	28.61 (1984)	31.83 (2007)
Italy	32.52 (1986)	35.52 (2010)
India	31.11 (1983)	33.91 (2009)
Russia	23.81 (1988)	40.94 (2010)
Spain	32.33 (1990)	35.75 (2010)
United Kingdom	36.21 (1991)	38.04 (2010)
United States	36.96 (1986)	41.12 (2010)

Table 1: Gini index for selected countries (years in parentheses). Source: FRED

for more than a decade.

In China and in other East Asian countries, due to the lack of a proper welfare state and of a reliable financial system, higher inequality yielded an excess of precautionary savings for businesses and households.[2]

Following growing income disparities, continental Europe (Germany in particular) experienced excess savings as well, even though, in our view, they were caused by the inertia of economic policy and by low investment rates, which depressed demand and income. As such, this part of the region relied on export-led growth alone.

These opposite imbalances compensated each other for almost two decades, resulting in an overall balance that the recent crisis proved to be fragile. The reason why increased inequality has led to excess savings in some areas, while resulting in excesses demand in others, lies in the interaction of the trend in income distribution, common to all countries, with institutional differences - most notably, the degree of financialisation - and the policy responses that have taken very different forms.

As a matter of fact, the development of financial markets seems to be a key factor that explains such differences among countries. As pointed out by Kumhof et al. (2012), the increase in income inequality in the United States and, in general, in more advanced economies, has not been tackled by means of political interventions to support the living standards of those who suffer from stagnating incomes. Rather, policy authorities have temporarily alleviated its consequences "through access to cheap borrowing, in other words through financial liberalization" (Kumhof et al., 2012). Krueger and Perri (2006) argue that the rise in inequality in the United States led to a change

[2] In addition, after the 1997 crisis, authorities in these countries started a policy of reserve accumulation to deal with possible sudden stops.

in the development of financial markets, which have allowed households to better insure against fluctuations of income. Therefore, in the United States, the reduction in income has been offset by private borrowing, made easier by a less regulated financial system, but also by a widespread perception of "end of history" which led to believe that all constraints to the unlimited growth of some sectors (financial, real estate) had been permanently removed. Consequently, aggregate demand has remained high, even if it has been debt-driven rather than income-driven.

Hence, as claimed by Van Treeck (2013), "in advanced economies with highly developed financial markets, including most notably the United States and the United Kingdom, rising inequality has led to a deterioration of national saving-investment balances, as the poor and middle classes borrowed from the rich and from foreign lenders to finance consumption".

However growing inequality in other regions of the world, such as China, led to a different outcome because "financial markets are less developed and hence do not allow the lower and middle classes to respond to lower incomes by borrowing" (Van Treeck, 2013). The implication is a weaker domestic demand and the emergence of an export-oriented growth model, where richer creditors lend to foreign rather than domestic borrowers. Also continental Europe has developed an export-oriented growth model, as stricter regulation of financial markets and less accommodating monetary policies have made borrowing for households and firms more difficult and expensive. Peripheral Europe also experienced a rise in top income shares in the recent decades (Atkinson et al., 2011). However, in contrast with the rest of the continent, these countries recorded growing level of household indebtedness as well as current account deficits (Kumhof et al., 2012).

Some authors point out that also policies have played a role in amplifying the imbalances among countries. For example, Rajan (2010) argues that monetary authorities in the United States fostered the speculative boom by implementing an expansionary policy in order to stimulate the economy, thus facilitating household access to credit markets and sustaining consumption for a while, albeit at the price of booming household debt. Rajan emphasises in particular the role of government failures: "the political response to rising inequality whether carefully planned or an unpremeditated reaction to constituent demands was to expand lending to households, especially low-income ones", so as to end up with rising household debt. While Rajan may be right in pointing at excessively lax monetary policy, the role of the central bank has only led to the amplification of a structural phenomenon, namely widening income disparities (Fitoussi and Saraceno, 2011).

One might also wonder why monetary policy has been the main policy instrument. Stiglitz (2012) suggests that political reasons matter in this case:

> High inequality is often accompanied by a demand for a smaller

government and more fiscal restraint. (...) Policies are often affected by lobbying, campaign contributions, and revolving doors, so that the wealthy have disproportionate influence. Thus, as inequality grows, at least in many countries, so too do constraints on the government's fiscal space (Stiglitz, 2012, p.33).

The paper is organised as follows: Section 2 introduces our macroeconomic model; Section 3 provides an analysis of model results obtained by means of Monte Carlo ripetitions; we also check for the robustness of our results through sensitivity analysis. Finally, Section 4 concludes.

2 The Model

In the light of the considerations above, we build a macroeconomic model with an agent-based household sector. Our goal is to show how the institutional setting and credit conditions interact with the impact of rising inequality on the performance of the economy and the accumulation of household debt. Our work follows part of the literature on macro agent-based models. In particular, Cardaci (2014) analyses the consequence of rising inequality in a context of peer effects in consumption and equity extraction processes. The paper shows that widening income disparities result in a debt-financed consumption boom that jeopardises the stability of the economic system (a similar result is found in Russo et al., 2015). Our paper represents a step forward. In fact, not only we include an analysis of the impact of inequality for different degrees of financialisation, but we also assess the effectiveness of different fiscal policy reactions. This is in line with the contribution by Dosi et al. (2013) that focuses on the effect of inequality under different monetary and fiscal policies. They show that more unequal societies suffer from more severe business cycles oscillations and higher unemployment rates thus increasing the likelihood of economic crises. Yet, their model allows for the accumulation of private debt by firms only. On the contrary, we apply our analysis on household loans since, in our opinion, the link between inequality and financial instability in the recent years ran precisely through household debt (Cardaci, 2014; Fazzari and Cynamon, 2013). On the other hand, this might allow for a generalisation of the policy implications of our findings.

Our model is also stock-flow consistent (SFC). The SFC approach is commonly used in the Post-Keynesian literature and dates back to the contributions by Tobin (1969, 1982) and, more recently, Godley and Lavoie (2007). The idea behind this methodology is that transactions in asset stocks imply the existence of an interlocked system of balance sheets, as Godley and Lavoie (2007) point out. As such, SFC models are built upon an accounting framework whose goal is to coherently integrate all stocks and flows of an economy, so that "every monetary flow, in accordance with the double-entry book keeping logic, is recorded as a payment for one sector and a receipt for another sector, and every financial stock is recorded as an asset for a sector and a liability for another sector" (Caiani et al., 2014).

Let us now go through the details of the modelling structure.

Our model follows the "KISS" (keep it simple, stupid!) principle. As such, we devote our effort to the development of the household sector, while simplifying all the others as much as possible. Hence, the distinctive features of our economy are as follows:

- There is only one representative firm which is owned by all households and distributes all its earnings thus retaining zero profits.
- There is no investment in capital goods.
- Households' desired consumption is based on imitative behaviour and, more precisely, on the Expenditure Cascades hypothesis (Frank et al., 2014)
- There is a credit market for non-collateralised loans to households.
- There is a public sector with a government that can issue bonds to finance its deficit (if any).

The model has a sequential structure regarding decisions about flows and actual balance-sheet transactions. The entire sequence of events in each period t can be summarised as follows:

1. Production takes place. The firm produces homogenous perishable goods using labour as the only input.
2. The firm distributes wages to all households. This process is based on individual income shares drawn from a Pareto distribution.
3. If the commercial bank has a positive net worth, it distributes the entire amount of profits to households based on the same income shares as in the previous point. However, in case of a negative net worth, the commercial bank is bailed out by the central bank via a transfer of assets (i.e. reserves). Note that, in any case, the commercial bank has zero net worth at the end of this phase.
4. Households pay taxes. Tax payment is based on a progressive system of taxation on income. Tax rates are computed endogenously in period t and they remain constant for all the remaining periods. Collected taxes add up to the government deposit account held by the central bank.

5. The government then pays back its principal and interest on bonds to each household, based on the repayment schedule set in the previous period.

6. Households compute their desired consumption based on imitative behaviour and assess their own financial position. This latter may be positive, if their internal resources are higher than their desired consumption and due debt, or negative, otherwise. Households with a positive financial position use the exceeding amount of internal resources to demand government bonds, whereas households with a negative financial position ask for a loan. Note that, as such, households can demand loans in order to finance desired consumption as well as to perform debt rollover, that is, to pay back the debt from the previous period.

7. Policy institutions decide their targets: the central bank sets the policy interest rate while the government sets its desired public expenditure. Both decisions are based on the value of the "demand gap" in the previous period and follow an anti-cyclical rule.

8. The bond market opens: if desired public expenditure exceeds collected taxes and past deposits, the government needs to borrow from households, thereby computing its supply of bonds. Total bond demand simply equals the sum of individual bond demand by each household, as mentioned in point 6. Note that the bond market may be in disequilibrium since total supply and demand are the result of independent decisions.[3]

9. The pay-back phase (PBP) begins: households pay back the loan (principal plus interest) from the previous period. This does not include borrowers who need to perform debt rollover, as they do not have the internal resources to meet their debt obligations entirely. Hence, they will enter the credit market trying to get a new loan and, afterwards, they will go through a second PBP in order to repay the old one.

10. The credit market opens: the bank sets its total available credit supply as a fraction of total credit demand and ranks households in ascending order based on their financial soundness. Loan applications, computed by households at step 6, are satisfied until the bank runs out of total credit supply. This implies that credit-rationing may occur in the market: more financially fragile households may not get any loan from the commercial bank. Credit-rationed households will not be able to finance their desired consumption entirely and to perform debt rollover.

[3]Note also that we don't allow for government debt monetisation, so that the amount of deficit is constrained by savings. This simplifying assumption plays little role, as in the simulations below government bond supply is always the short side of the market.

Hence they go bankrupt and as such they are not allowed to apply for a new loan for a number of periods.

11. A second PBP opens: households who needed debt rollover and successfully got a new loan in the credit market, can now pay back the loan from the previous period.

12. The goods market opens: government and households buy goods based on their desired level of consumption. If the output produced by the firm at step 1 is lower than overall desired consumption, rationing takes place. On the contrary, in case of excess supply, we assume the firm gets rid of the unsold amount of its perishable goods at no cost.

13. Finally, all macroeconomic variables (e.g. GDP, Public Debt, Private Debt) are updated.

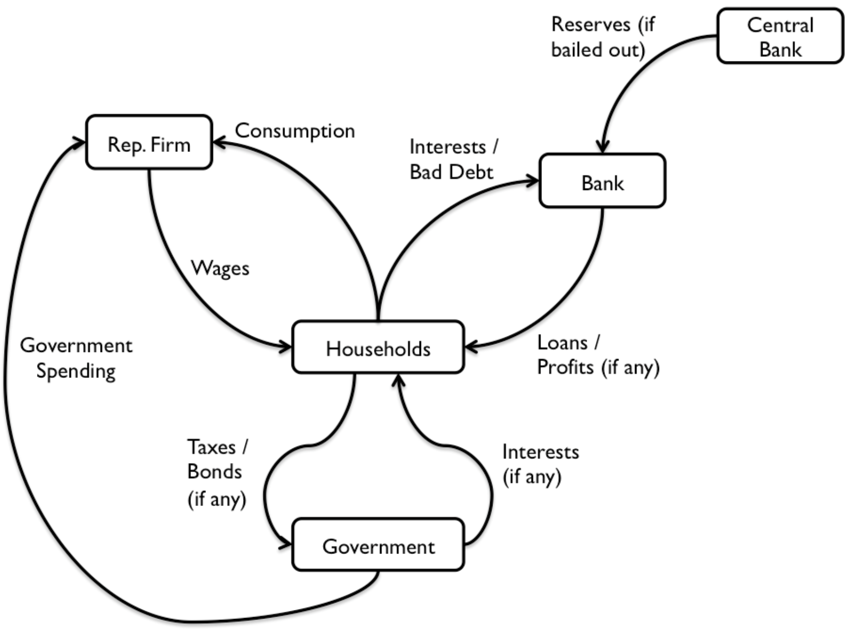

Figure 2: Transaction flows in our economy.

Figure 2 provides a graphical representation of all the transactions taking place in our artificial economy, based on the sequence reported above. These are represented as flows from a typology of agents to the others. In order to make sure that our model is stock-flow consistent so that no flow "leaks out" of the system, each agent is provided with a balance sheet that allows us to track and measure the levels of all stock variables at any point in time. Table 2 shows the balance sheets of all the agents in the economy at the end of each period, with the household sector represented in aggregate terms for simplicity.[4]

Household

Assets	*Liabilities*
Deposits ($D_{t,H}$)	Loans ($L_{t,H}$)
Bonds (B_t)	

Bank

Assets	*Liabilities*
Loans ($L_{t,H}$)	Households deposits ($D_{t,H}$)
Reserves (R_t)	Firm deposits ($D_{t,F}$)

Firm

Assets	*Liabilities*
Deposits ($D_{t,F}$)	

Government

Assets	*Liabilities*
Deposits ($D_{t,G}$)	Bonds (B_t)

Central Bank

Assets	*Liabilities*
	Reserves (R_t)
	Government deposits ($D_{t,g}$)

Table 2: Agents' balance sheets in our economy.

Stock-flow consistency implies that any transaction that takes place in the economy is matched by an identical change in the stocks held in the balance sheets of the agents involved. For example, when the firm pays the wage bill, it transfers all of its deposits to the household sector through the commercial bank. Table 3 provides a numerical example: firm deposits lower by their entire amount, whereas household deposits increase accordingly. This transaction is reported also on the liability side of the balance sheet of the bank. Yet, the net worth of the bank does not change since

[4]Note that central banks do not lend unsecured to commercial banks, as they usually take collateral to protect against the possibility of loss due to credit and market risk (Rule, 2015). Yet in our framework, when the commercial bank is bailed out by the central bank, it receives liquidity (i.e. new assets called *reserves*) without transferring any assets to the central bank. In other words, our simplifying assumption is that the bailout does not require any collateral or reimbursement and, as such, the central bank does not hold any asset.

a transfer of deposits does not modify the overall amount of liabilities it holds.[5] In general, at the end of each period, agents may have positive or negative individual net worth, depending on the difference between assets and liabilities. However, stock-flow consistency in our model implies that the overall value of the net worth in the economy must always be zero, not only at the end of each period t but also right after any transaction.

Household		Household	
Assets	*Liabilities*	*Assets*	*Liabilities*
$D_{t,H} = 100$	$L_{t,H} = 70$	$D_{t,H} = 180$	$L_{t,H} = 70$
$B_t = 20$		$B_t = 20$	
	$NW_{t,H} = 50$		$NW_{t,H} = 130$

Firm		Firm	
Assets	*Liabilities*	*Assets*	*Liabilities*
$D_{t,F} = 80$		$D_{t,F} = 0$	
	$NW_{t,F} = 80$		$NW_{t,F} = 0$

Bank		Bank	
Assets	*Liabilities*	*Assets*	*Liabilities*
$L_{t,H} = 70$	$D_{t,H} = 100$	$L_{t,H} = 70$	$D_{t,H} = 180$
$R_t = 110$	$D_{t,F} = 80$	$R_t = 110$	$D_{t,F} = 0$
	$NW_{t,B} = 0$		$NW_{t,B} = 0$

Table 3: Numerical example of a wage payment. The firm transfers all of its revenues to the household sector as wages. This implies a transfer of deposits from the balance sheet of the former to that of the latter. This modifies their net worth. Also the bank records this change on the liability side of its balance sheet, even though its overall net worth remains the same.

Let us now introduce the rules of behaviour for each category of agent and sector of the economy.

2.1 Production

The representative firm has a limited role to play in our model: it distributes wages and reacts to disequilibria in the goods market by changing total production. The firm is owned by the entire population of households, H, who all work for it. As shown in Equations 1 and 2, current production (Q_t) and

[5] In principle, such transfer of liabilities takes place among different banks and, as such, it has to be matched by an equal transfer of reserves on the asset side of their balance sheets. Nonetheless, this change does not occur in our case because our simplified framework features a single representative bank.

prices (P_t) depend on their level in the previous period and on a sensitivity parameter (ϕ_Q and ϕ_P respectively) multiplied by the demand gap. This latter is defined as the previous period difference between aggregate demand and production, divided by production itself, that is $gap_{t-1} = \frac{AD_{t-1}-Q_{t-1}}{Q_{t-1}}$. In other words, the demand gap represents a measure of the real term excess demand or supply in the past.

$$Q_t = Q_{t-1}\left(1 + \phi_Q \cdot gap_{t-1}\right) \quad (1)$$

$$P_t = P_{t-1}\left(1 + \phi_P \cdot gap_{t-1}\right) \quad (2)$$

At the beginning of each period, the firm distributes its entire revenues, collected at the end of $t-1$, to the population in the form of wages. The distribution process is based on constant individual income shares that are drawn from a Pareto distribution. This is consistent with empirical evidence suggesting that income is generally distributed according to a power-law distribution and, more specifically, to a Pareto, particularly at top of the income scale (Clementi and Gallegati, 2005; Jones, 2015).

2.2 Expenditure Cascades and Financial Assessment

Individual household income (Equation 3) is defined as the sum of wages ($w_{t,h}$), profits from the bank ($\pi_{t,h}$, if any) and the repayment schedule on government bonds from the previous period ($RSG_{t-1,h}$, if any).

$$y_{t,h} = w_{t,h} + \pi_{t,h} + RSG_{t-1,h} \quad (3)$$

After receiving income, households pay taxes based on a progressive tax system, with constant tax rates set in period 1. Hence, individual disposable income ($yd_{t,h}$) is given by income net of the due amount of taxes ($T_{t,h}$), as defined in Equation 4.

$$yd_{t,h} = y_{t,h} - T_{t,h} \quad (4)$$

Consumption behaviour in our model is based on peer effects and imitation. This is consistent with the empirical literature on behavioural economics, as reported in Cardaci (2014), Fazzari and Cynamon (2013) and Frank et al. (2014). In particular, similar to Cardaci (2014), the formulation of desired consumption in our model follows the Expenditure Cascades (EC) hypothesis introduced by Frank et al. (2014), with a slightly amended formulation (Equation 5).

$$C^d_{t,h} = k \cdot yd_{t,h} + a \cdot C_{t-1,j} \quad (5)$$

Therefore, h's desired consumption is a function of her disposable income ($yd_{t,h}$) as well as j's actual consumption in the previous period, where j is the household who ranks just above h in the income scale, so that $j = h+1$. k is "a parameter unrelated to permanent income level or rank" (Frank et al., 2014), while the sensitivity parameter a is such that $0 \leq a \leq 1$: "when $a = 1$, h fully mimics j's consumption; whereas when $a = 0$, h does not consider j's consumption" (Cardaci, 2014).

As already mentioned, households carry out an assessment of their financial position, by comparing their expected expenditures with their internal resources. That is, if the sum of desired consumption and the repayment schedule on loans from the previous period ($RS_{t-1,h}$[6]) is higher than the sum of their disposable income and past deposits ($D_{t-1,h}$), households have a negative financial position and apply for a loan ($L^d_{t,h}$) to the banking sector. That is:

$$\begin{aligned} &if \qquad C^d_{t,h} + RS_{t-1,h} > yd_{t,h} + D_{t-1,h} \\ &then \quad L^d_{t,h} = C^d_{t,h} + RS_{t-1,h} - yd_{t,h} - D_{t-1,h} \end{aligned} \tag{6}$$

On the contrary, households with enough internal resources to finance desired consumption and repayment schedule, ask for government bonds ($B^d_{t,h}$). Hence:

$$\begin{aligned} &if \qquad C^d_{t,h} + RS_{t-1,h} \leq yd_{t,h} + D_{t-1,h} \\ &then \quad B^d_{t,h} = yd_{t,h} + D_{t-1,h} - C^d_{t,h} - RS_{t-1,h} \end{aligned} \tag{7}$$

2.3 Bond Market

At the beginning of each period, the government sets its (G^d_t) as a percentage of GDP. As already pointed out, this decision follows an anti-cyclical rule. In particular, the government adjusts the initial value of such ratio ($\overline{\frac{G^d}{GDP}}$, computed in period 1) based on its sensitivity (ϕ_G) to the demand gap in the previous period.

$$\frac{G^d_t}{GDP_{t-1}} = \overline{\frac{G^d}{GDP}} - \phi_G \cdot gap_{t-1} \tag{8}$$

Afterwards, the government carries out its own financial assessment by computing the difference between its expected expenditure (the sum of desired public expenditure and the repayment schedule on public bonds issued in the previous period, RSG_{t-1}) and its available internal resources (the

[6] The repayment schedule on loans is defined in section 2.4.

sum of past deposits, $D_{t-1,g}$, and the amount of taxes collected, T_t). If this is negative, the government has enough resources to finance the expected expenditure. On the contrary, if the difference is positive, the government has to finance its expenditure by issuing new public bonds. The overall supply of bonds is defined in Equation 9.

$$BS_t = G^d_t + RSG_t - D_{t,g} \tag{9}$$

Note that government deposits at time t are defined as the sum between past deposits and tax revenues, so that $D_{t,g} = D_{t-1,g} + T_t$. We assume that bonds are one period debt contracts between households and the government. Hence, in the following period, the government will pay back RSG_{t-1}, which includes both principal and interests. We also make the assumption that the interest rate on bonds is equal to the policy rate set by the central bank (see Section 2.4).

It is wort noting that there is no mechanism that guarantees that the bond market is in equilibrium. In other words, as the formulation of bond demand and supply are based on independent decisions by households and the government, rationing may take place in the bond market. Indeed, if total bond supply is higher than demand, all households asking for bonds get the desired amount. Still, in the opposite case, all applicants are rationed so that the amount each h gets is equal to $B^d_{t,h}\frac{BS_t}{BD_t}$, where BD_t is total bond demand (i.e. $BD_t = \sum_h B^d_{t,h}$).

2.4 Pay Back Phase and Credit Market

As pointed out in Section 2.2, only households with a negative financial position enter the credit market. Note, however, that we distinguish two types of borrowers: consumption borrowers (CB) and borrowers in financial distress (FDB). CB are all households whose own resources are enough to pay back their repayment schedule on the loan from the previous period[7]. Hence, they enter the market in order to get a loan to finance their desired consumption only. On the contrary, FDB ask for a new loan not only to finance consumption but also to perform debt rollover. In other words, FDB use the new loan to pay back the previous one.

The commercial bank sets a maximum allowable credit supply as a fraction of total credit demand (Equation 10).

$$LS_t = v_t \sum_h L^d_{t,h} \tag{10}$$

[7] CB also includes households with zero repayment schedule, that is, those who did not take any loan in $t-1$.

Note that $v_t \in [v_{min}, v_{max}]$. That is, the commercial bank endogenously changes the value of v_t within two boundaries (v_{min} and v_{max}) that are exogenously set in the initialisation phase of the model (Conditions 11 and 12). In particular, v_t evolves as a function of systemic risk which is proxied by the household debt-to-GDP ratio in the previous period, $\frac{debt_{t-1}}{GDP_{t-1}}$. In fact, we introduce an exogenous parameter (*threshold*) that represents the sensitivity threshold to the level of the household debt-to-GDP ratio, so that if the ratio is higher (lower) than the threshold, the bank decreases (increases) v_t.

$$if \quad \frac{debt_{t-1}}{GDP_{t-1}} > threshold \quad then \quad v_t = v_{t-1} - \phi_v(v_{min} - v_{t-1}) \tag{11}$$

$$if \quad \frac{debt_{t-1}}{GDP_{t-1}} < threshold \quad then \quad v_t = v_{t-1} + \phi_v(v_{max} - v_{t-1}) \tag{12}$$

The sensitivity threshold, as well as the two boundaries for v_t, represent our key parameters in the simulation phase of the model as they act on the willingness to lend of the commercial bank and on its reaction to systemic risk. Hence, a more financialised economy is one in which both *threshold* and v_{max} are set to high values.

The commercial bank ranks households in ascending order based on a measure of their financial soundness - namely the total debt service ratio (TDS)[8] - and supplies credit by matching each individual demand until $LS_t = 0$. As a consequence, if $v_t < 1$, less financially sound applicants (namely, households with a higher TDS) will be rationed on the credit market thus getting no loans at all. Borrowers who are credit-rationed cannot pay back their previous loan and, in some cases, finance their desired consumption entirely. Therefore, they will go bankrupt and as such they are not allowed to apply for another loan for a limited period of time.

Similar to bonds, we assume each loan is a one-period debt contract corresponding to a repayment schedule defined as $RS_{t,h} = L_{t,h}(1 + r^L_{t,h})$, to be paid back entirely in the following period. Similar to Russo et al. (2015) and Cardaci (2014), the interest rate on loans is made up of three components, as described by Equation 13.

$$r^L_{t,h} = \overline{r_t} + \widehat{r_t} + r_{t,h} \tag{13}$$

$\widehat{r_t}$ is a system-specific component that reflects the sensitivity of the bank to the household debt-to-GDP ratio of the economy, so that $\widehat{r_t} = \rho\frac{debt_{t-1}}{GDP_{t-1}}$, while $r_{t,h}$ is a household-specific component equal to $\mu TDS_{t,h}$, where μ is the bank sensitivity to household total debt service ratio. Finally, $\overline{r_t}$ is the policy rate set by the central bank at the beginning of each period (Equation

[8] Following Cardaci (2014), TDS is defined as the ratio between household repayment schedule and disposable income.

14). Similar to desired public expenditure, the central bank reacts to changes in the demand gap.[9]

$$\overline{r}_t = \overline{r}_{t-1} + \phi_{CB} \cdot gap_{t-1} \tag{14}$$

Once transactions in the credit market are over, a new PBP begins: all FDB who successfully got a loan now pay back their due debt $RS_{t-1,h}$.

2.5 Goods Market

Both the government and households interact with the firm in order to buy goods. Note that each agent on the demand side may have an actual capacity of spending that differs from the desired one. As a matter of fact, even though the government is willing to spend an amount equal to G_t^d, it is possible that its liquidity does not allow to do so and its actual spending capacity is constrained by its current deposits ($D_{t,g}$), which include collected taxes, issued bonds and past deposits. Hence actual maximum government expenditure is defined as $min(G_t^d, D_{t,g})$. Similarly, some households might not be able to finance their desired consumption entirely due to credit rationing, as already pointed out. As a consequence, actual maximum expenditure for each household is equal to $min(C_{t,h}^d, D_{t,h})$.

Before transactions take place, the firm compares aggregate demand in real terms (Equation 15) with the amount of quantities produced.

$$AD_t = \frac{min(G_t^d, D_{t,g}) + \sum_h min(C_{t,h}^d, D_{t,h})}{P_t} \tag{15}$$

If the former is lower than the latter, each buyer will obtain the demanded amount of goods, while the firm will get rid of excess supply at no cost. In the opposite case, instead, all buyers in the goods market will be rationed. If such a circumstance occurs, the firm computes a "rationing ratio" equal to $\frac{Q_t}{AD_t}$. This applies equally to the government as well as each household, so that all buyers are rationed in the same way and actual household consumption and government spending are defined as $C_{t,h} = min(C_{t,h}^d, D_{t,h})\frac{Q_t}{AD_t}$ and $G_t = min(G_t^d, D_{t,g})\frac{Q_t}{AD_t}$.

3 Model Results

Model results are obtained by means of computer simulations. We start by replicating the following three scenarios:

[9]As quantities and prices move in the same direction, the central bank is implicitly targeting inflation as well.

- a baseline (BS) scenario with income shares that are fixed at the beginning of the first period and remain constant over time;
- a rising-inequality (RS) scenario in which we change the value of individual income shares over time to simulate increasing income disparities;
- finally, a credit-inequality (CS) scenario in which the maximum propensity to lend of the bank rises along with the same rise of inequality simulated in RS.

We also run some additional experiments to assess different model dynamics when financial conditions, as well as policy implementations, change.

For each scenario we perform 20 Monte Carlo (MC) repetitions selecting a different random seed at each run, similar to Delli Gatti et al. (2011) and Russo et al. (2015). The choice of our parameter vector, shown in Table 4, is based on the need to rule out explosive dynamics and unrealistic patterns. In addition, we also perform both univariate and multivariate sensitivity analysis in order to test the robustness of model results to changes in parameter values.

Parameter		Value
T	Number of periods	1000
H	Number of households	200
k	Propensity to consume for $h = 1 : H - 1$	0.8
k_H	Propensity to consume for $h = H$	0.6
a	Sensitivity parameter to j's past consumption	0.6
v_{max}	Maximum propensity to lend	0.4
v_{min}	Minimum propensity to lend	0.1
ρ	Bank sensitivity to debt/gdp ratio	0.005
μ	Bank sensitivity to TDS	0.005
ϕ_Q	Output sensitivity to output gap	0.01
ϕ_P	Price sensitivity to output gap	0.01
ϕ_G	Government sensitivity to output gap	0.05
ϕ_{CB}	Central bank sensitivity to output gap	0.05
ϕ_v	Speed of adjustment for credit supply	0.05
$freeze$	Number of "freezing" periods for bankrupt borrowers	5
$threshold$	Bank threshold for debt-to-GDP ratio	0.5

Table 4: Model calibration

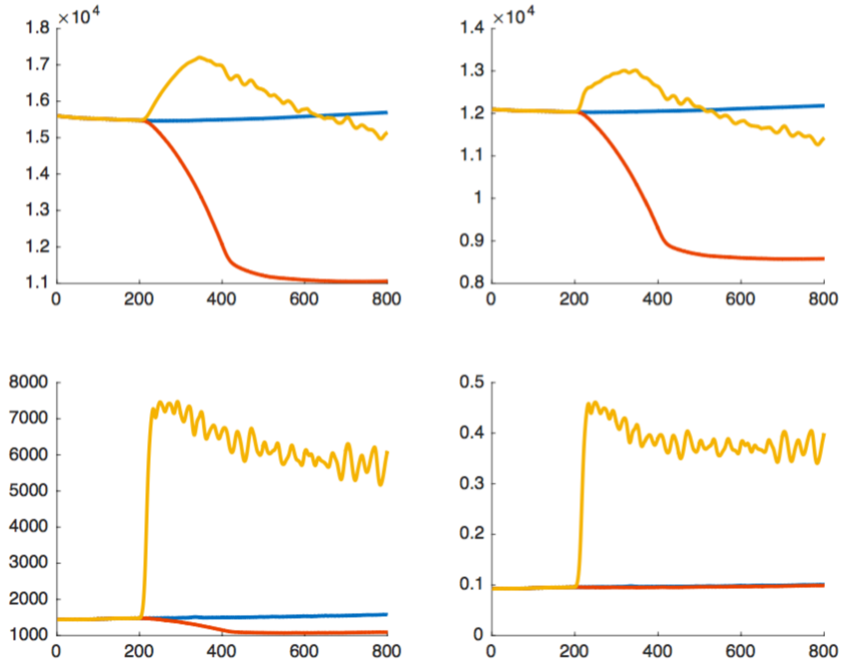

Figure 3: GDP (top left), aggregate desired consumption (top right), household debt (bottom left) and household debt-to-GDP (bottom right) in BS (blue), RS (red), CS (yellow).

3.1 Monte Carlo Analysis of the Three Scenarios

For each scenario, we compute the cross-simulation mean of the key variables. For example, we calculate GDP at each time t as the average of GDP across the 20 MC ripetitions for each of the three scenarios. Moreover, we drop the first 200 periods in order to get rid of transients, that is the stabilisation phase of the model. Graphs only show the last 800 periods for this reason. Furthermore, following Cardaci (2014), all data generated by our model are represented as simple moving averages in order to smooth out the cyclical fluctuations of the time series.

BS is based on the calibration shown in Table 4, while in the other two scenarios we implement the following shocks:

- RS: the income share of the top 10% increases gradually (from period 401 to period 600) from 22% to 37%.
- CS: we perform the same inequality shock as in RS, together with a sudden rise in v_{max} which increases from 0.4 to 0.8 in period 401.

All the key time series obtained by means of MC repetitions show smooth and minor oscillations along a stationary trend in the baseline scenario (as confirmed by Table 5, which reports also the average growth rates of GDP in all the 20 MC simulations for the baseline scenario). In particular, the model seems to stabilise along a quasi-steady state. As shown in Figure 3, GDP in BS is rather flat over time.

Simulation	*Average growth rate (%)*	*Mean*	*Variance*	*Standard Deviation*
1	1.51	15443.80	2848.26	53.37
2	1.31	15685.65	8572.67	92.59
3	1.11	15382.01	3138.18	56.02
4	0.17	15636.93	4992.87	70.66
5	0.61	15593.71	3554.80	59.62
6	1.47	15639.42	8035.21	89.63
7	1.03	15416.06	5673.53	75.32
8	0.89	15428.54	3084.45	55.54
9	0.97	15415.67	2321.31	48.18
10	1.09	15518.28	5624.1	74.99
11	1.07	15606.42	4321.62	65.74
12	0.3	15200.34	2895.02	53.8
13	0.76	15752.72	3546.91	59.55
14	1.39	15536.94	5783.84	76.05
15	0.19	15516.43	2847.19	53.36
16	0.35	15491.02	4382.62	66.2
17	1.1	15574.72	9465.53	97.29
18	0.72	15592.42	3043.92	55.17
19	1.16	15484.07	2836.83	53.36
20	0.36	15471.21	2838.9	53.28

Table 5: Key statistics for BS-GDP in the 20 MC simulations.

Let us provide a narrative for the other two scenarios.

- **RS**. Figure 3 shows quite distinctly that a rise in income disparities results in falling GDP. As a matter of fact, when income moves from the bottom to the top of the distribution, overall desired consumption rises for a very small number of periods due to stronger expenditure cascades. However, financial parameters (v_{max}, *threshold* and ϕ_v) in RS do not change compared to their baseline values and the economy remains poorly financialised as it is in BS. As a consequence, households do not find enough credit supply to finance their increased desired expenditure and demand for loans. Indeed, in the baseline the household debt-to-GDP ratio is well below the bank sensitivity threshold and, consequently, v_t rises endogenously up to $v_t = v_{max}$, $\forall t$. That is, in BS the banking system endogenously increases its willingness to lend up to its maximum value as it detects low systemic risk. Yet, as v_{max} is calibrated at a low value in BS and RS (see Table 4), the result of increasing inequality in our economy with a low degree of financialisation and credit availability is a recession with falling debt and desired consumption.

- **CS**. Similar to RS, as soon as income inequality starts to increase, household desired consumption grows because of stronger imitation effects. However, the degree of financialisation is different in CS, as the commercial bank has a higher maximum willingness to supply credit. That is, a greater value of v_{max} allows v_t to rise endogenously so that a broader number of borrowers actually finds the necessary external resources to finance their desired spending. In fact, even if income disparities become wider, GDP rises in CS as a result of debt-financed consumption. Also note that the default rate of borrowers actually goes down. This is not surprising: higher credit availability results in a greater number of households who successfully perform debt-rollover and as such more borrowers are actually able to pay back their older loans. Nonetheless, this also implies that household debt grows faster than GDP: the debt-to-GDP ratio increases as well, going beyond the threshold level set by the commercial bank. This is the turning point: the bank starts decreasing its willingness to lend and, as a consequence the portion of overall credit demand that is actually matched by credit supply drops thus triggering the recession. Two aspects are worth stressing: (1) the fall in GDP is slower than that of desired consumption and (2) credit demand and supply remain substantially higher compared to their baseline level, even though they both experience much wider oscillations along a roughly decreasing trend. The first point can be explained by the impact of public spending which decreases but at a fairly slower rate than private spending. The second point, instead is explained by looking at the number of households who need debt rollover, which remains stable at around 60% after the peak of GDP and debt. This entails a change in the nature of credit: the higher demand for credit after the recession comes from FDB and it is, as such, for debt rollover purposes rather than for consumption financing.

3.2 Financialisation and Institutional Setting

The results of our three main scenarios suggest that where credit constraints are relaxed, higher loan demand can be matched by a wider availability of credit thereby resulting in higher household debt that sustains aggregate demand at the price of greater instability; whereas, if access to credit is harder and its availability is subject to tighter regulation, widening income disparities are not compensated by increased borrowing and, as such, the economy performs badly.

We now want to provide a deeper analysis of the impact of growing inequality on household debt and the performance of the economy under different degrees of financialisation. To do so, we run two more sets of simulations by randomly drawing 20 different values for v_{max} and $threshold$.

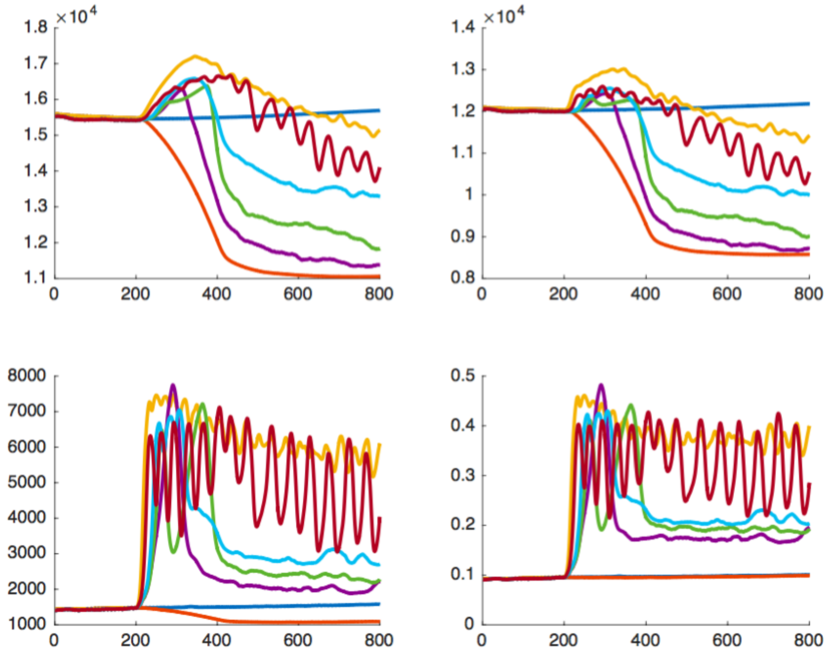

Figure 4: GDP (top left), aggregate desired consumption (top right), household debt (bottom left) and household debt-to-GDP (bottom right) for v_{max} equal to 0.5724 (purple), 0.5846 (green), 0.6023 (light blue), 0.6894 (dark red), compared to baseline (blue), RS (red) and CS (yellow).

For each of these values, we also perform 20 MC repetitions, each with a different random seed (for a total of 400 simulations).

In the first case we reproduce a multitude of scenarios where the bank has a different maximum willingness to lend, while in the second case we test how greater credit availability interacts with different sensitivities to the household debt-to-GDP ratio by the bank.

Let us start from changes in v_{max}. When inequality rises, we increase the maximum willingness to lend of the bank without changing the value of *threshold* or any other parameter in the model. Figure 4 reports our key results for selected values of v_{max}. The graphs show that a higher value of v_{max} corresponds to a greater boom and bust cycle, as expected. That is, a stronger degree of financialisation allows for more debt-financed consumption by households, while a lower amount of credit availability forces the economy into the recession since the downward pressure on the aggregate demand is not compensated by higher household debt.

Next we investigate the case of a different *threshold* in CS. That is, when inequality increases, the bank is willing to supply more credit, since v_{max} jumps from 0.4 to 0.8 in CS, but it also has different sensitivities to

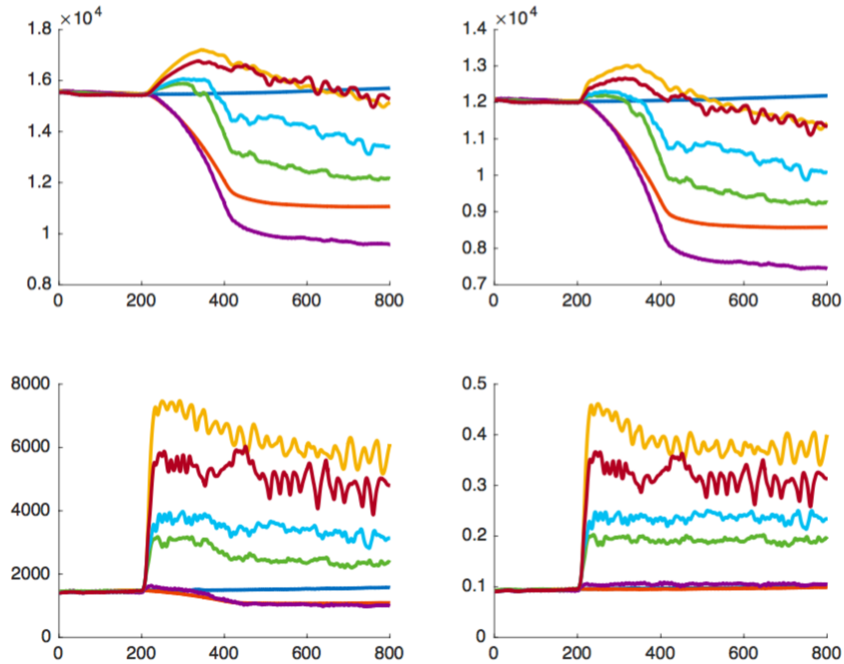

Figure 5: GDP (top left), aggregate desired consumption (top right), household debt (bottom left) and household debt-to-GDP (bottom right) for *threshold* equal to 0.1048 (green), 0.2041 (purple), 0.2533 (light blue), 0.3705 (dark red) compared to baseline (blue), RS (red) and CS (yellow).

the household debt-to-GDP ratio (starting from period 1 and letting the other parameters unchanged). Our results for selected values of *threhsold* are shown in Figure 5. Clearly, *threshold* is a key parameter in determining model dynamics. As a matter of fact, lower values of *threshold* imply a worse performance of the economy, regardless of the increased willingness to lend of the bank. In particular when *threshold* is less or equal to 0.1, the economy in CS performs even worse than in the RS scenario where $threshold = 0.5$ and $v_{max} = 0.4$. In general, our findings seem to bring about further evidence that the degree of financialisation matters, even when we look at another dimension, namely the sensitivity of the commercial bank to systemic risk.

3.3 Policy Responses

We now move on to the analysis of different policy interventions. In particular, we compare a "Keynesian" type of policy - consisting in a bolder reaction of desired government expenditure to the demand gap[10] - with an

[10]Notice that in our model "Keynesian" does not indicate a large government, but rather a proactive one. Our interpretation is consistent with the first part of the *General Theory*.

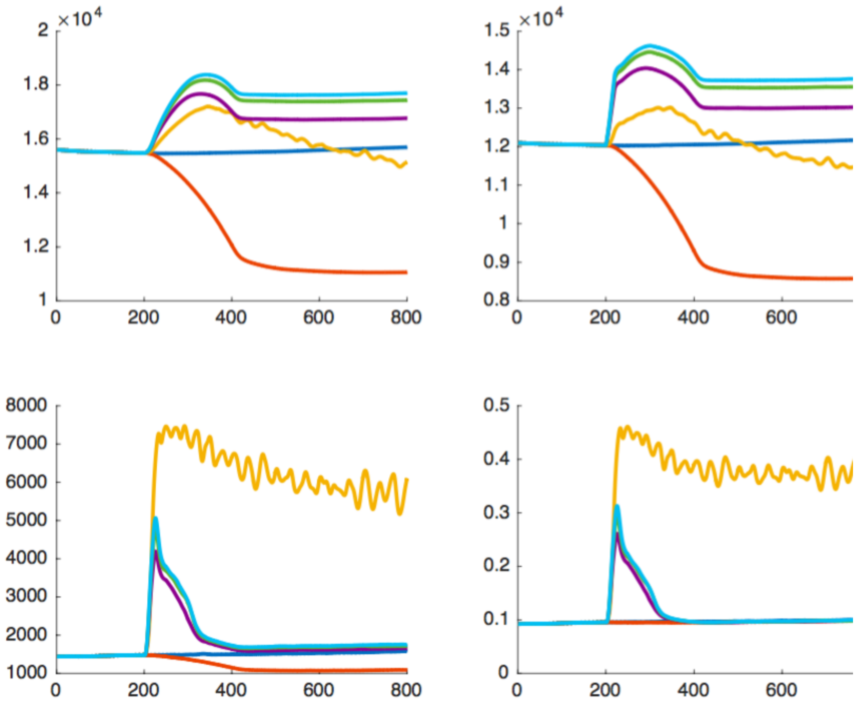

Figure 6: GDP (top left), aggregate desired consumption (top right), household debt (bottom left) and household debt-to-GDP (bottom right) for different levels of progressive tax system (purple, green and light blue) compared to baseline (blue), RS (red) and CS (yellow).

increase in "progressivity" of the tax system that tackles inequality by redistributing income from the top to the bottom of the population. Our results suggest that the second type of policy has a clearer and stronger effect on the overall economy with respect to an intervention of the first type.

Simulations are carried out following the same procedure introduced above: we randomly draw 20 different values for ϕ_G and for each of them we also perform 20 MC repetitions in each of the three scenarios (hence, we perform 1200 computer simulations in total). We find that, a greater value of ϕ_G does not avoid the recession that results from rising inequality in the RS scenario. Moreover, in the CS scenario, that is when inequality rises together with the maximum willingness to lend of the banking system, the impact of the Keynesian policy reaction is non tangible. That is, the time series for the key variables do not show any significant difference (in terms of magnitude, duration and volatility of the boom and bust cycle) compared to the standard time series obtained in the CS scenario with ϕ_G equal to its baseline value.

What happens if, instead, the government reacts to rising inequality by changing the tax rates such that it redistributes income from households at the top of the distribution to those at the bottom? In this case, the impact on the economy is strong and positive. Note that we analyse the fiscal reform in RS so that all model parameters, including the financial ones, do not change.

Selected simulations are reported in Figure 6. They all show that more progressive systems manage to counterbalance the (exogenous) change in the Pareto distribution that alters the original distribution of income. Regardless of the degree of progressivity, the economy has a higher and more stable GDP compared to the baseline, as well as a similar level of household debt. This latter is also much lower than in CS. In any case, a more progressive tax system results in a dramatic boom in GDP followed by a prolonged period of stability. This is not surprising: by counterbalancing the rising trend in inequality, the government provides poorer households with the necessary internal resources to finance their desired consumption. As a consequence, the household sector relies much less on debt accumulation so that both household debt and household debt-to-GDP stabilise around the baseline level after a certain number of periods.

As far as our result seem to push in favour of a structural reform with a more progressive tax system, for the sake of completeness it is worth pointing out that we do not take into account any consideration regarding the distortionary effect that greater progressivity may have on other aspects of the economy, such as the functioning of labour markets or firm profits and investment decisions. The interpretation of our results should therefore be limited to considering that an increase in progressiveness is more efficient than macroeconomic policies in tackling the expenditure cascades that follow an rise in inequality. Any further interpretation would be unwarranted given the simplified structure of our model.

3.4 Consumption and Income Inequality

One of the major advantages of agent-based models is that they allow to track and analyse the distribution of key economic variables among the population of the artificial economy. In particular, we are interested in assessing how consumption and income inequality change in the three basic scenarios introduced above. Notice that even though wages and bank profits are distributed based on exogenous Pareto shares, interests on government bonds are based on the stock of bonds held by each household. As such, they might allow income distribution to change endogenously.

In order to measure consumption (income) inequality we compute the ratio between actual consumption (disposable income) at the richest 20% and at the poorest 20% of the population. Figure 7 plots the time series of such ratios in BS, RS and CS.

In the BS scenario, the distribution of both consumption and income

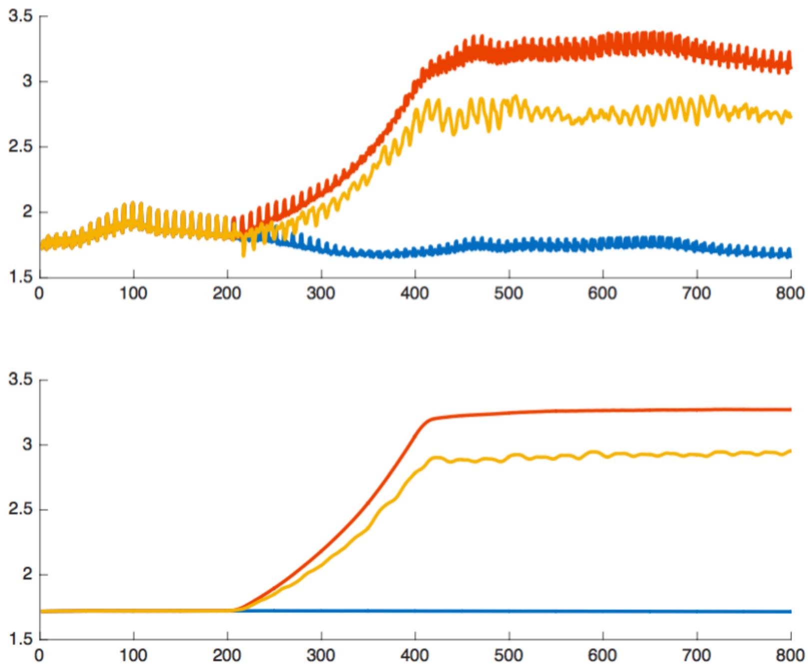

Figure 7: Consumption (top) and income (bottom) inequality in BS (blue), RS (red) and CS (yellow).

remains fairly constant. Following the inequality shock in both RS and CS, the two measures of distribution rise, thus indicating a stronger concentration of income and consumption at the top. Yet, income inequality is lower in CS compared to RS. This is explained by looking at the time series of household consumption for the same percentiles. These are reported in Figure 8, which shows that households at the top increase their consumption in CS, thereby accumulating lower savings and, consequently, government bonds. As such, interest income increases less than in the RS scenario thus contributing to a lower increase of income inequality in CS compared to RS. As expected, also consumption inequality is lower in CS with respect to RS. This is explained by the greater availability of credit to poorer households in the expansionary phase of the economy.

In general, one can observe that consumption inequality tracks income inequality in all scenarios, a behaviour that is confirmed by recent empirical analysis (Aguiar and Bils, 2011).

3.5 Sensitivity Analysis

In order to check whether our model results are biased by the specific combination of parameter values, we perform both univariate and multivariate

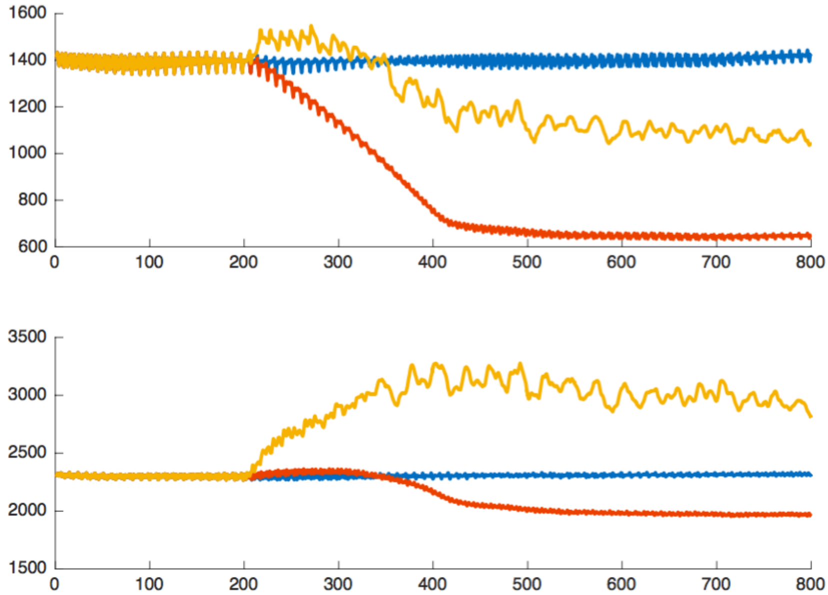

Figure 8: Household consumption for the poorest 20% (top) and richest 20% (bottom), in BS (blue), RS (red) and CS (yellow).

sensitivity analysis. This allows us to test the robustness of the model following changes in the parameter vector.

Univariate analysis consists in assessing variations in model outcome while performing changes in one parameter at a time, leaving all the others constant. As Delli Gatti et al. (2011) point out, "the model is then believed to be good if the output values of interest do not vary significantly despite significant changes in the input values".

In the univariate case, we select 12 parameters of our model and we randomly draw 20 values within a reasonable *min-max* interval for each individual parameter at a time, leaving all the other ones unchanged. Then, for each of the 20 values, we perform 20 MC repetitions, each with a different random seed, in the 3 scenarios (BS, RS and CS). Therefore, the univariate analysis of a single parameter implies 1200 simulations. Since we explore 12 parameters, we run 14400 simulations in total.

As a general comment, we highlight that for most variables the resulting variations in output are smaller than the variations in the parameters. This indicates that results are indeed quite robust with respect to univariate changes in model parameters.

Table 6 reports the variation for each parameter between its minimum and maximum value in the sensitivity analysis and the corresponding cross-series variation in GDP at time 500 for BS and at time 1000 for RS and CS[11].

[11] For the sake of simplicity, we report values for GDP only since our results show that

With the only exception of a and k, output variations in the baseline scenario are consistently small for a very wide range of values for each individual parameter. Notice that variations in two parameters, namely v_{max} and ϕ_v, do not determine any change in output in BS. Univariate analysis also shows that individual changes in a wide range of model parameters have no significant effect on the dynamics of the model in the RS scenario either, even though $freeze$ has a slightly more relevant role than in BS. Finally, as expected, all parameters have a more distinctive impact on model dynamics in CS: our analysis confirms the primary role of the consumption parameters, a and k, as well as of the financial parameters related to the behaviour of the banking system, namely *threshold* and v_{max}.

Parameter	*Variation in parameter (%)*	*Variation in GDP-BS at t 500 (%)*	*Variation in GDP-RS at t 1000 (%)*	*Variation in GDP-CS at t 1000 (%)*
k	65.1	12.68	25.60	102.18
a	302.64	28.4	60.37	231.22
v_{max}	103.56	0	0	53.69
ρ	355.25	1.3	2.15	14.38
μ	2505.26	0.39	1.59	19.39
ϕ_Q	1369.17	0.98	3.47	22.05
ϕ_P	1817.82	1.73	3.69	14.36
ϕ_G	274.37	2.38	1.59	9.71
ϕ_{CB}	288.55	1.22	1.39	14.08
ϕ_v	747.62	0	0	34.72
$freeze$	350	3.42	10.02	30.9
threshold	660.69	0.45	0.54	59. 44

Table 6: *Min-max* variations in parameter values for univariate sensitivity analysis, together with corresponding cross-series variation in GDP at time 500 in BS and at time 1000 in RS and CS.

The univariate analysis for the CS scenario shows that values of a between 0.4 and 0.6 result in shorter boom and longer busts, whereas $a > 0.6$ implies a wider duration of the expanding phase of the economy. In addition, values of k lower than 0.5 seem to counterbalance the impact of a higher willingness to lend, as the CS scenario collapses to the RS in this case. a and k are not the only relevant parameters in CS. As a matter of fact, our results suggest that ϕ_Q, ϕ_P, ϕ_v, *threshold* and $freeze$ have an impact on model dynamics in this scenario as well. In particular, higher values of ϕ_Q and ϕ_P imply greater booms and faster recessions. Higher values of ϕ_v and $freeze$ result in faster and stronger booms and longer busts over time, whereas the higher *threshold*, the greater and longer the boom before the bust.

Multivariate analysis tests changes in model results with different calibrations of model parameters. In this case, we build 20 parameter vectors

variations in the other key time series are in line with those for GDP.

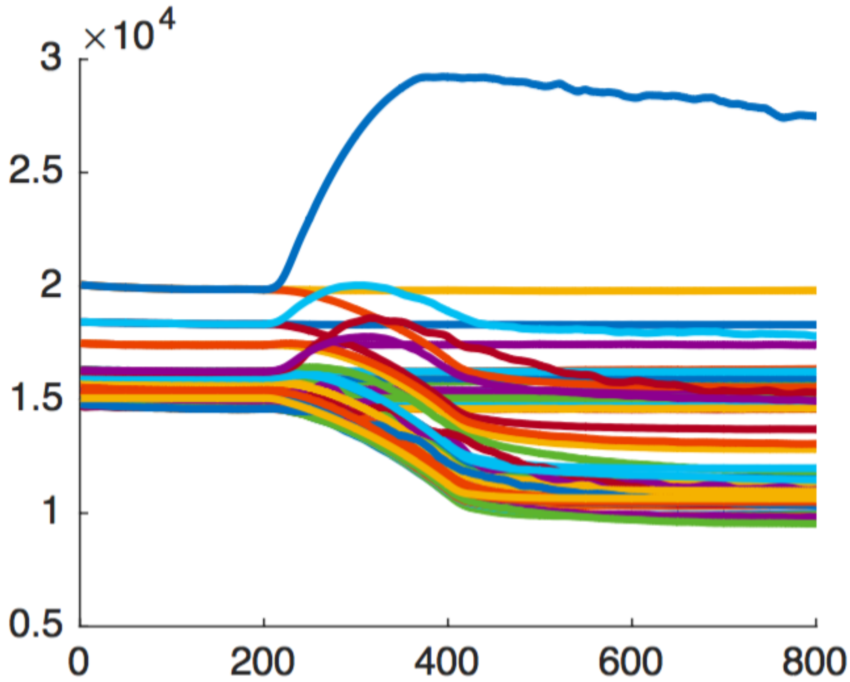

Figure 9: GDP in the multivariate sensitivity analysis.

for our model parameters. Each value in the vector is randomly draw within a reasonable interval. Then, for each of the 20 vectors, we perform 20 MC repetitions, each with a different random seed, in the three scenarios. Hence, in the multivariate sensitivity analysis, we run 1200 simulations in total.

The multivariate analysis shows that the behaviour of the model is robust to parameter changes. Figure 9, which shows GDP for each of the parameter vectors, proves that almost any combination of parameters leads to the same dynamics from a purely qualitative point of view. The only exception to this is represented by the highest blue line in the graph (Figure 9): in CS, for this specific combination of parameters, GDP booms in the expansion phase of the economy while falling at a dramatically slow pace during the recession. By looking at the calibration for this particular case, one may have an intuition about such dynamics: this scenario features a value of a and k close to 1, a very low value of $freeze$ (equal to 2), as well as a higher $threshold$ (around 0.6) and a much greater value for v_{max} (around 0.8). We believe that the explanation for the entity of the boom, as well as its sensationally slow negative growth in the recession, is to be found precisely in the extremely high values of a, k and v_{max} that allow the model to follow the same dynamics as in the standard CS with more pronounced values. In other words, GDP booms as a consequence of stronger expenditure cascades and greater availability of credit. However, after peaking, the economy enters a recession and GDP starts to fall. Its remarkably small negative growth rate might be the consequence of very low value of $freeze$ as it implies easier access to credit markets for both consumption and debt-rollover purposes. In other words, even though the bank lowers its endogenous willingness to lend, households who go bankrupt can still access the credit market after a very few periods and, as such, debt-financed consumption keeps going on during the recession (even though at a lower speed compared to the boom).

With the exception of the above mentioned case, we can generally conclude that results from our simulations are in line with those for the univariate case. That is, our multivariate sensitivity analysis confirms the primary role of just a few model parameters, namely a and k in determining model dynamics in BS and RS. It also highlights the importance of v_{max} and *threshold* in the CS case, thus proving the importance of reproducing alternative financial and policy scenarios by changing the values of such parameters.

4 Conclusion

Through an agent-based macroeconomic model with a stock-flow consistent structure, we showed how different institutional settings and levels of financialisation affect the dynamics of an economy hit by an increase of inequality. In fact, when income disparities become wider, a dilemma arises. That is, when the degree of financialisation is poor and financial institutions are less willing to lend, increasing inequality implies a drop in aggregate demand and output. On the contrary, when credit constraints are relaxed and the financial sector is prone to lend, a short term positive effect on growth comes at the price of greater financial instability: a debt-driven boom and bust cycle emerges. We then carried out an extensive sensitivity analysis, both univariate and multivariate, that confirms the robustness of our main findings.

Our results are in line with insights provided by Kumhof et al. (2012) and Russo et al. (2015). The latter, in particular, build an agent-based macroeconomic model showing that consumer credit has, on the one hand, a positive effect on aggregate demand even though, on the other hand, it accelerates the tendency of the economic system towards a crisis. However, our work also focuses on policy reactions to rising inequality. As a matter of fact, our results show that tackling inequality, by means of a more progressive tax system, can compensate for the rise in income disparities thereby stabilising the economy. Our findings also show that this is a better solution compared to a proactive (Keynesian) fiscal policy reaction, as the latter has no tangible counterbalancing effect with respect to increasing income inequality. Therefore, in order to avoid being caught in between the *Scyilla* of stagnant growth and the *Charybdis* of instability, it seems necessary to act on the structure of the economy and on the problem of inequality at its roots.

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