Approaches to the measurement and macroprudential treatment of systemic risk

Effective macroprudential oversight is only possible if systemic risk is properly understood and measured. Analysis is based on a broad range of approaches in order, if possible, to cover all important aspects of systemic risk. Macroprudential surveillance also requires a transparent and coherent set of instruments, which needs to be improved constantly through advances in measuring and analysing systemic risk. Many of these instruments originally constituted microprudential measures used to accomplish macroprudential objectives. Developing the necessary concepts and methodology, is, however, still in its infancy. The primary aim at present is therefore to further enhance the resilience of the financial system by creating a suitable set of macroprudential rules. Overall, supervisory agencies the world over currently face two challenges simultaneously: to make available the proper analytical tools and to establish an effective macroprudential framework and set of rules, including any necessary macroprudential intervention instruments. The Bundesbank is helping accomplish both objectives; first, by developing its own analytical methodology and, second, by participating in the relevant international bodies.

The present article begins by introducing some of the broad range of existing methodologies developed to measure systemic risk. The models presented mainly cover contagion effects in the banking system, which are the decisive factor in the endogenous momentum of financial crises. With regard to the need for better regulation, the article also illustrates ways of dealing appropriately with the systemic relevance of individual financial institutions. It is key here that incentives for financial institutions be created according to market-economy principles and in such a way that institutions, in their decision-making, take due account of the implications of their actions for systemic stability.

Overview

Interconnectedness in the financial system a major factor in current crisis

Financial crises follow typical patterns. Like others before it, the latest financial crisis was caused primarily by the bursting of an asset price bubble. Initially, the turbulence caused by the US subprime mortgage market appeared to be severe yet manageable overall. It was only a cascade of events which began in the summer of 2008 and featured massive disruptions to the functioning of the money markets, the insolvency of the US investment bank Lehman Brothers and the near-collapse of US insurance group AIG that caused the market turmoil to rapidly develop into a global financial crisis. The speed and momentousness of these developments set the current financial crisis apart from previous crises. One of the main factors in this was the high degree of global interconnectedness within the financial system.

Holistic view of financial system necessary

The new dimension of systemic risk caught both financial institutions and supervisory authorities unawares. The prevailing paradigm had been that a financial system was considered stable if individual actors had taken sufficient provisions to prevent their own default, out of self-interest, or as a result of disciplining market pressure or prudential rules. As was impressively demonstrated by the recent financial crisis, this view of financial stability, which is geared towards individual institutions, obviously does not go far enough. A broader view looks at the financial sector as a system of interdependent agents which is centred not on the solvency of individual intermediaries but on the proper functioning and performance of the system as a whole.[1] Microprudential supervision is supplemented by a closely related, but at core independent, macroprudential dimension. In the meantime, supervisory authorities around the world are conducting intensive work on eliminating existing gaps in the supervisory framework.[2] Creating a new supervisory architecture is designed to detect and combat systemic risk at an early stage.[3]

Systemic risk difficult to measure

Systemic risk has both a cross-sectional dimension, such as contagion effects between markets and financial intermediaries, which will be discussed in greater depth in this article, and a time dimension, as is reflected, for instance, in financial market actors' cyclical behaviour.[4] Everything centres on participants' interconnectedness and the resulting

1 The Bundesbank defines financial stability as the ability of the financial system to smoothly fulfil its key economic functions – in particular, the efficient allocation of financial resources and risks along with the provision of a well functioning financial infrastructure – at all times, including in stress situations and periods of structural upheaval. See Deutsche Bundesbank, Financial Stability Review 2010, p 7.
2 At the international level, work in the Financial Stability Board (FSB) and the Basel Committee on Banking Supervision (BCBS), amongst others, is currently strengthening inter-agency coordination and driving the development and implementation of effective regulatory and supervisory standards.
3 At the European level, a new financial supervisory system, the European System of Financial Supervisors (ESFS), has been created. Its members include the European Supervisory Authorities (ESAs) and the European Systemic Risk Board (ESRB), which is tasked with identifying and averting systemic risk in the EU. The ESRB has two policy instruments at its disposal: risk warnings and recommendations, which can be addressed to the EU, individual member states or groups thereof, as well as European or national supervisory authorities.
4 For a discussion of a specific example, see Deutsche Bundesbank, Financial Stability Review 2010, p 117.

contagion and domino effects.[5] One reason these risks played a fairly minor role in regulation and supervision in the past lies in the difficulty in reliably quantifying them. Neither a micro analysis of individual institutions nor a macro view, which looks at the aggregate, is capable of adequately capturing the complex network of financial market agents and financial relationships. In the final analysis, the quality and efficiency of surveillance and subsequent measures hinge on reliably identifying systemic risk and gauging its impact on financial stability. It is therefore decisive that more work be done on developing models to capture and quantify these risks.

Models to measure systemic risk under construction

Some of the models that the Bundesbank employs to monitor endogenous systemic risk will be introduced below.[6] These models shall serve to exemplify what such models can achieve, but also to illustrate the specific difficulties in identifying and measuring systemic risk. These approaches should be understood as a set of analytic instruments which each look at part of the whole complex of systemic risk, thereby making an important contribution to the development and calibration of macroprudential instruments. In the second part of this article, the example of systemically important financial institutions (SIFIs) will be used to show ways of dealing with systemic risk.

Measuring systemic risk

Direct contagion channels

A variety of features render the financial sector especially vulnerable to contagion risk. Through a large number of credit relationships, financial market agents are interconnected and thus mutually interdependent. For instance, banks obtain short-term funding on the interbank market and also have ties in the market for medium to long-term funding. If one institution becomes insolvent, this therefore impacts directly on its creditors. If these creditors have to write down their loans, this can trigger a chain reaction of sorts, with additional banks experiencing distress; the crisis then spreads.

Indirect contagion channels

That, however, is only the direct form of contagion through contractual relationships. In addition, there are also indirect contagion channels which can, precisely in crisis situations, come into play and thus become dangerous. One significant type of transmission mechanism involves “fire sales” of assets triggered by problems at individual institutions. These sales can cause a collapse of prices in certain market segments, indirectly leading other financial institutions with exposures to these markets to adjust their valuations. Under normal circumstances, an adjustment mechanism would set in, since investors would have an increased interest in buying undervalued assets; however, in a crisis, with potential buyers sustaining losses of their own, this does not take place. Maturity and liquidity transformation are decisive risk drivers in this context. Long-term illiquid

5 In the real world, endogenous and exogenous risks often overshadow one another. Contagion effects may often be preceded by an exogenous shock, such as a deterioration in macroeconomic conditions not originating in the financial system, or, theoretically, by a terrorist attack or natural disaster. Endogenous risks then hit a financial system that has already been weakened.
6 For an overview of the Bundesbank’s analytical instruments see Deutsche Bundesbank, Financial Stability Review 2010, p 50 ff.

assets are financed by relatively short-term borrowing. At the same time, the non-transparency of illiquid financial products often contributes to markets drying up. In the case of information-driven transmission channels, investors withdraw funds from institutions merely on the basis of market speculation, especially if there are any parallels with distressed institutions (because of similar business models, investments etc). Here, too, the impact depends decisively on the extent of maturity transformation and information asymmetry.

Contagion channels difficult to isolate

In the real world, the various contagion channels are difficult to isolate. This is also reflected in the variety of approaches to measuring endogenous systemic risk, which each emphasise different aspects. Network models and statistical interdependence models are used to analyse contagion channels.[7] Another category of model is designed to quantify individual financial agents' contribution to systemic risk.

Network model for the interbank market

Degree of interconnectedness and loss given default determine contagion effects

Network models, for many central banks now a standard instrument for analysing the interbank market, simulate direct contagion effects between agents. The interbank market can be seen as a network, in which the banks represent the hubs and bilateral lending relationships the spokes.[8] There are direct relationships between two banks as well as indirect connections across several hubs (banks). The structure of such a network, which can be described mathematically, plays a major role in determining to what extent defaults can propagate themselves in the system through a chain reaction. The level of banks' capital and the loss given default are key determinants of the momentum of the chain reaction. Various data are used to quantify the structure of the network. Information on capital adequacy and bilateral exposure volumes can generally be obtained from prudential reporting data. By contrast, loss given default must be estimated from balance sheet data. A model used by the Bundesbank extends the existing network approaches in one key point: loss given default is not assumed to be constant but instead modelled as a random variable.[9] This is because contagion risk can be considerably underestimated if, as is usually the case, loss given default is assumed to be constant (see box on page 42).

International network models needed

One major advantage of network models is that they explicitly model the transmission of shocks. This improves supervisors' ability to identify weaknesses in the financial system. However, network models also entail some severe disadvantages. One is that most models take insufficient or no account of changes in behaviour, such as portfolio shifts or limit adjustments. Here, it is not clear *a priori* whether such adjustment responses dampen or amplify the transmission of

7 For a detailed overview of new systemic risk models, see IMF (2009), Global Financial Stability Report April 2009, Responding to the Financial Crisis and Measuring Systemic Risks.
8 For a detailed overview of network models see C Upper (2007), Using counterfactual simulations to assess the danger of contagion in interbank markets, BIS Working Paper No 234.
9 The system analysed here consists of 15 major German banks with an international focus. See C Memmel, A Sachs and I Stein (2011), Contagion at the Interbank Market with Stochastic LGD, mimeo.

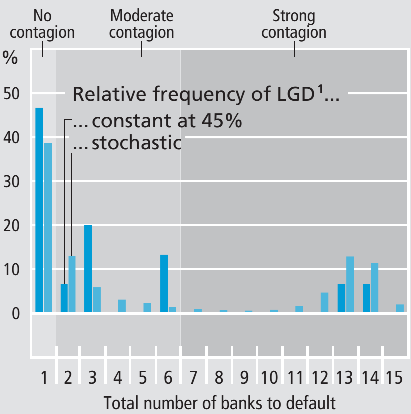
shocks. Another is that data constraints mean that only a cross-section of the global network can be modelled. The necessary data on connections to non-resident institutions are usually lacking. The Bundesbank therefore expressly supports international efforts to close existing data gaps.[10]

Modelling indirect contagion

Market co-movement as a reflection of systemic risk

Network models do not, as a rule, allow indirect contagion effects to be modelled. Moreover, since these models are based on balance sheet data and prudential reporting data, they are relatively "sticky" and less suited as a timely indicator for assessing the current stability situation. Statistical interdependence models seek to close this gap by using constantly available market prices to depict dependencies in the financial system. Statistical interdependence models differ methodologically from network models, in particular, in that they do not as such model cause-and-effect chains. They are based instead on statistical correlations.[11] At the core, statistical interdependence models measure how strongly financial institution A's (default) risk increases if another institution, B, becomes distressed. Thus, institution B's contribution to institution A's risk is measured. The corresponding risk metrics are usually taken directly from market data or derived from them (eg from CDS and bond premiums or probabilities of default derived from options or share prices). These are therefore market assessments of financial institutions' risk. The decisive question is whether the risk metrics "co-move". Co-movement indicates systemic risk.[12] Studies show that statistical dependencies change over time. This has implications for measuring contagion effects. Since dependencies shift when market turmoil occurs, it makes sense, when analysing contagion risk, to pay particular attention to observations made during periods of turmoil. Two main statistical methods have emerged: extreme value theory, in which the observation sample is *a priori* restricted to outliers, and quantile regression, which includes all observations but weights them differently.

Contagion effects in the interbank market caused by a distressed bank



1 The relative frequency of the "total number of banks to default" indicator derives from simulation runs for alternative assumptions of loss given default (LGD); in the simulations, with the default of one bank exogenously given, the total number of banks to default is calculated using the criterion of distress (tier 1 capital ratio < 6%) from 150,000 simulation runs; the analysis is based on 15 internationally active German banks.

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10 A joint FSB-IMF working group is currently developing proposals for closing data gaps among global SIFIs.
11 This constraint is irrelevant in practice, however, since the direction of contagion is generally obvious.
12 However, as discussed above, it is impossible to distinguish between the existence of common risk factors and the existence of contagion effects.

Modelling contagion effects in the interbank market

Analysis of contagion effects in the interbank market using a network model consists of several steps. First, the bilateral lending relationships need to be listed in as much detail as possible. For German credit institutions, relevant information is available in the credit register, which is operated by the Deutsche Bundesbank and in which all credit claims of German banks are recorded that exceed the €1.5 million reporting threshold. In this context, the term "claims" refers not only to classical loans but also includes securities, off-balance-sheet transactions and positions in financial derivatives. The individual banks' capital positions can be inferred from the regulatory reporting data. In a next step, the default of one or more institutions is assumed. The lending banks sustain losses which reduce their capital depending on the amount of the claim and the assumed loss given default (LGD). Creditor banks experience distress if their capital falls below the required minimum level. The chain reaction that ensues comes to a halt only if the capital of the remaining banks is sufficient to absorb the losses arising from defaulted exposures.

A key determinant of this process is the assumed LGD, which largely depends on the value of the collateral or of any guarantees furnished. However, because the LGD can only be approximated due to insufficient information, most empirical models used to analyse the interbank market assume constant LGDs in a simplified analysis.[1] By contrast, information available at the Bundesbank makes a more precise calibration possible. Write-downs in relation to the total of a bank's non-performing interbank loans serve as an approximation of the LGD. The model the Bundesbank uses goes one step further and models the LGD as a random variable. The variation of loss provision ratios (between institutions and over time) makes it possible to determine their empirical distribution and to approximate it using a density function. Approximation by way of a beta distribution has proven useful in this context.[2] Thus, a simulation run for contagion effects on the interbank market involves not only the – as before, exogenously – assumed default of an institution but also the realisation of an LGD. This means that a contagion channel is to be understood as the specific realisation of a random process. Information about the expected number of defaults can be derived by repeating simulation runs and forming mean values.

It can be seen that the assumption of stochastic LGDs has a decisive effect on the results. If, instead, a constant value such as the mean were assumed for the LGDs, the contagion risk would tend to be underestimated.

1 See C Upper (2007), Using counterfactual simulations to assess the danger of contagion in interbank markets, BIS Working Paper, No 234. — **2** See Deutsche Bundesbank, Financial Stability Review 2010, p 56.

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Contagion effects between financial intermediaries change in times of crisis

A Bundesbank study looks into the co-crash probabilities among various financial institutions.[13] The analysis is based on the observed CDS prices of the financial intermediaries in question, with the extreme values of these premiums of particular interest. In this context, the study looks at how a given institution's CDS premium reacts to extreme and adverse changes in other institutions' CDS premiums. In particular, the study determines the probability of a bank's CDS premium taking an extreme value if another observed bank's CDS premium is particularly high. One may also talk of conditional probabilities of default if high CDS premiums appear to indicate imminent default. Since observations of outliers are rare, methods from extreme value theory are used for the stable estimation of conditional probabilities of default.[14] In the analysis presented here, all conditional probabilities of default are calculated for over 200 financial intermediaries from 29 countries. Conditional probabilities of default changed considerably during the crisis years 2007-2010. This indicates that, during the crisis period, systemic importance – understood as rising probability of contagion – increased.

Regional contagion effects ...

Experience has shown that contagion effects occur not only between individual institutions but also between financial centres and across national borders. Regression models can be used to analyse these transmission channels. In the following, such a model will be used to demonstrate how regional shocks impact on the German financial system.[15] The median CDS premium serves as an indicator of the average default risk of the institutions in a given region. This indicator can also be calculated for sub-groups of financial institutions.

... from Europe, the USA and Asia-Pacific region captured

In order to expose potential differences within the German financial system, private banks, Landesbanken and insurance institutions are studied separately.[16] The paper examines contagion effects on the German financial sector from Europe (excluding Germany), the United States and the Asia-Pacific region.[17] The analysis contains a total of 148 financial institutions from 20 different countries. In the model, the median CDS premium of a region or group is "explained" by the median CDS premium of another region. The corresponding coefficient in the regression equation, which is estimated from the data, serves as an indicator of the extent of contagion. A high value corresponds to an increased danger of contagion. Breaking down the observation period into sub-intervals and estimating the coefficients separately enables the change in systemic risk over time to be shown.

Systemic risk rises in times of crisis

The results of this study show that contagion effects vary noticeably for the different groups of institutions. For banks, the Euro-

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13 See J Bosma, M Koetter and M Wedow (2011), A Credit Default Swap Measure of Bank Stability, mimeo.
14 The extreme value theory method is a non-parametric estimation procedure, which is not linked to certain assumptions regarding the underlying distribution, thereby ensuring a stable estimation of dependency structures.
15 See box on p 44 on the technical modelling of this approach and also N Podlich and M Wedow (2011), Spillovers between financial systems: a German perspective on systemic risk, mimeo.
16 The sample contains 19 private banks, 14 Landesbanken and 6 German insurers.
17 Europe: Portugal, Italy, Ireland, Greece, Spain, Switzerland, Sweden, Norway, the UK, Denmark, Iceland, France, Austria, Belgium and the Netherlands; Asia-Pacific: Singapore, Japan and Australia.

Contagion effects between financial systems – technical background of modelling

A model developed by the Bundesbank can be used to analyse the contagion effects that originate in Europe, the United States and the Asia-Pacific region on the German financial sector.[1] For this purpose, private credit institutions, Landesbanken and insurance companies are considered separately. The observation period runs from January 2005 until November 2010.[2] The median CDS premium of the institutions examined serves as an indicator of the general risk situation in the respective financial system. The median CDS premium of the German financial system is explained with the help of the median CDS premiums of other regions.

The estimation equations are specified using an ARMA-GARCH model with multiplicative heteroscedasticity. With this approach it is possible to model the (conditional) variance of the risk indicator in a time-variable manner; thus, extreme fluctuations of the risk indicator can be better taken into account.

$$\Delta Y_t^{DE} = \alpha_0 + \alpha_1 \Delta Y_{t-1}^{EU} + \alpha_2 \Delta Y_{t-1}^{USA} + \alpha_3 \Delta Y_{t-1}^{AP} + \beta' \Xi_t + \varepsilon_t \quad (1)$$

$$\delta_t^2 = exp(\theta_0 + \theta_1 X_{t-1}^{EU} + \theta_1 X_{t-1}^{USA} + \theta_1 X_{t-1}^{AP}) + \gamma_1 \varepsilon_{t-1}^2 + \lambda \delta_{t-1}^2 \quad (2)$$

$$\varepsilon_t = p_0 \varepsilon_{t-i} + \vartheta_0 \omega_t + \vartheta_1 \omega_{t-j} \quad with\ \omega \sim N(0,\ \sigma^2) \quad (3)$$

Here, Y_t is the median CDS premium, where the upper index denotes the region, ε_t the error term and δ_t^2 its variance.

Furthermore, the regression equations take into account general developments in the financial markets and the real economy ($\beta' \Xi_t$). The control variables are the iTraxx Non-Financials index, which is calculated from the 100 largest non-financial corporations, German DAX volatility (VDAX), the slope of the yield curve and the median yield of Federal bonds with a remaining maturity of 8 to 15 years. The non-stationarity of the variables necessitates modelling in differences (to be more precise, the differences in the logarithms).

Multiplicative heteroscedasticity is used to model the exogenous variables X^i of the variance equation.[3] To this end, ARMA-GARCH models are estimated for each of the three indices representing the three financial systems under consideration – Europe, the United States and the Asia-Pacific region. The squared residuals derived from these models are inserted into the variance equation (2).[4] The regression coefficients α_i act as an indicator of the degree of potential contagion. In order to analyse the change in contagion risk over time, the observation period is broken down into sub-intervals and the regression coefficients are estimated separately for each one. A rolling time window is used to obtain a continuous representation (see the chart on page 45).

1 Europe comprises Portugal, Italy, Ireland, Greece, Spain, Switzerland, Sweden, Norway, the United Kingdom, Denmark, Iceland, France, Austria, Belgium and the Netherlands; the Asia-Pacific region comprises Singapore, Japan and Australia. — **2** The sample includes 148 financial institutions from 20 countries. Source: Markit. — **3** See S Harvey (1976), Estimating Regression Models with Multiplicative Heteroscedasticity, Econometrica, Vol 44, No 3, p 461 ff. — **4** The specification of the models is examined by performing a Ljung-Box test (portmanteau test) and an LR test.

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pean market plays a much greater role relative to the US market than it does for insurers. One possible explanation is that insurance companies, especially reinsurers, hold globally more diversified investment portfolios. Again, systemic risk is seen to fluctuate considerably over time.

Indicators measure acute degree of danger

The above models only represent a small selection of the approaches to measuring contagion risk currently in use. The primary benefit of these models is their ability to assess the acute degree of danger. Since these models help to gauge the vulnerability of financial systems to systemic shocks, they can serve as starting points for macroprudential measures, provided they meet a certain standard of robustness. By contrast, they are less suited as early warning indicators, as they do not forecast systemic events.[18]

Modelling individual institutions' systemic importance

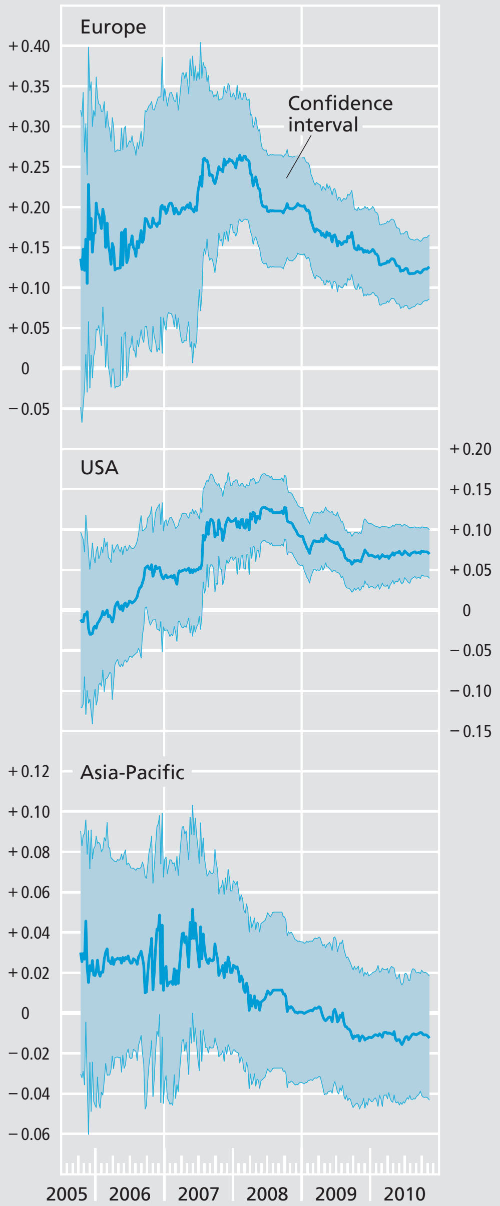
Individual financial institutions' contribution to systemic risk needs to be identified

An institution's systemic importance can cause negative externalities, amongst others if the market assumes that it enjoys an implicit government guarantee because it is considered "too systemic to fail". The basis for dealing with such institutions lies in identifying the degree of systemic importance, which can be regarded, for instance, as an individual institution's share of overall systemic risk. The literature contains initial approaches. Most proposals are based on an extension

18 See C Borio and M Drehmann (2008), Towards an operational framework for financial stability: 'fuzzy' measurement and its consequences, BIS Working Paper No 284.

Impact of regional contagion effects on the German financial system*

Weekly averages



Sources: Markit and Bundesbank calculations. — * Contagion effects from Europe, the USA and the Asia-Pacific region on the entire German financial system are studied throughout the observation period with the help of a rolling time window (200 days). A region's risk is measured using indices that are based on the CDS premiums of a regionally defined financial system. A 95% confidence level was assumed to calculate the confidence interval.

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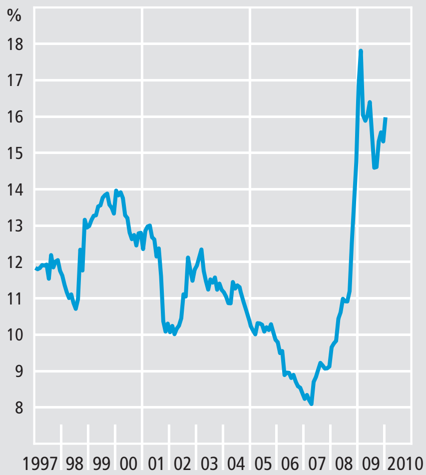
Systemic risk of internationally active banks*



Sources: Moody's KMV and Bundesbank calculations. — * Overall risk expressed as expected shortfall (ES) as a percentage of aggregate liabilities of all banks in the portfolio. The portfolio contains up to 86 internationally active banks. ES was calculated on the basis of variable probabilities of the systemic event (*q*) occurring.

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of statistic interdependence models. As explained in the previous section, these models measure the marginal impact of the (default) risk of Bank B on the risk of Bank A. This can be generalised so that the aggregate financial system, and not just an individual bank, is forced to "absorb" this particular bank's risk. The marginal impact of a bank on the system can be interpreted as that bank's contribution to systemic risk. One fundamental difficulty lies in finding a suitable definition of individual risk and systemic risk. Most proposals for measuring a financial institution's contribution to systemic risk focus on aggregate losses in assets' market value as an indicator of overall risk.[19]

An approach developed at the Bundesbank takes a slightly different path.[20] The underlying concept is to look at all credit institutions as a single loan portfolio. The system's losses are the result of "write-downs" on defaulted institutions' debt. Established credit risk models[21] may be used to determine the distribution of future (uncertain) losses.

Expected portfolio loss given a systemic event as a measure of overall systemic risk

On the basis of this underlying concept, systemic risk can be quantified and thus operationalised as the "expected shortfall" of the portfolio under observation. Expected shortfall (ES) is the expected portfolio loss caused by a rare systemic event. The rare event is defined here as losses in excess of a given threshold. A low probability that the rare event will occur implies a high loss threshold and vice versa. In traditional portfolio theory, the probability of occurrence is fixed at a given value. However, this would not appear to make sense from a macroprudential perspective. Systemic events become more likely if the situation of individual institutions deteriorates. It therefore seems appropriate to link the probability of systemic events occurring with institutions' individual probability of default.[22]

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19 For example, Adrian and Brunnermeier have developed a highly regarded approach; see T Adrian and M K Brunnermeier (2009), CoVaR, Federal Reserve Bank of New York, Staff Report No 348. This report gives the risk of market value losses using Value at Risk (VaR). The CoVaR measure proposed by the authors is defined as the VaR of the overall system conditional on the VaR of an individual institution *j*. According to Adrian and Brunnermeier, the difference between CoVaR and VaR measures the risk contribution of institution *j*.
20 See N Puzanova and K Düllmann (2011), Systemic Risk Contributions, mimeo.
21 See R Merton (1974), On the Pricing of Corporate Debt: The Risk Structure of Interest Rates, The Journal of Finance, Vol 29, No 2, pp 449-470; O A Vasicek (1987), Probability of Loss on Loan Portfolio, KMV Corporation.
22 In the approach proposed here, the probability of occurrence is set at the weighted average of the institutions' probability of default.

Assigning contributions to overall systemic risk to systemically important banks

The next step is to determine the contributions made by individual banks. This is done by calculating the change in the overall risk to the system – measured as expected shortfall – caused by a one-unit rise in that institution's external liabilities.[23] In economic terms, a bank's risk contribution represents the loss to be expected if this credit institution becomes distressed, provided the systemic event has occurred.

Relative size of a bank insufficient to capture its systemic importance

It becomes clear that the systemic importance of a bank cannot be measured solely in terms of its relative size. That means that a bank can be systemically important even though it plays a fairly subordinate role in terms of its external liabilities. This has consequences for the current debate on which institutions are to be regarded as systemically important. There is no doubt that supervisors need to pay more attention to systemically important banks. Quantitative models can help to identify such banks. A subsequent step could be to attach rules-based regulatory measures to systemic importance.

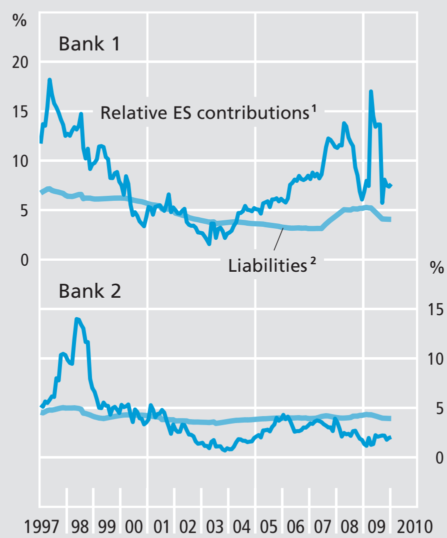
Dealing with systemic risk

Dealing with systemically important financial institutions

The models shown above exemplify the multidimensionality of measuring systemic risk and the associated challenges that adequate prudential supervision has to take into account. This is also true of the way of dealing with the risks emanating from SIFIs outlined below by way of example.[24]

SIFIs are actors in the financial system which, at least in principle, are identifiable by size,

Contribution of selected banks to systemic risk



Sources: Moody's KMV and Bundesbank calculations. — 1 As a percentage of total expected shortfall (ES) of the analysed banks. — 2 As a percentage of the total liabilities of the analysed banks.

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Insolvency of a SIFI implies negative externalities

interconnectedness and a lack of short-term substitutability. A key principle in the functioning of a market economy is that market players enter and exit the market. This mechanism does not work with SIFIs, since the insolvency of a SIFI would threaten the proper functioning of the market as a whole. This represents a negative externality on the financial system since the impact of SIFIs' individual

23 This method is based on the partial derivations of the portfolio expected shortfall according to individual banks' liabilities. The individual risk contributions being sought can now be calculated by multiplying these banks' individual marginal contributions by the volume of their respective liabilities. An efficient simulation technique (importance sampling) and a fast analytical approximation solution can be used to calculate expected shortfall at portfolio level and individual contributions to expected shortfall.

24 Mainly systemically important banks and insurers, but also certain funds, are classified as SIFIs. For an in-depth discussion of dealing with the risk posed by SIFIs, see also Deutsche Bundesbank, Financial Stability Review 2010, pp 107-110.

decisions on systemic stability are not adequately factored into their decision-making process. The benefits of their actions are weighed only against their private costs, not the macroeconomic costs to the system and to society at large. To date, the potentially high macroeconomic costs of an insolvency have led to implicit public guarantees since the government, in a crisis, is forced to implement support measures; the market prices this in, for instance in the form of financing advantages and lower risk premiums.[25] SIFIs thus enjoy competitive advantages which potentially hinder efficient resource allocation.

Set suitable incentives and strengthen individual responsibility

In order to strengthen individual responsibility and to create a level playing field, the regulatory framework needs to set the right incentives. Where these incentives are insufficient to control systemic risk, the framework needs to be extended to include additional direct measures. Improvements in the framework created by the new Basel III capital and liquidity requirements are a step in this direction; however, in some areas, additional action is needed in dealing with SIFIs. One key condition for individual responsibility is a credible insolvency code which also allows SIFIs to be wound up without creating prohibitively high costs to society at large. Bank insolvency legislation which gives supervisors the necessary instruments for efficient and quick resolution has an *ex ante* disciplining effect and should be supplemented with mandatory resolution plans (living wills) for financial institutions. Important steps in this direction were taken in Germany with the recent adoption of the Restructuring Act.[26] In addition, the adoption of the Basel III rules meant a general strengthening of the capital base. On the whole, however, the new capital and liquidity rules in conjunction with special insolvency legislation will likely not be enough to adequately contain the systemic risk emanating from SIFIs. The framework therefore needs to be complemented by additional regulatory measures.

Higher requirements in terms of supervision and risk management

Owing to the inherent risks of SIFIs, it appears appropriate in future to gear the intensity and requirements of supervision and risk management to the type (eg systemic importance for a certain market segment) and degree of financial institutions' systemic importance.[27] This presupposes that systemic importance can be established largely reliably. Quantitative models of the type described above can make a key contribution in this regard.

Restrictions on activities under discussion

More extensive direct intervention, which is being discussed in response to the financial crisis, focuses on directly regulating banks' size, eg via business volume, or business

25 Rating agencies circumvent this problem by publishing stand-alone ratings and ratings which take account of explicit and implicit guarantees.
26 See Act on the restructuring and orderly resolution of credit institutions, on the establishment of a restructuring fund for credit institutions and on the extension of the limitation period of management liability under the German Stock Corporation Act (Gesetz zur Restruktuierung und geordneten Abwicklung von Kreditinstituten, zur Errichtung eines Restruktuierungsfonds für Kreditinstitute und zur Verlängerung der Verjährungsfrist der aktienrechtlichen Organhaftung), October 2010. The EU is likewise working on a new crisis management framework in the financial sector which includes resolution plans and instruments and early intervention powers. See European Commission, An EU Framework for Crisis Management in the Financial Sector, October 2010.
27 See also FSB (2010), Intensity and Effectiveness of SIFI Supervision, Recommendations for enhanced supervision.

models, for example in the style of the Glass-Steagall-type banking system concept. In the United States, for instance, the Volcker Rule restricts banks' proprietary trading.[28] These measures can address components of systemic risk but not necessarily risks caused, say, by interconnections between institutions. The cases of the US investment bank Lehman Brothers and the LTCM hedge fund show that market players that are active only in certain business segments may also have an impact on the entire system and thus be systemically important. In addition, to a certain degree this could involve the loss of efficiency gains in the banking sector which are created by economies of scale or synergies and, in some cases, are beneficial to the economy as a whole.[29]

Internalisation of negative externalities

Generally speaking, approaches that seek to internalise the negative externalities caused by SIFIs are therefore preferable to direct restrictions on size or activities. Such approaches are more flexible and more in line with the principles of a market economy since market participants are free in their decisions once they have taken proper account of the risks. However, this presupposes that systemic risk – or individual institutions' contribution to such risk – can be quantified objectively. No such generally accepted standard has emerged yet, although promising work is being conducted in this field. The international debate is currently centred on two instruments for internalising the economic costs of systemic risk: systemic capital surcharges, also possibly in the form of contingent capital, and steering taxes ("Pigouvian taxes").[30]

Systemic capital surcharges improve incentive structures and increase resilience

In an ideal world, capital surcharges would be set such that the contribution of the institution in question to the risk of the overall system is adequately backed by capital.[31] Higher resilience reduces systemic risk overall. In the short run, surcharges initially act as quantitative regulation since asset growth is constrained by available capital. In the medium run, however, institutions can raise their capital and thus determine their size themselves. Capital surcharges also act like a price instrument in banks' decision-making processes as the financing structure shifts to

28 See US Securities and Exchange Commission (2010), Dodd-Frank Wall Street Reform and Consumer Protection Act, Title VI.
29 Empirical studies indicate, however, that the motivation for consolidation among the larger banks is no longer rising economies of scale but an expansion of market power and therefore margin increases. See D Focarelli, F Panetta and C Salleo (2002), Why Do Banks Merge: Some Empirical Evidence from Italy, Journal of Money, Credit and Banking, Vol 34, No 4, pp 1047-1066.
30 Capital surcharges are discussed in eg FSB (2010), Reducing the moral hazard posed by systemically important financial institutions; for a proposal for a Pigouvian tax see eg German Council of Economic Experts Working Paper 04/2010, Reducing Systemic Relevance: A Proposal. In addition to these instruments, the possibility of a progressive scale of deposit insurance premiums depending on the bank's contribution to systemic risk is being discussed; this would affect only deposit-taking institutions, however. See V Acharya (2009), Systemic Risk and Deposit Insurance Premiums, Comment, Vox research-based policy analysis and commentary from leading economists.
31 In frictionless capital markets, the ratio of equity to debt should theoretically have no bearing on banks' behaviour; see F Modigliani and M H Miller, The Cost of Capital, Corporation Finance and the Theory of Investment, The American Economic Review 48, 3, June 1958, pp 261-297. However, owing to information asymmetry, imperfect markets, tax aspects and the like, the capital structure is not irrelevant in practice.

more expensive capital, thus increasing the marginal costs of refinancing.[32]

Take uncertainty in the measurement of externalities into account

Theoretically, negative effects caused by systemic importance can be reversed or offset by regulation. However, in practice it is unrealistic to internalise all negative externalities since even the correct quantification of such effects is currently difficult. Capital surcharges are intended to take account of uncertainty in measuring externalities and also to include the potential welfare gains that international firms, for instance, experience as a result of large interconnected banks. Surcharges could take the form of equity or, in addition to or as a substitute for equity, conceivably also the form of contingent capital instruments. Their aim is to avoid discretionary intervention by regulators and instead provide for an automatic strengthening of the capital base in the event of a crisis.[33] The Financial Stability Board (FSB) and Basel Committee on Banking Supervision (BCBS) are currently developing proposals to flesh out the concept of systemic capital surcharges which are intended to increase institutions' individual resilience above and beyond the Basel III requirements. Other relevant work by the FSB relates to the intensity of supervision, and restructuring and resolution regimes.[34]

Pigouvian tax likewise internalises negative externalities

A Pigouvian tax is another way of internalising negative externalities. The tax rate is chosen such that the tax corresponds to the level of negative externalities. One advantage of this tax is that it pursues a precisely defined objective – reducing systemic importance – whereas capital surcharges are potentially intended to perform several tasks which are not always compatible: increasing resilience, internalising negative externalities and damping procyclicality. In the case of both the Pigouvian tax and capital surcharges, uncertainty in establishing systemic importance has thus far made it difficult to calibrate for the internalisation of negative externalities. This is one reason why enhancing resilience, which capital surcharges make possible, is an important aspect. In both cases, however, the affected institutions can be expected to take evasive action, such as transferring business lines abroad or to less regulated areas. Closing existing regulatory gaps will therefore be a decisive issue.

Market-based risks should not be neglected

The examples listed here refer to dealing with systemic risk caused by SIFIs. However, risk arises not just as a result of the systemic importance of individual financial institutions but potentially also as a consequence of herding behaviour among multiple market participants or weaknesses in market infrastructure, which allow a shock to spread within the system and thus jeopardise it. One possibility of

32 See eg German Council of Economic Experts Working Paper 04/2010, Reducing Systemic Relevance: A Proposal. In perfect capital markets, financing costs are independent of the financing structure. Owing to information asymmetry (but also to unequal tax treatment), equity is more expensive than debt in the real world. This distortion can promote negative externalities and is problematic from a financial stability perspective. See A R Admati, P M De Marzo, M F Hellwig and P Pfleiderer (2010), Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive, Stanford GSB Research Paper No 2063.
33 See also Deutsche Bundesbank, Financial Stability Review 2010, p 112.
34 See FSB (2010), Reducing the moral hazard posed by systemically important financial institutions, FSB (2010), Recommendations and Time Lines. For the G20's opinion on this issue, see G20 (2010), The G20 Seoul Summit, Leaders' Declaration.

combating this threat is to create buffers in network hubs in the financial market which prevent the transmission of shock waves. This could be accomplished, for instance, by increasingly settling transactions through central counterparties (CCPs), an approach which is currently being pursued.

Summary

Repercussions of changes in framework conditions on system stability should be taken into account

Identifying and measuring systemic risk in a bid to contain it is the precondition for any suitable reorganisation of the framework and of specific regulatory measures. Modelling contagion effects permits improved assessment of the risk that negative shocks will be transmitted between regions and financial intermediaries. By measuring the contributions which individual financial institutions make to systemic risk, macroprudential instruments such as capital surcharges can be calibrated such that SIFIs factor negative externalities into their decisions. Measuring systemic risk requires a broad spectrum of approaches in order to adequately capture the manifold aspects of risk. However, the process of developing suitable concepts and methodologies is still in its infancy. The repercussions of changes in framework conditions on the emergence of risk also need to be taken into account. This represents a challenge to future macroprudential regulation and supervision; the future stability of the financial system depends on this challenge being met.