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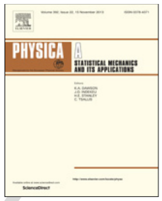

Q1 The evolution of risk and bailout strategy in banking systems

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HIGHLIGHTS

- We study contagion and bailout strategies in a stylised banking system over time.
- Banks adjust risk taking in response to system dynamics and regulatory intervention.
- Poor intervention strategies encourage excessive risk and hinder stability.
- Bailouts should consider the topology of and risk allocation on banking networks.
- Interventions aimed at bank configurations with anti-correlated risk are superior.

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ABSTRACT

In this paper we analyse the long-term costs and benefits of bailout strategies in models of networked banking systems. Unlike much of the current literature on financial contagion that focuses on systemic risk at one point in time, we consider adaptive banks that adjust risk taking in response to internal system dynamics and regulatory intervention, allowing us to analyse the potentially crucial moral hazard aspect associated with frequent bailouts. We demonstrate that whereas bailout generally serves as an effective tool to limit the size of bankruptcy cascades in the short term, inappropriate intervention strategies can encourage risk-taking and thus be inefficient and detrimental to long term system stability. We analyse points of long-term optimal bailout and discuss their dependence on the structure of the banking network. In the second part of the paper, we demonstrate that bailout efficiency can be improved by taking into account information about the topology of and risk allocation on the banking network, and demonstrate that finely tuned intervention strategies aimed at bailing out banks in configurations with some degree of anti-correlated risk have superior performance. These results demonstrate that a suitable intervention policy may be a useful tool for driving the banking system towards a more robust structure.

1. Introduction

The global financial crisis of 2007–08 and the potential collapse of major banking institutions around the world left governments facing a major dilemma; should they offer financial assistance to distressed banks in the form of a bailout, or leave them to go bankrupt and face the systemic consequences for the rest of the economy. Reluctantly, many institutions were offered assistance [1,2], including Northern Rock, Royal Bank of Scotland and Lloyds Banking Group in the UK, with some politicians suggesting that such intervention should never be allowed to happen again [3].

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Although the recent example saw their use on an unprecedented scale, bailouts have been a feature of crises dating back to the 1800s [4] and understanding their effective use is a problem that is well established in the literature. The main argument against bailing out banks is the creation of moral hazard, with empirical studies [5] demonstrating that banks will take more risk if they *know* they will be supported in the event of difficulty [6]. However, a bailout can offer protection against widespread contagion, such as the panic that swept through the financial markets in the wake of Lehman Brothers' insolvency. This situation has traditionally been viewed as a trade-off between the regulators' preference for minimising either moral hazard or contagion [7] and there is an extensive game-theoretic literature analysing the optimal regulatory policy [8], the timing of regulatory decisions [9,10] and whether the reduction in systemic risk may outweigh the moral hazard effect [11].

However, these models lack a detailed analysis of the true systemic risk within the interbank market, as they fail to capture network structure, heterogeneity and the fact that some banks might be Too-Big-To-Fail [12,13] due to the potentially catastrophic financial contagion their bankruptcy would cause [14]. The need for a better understanding of systemic risk [15] has led to a dramatic rise in papers analysing contagion using percolation dynamics [16,17], demonstrating that the financial system is robust-yet-fragile [18], with network connectivity acting as either a means of risk diversification or a means of contagion depending on the size of the shock applied to it [19,20]. Recent models have introduced endogenously-formed dynamic interbank networks and multiple contagion channels [21–23], which allow the market dynamics of a bankruptcy to be studied both ex ante and ex post. However, while these models can be used to calculate a systemic risk value for each bank [24], they are not suitable for analysing the effect of resolution policy as they assume banks' risk appetites to be fixed rather than adaptive, meaning that no moral hazard effect be captured in the system.

The novel aspect of the model we present is that banks within our system are adaptive, adjusting their strategy according to the success of their peers [25–27]. Accounting for this adaptability is a crucial aspect that has been missing from the contagion literature [28,29] and allows us to investigate the endogenous accumulation of risk [30] when banks increase their leverage [31], and homogenise their asset portfolios [32] and risk management [18]. Banks have been shown to load up on risky assets as the system moves into danger [33] and correlate their assets even though portfolio theory would suggest diversification [34].

The key to measuring the effectiveness of an intervention strategy by the regulator is a long term cost–benefit analysis [35]. Our model features two dynamic processes operating at different time-scales, with slow strategy updating coupled with fast contagion dynamics in a similar manner to Battiston [20]. This set-up allows us to model the long term dynamics of the system and the feedback between a regulator's bailout behaviour, systemic risk and economic performance. There are very few existing models that allow the long term effects of bailout policy to be investigated in a quantitative manner [3,36,37] and, to our knowledge, ours is the first to assess the effects of moral hazard and adaptive risk on bailout policy using a network contagion model.

Our approach allows us to analyse two key questions from the moral hazard and bailout literature. Firstly, we investigate the concept of "constructive ambiguity" [38], where the bailout response of the regulator is purely probabilistic. Secondly, we investigate preferential or "tiered" bailout strategies [39], where the intervention is dependent on either the size of the distressed bank [1] or the risk level of its immediate neighbours. Both approaches are assessed across different network configurations, using a utility function that incorporates bank dividends, bankruptcy costs and bailout costs [34]. This allows the overall social cost of different intervention strategies to be compared.

2. Materials and methods

2.1. Bank strategy

We model a set of N banks, each characterised by a strategy $0 \le x_i \le 1$ which determines the bank's intention to take on risk. Bank profit depends on this strategy, i.e. we set $\pi_i = f(x_i)$. We assume that risk-taking will generally result in larger (short term) profits, hence $f(\cdot)$ is assumed to be a monotonically increasing function of its argument. For simplicity we set $f(x) = x$. However, risk-taking is also associated with a higher degree of fragility, and thus we assume that a bank's likelihood of becoming bankrupt or suffering from asset write-downs is also an increasing function $g(x_i)$ of its risk-taking strategy x_i. For the purposes of this abstract model we assume that $g(x) = x$.

2.2. Bank network

Banks are connected via an undirected network of asset co-investments (or business relationships). A bank i with k_i network neighbours is assumed to have size k_i, i.e. the larger a bank the more asset classes it is invested in. In this sense we assume that banks' asset portfolios are maximally diversified [20].

Interdependency networks between banks are constructed as follows. Firstly, we consider a "regionalised" banking system, corresponding to networks given by 2D spatial grids with periodic boundary conditions and Moore neighbourhoods (one could interpret these as sets of regional assets, such that banks preferentially invest into assets in their geographical neighbourhoods). In order to consider globalisation, we build (regular) small-worlds from these networks by rewiring a fraction ρ of all links. In these two scenarios, a world consisting of equally sized banks is modelled. Secondly, in order to