

Box 6

MEASURING SYSTEMIC RISK CONTRIBUTIONS OF EUROPEAN BANKS

A clear lesson of the global financial crisis has been the propensity for company-specific risk to spill over to other firms. In fact, it is not just a company's size and idiosyncratic risk but also its interconnectedness with other firms which determine its systemic relevance. This realisation has underpinned not only a growing set of tools to capture such systemic risk, but also numerous regulatory initiatives to limit and mitigate it.

Of the multiple methodologies which have gained prominence to date in capturing systemic risk contributions of individual institutions, few have touched upon the time-varying nature of this process. This box illustrates a novel methodology that builds on the concept of value at risk (VaR) and can explicitly account for the time-varying interconnectedness within the banking sector. For each bank, the underlying statistical approach identifies the relevant tail-risk drivers as the minimum set of macro-financial fundamentals, firm-specific characteristics and risk spillovers from other banks driving its VaR. Detecting with whom and how strongly any institution is connected allows the estimation and construction of a tail-risk network of the financial system. A bank's contribution to systemic risk is then defined as the effect of an increase in its individual tail risk on the VaR of the entire system, conditional on the bank's position within the financial network as well as overall macro-financial conditions. The analysis¹ is based on publicly available market and balance sheet data and is applied to a sample of 51 large European banks.

The proposed concept is related to the widely used systemic risk measure of CoVaR.² However, the methodology outlined in this box does not constrain time variation in systemic risk to variation in idiosyncratic risk. More importantly, neither CoVaR nor alternative approaches to quantifying systemic risk contributions, such as marginal expected shortfall or distressed insurance premia, explicitly consider network interconnections, which are key determinants of banks' systemic risk contributions.³ Such approaches cannot detect spillover effects driven by the topology of the risk network and thus might underestimate the systemic importance of smaller but very interconnected banks.

The empirical implementation of the statistical model is based on a two-stage quantile regression. In the first step, bank-specific VaRs are estimated as functions of firm characteristics, macro-financial state variables as well as tail-risk spillovers of other banks. Hereby, the major challenge is to shrink the high-dimensional set of possible cross-linkages among all banks to a feasible number of relevant risk connections. Novel Least Absolute Shrinkage and Selection Operator (LASSO) techniques⁴ address this issue and allow the identification of the relevant tail-risk drivers for each bank in a fully automatic way. The resulting tail dependence network can be represented in terms of a network graph as illustrated in Chart A, which shows some indications of fragmentation of the European interbank market, as the banks in the programme countries are estimated to be disconnected from the other European banks. Moreover, during the European sovereign debt crisis, the tight interconnections between banks and sovereigns have played an important role. To account for this, sovereign bond yields are modelled (under an alternative

1 The analysis is based on F. Betz, N. Hautsch, T. Peltonen and M. Schienle, "Measuring systemic risk contributions of European banks", *ECB Working Paper Series*, forthcoming – building on N. Hautsch, J. Schaumburg and M. Schienle, "Financial Network Systemic Risk Contributions", SFB 649 Discussion Paper 2012-053, available at <http://sfb649.wiwi.hu-berlin.de/papers/pdf/SFB649DP2012-053.pdf>, 2012.

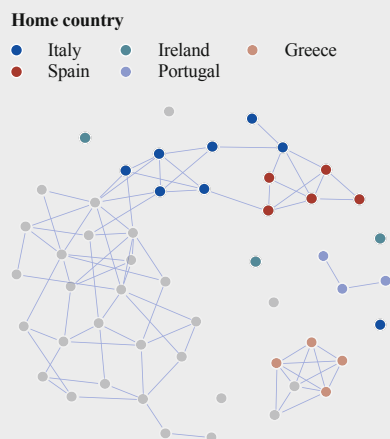
2 T. Adrian and M. Brunnermeier, "CoVaR", *Federal Reserve Bank of New York Staff Reports*, No 348, September 2011.

3 ECB, "Analytical models and tools for the identification and assessment of systemic risk", *Financial Stability Review*, June 2010.

4 A. Belloni and V. Chernozhukov, "l1-penalized quantile regression in high-dimensional sparse models", *Annals of Statistics*, Vol. 39, No 1, pp. 82-130, 2011.

Chart A Estimated tail dependency network for 51 large European banks

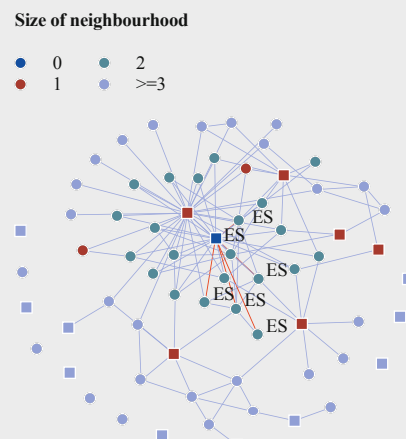
(2010 – 2012)



Sources: F. Betz, N. Hautsch, T. Peltonen and M. Schienle, “Measuring systemic risk contributions of European banks”, *ECB Working Paper Series*, forthcoming.
 Note: Banks in euro area countries under stress are marked with varying colours, while banks in other countries are marked in grey.

Chart B Visualisation of sovereign-bank interconnection using an estimated tail dependency network for 51 large European banks

(2010 – 2012; Spanish sovereign and banks are highlighted)



Sources: F. Betz, N. Hautsch, T. Peltonen and M. Schienle, “Measuring systemic risk contributions of European banks”, *ECB Working Paper Series*, forthcoming.
 Notes: Rectangles denote European sovereigns and circles large European banks. Petrol blue denotes banks directly connected to the Spanish sovereign (blue), reddish brown denotes banks and sovereigns connected to the Spanish sovereign through a bank, while light blue denotes banks and sovereigns where the connection to the Spanish sovereign is through two or more banks.

specification) as tail-risk drivers instead of state variables, and thus are also incorporated into the estimated tail dependency network (see Chart B).

In the second step of the empirical modelling strategy, to measure a bank’s systemic impact, the VaR of the financial system is regressed on the bank’s estimated VaR, while controlling for the pre-identified bank-specific risk drivers as well as macro-financial state variables.

A bank’s systemic risk contribution is determined as the marginal effect of its individual VaR on the VaR of the system and is called the systemic risk beta. It corresponds to the system’s marginal risk exposure due to changes in the tail of a firm’s loss distribution. The systemic risk beta is a function of firm-specific characteristics, such as leverage, maturity mismatch and size. To compare the systemic relevance of banks across the financial system, however, it is necessary to compute the total increase in systemic risk. Thus, banks are ranked according to their “realised” systemic risk beta, corresponding to the product of a bank’s systemic risk beta and its VaR, given by the fitted value of the first-stage regression. Accordingly, a bank’s balance sheet structure can affect its marginal systemic relevance, even though its individual risk level might be identical at different points in time.

The empirical analysis reveals a high degree of tail-risk interconnectedness among large European banks. In particular, it is found that the network risk interconnection effects are important drivers of individual risk, while an institution’s idiosyncratic risk is clearly a poor proxy of its systemic importance. The systemic risk assessment is complemented by the systemic risk networks, which yield qualitative information on potential risk channels and the roles of individual banks within the financial system. Moreover, the analysis also gives an interesting insight into banks’ contributions

to systemic risk during the European sovereign debt crisis. As illustrated in Charts A and B, the methodology is able to reproduce the fragmentation of the European interbank market and the tight interconnection between sovereigns and banks during the European sovereign debt crisis.