Journal of Economic Dynamics & Control 34 (2010) 1627–1650

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

The financial accelerator in an evolving credit network

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ARTICLE INFO

Available online 23 June 2010

JEL classification:
E32
D85
C63

Keywords:
Business fluctuations
Financial instability
Bankruptcy chains

ABSTRACT

We model a *credit network* characterized by credit relationships connecting (i) downstream (D) and upstream (U) firms and (ii) firms and banks. The net worth of D firms is the driver of fluctuations. The production of D firms and of their suppliers (U firms) in fact, is constrained by the availability of internal finance—proxied by net worth—to the D firms. The structure of credit interlinkages changes over time due to an endogeneous process of partner selection, which leads to the polarization of the network. At the aggregate level, the distribution of growth rates exhibits negative skewness and excess kurtosis. When a shock hits the macroeconomy or a significant group of agents in the credit network a bankruptcy avalanche can follow if agents' leverage is critically high. In a nutshell we want to explore the properties of a *network-based financial accelerator*.

1. Introduction

How do financial factors affect business fluctuations? The standard answer to this question in contemporary macroeconomics goes under the heading of *financial accelerator*, which essentially tells the following story: "To buy new capital goods, firms rely on several sources of financing. These include internal funds, such as retained earnings or capital infusions from firm owners, and external funds, such as the proceeds from loans and the sales of stocks and bonds. The amount of internal funds is related to the firm's cash flow. In response to a slowdown in sales, cash flow will likely decline, reducing the amount of internal funds and therefore increasing the amount a firm needs to obtain from external finance. But lenders will be less willing to loan funds to firms with smaller cash flow, and the value of firms' collateral is also likely to have decreased, further reducing their ability to obtain loans. Hence firms might be forced to reduce their investment. This reduction in turn will lead to lower output, lower cash flow, and yet again lower investment leading to a further deceleration in output. This theory provides a possible explanation for why changes in the amount of investment can have a multiplier impact on the broader economy" (*Economic Report of the President*, 2005, p. 59).

Central to this story is information, not only about the conditions of the parties in a credit relationship but also about the incentives that they face. The lender has to assess the risk involved in extending credit to the borrower, i.e. her ability and willingness to fulfill debt obligations. But information is asymmetric so that such an assessment is at best incomplete. In this context, a simple and easily available indirect sign of the borrower' s creditworthiness is a measure of her financial soundness captured, for instance, by *net worth*.

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0165-1889/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.jedc.2010.06.019

The models of the financial accelerator available so far, in particular Bernanke and Gertler (1989, 1990) and Bernanke et al. (1999), are based on the representative agent assumption. In the market for funds, for instance, a representative borrower interacts with a representative lender. A change in the *representative* borrower's net worth, therefore, is a metaphor for a change in *aggregate* net worth. As a consequence the financial accelerator works its way through the macroeconomy by means of changes in a proxy of economy wide financial robustness—aggregate net worth or cash flow. In the models—and generally also in the real world—this aggregate variable is pro-cyclical: for instance, in a recession, the financial accelerator effect "is roughly proportional to the size of the decline in GDP, since the change in cash flow and the value of collateral would be expected to be roughly proportional to the decline in output." (Bernanke and Gertler, 1989, 1990; Bernanke et al., 1999).

By definition, this *aggregate view* of the financial accelerator abstracts from the complex nexus of credit relationships among heterogeneous borrowers and lenders that characterize modern financially sophisticated economies. This shortcut simplifies the analysis to a great extent but is a serious drawback because the current literature ignores by construction at least three fundamental features of the real world amplification mechanism based on the effects of shocks on the network of credit relationships.

First and foremost, in the aggregate view, by construction the shock which originates the fluctuation is *aggregate*, i.e. uniform across agents. But in the real world an *idiosyncratic shock* can well be the source of an epidemic diffusion of financial distress which usually translates into a contraction of real GDP. In other words, in a financial network idiosyncratic shocks usually do not cancel out in the aggregate, especially if they hit crucial nodes (hubs) of the network.

Second, the aggregate view does not capture the fact that the spreading of a financial disease may proceed at different speeds in different parts of the macroeconomy. For some agents, financial robustness may be pro-cyclical—as predicted by the aggregate view—while for other agents it is financial fragility that may be pro-cyclical. In Minsky's financial instability hypothesis, for instance, the financial fragility of borrowers increases during "prosperous times" sowing the seeds of the next financial crisis and recession. When the economy is booming, in fact, firms in fact are eager to increase their debt (relative to net worth) and banks are willing to accommodate their financing needs because of the widespread expectations of abundant profits. More recently Adrian and Shin (2008) have brought attention to the pro-cyclicality of leverage, i.e. the typical measure of financial fragility, of some specialized lenders—especially investment banks. The unwinding of positions during the crisis in an attempt at de-leveraging has been an important factor of amplification of the crisis itself.

Last but not least, in a credit network the financial accelerator can lead to an *avalanche of bankruptcies*. Suppose, for instance, that a firm goes bust. Both the suppliers and the banks which made business with the bankrupt firm will bear the brunt of the default. The deterioration of the bank's financial condition due to the borrower's bankruptcy may be absorbed if the size of the loan is small and/or the bank's net worth is high. If this is not the case, also the bank goes bankrupt. If the bank survives, however, it will restrain credit supply and/or make credit conditions harsher—raising the interest rate on loans across the board—for all its borrowers. Therefore, the default of one agent can bring about an *avalanche of bankruptcies*. While the proximate cause of the bankruptcy of a certain firm in the middle of the avalanche is the interest rate hike, the remote cause is the bankruptcy of a firm at the beginning of the avalanche that forced the banks to push interest rates up. The interest rate hike leads to more bankruptcies and eventually to a bankruptcy chain: "the high rate of bankruptcy is a cause of the high interest rate as much as a consequence of it" (Stiglitz and Greenwald, 2003, p. 145). An avalanche of bankruptcies therefore is due to the positive feedback of the bankruptcy of a single agent on the net worth of the "neighbours", linked to the bankrupt agent by credit links of one sort or another.

Bankruptcy cascades may be of different size depending not only on the magnitude of the shock but also on the topology of the network. When the corporate and/or the banking sector are polarized, the vulnerability of the network to a shock—i.e. *systemic* risk—increases because the default of a highly connected agent, albeit a relatively rare event, may generate a non-negligible cascade of bankruptcies.

These are the crucial aspects of real world financial accelerator which we want to investigate. Therefore we must focus on the complex pattern of credit relationships, which is a natural research issue to be dealt with by means of network analysis. It is straightforward, in fact, to think of agents as *nodes* and of debt contracts as *links* in a *credit network*. In a nutshell we want to explore the properties of a *network-based financial accelerator*.

There are influential examples of network analysis applied to credit networks.[1] Allen and Gale (2001), for instance, put forward a theory of "financial contagion" in a network model of the interbank market. In this case, however, the networks considered are very simple and easy to study because they consist of few nodes organized in canonical forms. A non-negligible and growing literature has developed from these premises on the network of the interbank market (Freixas et al., 2000; Furfine, 2003; Boss et al., 2004; Iori et al., 2006; Nier et al., 2007). A different but no less important line of network research (Boissay, 2006; Battiston et al., 2007) focuses on the trade–credit relationships within the corporate sector, i.e. among suppliers of intermediate goods and producers of final goods along the "supply chain".

[1] Networks are the main subject of a rapidly growing literature which applies the conceptual and analytical tools already developed in sociology, computer science and physics to economics and/or provides new notions and methods to be applied specifically to economic phenomena. Recent books by Jackson (2008), Vega-Redondo (2007), and Goyal (2007) describe the frontier of research on economic networks.