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Systemic risk in financial systems: A feedback approach☆

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ABSTRACT

We develop an innovative framework to estimate systemic risk that accounts for feedback effects between the real and financial sectors. We model the feedback effects through successive deterioration of borrowers' creditworthiness and illiquidity spreading, thus giving rise to a micro-level financial accelerator between firms and banks. We demonstrate that the model converges to a unique fixed point and the key role that centrality plays in shaping the level of amplification of shocks. We also provide a mathematical framework to explain systemic risk variations in time as a function of the network characteristics of economic agents. Finally, we supply empirical evidence on the economic significance of the feedback effects on comprehensive loan-level data of the Brazilian credit register. Our results corroborate the importance of incorporating new contagion channels besides the traditional interbank market in systemic risk models.

1. Introduction

The financial crisis of 2008–2009 evidenced the high level of interconnectedness of financial systems worldwide by showing the feasibility of small shocks in potentially causing large disruptions in the economic environment (Gai et al., 2011). One component that contributes to the complexity of modern financial networks is that economic agents meet in a diversity of markets through nontrivial financial operations, thus giving rise to several contagion transmission channels. In turn, these contagion transmission channels are difficult to model in a computational environment because they are not independent and can therefore additively increase a negative impact in nonlinear ways. For instance, a shock to the economy can affect the financial sector, which can then feedback into the real economy and thus amplify the initial negative effects.

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According to the International Monetary Fund, the Financial Stability Board, and the G20 (IMF et al., 2009), there are three key criteria that are essential to assessing the stability of a financial system: size, substitutability, and interconnectedness.[1] Therefore, understanding how an interconnected environment influences feedback mechanisms that ultimately can impair the economy is critical for financial stability and systemic risk issues. In this spirit, Battiston et al. (2016) highlight that, though of great practical importance to policymakers and to the scientific community, the literature is still in its early stages in understanding systemic risk in financial networks as it does not adequately consider negative feedback mechanisms that potentially arise from economic agents, particularly that linking the real and financial sectors. Several papers have studied interbank lending and the emergence of systemic risk, addressing issues such as heterogeneity of the banking system and its impact on the financial system in terms of propagation and contagion of shocks (Iori et al., 2006; Krause and Giansante, 2012). Our paper contributes to this literature by incorporating new layers to the network analysis, comprised by loans made by banks to firms, and also purchases on credit between supplier and customer firms. In addition, by studying networks with banks and firms, we are able to incorporate feedback effects from the financial system to real economy and from the real economy into the financial system.[2]

This paper presents an innovative framework to estimative systemic risk via financial contagion that accounts for the negative feedback mechanism between the real and financial sectors. We model the feedback effects through successive deterioration of borrowers' creditworthiness and illiquidity spreading, thus giving rise to a micro-level financial accelerator between firms and banks. Though extensively studied from the macroeconomic perspective (Bernanke, 1983; Bernanke and Gertler, 1989; Bernanke et al., 1996), the micro-level financial accelerator between firms and banks in the context of systemic risk is a novel contribution of this paper. The general dynamics of our feedback engine is as follows: (i) firms that are affected by an external shock potentially default on their bank loans; (ii) affected banks reduce bank lending through a credit crunch on the real sector to comply with their regulatory capital requirements; consequently (iii) firms become even more distressed due to the reduction on credit and default on other bank loans, thus amplifying the initial shock.

Using loan-level data on the Brazilian financial and real sectors, we find that the feedback between the real and financial sectors is economically significant. Moreover, we find that firms respond differently to the feedback mechanism due to their contrasting profiles on the components that influence the feedback effect.[3] Our investigation highlights that models that do not consider the feedback effects could be (i) severely underestimating systemic risk and (ii) inconsistently ranking the riskiest firms and hence sectors in the economy. Considering that the financial system surveillance and policymaking depend on proper information regarding the systemic risk levels of the financial system, it becomes crucial to take into account feedback effects to effectively identify the largest sources of systemic risk of the economy.

We also demonstrate that the model presents strong theoretical properties such as the existence of a unique fixed point that depends on the network structure and the magnitude of the shock.[4] We further develop our theoretical findings taking as baseline this unique fixed point and derive useful systemic risk properties in its cross-sectional and time dimensions in evolving financial networks.[5]

In the cross-sectional component of systemic risk, we demonstrate how microeconomic shocks can develop into macroeconomic events in a system composed of banks and firms. This analysis serves to somewhat unbox the "black box" behavior of financial networks and thus show how economic interconnections between heterogeneous economic agents contribute to amplifying shocks, possibly leading to systemic events. We find that economic agents—firms or banks—that are more central in the network are the key sources of systemic risk in the financial system.[6] Our findings are useful not only to ranking and finding the key players inside financial systems but also to providing quantitative insights as to how harmful economic agents can be to the entire economy.

In the time component of systemic risk, we study how structural changes in the network affect systemic risk. All else equal, we find that the addition of a network connection, which can emerge when a bank lends to a new firm, changes systemic risk proportionally to the product between (i) the propensity of the bank of receiving shocks and (ii) the ability of

[1] Size refers to the volume of financial services provided by the individual component of the financial system. Substitutability measures the extent to which other components of the system can provide the same services in the event of a failure. Finally, interconnectedness accounts for the linkages with other components of the system and how shocks transmit between different markets or financial institutions.

[2] See also Markose et al. (2012) who develop an interesting idea of a super-spreader tax, which may help in mitigating potential socialized losses.

[3] For instance, in our sample, a great part of bank credit that firms in the tertiary sector take are short term while firms in the oil and gas sector normally hold long-term loans. In addition, the technology sector has difficulty in substituting banks due to their small number of bank counterparties while food and beverage sector shows the opposite pattern.

[4] Our work is also in line with Acemoglu et al. (2015a)'s findings who also show the existence of a unique fixed point that depends on the network structure and magnitude of the shock. However, their model focuses on the interbank market and thus does not incorporate firms nor the negative feedback mechanism that exist between banks and firms. In addition, contrasting to their work, our theoretical approach is still valid regardless of the shock magnitude.

[5] We can conceptualize systemic risk in two orthogonal but complementary dimensions: the cross-sectional dimension and the time dimension. In the first, we are concerned with how the structure of the financial system influences, and possibly amplifies, external shocks. In the time dimension, we usually look to which directions systemic risk can evolve as a result of economic agents' individual actions and other components, such as the macroeconomic cycle, that ultimately lead to variations on systemic risk of a financial system. While the cross-sectional component has been extensively studied by the literature (Gandy and Veraart, 2016; Acemoglu et al., 2015a; Elliott et al., 2014; Gai et al., 2011; di Giovanni et al., 2014), the time dimension is often overlooked.

[6] Our results add to Acemoglu et al. (2015a)'s findings by showing that network centrality still plays a major role even in a complex environment with economic agents with different nature and negative feedback rules.