

Gertrude Tumpel-Gugerell: Recent advances in modelling systemic risk using network analysis

Introductory remarks by Ms Gertrude Tumpel-Gugerell, Member of the Executive Board of the European Central Bank, at ECB workshop, Frankfurt am Main, 5 October 2009.

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Introduction

Ladies and Gentlemen,

I would like to welcome you to the workshop on “Recent advances in modelling systemic risk using network analysis” here at the ECB. A workshop on systemic risk that provides an analytical focus on the financial sector as a network of financial agents could not come at a more timely moment.

In 1896 the German sociologist Georg Simmel stated in his book “The Philosophy of Money”: “money is the spider that spins society’s web”. With this, Simmel already at the time pointed to the network aspect of money, how financial innovation can transform the economy and society; and the transformation process as changes in the complexity, size and nature of economic and societal networks.

The recent financial crisis has strikingly illustrated the interconnectedness that characterises the global financial system. In providing a framework for strengthening financial stability, policy-makers are currently not only refining the regulatory and institutional set-up, but also looking for new analytical tools that help to better identify, monitor and address sources of systemic risk. Therefore, I believe network analysis can make a relevant contribution and I am delighted that you have come together today to present and discuss new work in this field.

Let me give you three questions (from the perspective of a policy-maker) which today’s workshop would ideally shed light on:

- What are the key channels and systemically important players that need special attention?
- How can macro-prudential supervision take the interconnectedness into account?
- And can network methodologies provide us with a useful tool in this respect?

With these questions in mind, I have structured my introductory remarks into three parts. I will first give a short assessment of the relevance of systemic risk in the modern financial system. Then I will discuss the use of network theories for the analysis of systemic risk. Finally, I will briefly refer to network applications to payment and financial systems.

1. Systemic risk in the modern financial system

Systemic risk refers to the possibility that a triggering event such as a bank failure or a market disruption could cause widespread disruption of the financial system, including significant difficulties in otherwise viable institutions or markets. Preventing these negative externalities from impairing the functioning of the system and from spilling over to the real economy is a crucial element of the mission of central banks and of supervisory authorities.

In the last two years, the functioning of the global financial system has been challenged by an extraordinary sequence of such triggering events. This brought to the fore how complex and interconnected the financial system had become and, consequently, how problems in one part of the system could reach other parts, also very distant ones.

In July and August 2007 the asset-backed commercial paper (ABCP) market collapsed when investors realised that money market mutual funds had invested in paper backed by sub-prime assets. Investors became suddenly distrustful of all forms of private credit, especially structured products and other complex and opaque instruments, and this caused the funding for structured investment vehicles and special-purpose vehicles to dry up. Difficulties faced by conduits and other asset-backed programmes in rolling over their short-term funding forced them to look to bank sponsors for liquidity (this was the case, for instance, for IKB and Sachsen LB in Germany) or to sell assets. A crisis of confidence ensued which gripped money market mutual funds and the commercial paper market, notwithstanding their distance from the US housing market.

Such unstable dynamics, set off by increasing uncertainty about the size of losses in the system and, maybe more importantly, about their exact location, continued in the course of 2008. Then, the collapse of Lehman Brothers in September 2008 transformed a pessimistic and disoriented mood into full-blown panic and paralysis.¹

The biggest negative surprise following Lehman Brothers' default was its effect on money market funds. When one fund, Reserve Primary, "broke the buck" (that is, the value of investors' money fell below the notional amount invested), the sector was hit by a wave of redemptions that fuelled instability in the credit markets. Again, banks and companies relying on short-term funding through commercial paper or ABCP (i.e. debt backed by mortgages, credit cards and other consumer loans) could not roll over their debt, except at overnight maturities.

The ensuing dynamics in market participants' behaviour clearly illustrate the presence of knock-on effects, negative externalities, and a coordination failure in the *market network*. Each institution responded rationally given individually available information. However, each rational response had repercussions for the whole system.

The impact of systemic risk depends very much on the collective behaviour of financial institutions and their interconnectedness, as well as on the interaction between financial markets and the macroeconomy. Systemic stability is a public good. The recognition of this public good property underpins the recent emphasis on a macro-prudential approach to regulation and supervision.

From a micro-prudential perspective, a strengthened supervision of individual institutions' risk-taking incentives is also important. A key element of the risk management framework of banks is that they take into account, in terms of credit and liquidity risks, the exposure they have to particular (potentially systemically relevant) counterparties. Systemic risk is, generally, outside the control of each individual institution. But, by keeping liquidity buffers and capital reserves and by limiting large exposures and addressing dependencies, banks can contribute to an increase in the resilience of the system as a whole.

2. The use of network theories for the analysis of systemic risk

The financial crisis has reminded us how important it is to look at the links and connections of the financial system. We saw that major disruptions such as failure or a near failure of certain institutions rapidly spilled over to the whole financial system.

Therefore, network theory can help us to analyze the systemic risk of such disruptions (i) by looking at how resilient the system is to contagion; and (ii) what the major triggers and channels of contagion are.

¹ G. Tett (2009), "Markets 12 months after Lehman collapse", Financial Times, 9 September.

An important aspect of the analysis of systemic risk is that an apparently robust system may in fact be very fragile. This comes from the fact that a high number of interconnections within the network will serve as shock-amplifiers rather than as absorbers.

Another key aspect of the analysis is that within the network of the financial system, there are players with only a few connections, but also players that are highly connected. Obviously, such networks are extremely vulnerable if those highly connected players are disrupted. In fact, when a shock hits the system, the number of affected players can be especially low, but still propagate system-wide. Payment systems, for instance, are networks with such a property.²

Clearly, large and highly connected financial institutions are *systemically important*. This has important implications for macro-prudential surveillance, and hence for financial stability. Network analysis is crucial for the identification of such systemically important institutions and markets which are critical market players in the web of exposures. Monoline insurance providers and AIG provided an example of such critical players; key custodian banks or large correspondent banks play a similar role.

Let me add to this, that a particular institution might not only be critical to the functioning of financial markets or market infrastructures because other institutions are financially exposed to it, but also because other market participants rely on the continued provision of its services. For us as policymakers this is a crucial point, as the impact of a failure of a given market player also hinges on the ability of the financial infrastructure to support its resolution and to facilitate the orderly unwinding of positions. So let me now turn to the specific application of network theory to payment and financial systems.

3. Network analysis applications to payment and financial systems

Research in network theory has received relatively little attention in economics until the last decade. Therefore, I am delighted to see that this literature is growing and today's workshop clearly illustrates its growing importance.

The papers from today's program highlight how direct and indirect interlinkages and contagion dynamics among financial institutions, as well as among institutions, markets and infrastructures, can be significantly influenced by three important network characteristics: First, the degree of connectivity, second, the degree of concentration and third, the size of exposures. We see from the papers that network analysis can help to better understand the interlinkages and systemic connections in many different segments of the financial markets, ranging from money markets to networks of credit default swaps (CDSs), and from large-value payment systems to cross-sector exposures in the euro area financial system.

We see that this research gives important insights into the various amplification mechanisms in the global web of financial connections. Such amplification very much depends on a number of factors, such as the size of aggregate macroeconomic shocks, asset price volatility, liquidity risk and financial leverage. Moreover, network analysis can be used to simulate the effect of credit and funding shocks on banking and financial stability by taking into account – beyond the direct balance sheet exposures – also the impact of contingent claims and credit risk transfer techniques.

² See M. Pröpper et al. (2008), "Towards a network description of interbank payment flows", DNB Working Paper No. 177, for an analysis of Dutch payment flows; C. Pühr and S. W. Schmitz (2009), "Structure and stability in payment networks – a panel data analysis of ARTIS simulations" in H. Leinonen (ed.), [Simulation analyses and stress testing of payment networks](#), Bank of Finland, for the Austrian large-value payment system; and K. Soramäki et al. (2007), "The topology of interbank payment flows", *Physica A*, Vol. 379, pp. 317-333, for an analysis of Fedwire, the large-value payment system operated by the Federal Reserve.

I am glad that the workshop brings together a wide variety of applications. It demonstrates two key points: first, network analysis is advancing as a common tool for assessing dynamics within the various parts of the financial sector (from payment systems to interbank balance sheet exposures); and second, it reveals that a truly systemic perspective needs to combine the focus on various parts of the financial sector with an analysis of the interlinkages among them, ideally including the interaction with the real economy. This is, of course, an ambitious objective that calls for further research.

Conclusions

Let me conclude. The recent financial crisis has underscored the need for policy-makers and regulators worldwide to track systemic linkages.

Network analysis offers a very relevant tool for addressing this challenge. Its focus on interconnectedness and on systemically important market players makes it especially relevant for the assessment of the fragility or resilience of the financial system as a whole. By applying network theories we can benefit from the important progress made in other sciences to monitor and assess systemic risks, direct and indirect linkages, vulnerabilities and contagion. This is because networks allow us to look beyond the immediate “point of impact” of a shock, hence, also to the spillovers likely to arise from interlinkages in the system. Thus, network analysis can undoubtedly provide useful guidance for the analysis of systemic risk and can be a key tool for the future analysis of such risk.

For us, such analysis will be of crucial importance. As you know a European Systemic Risk Board will be established with the mandate to map financial risks and their concentration at the system level for the *macro-prudential* supervision of systemic stability. The mandates of other supranational institutions and fora, such as the IMF and the Financial Stability Board, also refer to network aspects of the financial system that have become apparent during the current crisis and that should be taken into account in order to obtain new measures of financial fragility.³

Also for the specific field of market infrastructures the relevance of network effects are being taken into account. The market for credit default swaps (CDS) has clearly revealed its systemic importance, as the default of one major counterparty has put the whole system under severe strain. Therefore, I welcome very much that central counterparties for credit default swaps have been established to address first, the high degree of interconnectivity between CDS markets and credit and cash securities markets, second, the high leverage embedded in these financial instruments, and third, the significant concentration of related risks in a small group of major market players. Effective implementation of central clearing of derivatives enables a significant reduction in counterparty risk, hence addressing some of the negative externalities that stem from the over-the-counter network that has formed over the years.⁴

Interlinkages within the financial system are nothing fundamentally new. However, business strategies developed by financial institutions over the last 20 years and financial innovations have made the system much more interconnected, complex and opaque than it was in the past.

I believe that policy-makers and regulators of today will be judged in the future on the basis of the regulatory measures and analytical tools they have applied to address the root causes

³ See IMF (2009), “Global Financial Stability Report”, Chapter II on *Assessing the Systemic Implications of Financial Linkages*, April, and E. Nier et al. (2007), “Network models and financial stability”, *Journal of Economic Dynamics and Control*, Vol. 31, pp. 2033-2060.

⁴ See also ECB (2009), “OTC derivatives and post-trading infrastructures”, September.

of the crisis. A key challenge is to transcend a purely national or sector-specific perspective and to take an approach that matches the global nature of financial networks. A key prerequisite for network analysis as a surveillance tool remains, however, the availability of relevant data. This holds true especially on a cross-border basis, but also at bank level. Going forward, regulators and overseers should continue to develop ways to systematically collect and analyse data. The crisis has clearly demonstrated that data confidentiality must not stand in the way of improvements in systemic risk analysis and assessment by policy-makers.

Once more, I welcome you to this workshop and I wish you productive and enriching discussions on this very relevant topic.