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Liaisons dangereuses: Increasing connectivity, risk sharing, and systemic risk

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ABSTRACT

The recent financial crisis poses the challenge to understand how systemic risk arises endogenously and what architecture can make the financial system more resilient to global crises. This paper shows that a financial network can be most resilient for intermediate levels of risk diversification, and not when this is maximal, as generally thought so far. This finding holds in the presence of the financial accelerator, i.e. when negative variations in the financial robustness of an agent tend to persist in time because they have adverse effects on the agent's subsequent performance through the reaction of the agent's counterparties.

1. Introduction

The recent financial crisis has shown that systemic risk has been dramatically underestimated (Bartram et al., 2007). Understanding the nature of systemic risk is crucial if appropriate policy responses are to be framed, especially since the impact of financial shocks on the real economy increases with the depth of the financial system (Kroszner et al., 2007). Moreover, it has been recognized that financial crises are characterized by the procyclicality of balance sheets and leverage across financial institutions. This is the case especially when they get connected to each other in the process of originating and distributing securities (Brunnermeier, 2008; Morris and Shin, 2008; Shleifer and Vishny, 2010). In general, financial ties of various types among institutions have in principle an ambiguous effect, since they allow for the diversification of risk, but open also the door to financial contagion (Allen and Gale, 2001). There is strong empirical evidence that in the unraveling of the recent crisis, contagion played a large role, propagated primarily through liquidity and risk-premium channels (Longstaff, 2010). The recent financial crisis has brought to the fore the crucial question of the relationship between the architecture of the global financial system and systemic risk (Allen et al., 2011). The common view in the literature has been so far that the beneficial effect of diversification always prevails and more integrated systems are more resilient (Allen and Gale, 2001). In contrast, a very recent stream of work has found conditions on the propagation of financial contagion and bankruptcies so that full risk diversification or full financial integration is not optimal (Allen et al., 2011; Castiglionesi and Navarro, 2010; Wagner, 2010; Stiglitz, 2010, forthcoming).

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This paper contributes to the debate on the resilience of financial networks by introducing a dynamic model for the evolution of financial robustness. We show that, in the presence of *financial acceleration and persistence* – i.e. when the variations in the level of financial robustness of institutions tend to persist in time or get amplified – the probability of default does not decrease monotonically with diversification. As a result, the financial network is most resilient for an intermediate level of connectivity.

Our work is related to several streams of the literature. We follow the standard approach in finance of modeling the default of one firm as a problem of first passage time in a stochastic diffusion process representing the valuation of corporate liabilities (Merton, 1974; Black and Cox, 1976; Longstaff and Schwartz, 1995). In particular, the index representing the distance to default or the level of creditworthiness (Hull and White, 2000) is assumed to evolve over time as a stochastic differential equation (SDE) with a lower absorbing barrier, so that the firm defaults when the index value becomes zero (or hits from above a positive "bankruptcy" threshold). In addition, one can compute numerically the probability of joint default of several firms in the presence of correlations among their level of creditworthiness (Hull and White, 2001; Zhou, 1997). However, key to the analysis of systemic risk is the endogenous determination of correlations arising from the external effects that the distress of an agent causes to her counterparties.

Several types of external effects have been investigated in the literature. On the one hand, the failure of one bank adversely affects other banks—financial contagion (Diamond and Dybvig, 1983; Allen and Gale, 2001; Stiglitz and Greenwald, 2003). This, in turn, can occur through several channels: (a) bank runs—where the failure of one bank induces depositors of other banks to withdraw their funds; (b) interbank lending—where the failure of one bank implies that others will not be fully repaid; and (c) real economic activity—where the failure of one bank has adverse effects on other bank borrowers, lowering their probability of repayment. On the other hand, agents may be adversely affected by the depreciation of a common asset—asset price contagion (Kiyotaki and Moore, 2002, 1997). Again, this can occur through several channels, the most important of which may be through the value of collateral, the impact of reduced collateral values on borrowing capacity, and thereby on real activity. Asset price contagion can also have more direct effects, e.g., through real wealth effects. All these mechanisms represent independent *contagion channels* which may interact during the development of a financial crisis. For instance, the default of a bank may trigger an avalanche of deposit withdrawals at other banks as well as a liquidity evaporation on the interbank market.

This paper focuses on credit inter-linkages. Credit contracts establish connections among banks on the interbank market, among firms and banks on the market for loans, among customers and suppliers in the market for trade credit. In other words, the credit market can be conceived of as a credit network in which nodes represent agents and links represent credit relationships. To complicate the picture further, banks are also connected to financial intermediaries in the so-called shadow banking system, while financial products such as credit default swaps establish financial ties between the seller of protection and the reference entity. The most influential example of network analysis applied to the propagation of distress in a credit network is the seminal paper by Allen and Gale (2001) on "financial contagion", which has triggered a significant body of work, both on interbank credit (Freixas et al., 2000; Furfine, 2003; Boss et al., 2004; Elsinger et al., 2006; Iori et al., 2006; Nier et al., 2007), as well as on bank–firm or firm–firm credit (Stiglitz and Greenwald, 2003; Boissay, 2006; Battiston et al., 2007).

To capture the interdependence among banks that arises from these network relationships, we model the evolution of the levels of financial robustness – meant as an equity ratio – of different agents as coupled stochastic processes, similar to Hull and White (2001). Much of the earlier literature was directed at valuing corporate liabilities. In contrast, our objective is to understand the interplay of financial interdependence among banks and financial acceleration in the emergence of systemic risk. We assume banks' equity levels (and thus the levels of financial robustness) are subject to idiosyncratic shocks, along the lines of previous works (Allen and Gale, 2001; Allen and Babus, 2009; Allen et al., 2011; Wagner, 2010; Castiglionesi and Navarro, 2010). Thus, banks have an incentive to engage in risk sharing by financing the liabilities of other banks. This reduces the fluctuations on the value of their asset portfolio and hence their failure probability and associated risk premia. To model this, we consider a set of banks in which balance sheets are interconnected in a network of liabilities, following the framework of Eisenberg and Noe (2001) and Shin (2008).

On the other hand, as we have noted, connections entail a negative effect, through contagion. Results on systemic risk can be sensitive to the exact way in which contagion is modeled. It is often assumed that the bankruptcy of one bank may cause the failure of all k connected banks (Stiglitz, 2010; Castiglionesi and Navarro, 2010). In an alternative setting, banks are assumed to be funded by investors, which upon the observation of a signal – the news that at least one bank will fail – decide whether to roll over the loans (Allen et al., 2011). If they do not roll over, then all banks have to liquidate. Notice that in either case the failure of one bank may trigger the failure of k banks, and so systemic risk increases with the connectivity of that bank. It is clear however that the diversification of the portfolios of counterparties of the failing bank lowers the likelihood of their failure. Thus, it is important to take into account the fact that financial ties are conducive of financial damage only proportionately to their relative weight in the portfolio of counterparties. On the other hand, we need to recognize that negative effects from one bank to another can arise well before the level of bankruptcy is reached. For instance, the fear of failure for a bank intertwined with another bank that faces a high risk of failure will drive up the interest rate which the former has to pay.

Because our model is dynamic and in continuous time, it allows us to consider the effect of variations in financial robustness from one bank to the others, rather than focusing solely on bankruptcy events. Moreover, in our model, the reason why we obtain an increase in the failure probability as connectivity increases is more subtle than in earlier contagion models and emerges from a milder assumption. We assume that counterparties of a bank are able to observe