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Leveraged network-based financial accelerator

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ABSTRACT

In this paper we build on the network-based financial accelerator model of Delli Gatti et al. (2010), modelling the firms' financial structure following the "dynamic trade-off theory", instead of the "packing order theory". Moreover, we allow for multiperiodal debt structure and consider multiple bank-firm links based on a myopic preferred-partner choice. In case of default, we also consider the loss given default rate (LGDR). We find many results: (i) if leverage increases, the economy is riskier; (ii) a higher leverage pro-cyclicality has a destabilizing effect; (iii) a pro-cyclical leverage weakens the monetary policy effect; (iv) a central bank that wants to increase the interest rate should previously check if the banking system is well capitalized; (v) an increase of the reserve coefficient has an impact similar to that produced by raising the policy rate, but for the enlargement of bank reserves that improves the resilience of the banking system to shocks.

1. Introduction

The financial accelerator (Bernanke and Gertler, 1989, 1990; Bernanke et al., 1999) is a positive feedback mechanism that can enlarge business fluctuations. Negative aggregate or idiosyncratic shocks on firms' output make banks less willing to loan funds, hence firms might reduce their investment and this leads again to lower output in a vicious circle. However, models of the financial accelerator available so far are generally limited, in our opinion, because of the Representative Agent assumption. The aggregate mainstream view of the financial accelerator abstracts from the complex nexus of credit relationships among heterogeneous borrowers and lenders that characterizes modern financially sophisticated economies. This causes one of the main problems with the current monitoring systems: they are based on the idea that micro- and macro-behavior should coincide. Then, crises are expected to require aggregate shocks, while in reality small local shocks can also trigger large systemic effects.

Delli Gatti et al. (2010) introduced the "Network-based financial accelerator": the presence of a credit network may produce an avalanche of firms' bankruptcies, then even a small shock can generate a large crisis. Indeed, bankruptcies deteriorate banks' financial condition leading to higher interest rates to all borrowers (Stiglitz and Greenwald, 2003,

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p. 145), thus increasing the weakness of the whole non-financial sector and the number of bankruptcies itself, in another vicious circle that can make banks go bankrupt too.

We want to enrich the "Network-based financial accelerator" with the standard financial accelerator mechanism, modelling the leverage cycle, because changes in leverage over the business cycle are an important amplification mechanism of shocks. Indeed, many papers recently have tried to understand the leverage process both for firms and banks: Adrian and Shin (2008, 2009, 2010), Brunnermeier and Pedersen (2009), Flannery (1994), Fostel and Geanakoplos (2008), Greenlaw et al. (2008), He et al. (2010), and Kalemli-Ozcan et al. (2011). The leverage level is a component of a more general discussion on firm and bank capital structure, such as in Booth et al. (2001), Diamond and Rajan (2000), Gropp and Heider (2010), Lemmon et al. (2008), and Rajan and Zingales (1995). In the economic literature there are many theories on capital structure, but, according to Flannery and Rangan (2006), the three most important ones are:

- "pecking order", proposed by Donaldson (1961) and revived by Myers and Majluf (1984), based on information asymmetry. It implies that investments are financed first with internally generated funds, then with debt if internal funds are not enough, and equity is used as a last resort;
- "trade-off", firstly observed in a paper concerning asset substitution (Jensen and Meckling, 1976), and in a work on underinvestment (Myers, 1977). It is based on the trade-off between the costs and benefits of debt and implies that firms select target debt-equity ratios;
- "market timing" of Baker and Wurgler (2002) founded on behavioral hypotheses. It implies that firms issue shares when the firm's market-to-book ratio is high.

The empirical literature has found contrasting evidence to support these theories. Then, a refined version of the trade-off theory was proposed: the "dynamic trade-off theory". In this theory firms actively pursue target debt ratios even though market frictions temper the speed of adjustment. In other words, firms have long-run leverage targets, but they do not immediately reach them, instead they adjust toward them during some periods. Dynamic trade-off theory seems to be able to overcome some puzzles related to other theories, explaining the stylized facts emerged from the empirical analysis and numerous papers conclude that it dominates alternative hypotheses: Flannery and Rangan (2006), Frank and Goyal (2008), Hovakimian et al. (2001), and Mehrotra et al. (2003). Moreover, Graham and Harvey (2001) conduct a survey where they evidence that 81% of the firms affirm to consider a target debt ratio or range when making their debt decisions.

To model the leverage cycle in a reliable way we apply the dynamic trade-off theory. Indeed, in this paper we build on the agent based model of Delli Gatti et al. (2010), omitting trade–credit relationships and substituting the packing order theory with the dynamic trade-off theory for firms' financial structure. Therefore, we assume that firms have a target leverage. This theory implies that a growing firm will increase its capital by increasing also its debt exposure, thus creating the basis for the subsequent crisis in good periods. Moreover, we allow for multiperiodal debt structure and consider multiple bank–firm links based on a myopic preferred-partner choice. In case of default, we also consider the recovery rate (RR) or loss given default rate (LGDR$=1-$RR) that is the second most important component of the credit risk models after the estimate of the probability of default (PD).

Our analysis is confined to the investigation of business fluctuations in the short-run given that we do not consider either the factors at the root of economic growth in the long period (technological innovations, labor productivity, population growth, and so on) or the inflation dynamics in the medium run (due to the interaction between firms' price-setting and workers' wage dynamics or the change of money supply, and so on). Nevertheless, we analyze the role of the central bank in stabilizing business cycles, in particular to prevent financial crisis due to bankruptcy cascades.

The paper is organized as follows. In the next section we present the general characteristics of our economy. Then, firms' behavior is analyzed in Section 3, while Section 4 considers the banking sector. Simulation results and sensitivity analysis to changes in the parameter values are presented in Section 5. Section 6 reports the sensitivity analysis on the parameter that controls the leverage pro-cyclicality. In Section 7 we propose some computational experiments on monetary policy and macroprudential regulation. Section 8 concludes.

2. Environment

Our economy is populated by households (final consumers and labor suppliers), firms and banks. Firms, indexed by $i=1,2,\ldots,I$, produce consumption goods. Banks, indexed by $z=1,2,\ldots,Z$, extend credit to firms.

We consider two markets: consumption goods and credit market. We will focus on the last market, making simplifying assumptions for the first one. Moreover, we do not explicitly model the labor market.[1]

In the market for consumption goods there are consumers and firms. Prices are exogenously determined: following Greenwald and Stiglitz (1993), we assume that on the market for consumption goods, prices are governed by a random process. We suppose that consumers buy all the output that firms produce and sell at a firm-specific stochastic price (fluctuating around a common average). Consider that this simplifying assumption makes us unable to analyze inflation

[1] The lack of this market does not change the theoretical framework compared to a model where the labor market is present, workers obtain a fixed slice of aggregate income and entrepreneurs set a mark-up on the labor cost.

or deflation dynamics. This implies that in our monetary policy experiments we cannot investigate the usual trade-off between inflation and output growth. However, prices on goods market have the important role of determining profits, which in turn affect the accumulation of net worth and financial fragility. Our analysis is confined to business cycle issues given that there are no growth-enhancing factors as population growth, labor productivity evolution, technological progress, and so on.

The second market is the credit one, where firms and banks, the main actors of the model, interact. The net worth of firms is the "engine" of fluctuations for the economy: we assume that the scale of production of firms is constrained only by their net worth, then it turns out to be the main driver of fluctuations. A shock to a firm affects the credit relationship between the firm and the bank: if the shock is large enough, the firm may be unable to fulfill debt commitments and may go bankrupt. In a networked economy, the bankruptcy of a firm may bring "bad debt" – i.e. non-performing loans – that affects the net worth of banks, which can also go bankrupt or, if they manage to survive, will react to the deterioration of their net worth increasing the interest rate to all their borrowers. Hence, borrowers may incur additional difficulties in servicing debt. The fact that a relatively small shock may be amplified by the credit network, was labeled as "network-based financial accelerator" in Delli Gatti et al. (2010).

The endogenous evolution of credit interlinkages affects the extent of bankruptcy chains: the default of a highly connected agent increases the probability of bankruptcy diffusion across the network. The structure of the network of credit relationships evolves endogenously due to a decentralized mechanism of interaction: in every period each firm looks for the bank with the lowest interest rate. Thus, prices on the credit market (that is, interest rates) have two important roles: (i) influence profits which affect the accumulation of net worth and financial fragility and (ii) shape the evolving topology of the credit network.

3. Firms

3.1. Capital structure

The core assumption of the model, following Delli Gatti et al. (2010), is that the scale of activity of the ith firm at time t – i.e. the level of production Y_{it} – is an increasing concave function of its net worth A_{it}. Indeed, we assume that the production function (called "financially constrained output function") is[2]

$$Y_{i,t} = \phi K_{i,t}^{\beta} \tag{1}$$

where $\phi > 1$ and $0 < \beta < 1$ are parameters uniform across firms and $K_{i,t}$ is the total capital of the i firm at time t, composed of net worth and debt (see Eq. (5)). However, $Y_{i,t}$ is a function of $A_{i,t}$ because we follow the dynamic trade-off theory for the capital structure of firms, then we assume that the amount of debt $B_{i,t}$ is a function of the net worth and of the leverage target $L^*_{i,t}$, where leverage $L_{i,t}$ is defined as debt on net worth ($B_{i,t}/A_{i,t}$).

Within the theoretical framework of the dynamic trade-off theory, firms are not at their desired level, but they try to move towards it. Moreover, in this model agents are not fully rational, thus they could be unable to exactly calculate the optimal leverage. Then we assume that firms have a leverage target set through an adaptive behavioral rule: the current leverage target is equal to the previous level modified by a random percentage increase (decrease) when its previous period gain is above (below) the financial costs. In other words, the leverage target increases when the expected profits are high compared to the passive interest rate and viceversa.

Accordingly, the leverage target for each firm is given by

$$L^*_{i,t} = \begin{cases} L_{i,t-1} \cdot (1 + adj \cdot U(0,1)), & \text{if } p^e_{i,t}/\sqrt{1 + A_{i,t}/A^{max}_{i,t}} \geq r^e_{i,t} \\ L_{i,t-1} \cdot (1 - adj \cdot U(0,1)), & \text{otherwise} \end{cases}, \tag{2}$$

where adj is a parameter that sets the maximum leverage change and it is multiplied by a random number drawn by a uniform distribution between 0 and 1, and the correction for the relative net worth $\left(\sqrt{1 + A_{i,t}/A^{max}_{i,t}}\right)$ has been introduced to consider the presence of decreasing return of scale in the production function.[3] In particular, we are assuming not fully rational firms: indeed, they are not able to perfectly forecast the expected price and the interest rate, so they use an adaptive (static) expectation according to which $p^e_{i,t} = p_{i,t-1}$,[4] and $r^e_{i,t} = r_{i,t-1}$. Then, this level changes among firms and over time given the evolution of $p_{i,t-1}$ and $r_{i,t-1}$.

Given the leverage target, firms fix a debt target $B^*_{i,t}$ in the following way:

$$B^*_{i,t} = A_{i,t} L^*_{i,t} \tag{3}$$

[2] The concavity of the financially constrained output function captures the idea that there are "decreasing returns" to financial robustness. Moreover, following Greenwald and Stiglitz (1993), this function can be thought of as the solution of an optimization problem of firms' expected profits net of expected bankruptcy costs. For a detailed discussion see Delli Gatti et al. (2010, pp. 1630–1631).

[3] In simulations the leverage level cannot be set below 1%.

[4] This model specification is robust to changes in the formation of price expectations, such as an exponential smoothing of previous observed prices.

In this way, a firm that has some reinvested profits, increasing $A_{i,t}$, will also ask banks' new debt funds to reach the desired level of leverage: the debt is built during growth periods.

We could also assume that this mechanism is driven by the bank side: banks are willing to lend money to profitable firms and firms use the available money; the reverse is true when firms have losses: banks constraint the amount of credit and firms are forced to reduce their debt exposure (as explained by the large literature on credit rationing, at least starting from Weiss and Stiglitz, 1981). Therefore, we assume that firms are averse to the risk of bankruptcy (see Eq. (1)), while banks finance firms without (credit) constraints, just for modeling purpose, given that the final outcome is the same. However, the evidence suggests that bank lending to firms declines during the crisis, but Adrian et al. (2012) show that the impact on real activity comes from the spike in risk premiums, rather than contraction in the total quantity of credit.

To make the model more realistic, we assume that debt lasts for two periods. To do it, every period each firm asks an amount of debt equal to the difference between the debt target and the residual amount of debt made in the previous period (and that will expire in the following one):

$$B_{i,t} = \max(B^*_{i,t} - B_{i,t-1}, 0) \tag{4}$$

Thus

$$K_{i,t} = A_{i,t} + B_{i,t} + B_{i,t-1} \tag{5}$$

If a firm suffers high losses that, reducing the net worth, make the debt target smaller than the previous debt, the firm does not ask new debt.

In this way we address four problems. First, we consider that firms prefer multiperiodal debt. Second, it is possible for firms to have two banks to obtain credit (in practice big firms often have syndicated loans or multiple banks). Third, given the previous features, we add another factor which is able to spread the financial instability in the network. Fourth, as implied by the dynamic trade-off theory, firms that suffer high losses may present a real debt higher than that implied by the current target because now the target is lower than the previous period debt; this rigidity may cause financial problems to firms.

3.2. Firm–bank interaction

In every period every firm asks for a debt that lasts two periods and whose amount is determined as explained in the previous sections. Thus, in every period firms usually have two debts, one of which is expiring and has to be renewed. Initially, the credit network, i.e. the links among firms and banks, is random. Afterwards, in every period each borrower observes the interest rates of a number χ of randomly selected banks. We assume, as done in Delli Gatti et al. (2010), that the firm changes the bank with a propensity ps of switching to the new lender, that is increasing (in a non-linear way) with the difference between r_{old} (the previous bank's interest rate) and r_{new} (the interest rate set by the observed potential new bank), only if it finds another bank that charges an interest rate lower than the current one. In symbols

$$ps = 1 - e^{(r_{new} - r_{old})/r_{new}} \quad \text{if } r_{new} < r_{old} \tag{6}$$

This procedure to choose the partner is activated in every period, but the partner is changed less frequently. In this way, we model the sticky connection between a borrower and linked banks, due to the (asymmetric) information on the firm owned by the bank.

However, the topology of the network is in a process of continuous evolution due to the changing interest rate charged by the banks. Indeed, banks characterized by more robust financial conditions can charge lower prices and therefore attract more new partners.[5] As a consequence, their profits go up and their financial conditions improve, making room for even lower interest rates in the future and attracting more new partners. This self-reinforcing mechanism gives rise to an endogenous evolution of the credit network that will be characterized by a right-skew distribution for node degree: there will be nodes characterized by a relatively high number of links (hubs) and nodes with a small number of connections.

The partner selection mechanism could have interesting effects on the whole system: when a negative shock hits a node – for instance a firm goes bankrupt – the lenders of the bankrupted firm react by raising the interest rate charged to all the other borrowers, as we will see in the section dedicated to banks. This interest rate hike may result in higher profits for the bank, if its clients do not change their borrowing relationships (because they do not find better partners in terms of significantly lower interest rates). However, firms facing a higher rate of interest on loans may go bankrupt, thus causing an "indirect" negative effect on bank's profits (as a consequence of non-performing loans). Instead, an interest rate hike may induce the borrowers to switch to lenders who offer more favorable conditions, with two possible effects: on one hand, mitigating the spreading of the shock to other firms, i.e. slowing down the financial accelerator (that is, the network effect mitigates financial instability); on the other hand, further weakening the bank that suffers for the bankruptcy (that is, the network effect amplifies financial instability).

[5] See Delli Gatti et al. (2010, pp. 1632–1633) for references on the relationship between banks' financial soundness and interest rate setting.

3.3. Profits

Profits ($Pr_{i,t}$) are a key component of the model for two reasons:

- they determine firms' net worth $A_{i,t}$ in the following way:
$$A_{i,t+1} = A_{i,t} + Pr_{i,t} \tag{7}$$
- they are used to set the target leverage as already seen in Section 3.1.

Profits are computed with the following formula:
$$Pr_{i,t} = p_{i,t} Y_{i,t} - R_{i,t} B_{i,t} - R_{i,t-1} B_{i,t-1} \tag{8}$$
where $Y_{i,t}$ is the output, $R_{i,t}$ is the interest rate paid on the last loan ($B_{i,t}$), $R_{i,t-1}$ is the interest rate paid on the loan received in the previous period ($B_{i,t-1}$) and $p_{i,t}$ is the stochastic gain on a unit of output that contains the stochastic price net of the expenses for producing the output itself (but for financial costs). In practice $p_{i,t}$ is composed of two parts
$$p_{i,t} = \alpha + g_{i,t} \tag{9}$$
where α is the expected gross per unit profit (that is net of financial costs), and $g_{i,t}$ is the random component for each firm in each period. We assume that the random part is a variable distributed as a Normal with zero mean and finite variance ($varp$). The rationale is the same explained in Delli Gatti et al. (2010): given the predetermined supply, the relative price is an increasing function of the demand disturbance. A high realization of $p_{i,t}$ can be thought of as a regime of "high demand" which drives up the relative price of the commodity in question. On the other hand in a regime of "low demand", the realization of $p_{i,t}$ turns out to be low and may push the firm to the bankruptcy.

3.4. Bankruptcy

At the end of each period, the net worth of the i firm is defined, as already seen, by $A_{i,t+1} = A_{i,t} + Pr_{i,t}$. The firm goes bankrupt if $A_{i,t+1} < 0$, i.e. if it incurs a loss (negative profit) and the loss is big enough to deplete net worth: $Pr_{i,t} < -A_{i,t}$. When a firm goes bankrupt, we assume that a new firm enters the market with a very small random net worth.

4. Banks

4.1. Profits

Banks' net worth $A_{z,t}$ evolves in the following way[6]:
$$A_{z,t+1} = A_{z,t} + Pr_{z,t} \tag{10}$$
where $Pr_{z,t}$ is bank z profit at time t, given by
$$Pr_{z,t} = \sum_i R_{i,z,t} B_{i,z,t} + \sum_i R_{i,z,t-1} B_{i,z,t-1} - r_t^{CB} D_{z,t} - c \cdot (A_{z,t} + D_{z,t}) - bad_{z,t} \tag{11}$$
where $R_{i,z,t}$ is the interest rate paid on $B_{i,z,t}$ (if firm i has not gone bankrupt), r_t^{CB} is the central bank official interest rate, $D_{z,t}$ is the amount of the z bank's deposits, c is a cost proportional to bank's size (proxied by net worth plus deposits) and $bad_{z,t}$ is the z bank's bad debt. In particular

- deposits $D_{z,t}$ are computed as the sum of all loans to firms, less than a fraction of the net worth and considering a reserve coefficient. In other words, deposits derive from extended credit as follows:
$$\sum_i B_{i,z,t} + \sum_i B_{i,z,t-1} = \rho A_{z,t} + (1-\mu) D_{z,t} \tag{12}$$
where μ is the reserve coefficient on deposits and ρ is the fraction of the net worth that could be lent.[7]
- bad debt $bad_{z,t}$ is computed as the sum of all the credit lent to firms gone in default in period t, multiplied by the loss given default rate (LGDR), that is 1 less than the recovery rate (RR); RR is computed as the ratio between the asset and the debt of the bankrupted firm and decreased by a fixed amount for the legal expenditure LE. In this way we insert the two most important components of the credit risk models: the probability of default (PD) and the loss given default rate (LGDR).

[6] The law of motion of banks' net worth is very simple, given that we do not consider many aspects such as dividends or right issues. The same holds for firms.

[7] We set the value of the parameter ρ as a function of μ, such that the interest rate set by the bank is decreasing in its net worth.

4.2. Interest rate setting

As already seen in Section 3.1, firms require credit from banks. Each bank sets a different interest rate on loans and these differences imply that firms sometimes change banks to obtain a lower interest rate, following the mechanism explained in Section 3.2.

We assume that the zth bank adopts the following rule in setting the interest rate on loans to the ith borrower:

$$R_{i,z,t} = f_1(L_{z,t}) + f_2(L_{i,t}) \tag{13}$$

Thus the interest rate is composed of two parts:

(i) a bank specific component: $f_1(L_{z,t}) = c(A_{z,t}/B_{z,t}) + (c + r^{CB})(D_{z,t}/B_{z,t}) + \theta$; this equation is derived by setting the bank profit equation (11) equal to zero and then adding a mark-up θ. This term decreases with the financial soundness of the bank proxied by the zth bank's leverage $L_{z,t} = D_{z,t}B_{z,t}$, indeed an increase of $A_{z,t}$, for a given level of extended credit $B_{z,t}$, reduces the deposits $D_{z,t}$ (see Eq. (12)). In other words, if the bank is in good shape from the financial point of view, it will be eager to extend credit at more favorable terms to increase its market share. This is in line with the assumption made by Delli Gatti et al. (2010) and the references therein included. Moreover, although many papers suggest that bank lending to firms declines during the crisis, Adrian et al. (2012) empirically find that the impact on the real economy mainly derives from the spike in interest rates, rather than the contraction in the quantity of credit.

(ii) a term that incorporates a risk premium increasing with borrower's leverage: $f_2(L_{i,t}) = \eta L_{i,t} BAD_{t-1}/B_{t-1}$; banks infer the expected loss rate (both the probability of default and the loss given default rate) from the previous period aggregate bad debt ratio ($BAD_{t-1} = B_{t-1}$) and then they estimate the expected default probability of each firm as an increasing function of borrower's leverage. The presence of this endogenous premium in the interest rate is a channel of the network-based financial accelerator.

5. Simulations

We analyze our economy by means of computer simulations. We assume that this economy is composed of 500 firms and 50 banks over a time span of 1000 periods. Figures and statistics are about the last 800 periods, given that the first periods are needed to initialize the simulations. At the beginning of the simulation, we set the net worth of each firm to 1 and of each bank to 10. We assume that, when a firm goes bankrupt, it is replaced by a new firm with net worth equal to a random number between 0 and 1; the same holds for banks in the interval 0–10; in this way the entrant is small relative to the size of incumbent firms/banks. We begin simulations with a baseline model considering the parameter values reported in Table 1.

In this section we report the simulation of the baseline model; Sections 5.1 and 5.2 present a robustness check and a summary of the sensitivity analysis, respectively. Section 6 proposes an extended analysis about the role of the adjustment parameter *adj*. Section 7 analyzes some policy experiments. However, we do not perform a validation exercise, given that we sketch many characteristics of the economic system and we neglect some others such as the labor market, even if we choose parameter values to reproduce some empirical regularities in the simulated data already explained by Delli Gatti et al. (2010). Indeed, even if all firms start from the same conditions, they become rapidly heterogeneous and a right-skew distribution of firms' size emerges. This feature also emerges for banks, which concurrently present a right-skew distribution of the number of borrower firms (the degree distribution of the credit network). The mechanism is simple: weaker firms grow less with less debt (or they could even go bankrupt), thus their banks grow less. Smaller and less profitable banks set higher interest rates and

- lose some customers, further reducing their own growth;
- decrease the growth of their residual borrowers, which face higher interest rates.

Table 1
Parameter setting of the baseline model.

Parameter	Value	Meaning
ϕ	3	See production function Eq. (1)
β	0.7	See production function Eq. (1)
α	10%	Expected gross profit, see Eq. (9)
varp	0.5	Profit variance, see Eq. (9)
adj	10%	Maximum percentage of leverage change allowed to firms
r^{CB}	2%	Central bank monetary policy rate, see Eq. (13)
μ	5%	Reserve coefficient on deposits, see Eq. (12)
θ	2%	Banks' mark-up, see Eq. (13)
η	0.5	Risk premium parameter, see Eq. (13)
c	5%	Bank operational costs, see Eq. (11)
LE	0%	Legal expenditure in case of firm default, that increases LGD
χ	5	Number of bank observed by each firm, every period

On the other hand, financially robust banks increase their market shares. Therefore, both the corporate and the banking sectors become polarized and the degree distribution becomes asymmetric.

Our model extends the analysis of the network-based financial accelerator proposed by Delli Gatti et al. (2010) by considering the effect of the dynamic trade-off theory and the endogenous evolution of the firms' leverage. Indeed, a firm that makes negative profit, lowers its activity, reducing both the amount of internal and external funds. Here we assume that the firm asks less credit, but this characteristic could be theoretically coupled with the unavailability of banks to loan funds to a firm with negative profit. Hence the firm reduces its investment, leading again to a lower output. Moreover, a firm could even be unable to pay its debt to banks and goes bankrupt. Its banks record a non-performing loan that reduces their net worth. If banks are not financially robust, they could also go bankrupt. Instead, if the loan is relatively small compared to the banks' net worth, they survive the loss; however, even in this case, banks increase the interest rates to other borrowers to cover the loss; the increased interest rates reduce the firms' profits, starting again the standard financial accelerator or, if other firms go bankrupt, enlarging the network-based mechanism. In both cases, with or without bank defaults, the initial shock spreads across the financial network, with the possibility to create an avalanche of bankruptcies, which amplifies business fluctuations. Therefore, the network makes possible that an idiosyncratic shock creates an extended/global crisis, without the need of a systemic shock.

In other words, simulations shown in Fig. 1 tell the following story: when a firm makes high profit, it increases its net worth. Thus, the firm wants (and has the possibility because banks evaluate it profitable) to obtain further funds from banks to enlarge its leverage. Moreover, it may have a higher target leverage: it is profitable to obtain more credit to invest in an activity with a high gain, higher than the lower cost of the credit. In good times there are the seeds of the subsequent crisis, with a possible high debt level. Then, in this case the pro-cyclicality of credit clearly emerges, given that during a first phase the increase of leverage (i.e., the debt grows more than net worth) boosts firms' growth until the system reaches a critical point of financial fragility and the cycle is reversed through deleveraging. This feature results clearly looking at Fig. 2: during an expansion the production growth allows to further expand the economy through increasing the leverage (negative lags in the figure show positive correlation between firms net worth and subsequent leverage); the increase of leverage, in turn, enlarges the production (first positive lags in the Figure), but after a while the rise of financial fragility eventually leads to a recessionary phase (negative values of cross correlations' positive lags). Indeed, when the leverage is high, this may boost production along an expansion, but the economy may also become more fragile and volatile, and then:

- a negative real shock for the firm can easily create a large loss when the debt is high, because there are high interests to be paid without a corresponding gain. According to what is said above about the influence of the leverage on net worth (and then production), the cross-correlation function between leverage and bad debt ratio (the sum of all the debts that

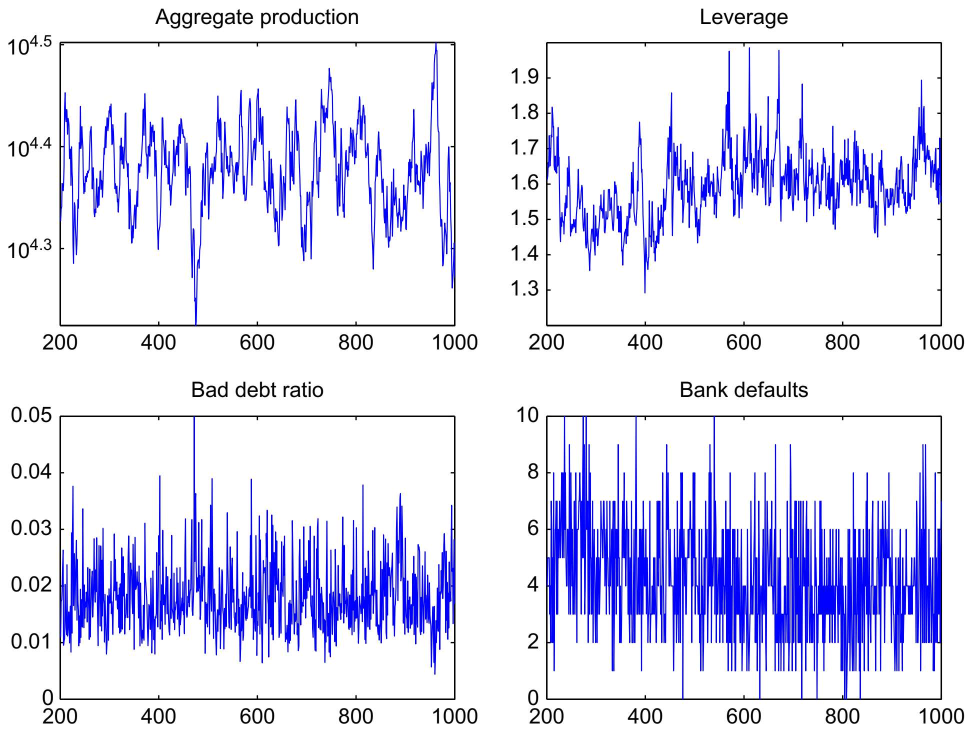

Fig. 1. Baseline model: simulation results.

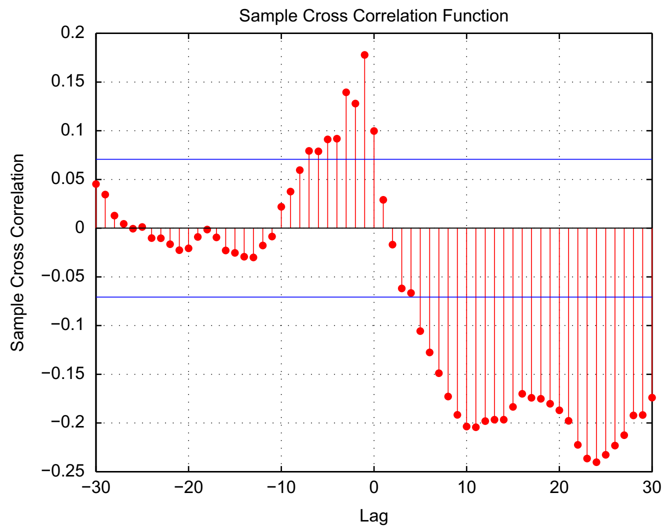

Fig. 2. Cross-correlation between firms' leverage and net worth.

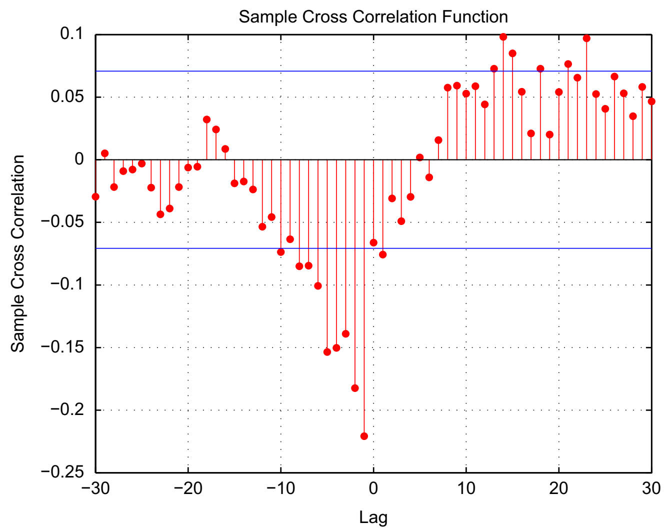

Fig. 3. Cross-correlation between firms' leverage and bad debt.

is not repaid by the firms defaulted in the period divided by the overall outstanding credit) highlights the mechanism of financial fragility (Fig. 3): during the expansionary phase of the cycle, the decrease of firm defaults reduces the bad debt ratio and the accumulation of capital proceeds; this allows firms to borrow more (negative cross-correlations of negative lags in Fig. 3) both because they are more capitalized and because banks are financially sounder. But, after some periods the increased leverage results in a "too-high" financial fragility and an increase of defaults (and of bad debt) follows (positive cross-correlations between leverage and subsequent bad debt ratio). Thus, with the variable leverage, the standard financial accelerator is even increased and we can call it "leveraged financial accelerator";

- the increased number of firm bankruptcies starts the "network-based accelerator"; the correlation between firm and bank defaults is clearly significant: in the same period firm and bank defaults are positively related, with a correlation coefficient equal to 20%. Now, the reduced bank capitalization due to the increased previous bad debt, tightens the credit supply and makes the interest rates higher for the other firms, so increasing the number of defaults: this is shown by the autocorrelation function of firms bad debt that shows significant positive values for some lags (see Fig. 4).[8]

[8] We can see it also in the unreported cross-correlation function between firm bankruptcies and bad debt ratio: a higher bad debt ratio increases the following periods bankruptcies and, by definition, bankruptcies increase the same period bad debt.

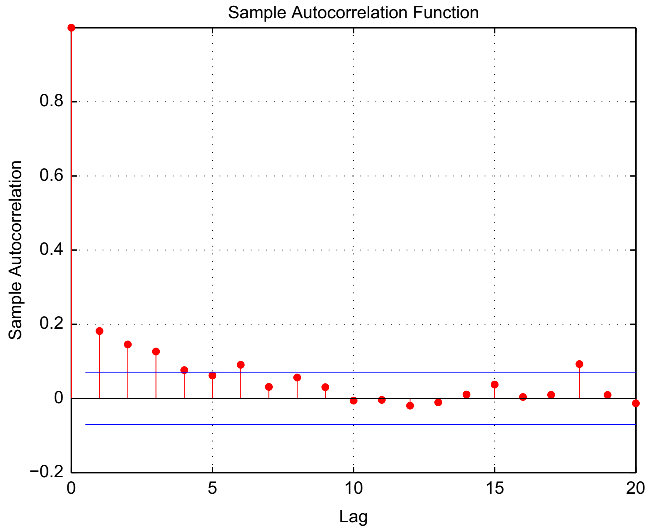

Fig. 4. Autocorrelation of bad debt ratio.

Fig. 1 shows that, in our simulations, financial fragility creates quite strong bankruptcy avalanches with the average number of defaulted banks in the same period that is equal to 4.25 but varies from a minimum of 0 to a maximum of 10; moreover, bankruptcies tend to cluster in subsequent periods; the distribution of bank defaults presents positive skewness (about 0.3) and high kurtosis (about 6). However, this propagation mechanism could be dampened (or increased) considering the interbank market,[9] that we want to introduce in further extensions of the present model. Finally, we observe that firm bankruptcies vary from a minimum of 87 (17.4% of overall firms) to a maximum of 149 (29.8%), with a mean of 117.7 and a distribution with a high kurtosis of about 6.

5.1. *Robustness check*

We implement a Monte-Carlo experiment repeating the simulation 100 times with different seeds of the pseudo-random number generation process, to check the robustness of our findings.

All the features of the baseline model are confirmed. Table 2 shows that the Monte-Carlo averages of simulations are included in a narrow range. The two cross-correlation functions between leverage and net worth or bad debt ratio, two of the most important characteristics emerging from simulations, confirm the cyclical behavior of leverage. Indeed, in almost all the 100 simulations, we detect a positive correlation between net worth and the subsequent leverage and a negative correlation between leverage and the following net worth. Moreover, we observe a strong evidence of negative correlation between bad debt ratio and the subsequent leverage, while a positive correlation between leverage and the following bad debt emerges.

5.2. *Sensitivity analysis*

In this section we briefly discuss the effects of changing some relevant model parameters (keeping all the other variables fixed at the level set in Table 1). In this way we check the sensitivity of our findings and some interesting results emerge:

- ϕ: a higher value of this parameter implies a higher volatility of aggregate production. It is worth to note that this is related to a higher level of the aggregate production itself. Then, a trade-off between production level and its volatility emerges.
- β: its increase rises the volatility of the aggregate production's growth rate, the leverage level, the number of defaults and the amount of the bad debt ratio. Moreover, it implies very strong cascade effects.
- α: the higher the average profit for firms the more stable the economic system is. Indeed, the number of firm defaults decreases and the overall banking system is less fragile (more capitalized); the increased stability emerges even if the system has a higher leverage, thus, a stronger economy can support a certain increase of leverage.

[9] There is an increasing literature branch that is studying the ability of the interbank market in reducing the systemic/contagion risk, since the seminal paper of Allen and Gale (2000), with works such as Acharya (2009), Allen et al. (2010), Brock et al. (2009), Castiglionesi and Navarro (2010), Gai and Kapadia (2010), Haldane and May (2011), Ibragimov et al. (2011), Ibragimov and Walden (2007), Nier et al. (2007), Shin (2008, 2009), Stiglitz (2010), Wagner (2009) and so on. Many of these papers highlight that an increasing connectivity of the interbank network implies a more severe trade-off between the stabilizing effect of risk diversification and the destabilizing effect of bankruptcy cascades.

Table 2
Mean, minimum and maximum of relevant statistics across 100 simulations.

	Mean	min	max
Growth std (%)	4.11	3.85	4.42
Leverage mean	1.59	1.55	1.62
Leverage maximum	1.97	1.82	2.30
Bad debt ratio mean (%)	1.84	1.73	1.96
Bad debt ratio max (%)	5.33	4.04	7.87
Bank defaults mean (%)	4.22	3.43	5.37
Bank defaults max (%)	11.44	9	15

Table 3
Sensitivity analysis on *adj*.

adj	6%	7%	8%	9%	10%	11%	12%	13%
Growth std (%)	3.53	3.69	3.91	3.98	4.12	4.20	4.37	4.55
Leverage mean	1.41	1.47	1.52	1.58	1.61	1.66	1.73	1.76
Leverage maximum	1.59	1.75	1.85	1.84	2.02	1.99	2.26	2.26
Bad debt ratio mean (%)	1.41	1.49	1.59	1.68	1.76	1.85	1.96	2.02
Bad debt ratio max (%)	3.83	4.60	4.71	5.33	4.91	5.81	5.07	6.64
Bank defaults mean	3.67	3.63	4.59	5.15	4.99	4.82	5.58	6.31
Bank defaults max	11	9	11	13	13	11	14	14

- *varp*: higher gain volatility implies a more volatile economy, with a growing number of firm bankruptcies, increasing the likelihood of bankruptcy cascades.
- η and θ: these parameters have similar effects on simulation results: if their value increases then the interest rate rises and a decrease of the firm leverage and of aggregate production follow; nevertheless the lower leverage, there is an increase of the bad debt ratio due to the interest rate hike and the economic slowdown, while bank defaults diminish due to a higher mark-up.
- *Initial conditions*: computer simulations are robust to changes in initial conditions concerning firms' and banks' net worth. We also simulate the system for different ratios between the number of firms and banks. Simulations are again robust when the number of firms per bank increases, but for a lower volatility of the growth rate, and a reduced number of bank defaults given that each bank has more customers.[10]

6. From variable to fixed target leverage

We devote this section to the sensitivity analysis of the parameter *adj* because this is the most important variable regarding the leverage behaviour. We change it from 6% to 13% with steps of 1%. As *adj* grows, an increase of all analyzed variables follows (see Table 3). In particular, a strong adjustment of the leverage level increases the volatility of the system both in terms of the aggregate production's growth rate,[11] firm failures (bad debt ratio), and bank defaults. It is worth to note that cascades of bad debt are more likely to appear for larger values of *adj* (for example, when $adj = 13\%$, the average of the bad debt ratio is around 2% and a cascade of almost 7% magnitude may happen). It clearly emerges that a higher mean leverage (due to the fact that the skewness of leverage distribution increases when *adj* is higher: the distribution of the leverage has a lower bound in 0, while it has not an upper bound theoretically) and a stronger pro-cyclicality of the leverage increases the "leveraged network-based financial accelerator" with a destabilizing effect on the economy. Instead, as *adj* decreases the pro-cyclicality of the leverage becomes less evident.

Geanakoplos (2010) finds that leverage is pro-cyclical, while Kalemli-Ozcan et al. (2011), as well as Adrian and Shin (2008, 2009) find that the leverage pattern for non-financial firms is acyclical (instead this is pro-cyclical for investement

[10] *Minor parameters:* the number of observed banks χ just influences the number of bank defaults, given that when firms have a larger set of banks among which to choose the best partner, they tend to concentrate on the cheapest ones, so implying the failure of minor banks. The parameter c has a similar effect. A relevant increase of bank defaults is also caused by an increase of parameter *LE*: if the recovery rate (RR) is reduced, the amount of bad debt increases for a given number of firm defaults; then, it strongly affects bank profits and the number of bank defaults. The policy maker has to develop the laws about bankruptcies also to improve the stability of banks. Finally, the fact that bank defaults are not strongly related to other output variables, and in particular to aggregate production, is the consequence of our simplifying assumption of one-to-one replacement of bankrupted agents. Indeed, in certain circumstances, for instance when χ, c or *LE* are "high", small banks tend to fail with a high probability and they are replaced by new "small" entrants that stabilize the system and, in turn, have a high probability to fail, and so on. As a consequence, the banking system becomes more concentrated and a large fraction of firms, that continues to borrow from large banks, does not have consequences from the high default rate of (small) banks. This is one of the assumptions we want to remove in our future research on the topic.

[11] The growth rate is calculated on firms' production only. The banking sector component is not included in the product computation.

Table 4
Sensitivity analysis on r^{CB}.

r^{CB}	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Growth std (%)	3.95	3.92	3.92	4.12	4.18	4.14	4.12	4.17
Leverage mean	1.68	1.66	1.64	1.61	1.60	1.57	1.55	1.53
Leverage maximum	2.12	2.08	2.03	2.02	1.98	1.89	1.98	1.86
Bad debt ratio mean (%)	1.36	1.50	1.63	1.76	1.92	2.06	2.22	2.41
Bad debt ratio max (%)	4.42	3.97	3.98	4.91	4.86	5.14	5.07	5.90
Bank defaults mean	2.10	3.10	4.12	4.99	5.76	7.59	9.20	9.90
Bank defaults max	7	10	10	13	14	16	18	19

Table 5
Sensitivity analysis on r^{CB} with leverage target = 1.5.

r^{CB}	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Growth std (%)	3.30	3.42	3.51	3.60	3.71	3.79	3.84	3.92
Bad debt ratio mean (%)	1.28	1.45	1.60	1.78	1.99	2.19	2.40	2.61
Bad debt ratio max (%)	3.16	3.36	3.80	4.22	4.83	5.25	5.62	5.54
Bank defaults mean	3.12	4.79	6.18	7.93	9.90	10.35	11.88	13.93
Bank defaults max	9	11	16	15	22	19	24	24

banks and large commercial banks). We simulate the model also for very low values of *adj* (for instance, 1%), finding that our model is able to reproduce also this acyclical pattern. The counter-cyclical behavior emerges for values of *adj* approaching zero. In the extreme case, when *adj* is zero, the financial structure of the model changes and it is based on a fixed leverage target (that is the standard trade-off theory). In this scenario, the leverage is counter-cyclical.[12] Accordingly, our model gives rise to different patterns of leverage along the business cycle: from pro-cyclical to acyclical and even counter-cyclical.

The simulation with fixed leverage target has a smaller standard deviation of the production growth (3.60%, as shown in Table 5, compared to 4.12% of our baseline model), because there is no pro-cyclicality of the leverage that increases investments in growth periods and decreases them during recessions: do not consider the leverage pro-cyclicality which makes it lose a component of volatility due to the financial accelerator.

Moreover, with the variable leverage also big firms go bankrupt, as shown by the maximum reached by the bad debt ratio that is higher than the maximum reached with fixed target leverage (4.91% vs 4.22%) even if the mean bad debt is similar and the number of firm defaults is higher when the target is fixed (the average is 117 vs 125, with a maximum of 148 vs 154). The reason is that a firm that has a high profit enlarges not only its net worth, but also its leverage, thus it could be financially fragile even with a high net worth.

The inverse relation between firm net worth and leverage is also the cause of another difference between the two simulations. Indeed, the number of bank defaults is higher if the leverage is fixed. The reason is that, in case of fixed leverage target, a negative correlation between net worth and leverage emerges: a net worth reduction can pursue the real leverage over the target; in this case banks do not constraint the credit to firms, then they are more exposed. Instead, the variable leverage simulation presents, as already explained, a positive correlation between net worth and leverage. In this way banks reduce their risks and their probability of default, reacting to the external changes.

7. Policy experiments

In this section we firstly show the effect of the sensitivity analysis on r^{CB} and then we analyze a couple of policy experiments: (i) monetary policy and (ii) macroprudential regulation. As already said, stochastic prices fluctuate around a common mean, then the central bank does not follow an inflation target strategy or somewhat similar focused on the control over inflation through interest rate changes. However, we find interesting to investigate the influence of monetary policy on the financial stability of the system.

[12] In this case, the exogenous choice of the fixed target leverage is fundamental, while in the variable leverage target setting the system evolves to an endogenous target, reducing the impact of the initial condition. In order to compare this simulation with the baseline one, we set the fixed target leverage at 1.5. The effective mean leverage is a bit over the target – about 1.6, very close to the mean leverage which emerges from the baseline model – and has a small, but non-null variance, because of the mechanism of Eq. (4) explained in Section 3.1. This mechanism is also the cause of the counter-cyclical pattern: a firm facing a huge net worth loss should proportionally reduce the debt, but it could be not feasible at all if the previous period debt is so high that push the leverage above the target.

7.1. Monetary policy

When r^{CB} (see Table 4) increases, firms' financial conditions weaken. This has two consequences:

- firm defaults and the bad debt ratio increase, leading to a higher number of bank defaults;
- firms ask for less credit, reducing the leverage.

The second effect counteracts the first. Indeed, if we repeat the same sensitivity analysis (as shown in Table 5) setting the leverage target at the fixed level of 1.5, we find that a higher interest rate has much stronger consequences: firm and bank defaults increase compared to the simulations with floating leverage, because the fixed level of the firm leverage does not allow the system to adapt itself to the new monetary conditions. For the same reasons, the rise of the interest rate set by the central bank leads to a stronger increase of growth volatility (whose level is higher with a variable target due to the procyclicality of leverage) in the case of fixed leverage.

Then, model findings suggest that the central bank should also consider this effect of monetary conditions on the leverage when deciding monetary policy changes. For example, a reduction of the interest rate made to revitalize the economy could increase the overall leverage and, then, the likelihood of bankruptcy chains.

Now we analyze the following policy experiment: we modify the interest rate during the simulation to show the different impacts of monetary policy in a context of fixed vs variable leverage. When the policy rate decreases (increases) a short-run expansion (restriction) of aggregate production follows (after a while the growth rate converges to the long-run level) with a fall (growth) of firm and bank defaults. Table 6 shows the effects due to a policy rate decreases from 3% to 1% at time 600, both for a simulation with fixed leverage and with variable leverage target. We can observe that the effect of the monetary expansion is stronger in the case of fixed leverage: the last two columns show the difference between growth standard deviation, bad debt ratio and bank defaults before and after the interest rate change. It is evident that neglecting the influence of the policy rate on leverage may lead the central bank to overestimate the strength of the monetary policy. As already observed, the reason is that the firm leverage increases due to the reduction of the interest rate: indeed, when the central bank interest rate is set at 3% the mean leverage is 1.55, with a standard deviation of 6.97% and a maximum of 1.78; instead, when the policy rate is set at 1% the mean leverage is 1.66, with a standard deviation of 7.87% and a maximum of 1.99; then, the higher and more volatile level of firm leverage counteracts the positive effects of the monetary expansion, making the economy relatively more fragile.

We try another experiment. In this case we keep the leverage target variable and we implement a monetary tightening from 2% to 4% in two simulations with a different value of bank costs c: 2% and 5%. As already explained, the monetary tightening creates a recession phase, but after a while the growth rate converges to the long-run level. However, after the recession phase, the number of bank defaults remains higher (from 6.05 to 8.67 mean bank default per period) in the simulation where c is 5%, because the banking system is less capitalized and the increased number of firm bankruptcies makes it more fragile. On the other hand, when c is equal to 2% there is no difference between the two sub-samples (before and after the monetary restriction), given that the bank failures are about 1 for each period in both cases. Thus, a policy implication emerges according to which, when the aim is to increase the interest rate, the central bank should also check if the banking system is well capitalized.

7.2. Regulatory policy

Let us now investigate the case for macroprudential regulation, that is the role of parameter μ. In Table 7 we provide the results of the sensitivity analysis on this parameter: as its value increases, a rise of the compulsory reserves on bank deposits follow. It emerges that a higher reserve coefficient on deposits μ leads to a slight increase of growth volatility, a decrease in the average level of firm leverage and its maximum value, an increase of both the mean and the maximum bad debt ratio, and an increase of both the bank default rate and its maximum value. Then, the effects are qualitatively similar to those emerged from the sensitivity analysis on the policy rate r^{CB}, given that an increase of the reserve coefficient results in a larger demand of liquidity (deposits) on the part of banks (to keep unchanged the supply of credit) that, in turn, leads

Table 6
Monetary policy with variable target leverage and fixed target leverage at 1.5.

Leverage	Variable	Fixed	Variable	Fixed	Variable	Fixed	Variable	Fixed
Sample	201:1000	201:1000	201:600	201:600	601:1000	601:1000	Δ	Δ
Growth std (%)	4.17	3.60	4.37	3.88	3.96	3.31	−0.41	−0.56
Bad debt ratio mean (%)	1.84	1.95	2.22	2.44	1.45	1.46	−0.76	−0.98
Bad debt ratio max (%)	4.99	4.93	4.99	4.93	3.18	3.07	−1.81	−1.86
Bank defaults mean	4.98	7.31	6.24	9.40	3.72	5.21	−2.52	−4.18
Bank defaults max	14	17	14	17	12	12	−2	−5

'variable Δ' represents the difference between column 'variable 601:1000' and column 'variable 201:600', while 'fixed Δ' represents the difference between column 'fixed 601:1000' and column 'fixed 201:600'.

Table 7
Sensitivity analysis on μ.

μ	2%	4%	6%	8%	10%	12%	14%	16%
Growth std (%)	4.09	4.10	4.22	4.14	4.06	4.20	4.23	4.24
Leverage mean	1.62	1.61	1.62	1.59	1.59	1.57	1.59	1.57
Leverage maximum	2.01	1.99	2.01	2.00	1.92	1.87	2.03	1.94
Bad debt ratio mean (%)	1.73	1.76	1.81	1.86	1.89	1.95	2.00	2.07
Bad debt ratio max (%)	5.73	4.86	5.91	6.33	6.27	6.79	7.98	7.23
Bank defaults mean	4.01	4.35	4.73	5.34	5.53	6.15	5.98	6.61
Bank defaults max	10	11	13	14	16	15	13	16

to a rise of financial costs for banks (passive interests on deposits). As a consequence, banks charge higher interest rates on their borrowers and this affects the economy in the usual way, that is by decreasing firm leverage and increasing bad debt and then bank defaults. Nevertheless, for similar levels of the mean interest rate set by banks and of the mean firm leverage, the monetary tightening due to an increase of the reserve coefficient μ produces a lower rate of bank defaults, compared to the number of bank failures consequent to an increase of the policy rate r^{CB}. This is due to the fact that the increase of μ has the following two counteracting effects at the same time: (i) makes banks to rise interest rates on borrowers, causing a higher bad debt, which in turn leads to more bank defaults; (ii) enlarges bank reserves and then the resilience of the banking system to the increased bad debt ratio.

However, a word of caution is in order. We propose an investigation of the response of the system to a static change in regulatory policy. Obviously, a time-varying macroprudential policy may perform better by increasing borrowing costs at an appropriate point in the credit cycle, so as to impede an excessive growth of credit and enhance the resilience of the financial system by making a subsequent financial crisis less likely. Nevertheless, to really analyze this feature the model should explicitly consider a constrained credit supply. For this reason, we plan to introduce this characteristic in a future version of the model.

8. Conclusions

In this paper we build on the agent based model of Delli Gatti et al. (2010), determining the firms' financial structure with the dynamic trade-off theory (Flannery and Rangan, 2006), adding multiperiodal debts and the loss given default rate in bankruptcies.

Then, we enrich the positive feedback mechanism tied to the network-based financial accelerator of Delli Gatti et al. (2010), with the pro-cyclicality of leverage. Indeed, a negative shock on firms' output makes banks less willing to loan funds (the same holds for risk averse firms characterized by dynamic trade-off theory), hence firms might reduce their investments both because of less internal funds and because of a reduced leverage due to the increased interest rates faced (or a credit constraint) and the reduced investment leads again to a lower output. Moreover, there is the network-based accelerator: bankruptcies deteriorate banks' financial condition and it leads to higher interest rates to all borrowers (Stiglitz and Greenwald, 2003, p. 145), further increasing the financial weakness of the whole non-financial sector. Thus, the presence of a credit network may produce an avalanche of firms' bankruptcies, in another vicious circle that can make banks go bankrupt too. The last mechanism makes possible that an idiosyncratic shock creates an extended/global crisis, without the need of a systemic shock.

A first result concerns the leverage: if it increases, the economy is riskier, with a higher volatility of aggregate production and an increase of firm and bank defaults. Moreover, if the leverage target is variable (positively related to gains and negatively related to interest rates), the pro-cyclicality of credit clearly emerges. During the expansionary phase of the cycle, profits make firms to accumulate capital and the decrease of firm defaults reduces the bad debt; this allows firms to borrow more because they are more capitalized and banks are financially sounder (thus lending at favourable terms). However, the risk premium could be higher due to the increased leverage. The higher leverage boosts firms' growth until the system reaches a critical point of financial fragility and the cycle is reversed through an increase of defaults. In this framework the network-based financial accelerator is even amplified and we can call it as "leveraged network-based financial accelerator".

In particular, if leverage changes rapidly (the parameter *adj* increases), the volatility of the system grows both in terms of the aggregate production's growth rate and in the number of failures. Moreover, cascades of bad debt are more likely to appear for larger values of *adj*: a higher pro-cyclicality of the leverage increases the "leveraged network-based financial accelerator" with a destabilizing effect on the economy.

Comparing the baseline scenario to a model with a fixed leverage target, some other features emerge: with variable leverage big firms go bankrupt too, because a firm that has a high profit enlarges not only its net worth but also its leverage, thus it could be financially fragile even with a high net worth. On the other hand, a variable leverage reduces the number of bank defaults because there is a strong credit constraint (interest rate hike) during the crisis.

As for monetary policy, when the policy rate decreases (increases) a short-run expansion (restriction) of aggregate production follows with a fall (rise) of firm and bank defaults. However, the presence of a variable leverage target weakens this effect because, for example, when policy rate decreases, firms ask more credit enlarging the leverage and this mechanism counteracts the standard expansionary effect, increasing the volatility of the system. Indeed, if we repeat the same sensitivity analysis setting the leverage target at a fixed level, we find that the monetary policy change has much stronger consequences. Thus, model findings suggest that the central bank should also consider this effect on the leverage when deciding monetary policy changes. For example, a reduction of the interest rate made to revitalize the economy, could increase the overall leverage and, then, the likelihood of bankruptcy chains. Moreover, a monetary tightening not only creates a recession phase, but it also induces a higher number of bank failures when the banking system is poorly capitalized. Then, when the aim is to increase the interest rate, the central bank should also check if the banking system is well capitalized.

We also explore the results of a macroprudential regulation experiment: an increase of the reserve coefficient has an impact similar to that produced by raising the policy rate, but for the enlargement of bank reserves that improves the resilience of the banking system to shocks.

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