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Financial fragility and distress propagation in a network of regions

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ABSTRACT

We investigate how the financial fragility in the real economy is affected by the average level of interdependence among agents across different regions of the economy. To this end, we develop a parsimonious agent-based model of firms and banks organized in geographic regions. The model is built on the framework of an existing class of models for business fluctuations. The goal of our exercise is to clarify the effect on systemic failures of the interplay between network interconnectedness and financial acceleration. In particular, we investigate the probability of individual and systemic failures with varying levels of interconnectedness. We find that, in the absence of financial acceleration, connectivity makes the system more resilient. In contrast, in the presence of financial acceleration, the probability of both individual and systemic failures are minimized at intermediate level of diversification.

1. Introduction

In the current discussion on financial crises, two dimensions are attracting growing interest. The first is the role of geographic space, given that most financial crises of the few last decades have originated in one country and propagated to several others (Dornbusch et al., 2000; Vitali and Battiston, 2011a). The second is the role of network spillover in the propagation of financial distress, both at the level of financial institutions within a single country and at the level of countries (Allen and Gale, 2000; Kali and Reyes, 2009; Horst, 2007; Prasad et al., 2003; Stiglitz, 2010).

In this paper, we aim to address a specific question, namely how the financial fragility in the real economy is affected by the average level of interdependence among agents across different regions of the economy both along the trade and the credit dimensions. A similar question has been investigated in the case of interbank networks by means of stylized models Gai et al. (2011) and Battiston et al. (2012b) in which the interconnectivity level among the agents is fixed exogenously and the effects of different levels of interconnectivity are compared statically. In the same spirit, here we develop a parsimonious agent-based model of firms and banks organized in geographic regions by building on the framework of an existing class of models for business fluctuations (Battiston et al., 2007; Delli Gatti et al., 2005, 2007, 2009, 2010).

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Thus the goal of our exercise is to clarify the effect on systemic failures of the interplay between network interconnectedness and financial acceleration in a model firm–bank network. In particular, we investigate the frequency of individual and systemic failures with varying levels of interconnectedness. In the absence of financial acceleration, we find that higher connectivity on both trade and credit networks makes univocally the system more resilient. In contrast, in the presence of financial acceleration, more credit links lead at some point to larger and more frequent crises. Hence, the frequency of both individual and systemic failures are minimized at an intermediate level of interconnectedness.

The existence of a trade-off between diversification and contagion as interconnectedness increases has been already documented in models of interbank networks, e.g. in Wagner (2011) and in models of country networks Stiglitz (2010). However, the debate is still open and every model utilizes some more or less explicit mechanism in order to obtain the tradeoff. Our contribution here is to investigate the firm–bank case and to provide an alternative explanation for the tradeoff that relies only on the financial acceleration mechanism and not, for instance, on some ex-ante cost associated to having more links. Moreover, we show that the tradeoff emerges directly at the level of the probability of systemic defaults before even considering the social costs of crises.

More in detail, we propose a multi-agent model in which firms and banks, belonging to various regions, interact in a network of credit. As in Battiston et al. (2012b), we investigate the fragility of the system taking into consideration two main mechanisms: (i) the financial accelerator and (ii) the contagion. The *financial accelerator* is a positive feedback on the financial fragility of the firms. This mechanism has been discussed by the literature on financial factors as responsible for business fluctuations and transmission of shocks (Greenwald and Stiglitz, 1993; Bernanke and Gertler, 1995; Bernanke et al., 2000; Stiglitz and Greenwald, 2003). Suppose, for example, that a firm experiences negative profits. If its equity base reduces more than its liabilities, then its financial fragility, measured as debt-to-equity ratio, increases. The bank lending credit to this firm will charge a higher interest rate in order to compensate for the increased risk associated to the firm financial position.[1] Higher financial costs will likely affect negatively the profits, pushing the firm into an even worse situation. In other terms, when a firm is hit by a negative shock, the probability that it will be more fragile in future periods is higher than the probability that it will be healthier. On the other hand, the *contagion* mechanism is due to the credit relationships between firms and banks. The financial distress of a firm affects other firms indirectly. When a firm faces consecutive losses, the bank will apply higher financing costs to all the firms in its credit portfolio. This, even if the other firms are still financially robust. Unlike in Battiston et al. (2012b), here we develop a richer model where balance sheets of agents evolve in time and become endogenously heterogeneous.

We do not aim to model here the evolution of the links among agents. Moreover, in our model the allocation of credit to firms and the demand of credit from firms to banks is only stylized. We do not model these aspects through optimization decision rules. Instead, we are interested in the point of view of the regulator who seeks to know what would be the desirable level of the average connectivity. To this end, we compare the default probability at different levels of connectivity that is homogeneous across agents and fixed exogenously as done in previous works, e.g. Gai et al. (2011), and Battiston et al. (2012b).

The main result of the model is that as long as regions are economically separated, agents do not benefit from potential access to other markets and they may be only affected by local financial instability. In contrast, when firm and banks can establish inter-regional relationships, although they benefit from diversification of individual risk, they are also exposed to financial contagion. In our model, risk diversification and interdependence, arising from economic integration among regions, go hand in hand.

The intuition suggests that as long as regions are economically separated, agents are not able to benefit from the potential access to other markets, but in exchange they are only affected by local financial instability and protected from global crises. In the case where agents have access to cross-region counterparties, both firms and banks benefit from individual risk diversification, but they are also exposed to systemic risk, i.e. the collapse of a large portion of the economic system. It is often argued that the more systemic (e.g. larger and severe) the distress event is, the more rare it is (e.g. less frequent). Our model shows instead that, in the presence of financial acceleration, when the economy is interconnected above a certain threshold, systemic events are not only larger but they are also more frequent.

Given the purpose of our exercise, we have made a number of simplifications and assumptions. For instance, we focus only on the bank–firm interaction, while we neglect the interaction among firms and the one among banks. We also neglect the effect of up- and down-turns of the economy on demand and prices. Moreover, although, over time, agents become endogenously heterogeneous in size, we make a strong assumption of symmetry regarding the number of their links and the geometry of their interactions. These hypotheses could be relaxed, certainly making the model more realistic, but would not help very much in addressing the question we address here.[2] Notice also that by assuming that the transmission of instability between firms happens only indirectly via the banks, makes the scenario of the model setting more conservative. In contrast, introducing also direct firm–firm relations as in Battiston et al. (2007) and Delli Gatti et al. (2009) would amplify the contagion and the emergence of larger avalanches of bankruptcies. Analogously, introducing correlations and feedback loops between up(down)-turns and prices or level of demand would exacerbate the instability of the economy.

[1] When the spread of a crisis across markets threatens the financial stability of countries, central banks usually adopt counteracting measures, such as reducing the interest rate in the attempt of making easier for firms and households to obtain the extension of loans from banks. For the sake of simplicity, in our model we do not consider any intervention by central banks.

[2] For completeness, some robustness analyses with empirical and heterogenous network structures are reported in the Appendix.