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A simulation approach to evaluate systemic risk

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ABSTRACT

In this paper we employ a simulation technique which illustrates the propagation of individual banks' default risk through the total banking market. The set-up of our theoretical model can be applied to a wide range of real-world banking systems as it allows for a convenient variation of the number of banks included, their relative market shares, capital ratios and the relation of risk weighted assets to other assets. Based on empirical rating transition probabilities, we utilise the model to measure the likelihood of individual defaults and to predict their consequences for the overall banking sector. We identify higher Tier 1 ratios as a major remedy against contagious effects.

1. Introduction

Although the repercussions of the recent international financial crisis are still perceptible and several problems have not been solved, some stylised facts seem to be more or less indisputable. The probably most important finding uncovered is that large internationally operating banking institutions suffered more severely from the turmoil than small regional financial intermediaries. The bankruptcy of Lehman Brothers challenged the global financial system as a whole. Therefore, to prevent national banking industries from collapsing, several governments subsidised their former domestic champions by injecting additional equity to compensate for massive losses from careless high risk investments (Katsimi and Moutos, 2010, p. 575).

Consequently, after the smoke had vanished politicians as well as regulators and academic researchers once again reflect the well-known characteristic of single banks obviously being a risk for the whole financial system. On first glance, solving the problem is rather simple by making big banks smaller. However, the crucial questions are which bank is 'big' in a systemic context and are there additional as well as alternative attributes which characterise a financial institution as a risk for the system?

In this paper we use a simulation technique, which is able to illustrate the propagation of individual banks' default risk through the total banking market. Therefore, we develop a specific framework that enables us to control for each single bank's size, riskiness of assets, market share, rating, and capital, respectively. Applying stochastic exogenous shocks which may initially worsen the rating of one or even more banks, the model simulates contagion effects within the system. By varying the economic features we try to estimate the particular impact of an isolated change of one variable on the shock's transmission. Our aims are

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both to present a theoretical setting that may be applied to existing financial systems and to identify major determinants of systemic risk. The paper is organised as follows: the next section briefly discusses different categories of risks for and of a financial industry, respectively. Section 3 reveals deeper insights in existing models as well as a critical review of the state of the art. A stylised methodology of our model is developed and executed in Section 4. An intensive discussion of the model's results is presented in Section 5. We close with some essential conclusions and hints for further research.

2. Risk and the system: Definitions

Since the early 1970s, academic research provided scepticism that financial markets function analogously to markets for real goods. Intrinsic imperfections, such as adverse selection or moral hazard caused by asymmetric information between borrowers and lenders, indicate the need for a particular regulation of the financial sector. Nevertheless, even extensive and specific regulative measures could not prevent financial crises in the past. This exceptional susceptibility of financial industries is mainly caused by the existence of systemic risk.

Systemic risk is characterised as a situation, where the distress of one institution endangers the rest of the financial system (Hellwig, 2009, p. 182). The main reasons are financial intermediaries which are supposed to be either 'too big to fail', 'too interconnected to fail' or 'too important to fail'. According to the well-established economic literature, a systemically important financial institution (SIFI) can trust in governmental support in cases of economic turbulences since otherwise the whole economy is threatened to collapse. Hence, SIFIs may be attracted by adverse incentives because their risky investments do not have to be fully covered by costly equity but may be bailed out by taxpayers. Therefore, regulation has to make sure that these negative external effects of systemic risk do not affect market outcomes.

The size of a financial institution can be regarded as the key measure of systemic risk. Drehmann and Tarashev (2011) demonstrate that 'size' (measured by a bank's liabilities to non-financial institutions) alone is a reliable proxy of systemic importance. The larger a bank is, the higher is the potential damage that arises from its failure. If a bank is assumed to be 'too big to fail' its prominent market share cannot be easily substituted by competitors. Furthermore, the collapse of a well-known bank negatively impacts confidence in the banking system as a whole. Until September 2008 Lehman Brothers Inc. was thought to belong to this category. Consequently, the massive irritations of the global financial markets during the days after Lehman's insolvency caused extraordinary losses all over the world. It is still uncertain whether a government rescue programme for Lehman Brothers would have been much cheaper than the necessary interventions following the bankruptcy. With the argument 'too big to fail' the German federal government subsidised Commerzbank AG as well as Great Britain's Treasury aided Northern Rock to survive (Schrörs and Luttmer, 2010).

We talk about 'too interconnected to fail' if a (even rather medium sized) bank has liabilities and claims against a large number of institutions in a single domestic market or a multi-national framework. An insolvency of an intermediary in a particular context like this leads to write-offs for numerous market participants and may, therefore, be followed by additional bankruptcies. Again the existence of the system as a whole might be at risk.

Both manifestations of systemic risk mentioned so far can be characterised by contagion or domino effects. According to Staub (1998), Hellwig (1998), Schnabel and Shin (2004) as well as Allen and Carletti (2006, 2008) at least three transmission channels can be distinguished:

- The necessary write-down of contractual claims induced by a bankruptcy of a single SIFI,
- Spill-overs on asset prices, caused by the liquidation of particular assets to prevent a SIFI from breakdown,
- The transfer of information about a bank in economic difficulties to similar institutions under the assumption that they all are following an identical business strategy.

Finally, all contagion effects may provoke an overall withdrawal of funds (i.e. a bank run) implying the collapse of the financial industry.

If a single institution is 'too important to fail', domino effects do not necessarily follow. The particular systemic risk stems from the bank's unique (and dominant) position in a specific segment of the financial architecture, e.g. the funding of private real-estate investments by providing mortgages. In the US, the Federal National Mortgage Association ('Fannie Mae') and the Federal Home Loan Mortgage Corporation ('Freddie Mac') are well-known examples, the Hypo Real Estate AG in Germany belongs to the same category. Only government support kept the respective financial systems alive when the turmoil threatened the institutions.

The scenario of 'too-many-to-fail' must be regarded as an indicator of systemic distress which is somehow different from the first three mentioned, in that it cannot be attributed to a single bank. Acharya and Yorulmazer (2007) demonstrate that in case of few bank failures, an acquisition by surviving institutions is likely. However, when the number of bank failures is large, regulatory authorities feel obliged to bail out some or all of the troubled banks. Therefore, banks tend to follow similar business models and to build up comparable portfolios of securities. Apart from that, herding behaviour is stimulated by the negative external effects that are caused by the failure of a single bank. According to Acharya (2009) the general increase in refinancing costs will outweigh the positive effect of on average higher market shares for the surviving institutions.[1] When all banks undertake correlated

[1] Acharya (2009, p. 226) explains the increase in deposit rates by a reduction in the aggregate supply of funds after the insolvency of one bank. A similar argument is brought forward by Diamond and Rajan (2005).