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Interconnectedness and contagion risk in the European banking sector

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*As part of the research on financial stability carried out at the Banque de France, a tool has been developed to analyse the effect of the financial interconnections between European banking groups on contagion risk. This model makes it possible to assess the resilience of the European banking sector as a whole, as well as the bank-level characteristics that make a single bank more "vulnerable" to contagion or more "systemic" for its counterparties. Overall, we find that the estimated impact of contagion is highly heterogeneous across simulations, depending on the identity of the defaulting bank and the interbank network structure at the time the default occurs. For example, in 2008, for an average stress scenario, the default of the most systemic bank, after contagion effects, would have caused losses equal to about 13% of the Common Equity Tier 1 (CET1) capital of the banking system. For a few extreme cases, however, the losses would have reached up to 30% of the financial system's capital (*i.e.* about EUR 300 billion) and triggered the default of 14 other institutions. While sizeable factors of vulnerability have persisted for some countries over the 2009-2012 period, the results indicate that over time the European banking system has become more resilient to contagion risk arising from interbank exposures.*

The global financial crisis has revealed the key role of interconnectedness between financial institutions and other entities in the financial system. While interconnections contribute to well-functioning financial markets in calm times, they are also channels that transmit tail risks when they materialise. Contagion phenomena may thus amplify shocks and weaken the financial system as a whole. Short- and long-term interbank exposures can indeed become important contagion channels for shocks and lead to "cascade" failures (or domino effects). This direct contagion channel has often been investigated by central banks and in the academic literature.[1] The effects being estimated are overall of small magnitude, reflecting both the restrictive model hypotheses and the fact that only domestic exposures are accounted for in a given banking sector. The model and the data used by the Banque de France make it possible to overcome these constraints and to assess the dynamic effect of contagion at times of financial stress.

A network model to assess financial contagion risk

The model developed at the Banque de France features the interaction of three contagion channels

1 *See Upper (2011) for a critical survey of the literature on interbank contagion. The following are a few representative country studies: Furfine (2003) for the United States, Upper and Worms (2004) for Germany, Mistrulli (2007) for Italy, and Fourel* et al. *(2013) for France.*

that happened to be at play during the financial crisis: (1) exposures to a common risk factor (*e.g.* to the market price of some assets); (2) exposures to credit and counterparty risk in the interbank market; and (3) exposures to short-term liquidity risk (inability to roll over a loan overnight or with a 7-day maturity). These three channels make it possible to better assess the spread and consequences of financial contagion, as measured by the number of defaulted banks or the capital losses suffered.

Our analysis is based on bilateral interbank exposures and on balance sheet data for 73 European banking groups.

By combining two networks of exposures, one for short-term and one for long-term exposures, we focus on the consequences of the following stress scenario:

- a common shock to the stock market, *i.e.* a drop in stock prices leading to an average loss of 3.4% of the financial system's capital, but which could lead to losses of up to 16% of the system's capital;[2]
- the default of one of the 73 European banks in the network.[3]

Several mechanisms are at play in the network. First, the market shock reduces the equity capital of the sample banks. In parallel, all banks exposed to the defaulting bank *via* long-term exposures also take losses (given an assumed recovery rate); these losses, combined with the lower capital ratio following the market shock, may trigger a contagion phenomenon. A mechanism of cascade defaults is triggered if the total losses suffered by one bank exceed its available equity capital, under the assumption that external equity capital cannot be issued in the midst of a crisis. The defaulting banks are then removed from the system.

For the surviving banks, a sizeable aversion to lend excess liquidity over short horizons then appears. The larger the losses incurred, the more a bank becomes reluctant to roll over unsecured short-term loans to other institutions. The riskier institutions (those that have a higher leverage ratio) face greater funding strains. If it is impossible for a bank to roll over its short-term debt, it becomes "illiquid" and defaults. The bank's counterparties write the loan down as an additional loss and may themselves subsequently default. The contagion mechanisms continue to unfold until no additional bank defaults. In the end, for each stress scenario, the model makes it possible to obtain the total number of defaulting banks and the aggregate equity capital losses for the banking system.

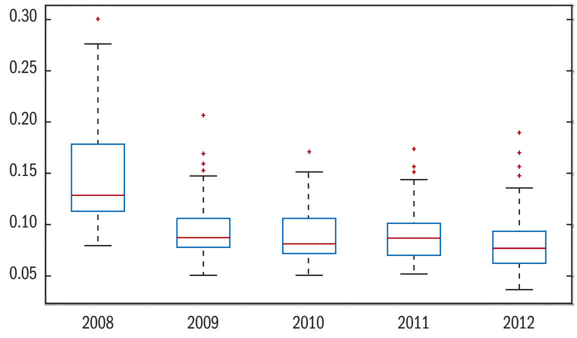
Wide-scale contagion effects in 2008, but improved resilience of the European banking sector post-crisis

Chart 1 shows the distribution of losses caused by the combination of the two channels of contagion – credit risk (*via* long-term exposures) and liquidity risk (*via* short-term exposures) – on a large number of short- and long-term networks simulated from TARGET2 data (cf. Box).

The analysis reveals highly dispersed results depending on the underlying network of exposures at the time of the shock. In 2008, following an average market shock, the default of the most systemic bank would have led to median losses of about 13% of the Common Equity Tier 1 (CET1) capital

C1 Distribution of the losses caused by the two contagion channels following a market shock and the default of the most "systemic" bank

(y axis: maximum losses as % of total capital)



Note: The box plots represent the distribution of maximum capital losses caused by a market shock and an idiosyncratic shock (a bank default) from 2008 to 2012 as a fraction of the total system capital. The statistics depicted in each box plot are standard: the first and third quartiles (the bottom and top of the box, in blue), the median (in red), and the 5th and 95th percentiles (the ends of the whiskers). Each red point corresponds to a pair of interbank networks of short and long term exposures. Simulations are based on 100 pairs of networks. For each year and for an average market shock, the box plot shows the losses caused by the worst idiosyncratic shock (the most contagious initial default).
Source: Gabrieli, Salakhova and Vuillemey (2015).

2 *We use a one-factor model for the stock prices of listed European banks in the sample, and simulate 500 market shocks. Following the shock, the banking system loses on average 3.4% of the CET1 equity capital and at most 16%. For each bank that is directly affected by the market shock, the average CET1 loss is 5%, but the maximum loss can be up to 25%. For more details on the market shock, see Appendix A.1.1 in Gabrieli, Salakhova and Vuillemey (2015).*

3 *This analysis significantly enlarges the sample of banks considered compared to previous studies (where the sample is typically restricted to one domestic banking sector). The sample used includes all European G-SIBs (Global Systemically Important Banks), but also smaller banks such as saving and cooperative banks (e.g. the German "Landesbanken" and the Spanish "cajas"). For the list of the 73 banks, see Gabrieli, Salakhova and Vuillemey (2015).*

Simulation of multiple probability-based networks from true bilateral exposures

Networks of exposures are simulated using an algorithm integrating the probability that two banks are exposed to one another. These probabilities of being interconnected are computed using actual interbank loans observed in TARGET2. We assume that two institutions that are more exposed to one another in the money market, as observed in the TARGET2 dataset, have a higher probability of being linked (i.e. of being exposed to one another via short or long-term debt) in a larger number of networks. Thus, the simulated networks resemble real-world interbank systems. In particular, they bear out certain structural characteristics – such as high concentration and a core-periphery structure – documented for TARGET2 networks. For more details, see Gabrieli, Salakhova and Vuillemey (2015).

of the European banking system (corresponding to 4 to 5 cascade failures). In the extreme case, however, for some interbank exposure networks, losses could have reached 30% of the system's equity capital (about EUR 300 billion) and triggered the default of 14 other institutions. While these results sound alarming, the analysis also shows that the European banking system became more resilient to interbank contagion from 2009 onwards.

The improved resilience of the European banking system over time seems to be explained by the deleveraging by financial institutions in the post-crisis period, especially after the EBA capital exercise, and by the reduced level of interbank exposures. Such a reduction primarily affects cross-border exposures, while domestic exposures increased during our sample period.

This suggests that greater fragmentation of the interbank network can be a positive factor for the stability of the system as a whole. The results also highlight the key importance of high levels of capital and of a moderate reliance on short-term funding in times of stress.

Nonetheless, we also observe that a greater fragmentation of interbank networks has been accompanied by a higher concentration of exposures on a few banks that have become more interconnected and more "central" within the network than before. The relation between market fragmentation and the resilience of the system is thus far from obvious. On the one hand, a network that is less interconnected is more robust to contagion on average; on the other hand, it increases bank-level risk which, because of second-round effects (liquidity hoarding in the money market and cascade failures due to exposures vis-à-vis undercapitalised or illiquid counterparties), may threaten the financial system as a whole in the case of extreme financial stress – for example following the default of the most "central" bank in the network.

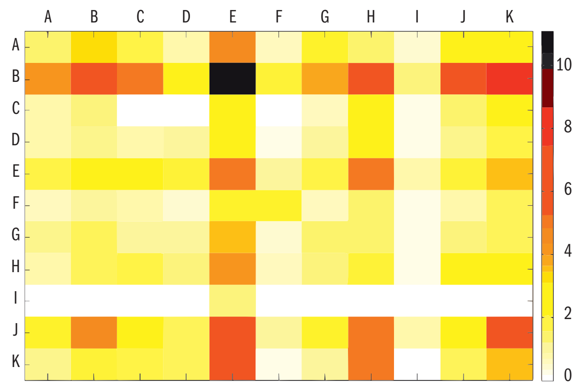
An econometric analysis conducted using the results indeed suggests that a greater bank-level systemicity in Europe is related, to a significant extent, to the centrality of a bank within the interbank networks simulated from TARGET2 payments data. Other explanatory factors include: balance sheet ratios, a high level of short-term funding and high exposure towards banks that are highly exposed to the market shock.

What are the vulnerability and systemicity of national banking systems in Europe?

The model can also be used to analyse cross-border contagion and identify the national banking sectors that would be most affected by the default of a foreign bank. The heatmap in Chart 2 depicts the spread of cross-border contagion in Europe at the end of 2008, where countries have been anonymised. Each cell represents the share of capital of the banking sector in country A that would have been lost following the default of a bank in country B. Darker columns in the heatmap indicate the banking sectors that are potentially the most dangerous for their European counterparties as of end-2008.

The banks of country E are among the most systemic for their European counterparties, especially for banks

C2 Distribution of domestic and cross-border losses caused by the two contagion channels following a market shock and the default of the most "systemic" bank



Note: The losses for each national banking sector are computed as a percentage of the domestic system's initial capital. The scale of losses is indicated on the right-hand side of the chart.
Source: Gabrieli, Salakhova and Vuillemey (2014).

in countries B, H, J and K, as well as for their domestic counterparties. Banks in countries B, H, J and K are also among the most systemic in 2008.

Conclusion

This new simulation tool, which accounts for the interaction of various contagion channels and their effects on the whole financial system, provides a "macroprudential" complement to microprudential stress tests. Bearing in mind all of the necessary precautions for this kind of exercise, the proposed framework makes it possible to enhance the surveillance of market fragmentation and of the concentration of interbank exposures, *via* which contagion may occur. An impact study of reforms aimed at limiting the concentration of exposures (or the centrality of some market participants), or at raising regulatory capital and liquidity requirements, can thus be considered for future work.[4]

4 *It should be noted that the results are currently being re-estimated using a new dataset of money market loans including originators and beneficiaries of TARGET2 payments (*i.e.* indirect TARGET2 participants) rather than settlement banks (*i.e.* direct TARGET2 participants). This dataset makes possible a more reliable representation of the universe of interbank money market loans, and potentially affects the construction of the probability maps that we use to simulate probability-based networks of interbank exposures. In particular, the geographical patterns of cross-border contagion identified may differ from those obtained using the dataset with settlement banks. While the difference may possibly be large for specific simulated networks, the impact on average results –* e.g. *those presented* via *heatmaps – is less clear-cut.*

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