

B THE CONCEPT OF SYSTEMIC RISK

Research, in conjunction with market intelligence and current policy analysis, can make an important contribution to the understanding of systemic risk. It is one element in learning the lessons from the financial crisis and in supporting ongoing efforts to further develop the macro-prudential dimension of financial supervision. This special feature briefly discusses the concept of systemic risk and surveys the existing research literature. Research in the last two decades has made significant progress in analysing systemic risk, in particular contagion risks. It has also documented the relevance of macroeconomic shocks and started to analyse endogenously pro-cyclical behaviour from the perspective of systemic risk. Some of the analyses described important features of the present crisis. Substantial further research efforts, however, need to be made, inter alia, to develop aggregate modelling frameworks that capture realistic features of financial instability, to better understand the endogenous build-up and unravelling of widespread imbalances and to assess the systemic importance of non-bank financial intermediaries.

INTRODUCTION

The financial and economic crisis that has shaken the world economy for more than two years illustrates the relevance of systemic risk. Broadly speaking, it refers to the risk that financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially.

The objective of this special feature is to characterise the phenomenon of systemic risk from an academic research perspective. In so doing, some important elements of the concept of systemic risk are described and the academic research literature is surveyed.¹ The feature also points out where research explained factors that played a role in the present crisis, either before it broke out or thereafter, but it does not aim at providing an overview of the crisis. The next

section contains the conceptual discussion. The third section surveys theoretical research and the fourth section empirical research on systemic risk. The last section concludes and proposes some lines for future research.

CONCEPT

There is no commonly accepted definition of systemic risk at present. One perspective is to describe it as the risk of experiencing a *strong* systemic event. Such an event adversely affects a number of systemically important intermediaries or markets (including potentially related infrastructures).² The trigger of the event could be an *exogenous* shock (idiosyncratic, i.e. limited in scope, or systematic, i.e. widespread), which means from outside the financial system. Alternatively, the event could emerge *endogenously* from within the financial system or from within the economy at large. The systemic event is *strong* when the intermediaries concerned fail or when the markets concerned become dysfunctional (in theoretical terms this is often a non-linearity or a regime change). One can distinguish between a “horizontal” perspective of systemic risk, where attention is confined to the financial system, and a “vertical” perspective of systemic risk in which the two-sided interaction between the financial system and the economy at large is taken into account. Ideally, the severity of systemic risk and systemic events would be assessed by means of the effect that they have on consumption,

¹ For extensive discussions of the concept of systemic risk and comprehensive literature surveys on which this special feature heavily draws, see O. de Bandt and P. Hartmann, “Systemic risk: A survey”, *ECB Working Paper Series*, No. 35, November 2000, and O. de Bandt, P. Hartmann and J. Peydró, “Systemic risk in banking: An update”, *ECB Working Paper Series*, forthcoming, and in A. Berger, P. Molyneux and J. Wilson (eds.), *Oxford Handbook of Banking*, Oxford University Press, 2009. For reasons of space, this feature cannot survey the more practical and descriptive literature. Nor does it intend to derive policy recommendations for macro-prudential supervision or regulation.

² The failure of a large and complex financial institution (such as that of Lehman Brothers in September 2008) implies a particularly high risk of a systemic event. How to identify large and complex banks is discussed in ECB, “Identifying large and complex banking groups for financial stability assessment”, *Financial Stability Review*, December 2006.

investment and growth or economic welfare broadly speaking.³

The important distinctions between idiosyncratic or systematic factors, exogenous or endogenous triggers and sequential or simultaneous impacts illustrate the complexity of this phenomenon. One way to reduce the dimensions resulting from the combination of these elements is to limit attention to three main “forms” of systemic risk: the contagion risk, the risk of macro shocks causing simultaneous problems and the risk of the unravelling of imbalances that have built up over time. These three forms of risk are not mutually exclusive and may materialise independently or in conjunction with each other. Contagion usually refers to a supposedly idiosyncratic problem that becomes more widespread in the cross-sectional dimension, often in a sequential fashion. An example is one bank failure causing the failure of another bank, even though the second bank initially seemed solvent. The second form of systemic risk refers to a widespread exogenous shock that negatively affects a range of intermediaries and/or markets in a simultaneous fashion. For example, it has been observed that banks are vulnerable to economic downturns. The third form of systemic risk refers to the endogenous build-up of widespread imbalances in financial systems over time, as in the case of a lending boom. The subsequent (endogenously or exogenously caused) unravelling of the imbalance may adversely affect many intermediaries and/or markets at the same time. The last two forms of systemic risk are particularly relevant for the pro-cyclicality of financial systems, although contagion can also play a role in it.

Behind the three forms of systemic risk are a variety of market imperfections, such as asymmetric information, externalities and the public-good character of systemic stability, incomplete markets, etc. They lead to a greater fragility of financial systems in comparison with other economic sectors, because of (i) the information intensity and inter-temporal nature of financial contracts, (ii) the balance-sheet structures of financial intermediaries

(often exhibiting high leverage and maturity mismatches) and (iii) the high degree of interconnectedness of wholesale financial activities. The combination of the above market imperfections with the three features of financial systems paves the way for powerful feedback mechanisms, amplification and non-linearities. Research supporting macro-prudential supervision needs to capture situations of “true” instability by explicitly modelling these features and imperfections and how they may lead to *strong* systemic events.

The survey of research can be structured according to the three forms of systemic risk described above.

THEORETICAL RESEARCH

CONTAGION

Academic research has produced a wealth of papers on contagion phenomena. Most of this literature deals with contagion among banks, within large-value payment systems and among major financial markets.⁴

It is well known that banks which are not covered by deposit insurance schemes are prone to runs of retail depositors. These runs can be contagious if depositors are imperfectly informed and update their beliefs about the health of their own bank on the basis of on runs they observe on other banks.⁵ The introduction of a well-designed deposit insurance scheme, as present in most industrialised countries today, would shut this channel down. This is probably

³ This description of systemic risk is very similar to the definition of financial stability used in this FSR (see the Preface). The two are mirror images; the former describes the risk of widespread instability, whereas the latter describes stability.

⁴ In this special feature only bank and payment system contagion will be covered. For an overview of financial market contagion research, see ECB, “Financial market contagion”, *Financial Stability Review*, December 2005. For a survey of the macroeconomic currency contagion literature, which is mainly relevant for fixed exchange rate regimes, see de Bandt and Hartmann (2000), op. cit.

⁵ Y. Chen, “Banking panics: The role of the first-come, first-served rule and information externalities”, *Journal of Political Economy*, 1999.

the reason why this was not a major transmission channel in the present crisis.⁶

By contrast, interbank markets have been a primary locus of systemic risk in the present crisis. The research literature has pointed to the dangers of unsecured interbank markets in times of instability since about the mid-1990s.⁷ One channel for contagion is through the physical exposures among banks in these markets. If they tend to experience differential liquidity shocks (e.g. through depositor withdrawals or changes in asset valuations that differ across banks), they benefit from lending to each other rather than each of them holding more liquid assets *ex ante*. In certain severe realisations of liquidity needs, however, the overall amount of liquid assets in the system may not be sufficient to honour all interbank market contracts and contagious bank failures may occur.⁸ In other words, the benefits of sharing risk among banks come at the cost of contagion risk.⁹ This research also found that interbank lending structures that are more complete or diversified (many banks lend to each other) should be more stable than incomplete structures, where different banks lend to each other in chains or a few banks distribute liquidity to the other banks (money centre banks).

Subsequent research has applied network theory, where banks are the “nodes” and interbank loans the “arcs”, arguing that banks may sometimes be willing to provide liquidity assistance to each other in order to avoid the collapse of the whole network.¹⁰ If there is moral hazard in banks and interbank linkages are endogenous, then interbank contagion must be a rare phenomenon since banks would otherwise not lend to each other. Contrary to previous research, however, in such an environment the contagion risk seems to be larger when lending structures are more complete.¹¹

Another channel for interbank contagion emerges through information problems, notably asymmetric information leading to adverse selection phenomena.¹² In fact, it has been observed that adverse selection (the inability of banks to distinguish between good and bad assets or counterparties leading them to stop lending

and hoard liquidity) rendered money markets dysfunctional and thereby constituted a powerful channel for the transmission of the present crisis.¹³ For example, if it becomes known that there is a significant portion of impaired assets and banks are privately informed about the risk of their own assets, then the resulting increase of interbank rates drives out safer banks that need to borrow liquidity. Rates will increase further since only an adverse selection of riskier banks continues to borrow. This in turn may motivate banks with a liquidity surplus to stop lending to these borrowers and instead hoard liquidity, causing the market to break down.¹⁴

6 Where deposit insurance is partial, bank runs can still happen, as the Northern Rock case illustrates.

7 J.C. Rochet and J. Tirole, “Interbank lending and systemic risk”, *Journal of Money, Credit and Banking*, 1996.

8 F. Allen and D. Gale, “Financial contagion”, *Journal of Political Economy*, 2000; and X. Freixas, L. Parigi and J.C. Rochet, “Systemic risk, interbank relations and liquidity provision by the central bank”, *Journal of Money, Credit and Banking*, 2000.

9 There is another trade-off in such short-term wholesale funding markets related to incentives (R. Huang and L. Ratnovski, “The dark side of bank wholesale funding”, *Federal Reserve Bank of Philadelphia Working Paper*, No 09-3, September 2008). On the one hand, the possibility that short-term financiers deny to roll over debt should impose discipline on the investment behaviour of borrowers. On the other hand, when assets are arm’s length, evaluated by intermediaries (e.g. credit rating agencies providing frequent public signals) and supposedly tradable (reducing liquidation costs), the incentives for wholesale financiers to collect costly information decline and the discipline vanishes. If a noisy public signal suggests a problem under these circumstances, then wholesale financiers may abruptly withdraw their funding.

10 Y. Leitner, “Financial networks: Contagion, commitment, and private sector bailouts”, *Journal of Finance*, 2005.

11 S. Brusco and F. Castiglionesi, “Liquidity coinsurance, moral hazard and financial contagion”, *Journal of Finance*, 2007.

12 M. Flannery, “Financial crises, payment system problems and discount window lending”, *Journal of Money, Credit and Banking*, 1996.

13 R. Ferguson, P. Hartmann, F. Panetta and R. Portes, “International financial stability”, *Geneva Report on the World Economy*, No 9, November 2007; N. Cassola, M. Drehmann, P. Hartmann, M. Lo Duca and M. Scheicher, “A research perspective on the propagation of the credit market turmoil”, *ECB Research Bulletin*, No 7, ECB, June 2008.

14 F. Heider, M. Hoerova and C. Holthausen, “Liquidity hoarding and interbank market spreads: The role of counterparty risk”, *ECB Working Paper Series*, forthcoming. This mechanism combines an aggregate shock (see next sub-section), the worsening of credit conditions leading to higher rates, with contagion since risky banks impose an externality on safe banks that may prevent the latter from borrowing the liquidity they need. For contagion through adverse selection more generally, see S. Morris and H. Shin, “Contagious adverse selection”, mimeo, Princeton University, May 2009 (available at: <http://www.princeton.edu/~hsshin/www/ContagiousAdverseSelection.pdf>).

Contagion can also happen in large-value payment systems. The literature has very much focused on trade-offs between risk and efficiency, comparing different ways in which the settlement process can be organised in these systems. Pure gross systems, in which each payment is settled independently in real time, would not be subject to contagion risk, but they tend to be costly for banks, which have to hold a lot of liquid funds that cannot be invested. Pure net settlement systems can be subject to extensive systemic risk, because the netting of different payments against each other and infrequent settlements can lead to an accumulation of exposures.¹⁵ Gross settlement systems, however, can be subject to “gridlock” and costly payment delays. When the opportunity costs of liquidity in terms of foregone interest are high, or when banks have doubts about the solvency of their counterparties, they may choose not to make pay-ins. In an extreme case, a system may grind to a halt.¹⁶

Most real-world systems are therefore hybrid and have risk management features that try to balance efficiency and risk. For example, real-time gross settlement systems allow for intraday overdrafts that are either collateralised or priced. Alternatively, netting systems have caps and collateral requirements, and settle in frequent cycles. In fact, in the present crisis, payment and settlement system problems did not play a significant role. The main issues with respect to market infrastructures emerged in the clearing and settlement of over-the-counter (OTC) derivatives, which is, however, a relatively new research field.¹⁷

The recent research literature has put a great deal of emphasis on liquidity problems and endogenously emerging risks. For example, the specific knowledge that banks possess about their borrowers makes bank loans particularly illiquid. When a bank fails, this knowledge is destroyed, the common pool of liquidity shrinks and the resulting shortage may cause other banks to fail.¹⁸ As the number of bank failures increases, the value of such illiquid bank assets

goes down (“cash-in-the-market pricing”), worsening the problems in the banking system.¹⁹

Endogenously emerging risks and liquidity problems are made worse by contagious “fire sales” of assets in stress situations. For example, when a variety of financial intermediaries (not only banks) hold similar asset portfolios, problems in some may force them to sell illiquid assets. This will put downward pressure on asset values, causing losses in other intermediaries, forcing them, in turn, to sell illiquid assets.²⁰ Moreover, dangerous downward spirals of asset prices and quantities can emerge through adverse interactions between market liquidity (ease of trading) and funding liquidity (availability of financing).²¹ Traders providing liquidity to markets may fund their activities through collateralised borrowing. When there is an adverse shock to asset prices, financiers will increase margin requirements, making funding more difficult and constraining traders’ ability to provide market liquidity. The reduced market liquidity, in turn, leads to further asset price declines and more expensive funding. Such vicious downward spirals in liquidity played a significant role in the present crisis.

15 X. Freixas and B. Parigi, “Contagion and efficiency in gross and net interbank payment systems”, *Journal of Financial Intermediation*, 1998.

16 C. Kahn, J. McAndrews and W. Roberds, “Settlement risk under gross and net settlement”, *Journal of Money, Credit and Banking*, 2003.

17 D. Duffie and X. Zhu, “Does a central clearing counterparty reduce counterparty risk?”, *Rock Center for Corporate Governance at Stanford University Working Paper*, No 46, May 2009.

18 D. Diamond and R. Rajan, “Liquidity shortages and banking crises”, *Journal of Finance*, 2005.

19 V. Acharya and T. Yorulmazer, “Cash-in-the-market pricing and optimal resolution of bank failures”, *Review of Financial Studies*, 2008.

20 R. Cifuentes, H. Shin and V. Ferrucci, “Liquidity risk and contagion”, *Journal of the European Economic Association*, 2005.

21 M. Brunnermeier and L. Pedersen, “Market liquidity and funding liquidity”, *Review of Financial Studies*, 2008. The mechanism is not only relevant for contagion, but also amplifies the procyclicality of financial systems (the third form of systemic risk surveyed below).

MACROECONOMIC SHOCKS

Many financial crises in history have been associated with macroeconomic downturns. Banks are vulnerable to them because credit risk materialises on their asset side, whereas their liabilities (deposits) remain unaffected. If also liabilities were to be contingent on the state of the macroeconomy and therefore depositors would share the burden of asset losses, then banks' vulnerability to macro shocks may be attenuated.²² Macro shocks and contagion can also interact, because banks that are weakened by an aggregate shock are more vulnerable to contagion.²³

Other aggregate shocks that can bring down a larger number of intermediaries at the same time include widespread crashes of, or the evaporation of liquidity in, major financial markets.

UNWINDING OF IMBALANCES

History suggests that systemic financial crises can also emerge through the endogenous build-up and unravelling of widespread imbalances.²⁴ Financial behaviour tends to be pro-cyclical in that, in good times, consumption and/or (financial or real) investment increase, generating income which fuels the financing of more consumption and/or investment, with increasing risks being neglected. Even small (exogenous or endogenous) events can then lead to a repricing of risk and an end of the credit boom, which then unravels, adversely affecting many intermediaries and/or markets at the same time.

The research literature has highlighted at least four reasons why widespread imbalances can build up over time, making financial systems systemically vulnerable. First, there are strong incentives for herd behaviour in financial markets, which leads intermediaries or other agents to invest in similar risks. If relative returns of different investments are highly uncertain, then investors may infer the most promising opportunities from the behaviour of other investors. Such information externalities can lead to rational herding waves.²⁵ Moreover, investment managers and loan officers may

mimic others when their own evaluation, pay or reputation depends on their performance relative to the rest of the market.²⁶

Second, low interest rates across the maturity spectrum may encourage risk-taking, and some observers argue that this was a factor in the build-up to the present crisis. For example, as interest rates go down, incentives for banks to screen borrowers diminish.²⁷ Alternatively, low rates increase collateral values, such as real estate prices.²⁸

Generally, collateral enhances the borrowing capacity in the economy and may therefore contribute to leverage cycles. When an industry benefits from a positive shock, the enhanced financing of investment bids up collateral values, which in turn allows more borrowing and investment. Moreover, other industries that possess similar collateral also benefit from the collateral price increases, borrow more, invest more and thereby "widen" the leverage cycle.²⁹ Further amplification may emerge from softening and tightening of lending standards over the cycle due to changing investor sentiment or moral hazard.³⁰

22 M. Hellwig, "Liquidity provision, banking, and the allocation of interest rate risk", *European Economic Review*, 1994.

23 Y. Chen (1999), op. cit.

24 H. Minsky, "A theory of systemic fragility", in E. Altman and A. Sametz, *Financial Crises: Institutions and Markets in a Fragile Environment*, Wiley, 1977; and C. Kindleberger, *Manias, Crashes and Panics: A History of Financial Crises*, Macmillan, 1978.

25 A. Banerjee, "A simple model of herd behaviour", *Quarterly Journal of Economics*, 1992; S. Bikhchandani, D. Hirshleifer and I. Welch, "A theory of fads, fashions, customs and cultural changes in informational cascades", *Journal of Political Economy*, 1992.

26 D. Scharfstein and J. Stein, "Herd behaviour and investment", *American Economic Review*, 1990.

27 G. Dell'Arricia and R. Marquez, "Lending booms and lending standards", *Journal of Finance*, 2006.

28 For further theoretical discussion, see Chapter 9 on "Bubbles and crises" in F. Allen and D. Gale, *Understanding Financial Crises*, Oxford University Press, 2007.

29 N. Kiyotaki and J. Moore, "Balance sheet contagion", *American Economic Review*, 2002.

30 A. Fostel and J. Geanakoplos, "Leverage cycles and the anxious economy", *American Economic Review*, 2008; A. Shleifer and R. Vishny, "Unstable banking", *Journal of Financial Economics*, forthcoming; and M. Ruckes, "Bank competition and credit standards", *Review of Financial Studies*, 2004.

Fourth, the theoretical literature argues that financial safety net provisions can lead to moral hazard and greater risk-taking. For example, risk-insensitive deposit insurance lowers depositors' incentives to monitor bank risks.³¹ Moreover, the riskier the bank the higher the value of the insurance.³² Similar effects could emerge from public bailouts and "lending of last resort", but some positive level of moral hazard may also be necessary to contain systemic risk.³³ Since monetary policy cannot discriminate across agents and since agents may anticipate emergency reductions of interest rates in a crisis, different agents may choose similar illiquid and risky investments.³⁴

EMPIRICAL RESEARCH

CONTAGION

The early literature has tried to capture contagion risk with event studies of the effects of bank failures on the stock prices of other banks, mainly using data for the United States. For a number of medium to large failures, some nationwide effects could be identified, whereas in other cases the effects remained within the same region.³⁵ In broader US studies, the "bad news" events are loan-loss reserve, dividend reduction or regulatory enforcement announcements. Results on contagion effects are mixed, depending on the type of banks considered.³⁶ Sometimes even competitive effects (or "flight to quality") can emerge, in which some banks in the same region benefit from the problems of others. A series of other papers, however, argues that adverse stock market reactions were more related to similar exposures across the banks considered (for example to the Latin American debt crisis) rather than pure contagion.³⁷ In other words, it is sometimes hard to empirically distinguish contagion from aggregate shocks or unravelling of imbalances.

Since regular stock price reactions may be relatively remote from strong systemic events, more recent research has focused on particularly large stock price reactions. Extreme-value theory is specifically designed for such "crashes" and permits multivariate extreme

spillover risk among large and complex banks to be estimated.³⁸ Between the early 1990s and the early 2000s this measure of systemic risk was larger in the United States than in the euro area. Moreover, it has increased substantially in the United States, and only mildly in Europe over the same period. Using a multinomial logit model for less extreme bank stock measures, one finds that cross-border contagion risk among some major European countries was significant and increased over a similar period of time.³⁹

- 31 A. Boot and A. Thakor, "Bank regulation, reputation and rents: Theory and policy", in C. Mayer and X. Vives (eds.), *Capital Markets and Financial Intermediation*, Cambridge University Press, 1993.
- 32 R. Merton, "An analytical derivation of the cost of deposit insurance and loan guarantees: An application of modern option pricing theory", *Journal of Banking and Finance*, 1976.
- 33 C. Goodhart and H. Huang, "The lender of last resort", *Journal of Banking and Finance*, 2005.
- 34 E. Farhi and J. Tirole, "Collective moral hazard, maturity mismatch and systemic bailouts", *NBER Working Paper*, No 15138, National Bureau of Economic Research, July 2009.
- 35 J. Aharony and V. Swary, "Contagion effects of bank failures: Evidence from capital markets", *Journal of Business*, 1983; V. Swary, "Stock market reaction to regulatory action in the Continental Illinois Crisis", *Journal of Business*, 1986; J. Peavy and G. Hempel, "The Penn Square bank failure: Effect on commercial bank security returns – a note", *Journal of Banking and Finance*, 1988.
- 36 D. Docking, M. Hirschey and V. Jones, "Information and contagion effects of bank loan-loss reserve announcements", *Journal of Financial Economics*, 1997; and M. Slovin, M. Sushka and J. Polonchek, "An analysis of contagion and competitive effects at commercial banks", *Journal of Financial Economics*, 1999. Similarly mixed results were found in studies using debt rather than stock prices (E. Cooperman, W. Lee and G. Wolfe, "The 1985 Ohio thrift crisis, the FSLIC's solvency, and rate contagion for retail CDs", *Journal of Finance*, 1992).
- 37 M. Smirlock and H. Kaufold, "Bank foreign lending, mandatory disclosure rules, and the reaction of bank stock prices to the Mexican debt crisis", *Journal of Business*, 1987; J. Musumeci and J. Sinkey, "The international debt crisis, investor contagion, and bank security returns in 1987: The Brazilian experience", *Journal of Money, Credit and Banking*, 1990; L. Wall and D. Peterson, "The effect of Continental Illinois' failure on the financial performance of other banks", *Journal of Monetary Economics*, 1990; I. Karafiath, R. Mynatt and K. Smith, "The Brazilian default announcement and the contagion hypothesis", *Journal of Banking and Finance*, 1991; and B. Kho, D. Lee and R. Stulz, "US banks, crises and bailouts: From Mexico to LTCM", *American Economic Review*, 2000.
- 38 P. Hartmann, S. Straetmans and C. de Vries, "Banking system stability: A cross-Atlantic perspective", *NBER Working Paper*, No 11698, National Bureau of Economic Research, October 2005.
- 39 R. Gropp, M. Lo Duca and J. Vesala, "Cross-border contagion risk in Europe", in H. Shin and R. Gropp (eds.), *Banking, Development and Structural Change*, Special Issue of the International Journal of Central Banking, 2009.

Market-based data such as stock prices may be distorted by mispricing. This is one reason why another branch of recent research uses balance-sheet data (in particular interbank exposures and capital) to assess contagion risk with counterfactual simulations. One or several banks are assumed to fail and it is derived how many other banks would fail as a consequence. For some countries, simulated contagion risk is rather limited.⁴⁰ For other countries, the results suggest more significant contagion risk.⁴¹ Generally, however, the results are very sensitive to assumptions about how much money is recovered from the assets of failing banks. In a number of cases, evidence is found that cross-border contagion risks in Europe are increasing. Since these simulations ignore endogenously emerging risks and feedback effects, they may, however, also exhibit biases.

Related contagion simulations, using actual payment data or Monte Carlo analysis, have also been undertaken for large-value payment systems. Early research suggested significant systemic risk in net settlement systems.⁴² More recent research, however, seems to indicate that much improved risk management in different types of large-value payment systems contains systemic risk.⁴³ Accordingly, in the present crisis, payment system problems did not play any particular role.

Yet another approach tries to identify bank contagion effects by analysing deposit flows, in particular when there is no deposit insurance. Research on various episodes during the Great Depression in the United States finds that “bad news” about some banks led depositors on some occasions to withdraw their deposits from other banks and on other occasions to deposit their money in other banks (“flight to quality”).⁴⁴ Sometimes withdrawals from surviving banks were similar to withdrawals from failing banks, suggesting in some cases contagious behaviour from uninformed depositors, and in other cases not.⁴⁵ For a large Indian bank failure in 2001, it has been documented that retail deposit withdrawals at other banks were larger when

those banks had interbank market exposures to the initially failing bank.⁴⁶

Banking crises during the Great Depression were also examined using a duration model, where the survival time of US banks is explained with micro and macro variables.⁴⁷ After controlling for these variables, survival times remain related at the regional level, which is consistent with regional contagion effects. Finally, the free banking era in the United States (1837 to 1863) was studied, analysing whether bank failure rates were autocorrelated after controlling for macroeconomic fundamentals. Depending on the crisis considered during this period, clustering of failures was sometimes found and sometimes not found, which is consistent with occasional episodes of bank contagion.⁴⁸

40 See C. Furfine, “Interbank exposures: Quantifying the risk of contagion”, *Journal of Money, Credit and Banking*, 2003, for the United States; H. Elsinger, A. Lehar and M. Summer, “Risk assessment for banking systems”, *Management Science*, 2006, for Austria; H. Degryse and G. Nguyen, “Interbank exposures: An empirical examination of contagion risk in the Belgian banking system”, *International Journal of Central Banking*, 2007, for Belgium; and P. Mistrulli, “Assessing financial contagion in the interbank market: Maximum entropy versus observed interbank linkages”, *Banca d’Italia Temi di Discussione*, No 641, September 2007, for Italy.

41 See C. Upper and A. Worms, “Estimating bilateral exposures in the German interbank market: Is there a danger of contagion?”, *European Economic Review*, 2004, for Germany; and I. van Lelyveld and F. Liedorp, “Interbank contagion in the Dutch banking sector”, *International Journal of Central Banking*, 2006, for the Netherlands.

42 See D. Humphrey, “Payments finality and risk of settlement failure”, in A. Saunders and L. White (eds.), *Technology and the Regulation of Financial Markets: Securities, Futures, and Banking*, Lexington Books, 1986, for US CHIPS.

43 M. Bech, L. Nartop and J. Marquardt, “Systemic risk and the Danish interbank netting system”, *Danmarks National Bank Working Paper*, No 8, 2002; P. Galos and K. Soramäki, “Systemic risk in alternative payment system designs”, *ECB Working Paper Series*, No 508, ECB, July 2005.

44 A. Saunders and B. Wilson, “Contagious bank runs: Evidence from the 1929-33 period”, *Journal of Financial Intermediation*, 1996.

45 C. Calomiris and J. Mason, “Fundamentals, panics and bank distress during the Depression”, *American Economic Review*, 2003; and C. Calomiris and J. Mason, “Contagion and bank failures during the Great Depression: The June 1932 Chicago bank panic”, *American Economic Review*, 1997.

46 R. Iyer and J. Peydró, “Interbank contagion at work: Evidence from a natural experiment”, *Review of Financial Studies*, forthcoming.

47 C. Calomiris and J. Mason (2003) op. cit.

48 I. Hasan and G. Dwyer, “Bank runs in the free banking period”, *Journal of Money, Credit and Banking*, 1994.

MACROECONOMIC SHOCKS

The role of economic downturns as a causal factor for systemic banking crises is well documented in the research literature. For example, most banking panics in the United States in the second half of the 19th and in the early 20th century could have been predicted with a standard business cycle forecasting model.⁴⁹ Also more recent studies of systemic banking crises or bank distress that introduce macroeconomic fundamentals (such as GDP growth, real interest rates or inflation) as explanatory variables typically find them to be significant, irrespective of the episodes or countries considered.⁵⁰

Extreme-value theory can be used to derive so-called tail-betas for banks. They reflect extreme systematic risk, measuring how extreme crashes in the market factor influence the likelihood of extreme crashes in individual bank stocks. Recent research suggests that such extreme systematic risk is a relevant form of systemic risk, which increased along similar lines in the euro area and the United States between the early 1990s and early 2000s.⁵¹

UNWINDING OF IMBALANCES

How the pro-cyclicality of financial systems contributes to the occurrence of systemic crises has not been tested econometrically to any significant extent. An exception is a large cross-country panel study of lending booms between 1960 and 1996, which finds that the probability of banking crises right after lending boom periods is higher than during tranquil periods.⁵²

One important element of pro-cyclicality is how lending standards evolve over the cycle. Recent research suggests that lending standards in US mortgage markets declined in the run-up to the present crisis. Moreover, lending standards declined by more in regions with larger mortgage credit booms, larger housing price booms and higher mortgage securitisation rates.⁵³

The role that monetary policy can inadvertently play in pro-cyclicality through its impact on financial risk-taking has been documented in recent empirical research. While reductions

in interest rates first have a positive effect on the net present value of loans, as loan rates decrease and remain low for a longer period of time banks tend to move into riskier loans to re-establish profitability.⁵⁴ The risks that build up materialise particularly strongly when rates rise fast thereafter.

Finally, although financial regulation is designed to stabilise financial systems, it may still contain pro-cyclical components. A variety of recent simulation studies, for example, have found that moving from the Basel I to the Basel II capital adequacy rules could enhance the contribution of regulatory capital to pro-cyclicality.⁵⁵

49 G. Gorton, "Banking panics and business cycles", *Oxford Economic Papers*, 1988.

50 A. Demirgüç-Kunt and E. Detragiache, "The determinants of banking crises in developing and developed countries", *IMF Staff Papers*, 1998; and B. Gonzalez-Hermosillo, "Determinants of ex-ante banking system distress: A macro-micro exploration of some recent episodes", *IMF Working Paper*, No WP/99/33, 1999.

51 P. Hartmann et al. (2005), op. cit.; S. Straetmans, W. Verschoor and C. Wolff, "Extreme US stock market fluctuations in the wake of 9/11", *Journal of Applied Econometrics*, 2008. European banks with greater non-interest generating activities tend to be more vulnerable to this extreme systematic risk (O. de Jonghe, "Back to the basics in banking? A micro-analysis of banking system stability", *Journal of Financial Intermediation*, forthcoming).

52 P.-O. Gourinchas, R. Valdes and O. Landerretche, "Lending booms: Latin America and the world", *Economia*, 2001. W. Hunter, G. Kaufman and M. Pomerleano (eds.), *Asset Price Bubbles: The Implications for Monetary, Regulatory, and International Policies*, MIT Press, 2003, contains many articles discussing theoretical and empirical analyses, historical episodes and policy issues. Special Feature D in this Review discusses tools to detect asset price misalignments.

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54 G. Jimenez, S. Ongena, J. Peydró and J. Saurina, "Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking?", *CEPR Discussion Paper*, No 6514, 2007; V. Ioannidou, S. Ongena and J. Peydró, "Monetary policy, risk-taking and pricing: Evidence from a natural experiment", *Center Discussion Paper Series*, No 31S, 2009; and Y. Altunbas, L. Gambacorta and D. Marques-Ibanez, "An econometric assessment of the risk-taking channel", paper presented at the BIS/ECB conference on "Monetary Policy and Financial Stability", Basel, September 2009 (available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1459627).

55 Special Feature C, entitled "The pro-cyclical effects of Basel II: A selected review of the literature", in this FSR discusses pro-cyclical effects of the Basel II capital standards and provides a selective overview of the literature.

In fact, there seems to be a trade-off between micro efficiency and macro stability. The more granular the regulatory risk weights, the more pronounced the pro-cyclical effect of regulation.

CONCLUDING REMARKS

The need to strengthen macro-prudential financial supervision in Europe and worldwide requires a deep understanding of systemic risk. Given the high mobility of financial activities in present times, the analysis of systemic risk should cover all components of financial systems and consider exogenous and endogenous sources of risk, including feedback effects and non-linearities. Moreover, the effects of financial innovation on the structure and risks of financial systems need to be incorporated in relevant models. The analysis also needs to include the two-sided relationship between financial systems and the economy at large.

Academic research has made good progress in enhancing the understanding of systemic risk over the last two decades both from a theoretical and from an empirical perspective. For example, important elements of the present crisis have been analysed in the literature, some before the crisis broke out. But significant open issues remain. For example, it remains a challenge to clearly distinguish different forms of systemic risk in empirical research. Further research efforts could also be particularly valuable in the following areas. First, researchers need to develop broad modelling frameworks that cover the most important aspects of systemic risk and are widely accepted in the profession. For example, existing macroeconomic models do not at present feature relevant aspects of financial instability.⁵⁶ Second, academic research should pay further attention to the sources of the build-up of widespread imbalances and their endogenous unravelling. For example, the benefits and costs of major financial innovations need to be better understood and documented. Third, the systemic importance of some non-bank financial intermediaries, and of different bank business models, needs to be

studied.⁵⁷ Fourth, the benefits and costs of over-the-counter versus on-exchange trading, as well as the role of central clearing counterparties, particularly for derivatives, deserve greater attention in macro-prudential research.

Research advances in these directions, in particular when combined with market experience and current policy analysis, will be of great help in further developing macro-prudential supervision and in supporting the bodies that are currently being set up in Europe and elsewhere.⁵⁸

⁵⁶ General equilibrium models with default are an important step in the right direction (see C. Goodhart, P. Sunirand and D. Tsomocos, "A risk model for banks", *Annals of Finance*, 2005; and C. Goodhart, P. Sunirand and D. Tsomocos, "A model of financial fragility", *Economic Theory*, 2006).

⁵⁷ Special Feature E, entitled "The importance of insurance companies for financial stability", in this Review discusses the importance of insurance companies for financial stability.

⁵⁸ Special Feature A, entitled "Towards the European Systemic Risk Board", in this Review describes the establishment of the European Systemic Risk Board.