Journal of Economic Dynamics & Control 34 (2010) 2358–2374

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

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

Systemic risk, financial contagion and financial fragility

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ARTICLE INFO

Available online 30 June 2010

JEL classification:
C15
C63
D53
D85
G01
G21

Keywords:
Systemic risk
Monte Carlo simulation
Financial contagion

ABSTRACT

Although it is hard to arrive at a widely accepted definition for *Systemic Risk*; it is generally acknowledged that it is the risk of the occurrence of an event that threatens the well functioning of the system of interest (financial, payments, banking, etc.) sometimes to the point of making its operation impossible. We model systemic risk with two main components: a random shock that weakens one or more financial institutions and a transmission mechanism which transmits and possibly exacerbates such negative effects to the rest of the system.

Our model could be conceptually represented by a network already described in previous works. In this work we show how is possible to estimate the distribution of losses for the banking system with our model. Additionally, we show how it is possible to separate the distribution of losses into two components: the losses incurred by the initial shock and the losses resulting from the contagion process. Finally, once the distribution is estimated, we can derive standard risk measures for the system as a whole.

Another important contribution of this work is that we can follow the evolution of certain risk measures like the expected loss or the CVaR in order to evaluate if the system is becoming more or less risky, in fact, more or less fragile. Additionally, we can decompose the distribution of losses of the whole banking system into the systemic and the contagion elements and we can determine if the system is more prone to experience contagious difficulties during a certain period of time.

1. Introduction

The understanding of systemic risk is of central importance for maintaining financial stability. However, there is an almost complete lack of methods and tools to measure it. Two of the main reasons of this lack are the difficulty of the task itself and the lack of the necessary data to perform such a task. However, there have been some recent advances in overcoming the inherent problems of measuring systemic risk.

There are many different definitions of systemic risk. For example, Kaufman defines it as "the probability that cumulative losses will accrue from an event that sets in motion a series of successive losses along a chain of institutions or markets comprising a system… . That is, systemic risk is the risk of a chain reaction of falling interconnected dominos" (Kaufman, 1995). According to de Bandt and Hartmann (2000) "Systemic risk (in the narrow and broad sense) can then be defined as the risk of experiencing systemic events in the strong sense". The Bank for International Settlements (BIS) in its

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doi:10.1016/j.jedc.2010.06.004

annual report of 1993–1994 states: "Systemic risk is the risk that the failure of a participant to meet its contractual obligations may in turn cause other participants to default, with the chain reaction leading to broader financial difficulties".

The European Central bank describes Systemic Risk in its 2004's annual report[1] in the following way:

> The risk that the inability of one institution to meet its obligations when due will cause other institutions to be unable to meet their obligations when due. Such a failure may cause significant liquidity or credit problems and, as a result, could threaten the stability of or confidence in markets.

Finally, in Schwarcz (2008), the author tries to reconcile all the above and some further definitions of systemic risk. In that paper, Schwarcz arrives at the following general definition for systemic risk:

> …the risk that (i) an economic shock such as market or institutional failure triggers (through a panic or otherwise) either (x) the failure of a chain of markets or institutions or (y) a chain of significant losses to financial institutions, (ii) resulting in substantial financial-market price volatility (which price volatility may well reflect increases in the cost of capital or decreases in its availability).

From all the above enumerated definitions we extract two main components to conceptually model systemic risk: first, an initial random shock which affects (even to the point of failure) one or more financial institutions and second, a contagion mechanism which transmits such negative effects to other institutions on the system. The contagion mechanisms are multiple; for example, the payment systems or the interbank market, just to mention two of the most studied contagion mechanisms.

The main reason why it is important to measure systemic risk is to allow better decision making and risk management for central banks and financial regulators. In fact, systemic risk has become one of the main concerns on every regulator's agenda. On the academic side, there is a considerable increase in the research and the number of publications on systemic risk and related topics for obvious reasons. For example, in Barnhill and Souto (2008) the authors propose to use portfolio simulation to study systemic risk in Brazil. In Bartram et al. (2007), the authors find that the probability of a breakdown of the international financial system is small; although, things have changed recently and their conclusions may not hold any more. In Lehar (2005), the author proposes a risk management methodology for assessing the risk in the regulators' portfolios (financial systems); however, the author discards contagion as an important element in systemic risk. Nevertheless, as we already said, things have changed a lot in recent times. The above mentioned papers differ on the approaches and on the specific issues they try to tackle but the common goal is to understand more, to measure and to manage systemic risk.

We have used the *Systemic Risk Network Model* (SyRNet) fully described in Márquez-Diez-Canedo and Martínez-Jaramillo (2007) and Márquez-Diez-Canedo and Martínez-Jaramillo (2009) on previous occasions first to estimate the distribution of losses, to perform stress tests and to investigate the effect that different levels of correlation have on the distribution of losses. We have proposed in Márquez-Diez-Canedo and Martínez-Jaramillo (2007) and Márquez-Diez-Canedo and Martínez-Jaramillo (2009) a measure of system fragility which we have now changed in order to make it more robust. Additionally, the simulation model has been modified in order to make the concept of losses more consistent and we report our proposed measure of fragility on a monthly basis for the year 2008 until June 2009.

The remaining part of this paper is organized as follows: In Section 2, we begin by reviewing the literature we consider relevant to our work on systemic risk and financial contagion. Section 3 deals briefly with the model used to study systemic risk. We explain how the proposed model captures the relationship between banks through interbank loans and how the dynamics of the contagion mechanism is characterized.

In Section 5 we show how to obtain the distribution of losses in the financial system due to the initial shock and contagion, through an efficient simulation procedure. Section 4 presents a proposal of a measure of financial fragility for the banking system. In Section 6, we use the model, we explain the experiments performed, the data used and the results obtained. Finally, in Section 7, we summarize our findings and propose possible lines of further research.

2. Systemic risk and financial contagion

Financial contagion is a central concept in the study of systemic risk as has been observed from the definitions given in the previous section because it can be considered one of the main components of the systemic risk concept. The literature on financial contagion is vast and it is not our intention to give complete survey of it here. However, we will briefly mention some of the closest works to our own research in order to place our work in context. In particular, we study financial contagion through the interbank market as is commonly done in several works like Iori and Jafarey (2001), Nier et al. (2006), Boss et al. (2004b), and Muller (2006).

In Upper (2007), the author summarizes the research on financial contagion and studies the assumptions made by the authors of the reviewed papers. In that paper, the author urges the development of models in which a probability measure can be assigned to the failure scenarios because it is not enough to know what happens if a particular bank fails and then

[1] Source Publication: European Central Bank, 2004, Annual Report: 2004, ECB, Frankfurt, Glossary.