MEASURING SYSTEMIC RISK IN FINANCIAL MARKETS

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Abstract

This encyclopedic essay surveys the most recent and relevant contributions on the fragmented and controversial issue of systemic risk measurement in financial markets. Considering the difficulties faced by the literature in providing an effective and quantitative measurement instrument on systemic risk, this paper underlines the most important contributions on this topic and offers a wide overview of systemic risk and its measurement. Having a comprehensive understanding of this issue is of crucial importance for both the investment bankers involved in sophisticated risk management operations, and the policymakers in better understanding the implications of the magnitude of systemic failure.

Bank failures and subsequent macroeconomic breakdowns constitute a threat for overall financial stability, and at the same time, a financial dislocation with incalculable consequences for both the financial and real economy. The de Larosière Group (2009) on financial supervision in the EU has analyzed many drivers as causes of the recent turmoil in the financial system. The first concerns the failure in **risk** assessment procedures, both from the side of financial banks and firms, and from the side of institutions that have been established with the mandate to guarantee efficient economic and financial regulation and supervision (Basil I and

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II)[2]. The overestimation of regulators of the ability of financial firms to manage situations of financial distresses, and the corresponding underestimation of minimum capital requirements, represent weakness that has to be considered to fully understand the macroeconomic forces underlying financial soundness. Second, the exponential development of derivative instruments has complicated the evaluation of risky assets in any field of financial engineering, shedding light on the unreliability of current model-based risk assessments (i.e. **CAPM** and VaR[3]). It has contributed to generating a parallel hidden banking system with reduced information about the size or origin of credit risks, highlighting a lack of transparency in many segments of the international financial system. In this regard, a special role has been played by the sudden growth of **Over-the-Counter** credit derivatives markets. Even if these markets were initially envisaged as a powerful risk management instrument mitigating the likely negative states of nature, in reality they have in fact spread the threat of systemic risk. Third, the "originate-to-distribute" model has created huge possibilities and incentives for speculators, diverting attention of the solvency capacity of third-party counterparts (Van den End, 2009).

Despite the importance of having a comprehensive knowledge of this phenomenon, the literature fails to provide an exhaustive understanding of measuring the effects and magnitude of systemic failure, both from a horizontal perspective (spreading of the crisis among institutions, banks and firms) and from a vertical perspective (the deep of the crisis and which agents will be involved, from big **investment funds** to

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[2]As expressed in Acharya et al. (2010) "Basel I and Basel II are designed to limit each institution's risk seen in isolation; they are not sufficiently focused on systemic risk even though systemic risk is often the rationale provided for such regulation".

[3]The CAPM (Capital Asset Pricing Model) model describes the relationship between risk and expected return and it is used in risky securities pricing activities. For an exhaustive explanation about CAPM see Jensen, M, C., Black, F., and Scholes, M.S "The Capital Asset Pricing Model: Some Empirical Tests" *Studies in The Theory of Capital Markets",* Praeger Publishers Inc., 1972. The VaR model computes the maximum loss associated with an asset or a financial portfolio given a certain level of confidence. For VaR see Jorion, P., (2006) "Value at Risk", *McGraw-Hill, 3rd edition.*

private investors). Furthermore, considering the lack of consensus of what systemic risk is and the difficulty in detecting an independent and clear measure suitable for any scenario and market, there are a distinct number of reliable quantitative indicators utilized to measure the first signs of financial distress[4].

Turning to the literature, I propose a dual classification to study the principal measurement tools of systemic risk. I have opted for a different choice from that recently proposed in Billio et al. (2010), as I consider that the **contagion** among banks and subsequent spillover effects coming from the insolvent bank can be classified in one category to have a complete understanding of this topic. Accordingly I have carried out this review of systemic risk measures in two broad categories:

a) The first group focuses on monitoring traditional macroeconomic indicators of financial soundness and stability;

b) The second group analyzes the interlinkages among financial institutions through the analysis of the assets of financial institution.

The first group of contributions relies on bank capital ratios and bank liabilities indicating that aggregate macroeconomic indicators can provide a valid and useful instrument to predict systemic risk threat. Through the study of macroeconomic fundamentals, Gonzalez-Hermosillo et al. (1997), Gorton (1998) and Gonzalez-Hermosillo (1999) support the functioning of macro analysis in estimating systemic risk. More recently Bhansali et al. (2008) derive the "systemic credit risk" variable from index credit derivatives and find that systemic risk during the 2007-2009

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[4]Despite the fact that a major focus of the literature on systemic risk is focused on quantitative measures, there are also some contributions that take into consideration qualitative measuring instruments (Nelson et al.2005). For qualitative information tools we mean formal surveys of investors and bank senior loan officers, and informal contacts with market participants. In particular, considering the short amount of time available for decision making in the investment banking sector, this qualitative information assumes a precious (use another word here) connotation unexpected events come up quickly, and there is no time to wait for an official response from quantitative surveys and analyses.

financial crises shows a double value compared to May 2005. De Nicolò and Lucchetta (2009) first use a dynamic factor model to work out joint forecasts of indicators of systemic real risk and systemic financial risk, and second, elaborate stress-tests of these indicators as impulse responses to structurally identifiable shocks. The use of aggregate indicators, if on one side appears to be the more suitable instrument for systemic risk assessment, on the other side illustrates its limitations for the infrequent character of the data under analysis. Macroeconomic indicators are characterized by monthly observations and are unreliable in capturing market-tensions released by sudden news and unexpected events, that, as the recent financial crises has illustrated, can develop very rapidly with dramatic consequences on capital markets. Further, focusing on broad drivers of the financial system, this approach is bounded by the scarce information about the state of individual financial institutions, in particular, interlinkages between institutions.

The second group analyzes the interlinkages between financial institutions as well as exposures among banks that, through their business, can influence each other in situations of financial distress. De Bandt and Hartmann (2000) provide an interesting survey of this category of study. A more recent contribution is given by Lehar (2005), assessing the probability that a certain number of banks within a time period will go to bankrupt due the decrease in their asset value below a well-defined liabilities value. This view comes from the structural model from Merton (1974), wherein a bank's default occurs when the asset banking values stand below a given threshold value.[5] Adrian and Brunnermeier (2009) define CoVaR as the VaR of financial institutions conditional on other institutions that experience, at the same time, financial distress. De Nicolò and Lucchetta (2009) investigate the transmission channels and contagion effects of certain shocks between the macroeconomy, financial markets and intermediaries. Huang et al. (2009) use as a proxy of systemic

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[5]These models use option prices to approach credit risk measuring on equity markets. See also KMV models.

risk, the price of insuring a dozen of the major U.S banks against financial turmoil using both ex-ante bank default probabilities and forecasted asset-returns correlations. As the recent financial crisis has underscored, the need to understand the interlinkages between financial firms and the use of aggregate indicators is of crucial importance to construct better macro prudential indicators for policy makers and regulators and, at the same time, to have a deep understanding of the key drivers of systematic financial risk. For this purpose, the analysis of interlinkages between financial institutions is of key importance, both from a domestic and international point of view. In this regard **IMF** (2009) surveys four different methods to assess interlinkages among financial institutions:

• The *network approach*: here the interbank market spreads the transmission of financial stress through the banking system. Allen and Babus (2008) state that network analysis is the best approach to lead an in-depth analysis of systemic risk, as it allows the regulator to analyze not only the fulcrum of the problem, but also the spillover effects from direct financial linkages[6] through the construction of a matrix of inter-institution exposures that includes gross exposures among financial institutions (both national and international);

• The *co-risk model* (or co-movement risk model): in this specification, the probability of default of one institution is directly linked to the default risk of another institution. As underscored in Brunnermeier et al. (2009, p.5), "*It may be that the best way to assess the implications of endogenous co-risk measures that measure the increase in overall risk after conditioning on the fact that one bank is in trouble*". Empirical studies during the past ten years, including de Vries et al. (2001), Longin and Solnik (2001) and Chan-Lau (2004) find clear evidence that co-movement among financial variables is stronger during troubled times than during normal times;

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[6]For a comprehensive survey of the literature see Upper (2007).

- The *distress dependence matrix*: this model studies the probability of default of a pair of banks, taking into account a panel of financial banks. Through this method, it is possible to assess the probability of a financial institution experiencing distress conditional on another institution that shows clear signs of financial trouble. Goodhart and Segoviano (2008) offer a brilliant contribution to this technique;

- The *default intensity model*: this model is able to capture the probability of default of a large part of financial institutions through linkages among certain institutions. These kinds of models are worked out in terms of default rate jumps that occur in failure events, reflecting the increased likelihood of further events due to spillover effects. In this regard Giesecke et al. (2009) capture the clustering of the economy-wide default events as represented by the fitted intensity.

Notwithstanding this insightful IMF classification, there are still substantial empirical contributions that deserve to be included in this analysis. Prices of financial assets, interest rates, financial stocks and flows represent good proxies as indicators of systemic risk. Their characteristics of being continuously available on the market with the capacity of representing the mirror of firm and banking performance make these variables valuable tools of systemic risk measurement. In this contest Bartram et al. (2005) propose three different approaches to estimate systemic risk. The first methodology assesses the risk of a systemic failure observing the market reaction to global financial shocks for a subset of banks that are not directly exposed[7] to the shock. **Stock market** reactions of an unexposed bank to the shock will be interpreted as a measure of systemic risk. The second approach is given by an assessment of the default probabilities of banks during a time of crisis. In order to

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[7]Bertrand et al. (2005) argue that in efficient capital markets, negative information (as 9/11) will affect bank performances that are exposed to the events in question. Unexposed banks will be unaffected by these effects.

estimate the probabilities of default they take into consideration a structural model, an idea of default developed by Merton (1974) estimated from an observed series of equity prices. In the third and last approach Bartram et al. (2005) follow the estimation procedure applied by Duan (2000), Duan et al.[8] (2003), and Camara[9] (2004) assessing systemic risk in the banking system through the probability of bank default implied in their equity option prices. One of the most recent contribution of this class of indicators is provided by Capuano (2008), developing a framework to derive a market-based measure of probability of default. This probability of default is defined as the probability that the value of the underlying asset will fall below a given threshold value that constitutes the default barrier itself. As a contrast to Merton's (1974) work, Capuano (2008) does not fix any predetermined ad-hoc default barrier, but determines such barrier endogenously.

Using a VaR approach, Acharya, et al. (2010), define systemic risk as the likelihood of experiencing cumulative losses in financial system that exceed the predicted by VaR model. Further, they propose a tax (fee) that would require being divided into two components: (i) a component directly linked to the institution-risk and representing the expected loss on its guaranteed liabilities, and (ii) a systemic-risk component, namely, the risk is measurable when the financial sector becomes undercapitalized.

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[8]Duan et al. (2003) derive a maximum-likelihood approach where the likelihood function for the equity value of the firms is derived in a structural model framework. Through maximizing this function, it is possible to obtain the implied default probabilities of the firm.

[9]Camara (2004) develops an option pricing model in which asset prices follow a geometric random walk but may jump to zero (bankruptcy) with a finite probability distribution.

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