Measuring the systemic importance of financial institutions using market information

Carlos Castro Iragorri
Stijn Ferrari

Introduction

The recent crisis has shifted the focus from the assessment of the resilience of individual financial institutions towards a more systemic approach. Hence, it is expected that macro-prudential supervision and regulation will play a vital role in the new financial architecture. In particular, experts are advocating financial regulation focused on limiting systemic risk. As illustrated by the current crisis, an important aspect of systemic risk, which broadly speaking is the risk of a widespread crisis in the financial system, is the propagation of adverse shocks to a single institution through the rest of the system. Therefore, mitigating the risk stemming from so-called systemically important institutions, i.e. the financial institutions whose failure generates a large adverse impact on the financial system, has been identified as an important policy item. In particular, consideration is currently being given in a number of jurisdictions to the possibility of applying special policies, such as a tax or capital surcharge, to systemically important institutions. The purpose of this type of regulations would be to reduce the probability of failure of systemically important institutions and to mitigate the impact of their failure if that nevertheless occurred.

Yet, a crucial step in macro-prudential supervision and regulation aimed at reducing the risk of systemically important institutions is to identify which institutions are in fact systemically important. However, this is not a straightforward task, and the existing proposals on the matter still seem far from having developed the ideal measure of systemic importance.

The purpose of this article is to provide a conceptual discussion regarding the notion of systemic importance, to identify specific issues that need to be taken into consideration when designing a measure of systemic importance, and to review existing measures of systemic importance based on market information. Measures based on market information have recently attracted considerable attention, as they only require publicly available data that in many cases are quicker than the alternative approaches at detecting (changes in) systemic importance.

The absence of a solid conceptual background for measuring systemic importance hampers the design of proper measures of the systemic importance of financial institutions, and blurs the comparison of the various approaches suggested in the evolving literature in this field. In this context, we argue that, although systemic risk and systemic importance have some similarities, they are distinct concepts that differ in their defining aspects and drivers. In order to properly measure the systemic importance of a financial institution, the measure must concentrate on the institution's potential impact on the system in the event of failure or distress, which largely boils down to capturing the spillover or contagion effects from the institution in question to the rest of the system. This entails a major challenge, as spillover effects operate through several channels, both direct and indirect. In addition, determining systemic importance of a financial institution may entail separating spillover or contagion effects from the effects of a systematic shock through common exposures, as well as identifying cascade or domino effects. Our assessment of existing measures against this background suggests that none of the proposed measures seems to actually succeed in precisely identifying the impact on the system of the failure or distress of an individual financial institution.

The remainder of the article is organized as follows. Section 1 presents a conceptual discussion on the notion of systemic importance and its main drivers. In this section, we also advance some specific identification issues that need to be taken into consideration when designing a measure of systemic importance. Section 2 discusses the use of market information for the measurement of systemic importance and presents the methodologies used in the construction of the existing measures of systemic importance based on market information. A critical assessment of these measures against the main issues identified in Section 1 will be presented in Section 3. Section 4 offers some concluding remarks.

1. The concept of systemic importance

In this section we define the concept of systemic importance and identify the main factors that affect an institution's systemic importance. These will determine which type of information a measure of systemic importance should contain, and to which factors or drivers it should respond. We first briefly discuss the definition and driving factors of the more general notion of systemic risk. The purpose is to highlight the differences between the concepts of systemic risk and systemic importance. In particular, we will argue that some of the factors that affect the level of systemic risk should not be reflected in the measure of an individual institution's systemic importance. Finally, we end this section by discussing some specific issues which concern identification of the impact of a financial institution's failure or distress.

1.1 Defining systemic importance

1.1.1 Systemic risk

Given the many systemic risk sources and channels, there is no generally accepted definition of systemic risk. In some cases, a description of the "phenomenon" of systemic risk and its different dimensions is given, rather than a succinct definition. [1] More concise definitions of systemic risk can be found in e.g. Acharya et al. (2009, p.283) and IMF/BIS/FSB (2009, p.2), who define systemic risk as *"the risk of a crisis in the financial sector and its spillovers to the economy at large"* or *"a risk of disruption to financial services that is (i) caused by an impairment of all or parts of the financial system and (ii) has the potential to have serious negative consequences for the real economy"*, respectively. Finally, more applied papers that attempt to measure the level of systemic risk generally narrow their focus on the vulnerabilities and effects within the financial sector itself, ignoring the potential spillovers to and from the real economy. In these papers, systemic risk refers to the risk of the simultaneous failure of a substantial number of financial institutions. [2]

1.1.2 Systemic importance

Like the concept of systemic risk, the definitions of a systemically important financial institution seem to differ in specific respects. The main differences again relate to the scope of the definition, i.e. whether the focus should only be on the financial system or on the real economy as well. For instance, whereas ECB (2006, p.132) in its discussion of large and complex banking groups refers to "*institutions whose size and nature of business is such that their failure and inability to operate would most likely spread and have adverse implications for the smooth functioning of financial markets or other financial institutions operating within the system*", IMF/BIS/FSB (2009, p.8) states that for assessing the systemic importance of financial institutions the main criteria relate to *"their potential to have a large negative impact on the financial system and the real economy"*. Similar definitions that also consider the impact on both the financial system and the real economy can be found in FSA (2009), Thomson (2009) and Zhou (2009). Finally, IMF/BIS/FSB (2009, p.5) notes that with respect to systemic importance *"some authorities focus on the impact on the* financial system*, while others consider the ultimate impact on the* real economy *as key"*.

Hence, in its narrowest sense, a financial institution can be considered to be systemically important if its failure or distress would have a significant adverse impact on the financial system. This impact will to a large extent result from spillover or contagion effects, which, as we discuss below, operate through many different channels. As a consequence, and owing to several other issues that will be identified in the remainder of this article, measuring the impact on the financial system of the failure or distress of a financial institution, and hence deciding on that institution's degree of systemic importance, is by no means a straightforward task.

(1) See e.g. ECB (2009) and IMF (2009).
(2) See e.g. Lehar (2005), Giesecke and Kim (2009), Huang, Zhou and Zhu (2009a,b), and Tarashev, Borio and Tsatsaronis (2009a,b).

1.2 Drivers of systemic importance

1.2.1 Drivers of systemic risk

In general, the level of systemic risk is determined by two general types of drivers : the default probabilities of the system's institutions, and the dependence or correlation of defaults of institutions in the system.

Individual default probabilities

The first driver of systemic risk is the level of individual risk facing the institutions in the system ; the higher the probabilities of default of those individual institutions, the greater the risk of the simultaneous failure or distress of a substantial number of financial institutions, and hence, the higher the level of systemic risk.

Dependence of defaults

The dependence structure or correlation of the defaults of the different institutions in the system determines the degree of default clustering in the system, i.e. the probability that the failure of a substantial number of financial institutions occurs at the same time. This dependence structure is essentially determined by two underlying forces : common exposures and spillover channels.

Common exposures The degree of common exposures of financial institutions determines to what extent the institutions' asset portfolios are vulnerable to similar risk factors. When financial institutions are to a large extent exposed to common risk factors, a systematic shock may adversely affect many institutions at the same time and pose a potentially large threat to the stability of the financial system : thus, common exposures increase the risk of the simultaneous failure or distress of a substantial number of financial institutions, and therefore the level of systemic risk.

Spillover channels The second determinant of risk dependence in the system is the presence of spillover or contagion channels, through which (idiosyncratic) shocks may spread from one institution to the rest of the financial system. If shocks to an institution easily spill over to the other institutions in the system, this again raises the probability that a substantial number of financial institutions fails at the same time.

The literature has identified several direct and indirect channels through which spillover effects operate. [1] The most obvious spillover channels are direct exposures between financial institutions through the interbank money market and counterparty relations (e.g. derivative markets, payment systems). However, there are also indirect contagion channels, such as the adverse price effects on the asset portfolio of other financial institutions in the system in the case of asset fire sales by a particular institution in distress. In addition, owing to imperfect and asymmetric information, the failure of one institution may trigger contagious bank runs in retail and wholesale (e.g. interbank) markets. Finally, the failure or distress of a financial institution may lead to negative feedback loops between the financial sector and the real economy. Overall, these channels can be classified as specific elements of the general concept of "interconnectedness", both between financial institutions within the financial system and between the financial system and the real economy : i.e., spillover channels directly or indirectly interconnect the different financial institutions in the system (and the financial institutions with the real economy). Finally, note that these channels are not mutually exclusive and may co-exist.

1.2.2 Drivers of systemic importance

The importance of spillover effects in determining the impact of a financial institution on the system in the case of failure or distress implies that the presence of systemically important institutions increases the potential level of systemic risk. On the other hand, even in the absence of (individually) systemically important institutions, the level of systemic risk may be high ; for instance, consider a financial system consisting of small and unconnected banks with a large degree of common exposures. In the following paragraphs, we discuss the extent to which the main drivers of systemic risk also apply as determinants of systemic importance. We also briefly discuss two additional factors that have been commonly identified as drivers of systemic importance : the institution's size and the substitutability of its activities. [2]

Individual default probabilities

In measuring the systemic importance of a financial institution, it is important to distinguish between the default probability of the institution in question, and the default probabilities of the other institutions in the system.

Default probability of the institution in question As systemic importance is determined by the impact on the system of a financial institution's failure or distress, and not by the probability of such an event occurring, the

(1) For a survey of the theoretical and empirical literature on systemic risk, see e.g. de Bandt and Hartmann (2000) and ECB (2009).

(2) See ECB (2006), FSA (2009), IMF/BIS/FSB (2009), and Thomson (2009). Other potential (indirect) factors identified in these works are for instance the institution's complexity and the type of assets it is holding.

default probability of the financial institution in question is a not a driver of systemic importance. In particular, a sound bank may also be systemically important.

Default probabilities of the other institutions in the system The above argument does not imply, however, that the default probabilities of the other institutions in the system may not affect the systemic importance of a particular financial institution. In particular, the potential impact of the failure or distress of a particular financial institution is likely to be larger in stress periods, when the default probabilities of the other institutions in the system are greater, than in normal times. For this reason, the assessment of systemic importance involves a major element of state dependency and time-variability.[(1)] As argued by FSA (2009), IMF/BIS/FSB (2009) and Thomson (2009), this may make it difficult for supervisors and regulators to determine a priori the degree of systemic importance of the financial institutions in the system. Note, however, that the poor financial health of the other institutions in the system would not be a sufficient condition per se for a large systemic impact in the case of the failure or distress of the institution in question ; the idiosyncratic failure or distress of a small and unconnected institution should not necessarily have a large impact on the rest of the system, even in stress periods. Therefore, the default probabilities of the other institutions in the system are rather an indirect driver that may strengthen the effect of shocks that propagate through the system.

Dependence of defaults

Common exposures While the common exposure to a systematic shock affects the level of systemic risk, in that a systematic shock may adversely affect many institutions at the same time, the joint vulnerability to adverse systematic shocks is not a determinant of systemic importance. In particular, although a group of banks with an exposure to a common factor may be argued to be "systemically important as a herd", the idiosyncratic failure or distress of a small institution in this herd that is only correlated to the other institutions through their common exposures should not necessarily have a large impact on the rest of the system.

Common exposures may nevertheless be a driver of systemic importance, in that they may strengthen the degree to which idiosyncratic shocks propagate through the system, for instance through the asset fire sales channel. In particular, the greater the degree of commonality between the failing or distressed institution's assets and those of the rest of the system, the larger the potential adverse price impact of asset sales by the failing or distressed institution on the asset portfolio of the other institutions in the system. Hence, although common exposures as such are not a direct driver of an institution's systemic importance, this factor may, like the financial condition of the rest of the system, nevertheless play an indirect role in determining the strength of spillover channels.

Spillover channels Since systemic importance is defined as the potential impact of a financial institution on the system, the presence of spillover or contagion channels, or more generally the interconnectedness of the institutions in a financial system, is clearly a driver of systemic importance. As discussed in Section 1.2.1, there are many potential channels through which spillover effects operate, such as direct exposures between financial institutions through the interbank money market and counterparty relations in derivative markets or payment systems. Essentially, if there were no channels directly or indirectly interconnecting the various financial institutions in the system (and linking the financial institutions to the real economy), there would be no possibility for shocks to propagate through the system : that would therefore limit the degree to which institutions are likely to be systemically important.

Additional factors

Size The size of a financial institution can be intuitively expected to be an important determinant of its systemic importance ; the larger an institution in terms of exposures, transaction volumes or the volume of assets managed, the larger the potential disruptions to the system in the case of failure or distress. The impact of size can be direct, in that the failure of a large player in the system potentially has a severe adverse impact on the functions performed by the system, or indirect, in that size increases a financial institution's impact through the various spillover channels identified in Section 1.2.1. In this context, it is not necessarily the financial institution's absolute size that matters ; it is often the relative size in a market or product class that determines a financial institution's impact in the case of failure or distress. For instance, the failure of a smaller institution in terms of total assets may have a large impact if the institution has a dominant position in a key financial market.

Substitutability An additional determinant of a financial institution's systemic importance is the degree of substitutability of the institution's activities ; the more difficult it is for other institutions in the system to provide the same or similar services, the less substitutable and therefore the

(1) This may also be the case, for example, simply because measures of interconnectedness can vary on a daily or even intradaily basis (FSA, 2009).

more important the institution may be. Examples of key services for which financial institutions may lack immediate substitutes are clearing and settlement and brokerage services. The potential costs from a lack of substitutability can be expressed in two dimensions: costs of delay and lower cost efficiency of performing the activities. First, it may be that other institutions are able to assume the failing or distressed financial institution's activities without additional cost, but there is a substantial delay in the continuation of the activities. This interruption of the activities performed by the failing financial institution may inflict large losses upon the system. Second, other institutions may be able to resume the failing or distressed financial institution's activities without delay, but at higher cost. This again increases the losses for participants in the system. Finally, these costs are likely to be much more of a concern when the services provided are large in volume, or where they provide a key link in connections among financial institutions (IMF/BIS/FSB, 2009).

1.3 Identification of systemic importance

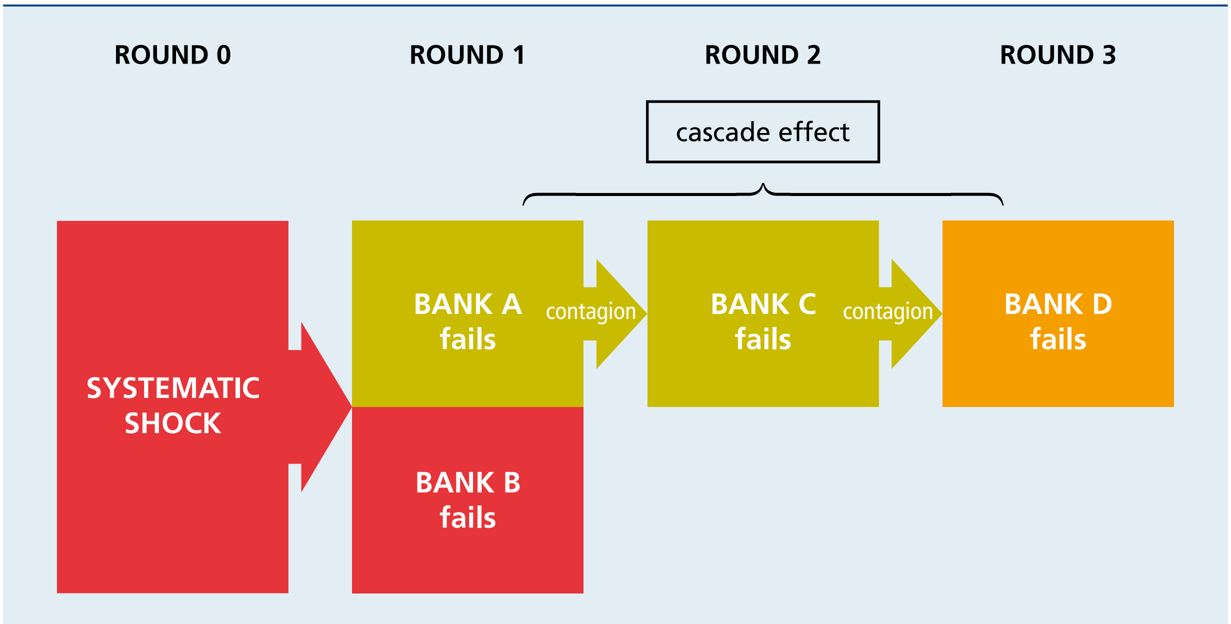
The above discussion indicates that a measure of a financial institution's systemic importance should capture the impact of the institution's failure or distress on the financial system. Consequently, the measure should intuitively depend on the drivers of systemic importance identified above, e.g. a financial institution that is highly interconnected with the rest of the system should be identified as systemically more important than an identical institution which is less interconnected with the other institutions in the system. However, we have also argued that while some factors, such as the default probability of the institution in question, may affect the level of systemic risk, they should not influence the measure of systemic importance of an individual financial institution. In the remainder of this section, we discuss some specific issues related to the identification of the impact of a financial institution's failure or distress that need to be taken into consideration when designing a measure of systemic importance.

We shall base our discussion on a hypothetical example, aiming to identify the systemic importance of Bank A. In particular, as depicted in Chart 1, suppose the financial system is hit by a systematic shock. In the first round, this systematic shock causes Bank A and Bank B to fail. The failure of Bank A in turn causes Bank C to fail. Finally, in the last round, the failure of Bank C causes Bank D to fail.

1.3.1 Spillover effects versus common exposure to systematic shocks

The first issue that arises in this context is that, in determining a financial institution's impact on the system in the case of failure or distress, it is important to separate spillover or contagion effects from the effects of a systematic shock through common exposures. That is, the failure of Bank B, which occurs simultaneously with that of Bank A, should not be considered as part of the impact of Bank A's failure. Ideally, the assessment of the impact of a financial institution's failure on the system would be based

CHART 1 ILLUSTRATION OF THE IDENTIFICATION ISSUES INVOLVED IN DETERMINING SYSTEMIC IMPORTANCE



on a failure of the institution caused by an idiosyncratic shock. The extent to which this idiosyncratic shock propagates through the system will determine the financial institution's impact, and hence its systemic importance. Evaluating a financial institution's impact on the system on the basis of its failure due to a systematic shock that has a simultaneous effect on a significant part of the system may substantially overestimate the institution's impact, if the direct impact of the systematic shock on institutions other than the financial institution in question is not separated from the indirect impact through spillovers from that institution to the other institutions in the system. In our example, if the failure of Bank B is considered to result from the failure of Bank A, Bank A's systemic importance will clearly be overestimated. The methodological corollary of this argument is that the measurement of a financial institution's systemic importance may entail the separate identification of spillover effects and common exposures as drivers of the dependence or correlation of the financial institutions' defaults.

1.3.2 Cascade or domino effects

The second identification issue relates to the identification of cascade or domino effects, where the failure of one financial institution causes the failure of other financial institutions in a first round, and these in turn cause the failure of several other institutions in a second round (and so on). In our example, the failure of Bank A causes Bank C to fail, which in turn causes Bank D to fail. In this case, the total impact of the failure of the first financial institution (Bank A) also depends on the impact that each of the other failing institutions have in the next rounds, i.e. the impact of Bank C on Bank D. This raises the question as to whether only the first-round effects or the effects of all rounds should be taken into account when assessing the degree of systemic importance for the purpose of applying a special policy such as a tax or capital surcharge on systemically important institutions.

2. Measuring systemic importance using market information

In this section we provide an overview of the methodologies used in the existing measures of systemic importance based on market information. First, however, we briefly discuss the motivation for using market information for the measurement of systemic importance.

2.1 Motivation for using market information-based approaches

As already noted above, given the many different channels through which spillover or contagion effects operate, measuring a financial institution's degree of systemic importance is not a straightforward task. In general, one can distinguish three broad approaches among the existing techniques: the indicator-based approach, the network approach, and the market information-based approaches.

Indicator-based and network approaches

Indicator-based approach This approach consists of aggregating several quantitative indicators to produce a measure of systemic importance.[1] These indicators proxy for different factors that could render a financial institution critical for the stability of the system, i.e. the drivers of systemic importance identified in the previous section. Some indicators that have been proposed in the literature include, for instance, total assets (to proxy for size), total interbank liabilities and assets (to proxy for interconnectedness) and the share of non-traditional banking activities (to proxy for substitutability). Each institution receives a score for each indicator, after which an aggregation technique is applied to produce a single synthetic measure of its systemic importance.

Network approach A second approach taken to measure systemic importance makes use of network theory to map the interconnections or interlinkages between the financial institutions.[2] This requires *inter alia* data on interbank loans, including cross-border exposures, as well as information on credit risk transfer instruments. Once these interlinkages are properly established, simulations of shocks to specific institutions allow tracking of the cascade or domino effects on other institutions in the network. The strength of such cascade or domino effects can be used to determine the systemic importance of a particular institution.

Not only are the data requirements for the above two approaches quite substantial, the data needed for this type of analysis are often not (publicly) available. Although there are currently initiatives under way that aim at satisfying some of the substantial data demands for assessing the systemic importance of financial institutions[3], considerable data gaps exist and will probably persist in the future. This is especially true for the interconnections among financial institutions, which are one of the main drivers of systemic importance. In addition, the two approaches discussed above have some serious shortcomings. For instance, it is not clear what weight to

(1) See ECB (2006), IMF/BIS/FSB (2009), and Thomson (2009).
(2) See e.g. Wells (2002) for the UK, Furfine (2003) for the US, Upper and Worms (2004) for Germany, and Nguyen and Degryse (2007) for Belgium. For a more complete list of applications for different countries, see IMF (2009).
(3) See Praet (2010).

place on the various indicators in the aggregation of the individual indicator scores in the indicator approach. In addition, the aggregation of scores on separate indicators is unlikely to take sufficient account of the interactions between the various drivers of systemic importance. As for the network approach, an important criticism is that the financial institutions' behaviour in reaction to the failure of another institution in the system is not taken into account.

Market information-based approaches

Given the substantial data requirements and the shortcomings of the indicator and network approaches, techniques using market information have recently received considerable attention. In general, the only inputs required in these approaches are market prices (e.g. CDS, equity) for the financial institutions in the system, possibly combined with the financial institutions' balance sheet information. Therefore, the main advantage of market information-based approaches compared to alternative approaches is the public availability of the data. As this is true for many geographical areas, it allows consistent assessment of systemic importance for financial institutions located in different countries and banking systems. In addition, market data are available at a high frequency (at least daily) and are forward-looking, implying that in many cases (changes in) systemic importance can be detected in a more timely manner than in the alternative approaches.

Obviously, approaches based on market information also have their shortcomings. A first disadvantage of using market information is that market prices are only available for listed firms. This may mean that not all potentially relevant institutions in the system can be taken into account in the assessment of systemic importance. A second shortcoming relates to the information content of market prices. First, the underlying assumption when using market information for risk assessment is that markets are efficient. Furthermore, even if markets are informationally efficient, all relevant private information may not be reflected in the prices. Second, movements in both equity and CDS prices may be driven by factors unrelated to credit risk, such as changes in the liquidity premium or investor risk aversion. (1) In addition, in periods of crisis, the information content of market prices may be affected by public intervention, for example.

Despite these shortcomings, the public and timely availability and the forward-looking nature of the data used in these market information-based approaches may make them potentially useful for macro-prudential policy and regulation, at least as complements for the systemic importance measures produced by the other approaches.

2.2 Overview of methodologies used in market-based measures of systemic importance

The systemic importance of a financial institution is determined by some measure of the impact of the institution on the financial system. (2) In this subsection we offer an overview of the techniques used to construct market information-based measures of systemic importance, developed both before and during the current financial crisis.

In general, one can distinguish between measures that assess the impact of the failure or distress of a particular institution in terms of the likelihood of spillover effects, and measures that assess the severity of the losses

(1) See e.g. Annaert et al. (2010).
(2) This definition of systemic importance, which only considers the effects across financial institutions and disregards any effects on the real economy, is the one usually adopted in the applications which measure systemic importance using market information.

TABLE 1 CLASSIFICATION OF METHODS TO ASSESS SYSTEMIC IMPORTANCE USING MARKET INFORMATION

Method	Approach	Basic assessment	Applications
Co-risk approach	infer the impact of the failure or distress of a financial institution directly from market data	robust because of minimal assumptions, but the scale of the systemic importance measure is hard to interpret	Adrian and Brunnermeier (2009), IMF (2009)
Portfolio approach	first quantify total risk in the system, then determine the contribution of each individual institution to system-wide risk	efficient way to condense the information on losses of all individual institutions into losses of the entire system, the systemic importance measure has interpretable scale, but strong assumptions	Elsinger, Lehar and Summer (2006a), Huang, Zhou and Zhu (2009b), Tarashev, Borio and Tsatsaronis (2009a,b), Gauthier, Lehar and Souissi (2010)

associated with the failure or distress of the institution. Applications of the former class of measures generally consider the probability of the failure or distress of a number of institutions in the system conditional on the failure of another institution. [1]

In this article we focus on measures that capture the severity of losses. [2] In particular, we distinguish between (i) methods that infer the impact of the failure or distress of a financial institution directly from market data, without any need to quantify the overall risk in the system in advance, and (ii) methods that first quantify the overall risk in the system and then determine the contribution of each individual institution to system-wide risk to determine systemic importance. We label the first type of method as the co-risk approach, and refer to the second type as the portfolio approach. Table 1 provides an overview of this classification.

2.2.1 The co-risk approach

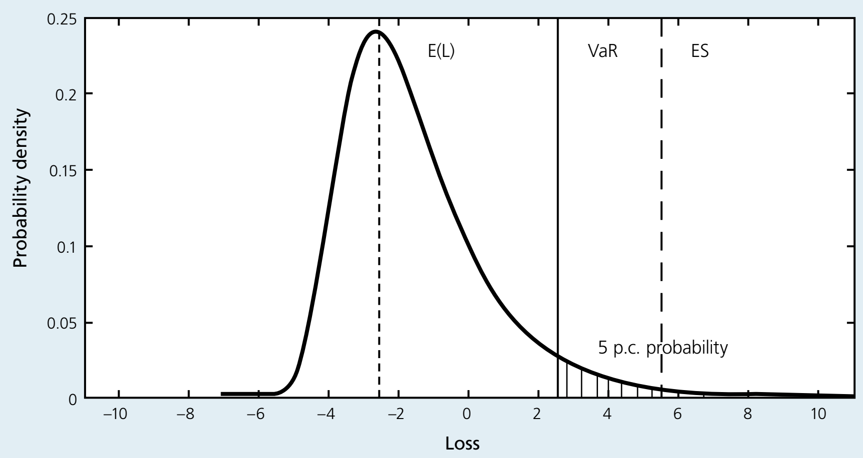
Co-risk measures of systemic importance generally infer the impact of the failure or distress of a financial institution directly from market data, such as stock returns or CDS spreads, without relying on a structural credit risk model to first quantify total risk in the system. The advantage of these approaches is therefore that they require little information and make use of statistical methods with minimal assumptions, to obtain an estimate of a financial institution's potential impact on the system.

(1) See e.g. Hartmann, Straetmans and de Vries (2005), Geluk, Haan and de Vries (2007), Segoviano and Goodhart (2009), and Zhou (2009).
(2) As discussed by Zhou (2009), likelihood-based measures of systemic importance may not provide sufficient information on the systemic importance of a financial institution.

Box 5 – Value-at-risk and expected shortfall

The most commonly used risk measures are those that focus on extreme losses (i.e. the tail of the distribution): value-at-risk (VaR) and expected shortfall (ES).

The chart below illustrates the concepts of VaR and ES. The chart shows the probability density of a loss distribution *L* of a hypothetical financial institution. [1] In addition, the chart contains a series of vertical lines, indicating the mean loss (*E(L)*), and the 95 p.c. VaR ($VaR_{95\%}$) and ES ($ES_{95\%}$), respectively. Note that since the chart depicts a



Source: McNeil, Frey and Embrechts (2005).

(1) VaR and ES can also be derived for distributions other than loss distributions, e.g. the distribution of stock returns or CDS spreads.

loss distribution, negative losses imply positive profits; as *E(L)* = –2.5 < 0, the financial institution is on average expected to make a positive profit. In addition, the loss distribution is asymmetric (skewed to the left); therefore, even though the institution on average makes a positive profit, the probability of extreme losses for the financial institution is larger than the probability that extremely large profits will be realised.

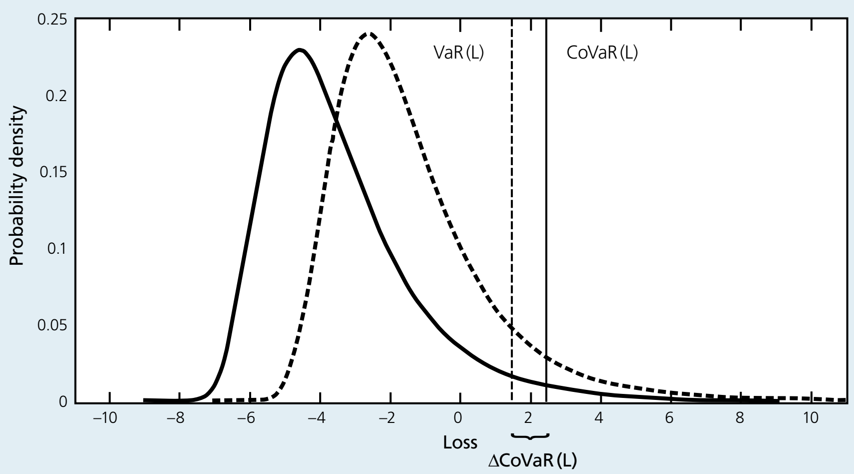
The chart shows that the $VaR_{95\%}$ is approximately 2.5, indicating that there is a 5 p.c. probability that the losses of the financial institution amount to at least this figure for a given time horizon.

Expected shortfall is an alternative risk measure that considers additional information from the tail of the loss distribution, beyond the threshold value considered exclusively by the VaR risk measure (as indicated by the shaded area in the chart). The idea behind ES is to obtain a weighted average of all values above VaR, i.e. the average loss level above the $VaR_{95\%}$-level of 2.5 and thus to obtain an average value for the tail of the distribution of the losses. In the chart above, $ES_{95\%}$ is approximately 5.5.

Intuitively, co-risk measures determine the systemic importance of a financial institution as the increase in the risk of the financial system when the institution in question encounters distress. Perhaps the best known co-risk measure of systemic importance is ΔCoVaR proposed by Adrian and Brunnermeier (2009). The calculation of ΔCoVaR makes use of the risk measure value-at-risk (VaR, see Box 1 for an illustration) and involves two main steps. First, the (unconditional) VaR from the distribution of, for instance, stock returns for the index of financial institutions (the system) is computed. This represents a VaR for the financial system. Second, the conditional VaR (CoVaR) is computed as the VaR for the distribution of the stock returns of the index of financial institutions, conditional on the stock return of the financial institution in question being at its VaR-level (in distress). The difference between CoVaR and the unconditional VaR of the system is called ΔCoVaR, which is the eventual measure of systemic importance.

Chart 2 illustrates the use of ΔCoVaR to measure systemic importance. The numerical example is based on hypothetical stock returns for the index of financial institutions in the system, whose probability distribution *L* is plotted as the solid line in the chart. Similarly, it is possible to obtain a probability distribution of the stock return of the system, conditional on the institution in question being in distress (the dashed line). Therefore, the impact of the failure or

CHART 2 ILLUSTRATION OF ΔCoVaR



distress of the institution on the system, i.e. its systemic importance, could be obtained from the difference in the VaR for the conditional and the unconditional stock return distribution. In Chart 2, the $VaR_{95\%}(L)$of the system is approximately 1.5, and the $CoVaR_{95\%}(L)$ of the system (i.e. the VaR of the system conditional on the financial institution in question being in distress) is approximately 2.5 ; then, the increase in the risk of the financial system when the institution encounters distress (ΔCoVaR) is 1.

Since co-risk measures are pairwise measures, they may also be used to measure the impact of a financial institution on each of the other individual institutions in the system, rather than on the entire system at once. IMF (2009) considers a mapping of all pairwise co-risk measures across a number of institutions in the financial system. (1) One way to obtain from this mapping an indication of the overall systemic importance of a financial institution may be to look at the average impact of the institution on all of the other institutions.

While co-risk measures may provide an assessment of the systemically important institutions with only minimal distributional assumptions and no need to first quantify overall risk, these approaches have important drawbacks as well. One drawback is the interpretability of the scale of the measure of systemic importance. Thus, there seems to be no obvious answer to the following question : when is the impact of a financial institution on the system (or on another institution) large enough for the institution to be considered as systemically important ? The challenge is to determine a cut-off value that provides a clear and transparent method of ranking institutions according to their systemic importance.

2.2.2 The portfolio approach

In general, measuring the systemic importance of each of the institutions in the financial system via the portfolio approach involves two steps : (i) quantification of the overall risks in the system ; and (ii) determining the contribution of each individual institution to system-wide risk. Since the overall loss in the system provides a maximum scale as a benchmark for the individual institutions' contributions to total losses, the interpretability of the scale of the measure of systemic importance is not an issue, and individual institutions can easily be ranked. We now discuss the two steps of the portfolio approach in more detail.

(1) Rather than using ΔCoVaR, which is the difference between the conditional and the unconditional VaR, IMF (2009) considers a relative co-risk measure : the ratio of the conditional VaR (CoVaR) over the unconditional VaR, minus 1 (times 100).

Step 1 : Quantification of systemic risk

Perhaps the most widely used technique for quantifying the overall risks in the system has its origins in Merton's firm value model or contingent claims analysis. Merton's model is an essential starting point for modelling credit risk of an individual firm. In this model, the value of the firm's equity at some point in time is equal to the payoff of a European call option on the asset value. This means that a firm's probability of default essentially depends on three parameters : the firm's leverage, and the volatility and mean return of the asset value process. Multivariate extensions of Merton's model are of general use for modelling the default risk of a portfolio of firms ; these are the so-called structural models of portfolio credit risk. In the context of measuring systemic risk, the relevant portfolio is that of the financial institutions that make up the financial system.

To quantify systemic risk, an aggregate loss distribution is derived from the individual losses of each institution, under assumptions regarding the likelihood of default (PDs) and severity of losses (LGDs), together with an assumed dependence structure across the institutions. The aggregate loss distribution represents the distribution of total losses of the financial system. A measure of portfolio risk, or in this case system-wide risk, will be a function of the estimated aggregate (portfolio) loss distribution. The most commonly used risk measures are those that focus on extreme losses (i.e. the tail of the distribution) : value-at-risk (VaR) and expected shortfall (ES). Box 1 discusses these risk measures, which are used to quantify systemic risk.

The main advantage of the portfolio approach is its ability to condense the information on losses of all individual institutions into losses of the entire system in an efficient manner. However, this efficiency comes at a price of imposing strong assumptions, such as distributional assumptions and assumptions regarding portfolio diversification and default correlations. As a consequence, a substantial degree of model risk is embodied in the analysis ; small changes in the assumptions may alter not only the estimated level of systemic risk, but also the set of institutions that are identified as systemically important.

Step 2 : Allocation of systemic risk

Once systemic risk is quantified, the contribution of each financial institution can be determined. This contribution will be the eventual measure of the institution's systemic importance. Thus, in the portfolio framework, determining the systemic importance of a given financial institution boils down to a problem of allocation among the institutions of the system: many allocation schemes are available for that purpose. In particular, allocation schemes can be divided into mechanisms based on discrete contributions, partial contributions, the Shapley value, and the continuous marginal allocation.[1] In the following paragraphs, we provide an intuitive description of these allocation schemes.[2]

Discrete contribution Intuitively, the discrete contribution method considers the difference between a risk measure based on the loss distribution of the entire system and a risk measure based on the loss distribution of the system excluding the institution in question. This difference between the evaluated risk functions indicates the systemic importance of the institution. An example of a discrete allocation method is incremental VaR (*iVaR*). For *iVaR*, first, the VaR of the loss distribution derived for the entire financial system is computed. Second, VaR is computed for the loss distribution derived for the system consisting of all institutions except the institution in question. The difference between both VaR-measures is the incremental VaR. Applications of incremental VaR can be found in Elsinger, Lehar and Summer (2006a) and Gauthier, Lehar and Souissi (2010).

Partial contribution This class of allocation mechanisms is very similar to the discrete contribution method. The partial distribution approach focuses on the difference between a risk measure based on the loss distribution of the entire system (as in the discrete distribution) and a risk measure based on the loss distribution of the entire system conditional on the institution in question being in distress. In the case of the partial contribution method, systemic importance is measured as the difference between an unconditional and a conditional loss distribution, where in the latter case the financial institution in question is at some particular risk (distress) level. An example of a partial allocation method is ΔCoVaR (see Section 2.2.1 for a graphical illustration of ΔCoVaR in the context of co-risk measures). We refer to Elsinger, Lehar and Summer (2006a) that introduce conditional expected shortfall as a measure of systemic importance, and Gauthier, Lehar and Souissi (2010) for an application of ΔCoVaR in the portfolio approach.

Shapley value Neither the discrete contribution method nor the partial contribution method is "additive", i.e. the sum of the risk contributions (the indicators of systemic importance of each institution) will not add up to the overall risk of the portfolio (systemic risk) for these methods. An approach that does possess the additivity property is the Shapley value, which represents an average of the institution's discrete contributions to the risk of each possible subportfolio (or "coalition") that includes this institution. The use of the Shapley value for determining the systemic importance of financial institutions was introduced by Tarashev, Borio and Tsatsaronis (2009a,b), and applied in a real data setting covering six Canadian banks by Gauthier, Lehar and Souissi (2010).

Continuous marginal allocation The final class of allocation methods is the continuous marginal allocation. Unlike the three previous methods that calculate contributions or allocations based on large changes in the portfolio, i.e. either dropping the institution in question from (a subset of) the portfolio (*iVaR*, Shapley) or conditioning on the distress of this institution (ΔCoVaR), the continuous marginal allocation method measures the change in the risk measure of the portfolio due to a small change in the portfolio composition. Intuitively, systemic importance based on the continuous marginal allocation method equals the VaR of the loss distribution of the entire system and the VaR of the loss distribution of the system with the portfolio weight of the institution in question changed by only a marginal amount. Like the Shapley value, this approach is additive, so the systemic importance indicators of the financial institutions in the system sum up to the total level of systemic risk. An application of a continuous marginal allocation method in the context of measuring systemic importance can be found in Huang, Zhou and Zhu (2009b).

3. Assessment of existing market-based measures of systemic importance

In this section we present an assessment of the existing techniques in light of the main issues identified in Section 1. We first check whether the proposed measures of systemic importance are designed so as to capture the impact on the financial system of the failure or distress of a financial institution. Second, we assess to what extent the measures actually succeed in measuring the impact of an institution's failure. The aim is not to offer an exhaustive overview of all the properties of the existing measures, but rather to signal some potential weaknesses of different techniques.

Measuring impact rather than fragility

Given the lack of conceptual agreement on systemic risk and systemic importance pointed out in Section 1, it is not uncommon to find that some approaches claiming to

(1) See e.g. Tasche (2000) and Koyluoglu and Stoker (2002) for a formal definition of the allocation schemes.

(2) Note that the allocation schemes could, in principle, also be applied to directly infer systemic importance from market data. This is for example the case for ΔCoVaR, that has been applied both as a co-risk measure and as an allocation scheme in the portfolio approach.

measure systemic importance may actually be measuring a different, but slightly related concept, such as the systemic fragility of a financial institution. Systemic fragility is defined as the impact on some financial institution *i*, measured conditional on the distress of the system. One might argue that systemic fragility is the opposite of systemic importance. [1]

The distinction between measures of systemic importance and systemic fragility is rather obvious for approaches that are based on conditional events. For example, partial contribution methods and co-risk measures, such as ΔCoVaR, which considers the change in the risk of the system due to the distress of one institution, are clearly measures of systemic importance. [2] The distinction, however, may be less clear for the allocation methods (other than the partial contribution) that are used to determine systemic importance in the portfolio approach. As a result, even though some authors argue that they are measuring systemic importance, they are actually measuring systemic fragility. For instance, (continuous) marginal risk contributions may result in a measure of systemic importance consisting of the losses of the institution in question in the case of the financial system being in distress. Clearly, this is a measure of systemic fragility : i.e., the extent to which the institution in question is impacted in the case the system is in distress, rather than a measure of the institution's impact on the financial system.

Identification of impact

As discussed in Section 1.3, there are two issues in identifying the impact of the failure or distress of a financial institution. First, in determining a financial institution's impact on the system in case of failure or distress, it is important to separate spillover or contagion effects due to the institution's failure from the effects of a systematic shock through common exposures, which may cause simultaneous failures of this institution and others. Second, the methodology to determine systemic importance should allow the identification of cascade or domino effects and take these into account in the assessment of systemic impact.

Spillover effects versus common exposure to systematic shocks Co-risk measures provide enough flexibility so as to properly account for common risk exposures and therefore separate the direct effect of the institution on the system from the correlation in failures stemming from common exposures.

In contrast, the existing measures of systemic importance based on the portfolio approach do not disentangle the common exposure component from the spillover channel component in the institutions' dependence structure. In the portfolio approach, the model design often includes some form of factor structure that determines the dependence between the asset values of the financial institutions, and accounts for the common exposure in the portfolio of financial firms.

Overall, the measurement of systemic importance of the financial institutions calls for the separate identification of the contagion effects and common exposure as drivers of the dependence in the individual institution's risk levels. The importance of properly identifying these two sources of default clustering is an issue that has started to receive attention in the credit risk literature ; hopefully it will soon be introduced in the portfolio-based methodologies that measure systemic importance. [3] The evolving methodologies may indeed profit from the literature on measuring contagion effects, which was primarily developed to analyse international stock market co-movement in the late nineties (1994 Mexican peso crisis, 1997 east Asian crisis). [4] Such literature provides a way to test for the existence of contagion effects and simultaneously account for common exposures. However, the downside is that the application of the test is on observed episodes of distress ; such an *ex-post* approach can render the methodology less useful for macro-prudential purposes.

Cascade or domino effects A second issue is that the methodology to determine systemic importance should allow taking cascade or domino effects into account in the assessment of systemic impact. However, none of the currently proposed applications based on market information is able to take this issue into account. For example, ΔCoVaR measures the total impact of a particular institution on the system ; no distinction is made between whether this impact is entirely the direct consequence of the institution's failure or the result of a sequence of failures in a cascade or domino chain. The same is true for the applications of the portfolio approach. Perhaps the most appropriate platform to capture cascade or domino effects is a network-based approach, as briefly discussed in Section 2.1. Along these lines, a series of papers by Alfred Lehar and co-authors introduce a hybrid model that combines the portfolio approach with a network model. [5] That is, their model consists of two components : a multivariate version of Merton's model, and a network model for interbank obligations. This second component

(1) If we denote systemic importance as the impact on the system measured conditional on the distress of some financial institution *i* ; then fragility is the impact on some financial institution *i* measured conditional on the distress of the system.
(2) The difference between measures of systemic importance and systemic fragility is also straightforward for the class of likelihood-based approaches.
(3) See e.g. Azizpour and Giesecke (2008), Giesecke and Kim (2009) and Lando and Nielsen (2009).
(4) See e.g. Claessens and Forbes (2001).
(5) See e.g. Elsinger, Lehar and Summer (2006b), and Gauthier, Lehar and Souissi (2010).

is able to capture two important factors of contagion: spillover effects and feedback loops. The authors stress the importance of mapping the exposures across institutions in order to fully capture the individual institution's risk and it implications on the system.

Concluding remarks

This article examines the conceptual background relating to measuring the systemic importance of financial institutions. First, although systemic risk and systemic importance have some similarities, they are distinct concepts that differ in their defining aspects and drivers. Second, in order to properly measure the systemic importance of a financial institution, the measure must concentrate on the institution's potential impact on the system in the event of failure or distress, which largely boils down to capturing the spillover or contagion effects from the institution in question to the rest of the system. This entails a major challenge, as spillover effects operate through several channels, both direct and indirect.

In addition, the design of systemic importance measures raises several methodological challenges. One of these is the need to identify contagion or spillover effects due to an institution's failure separately from common exposure effects which can cause the simultaneous failures of several institutions. These challenges, together with state variability and time dependence of systemic importance, are critical, in that they render the a-priori assessment of systemic importance a difficult task. As a consequence, it may be desirable to evaluate the impact of a financial institution's failure or distress in some type of through-the-cycle or stress-testing framework, where other institutions' default probabilities and the dependence of institutions' defaults are evaluated at stressed levels. This might imply removing the time variation of systemic importance and only considering the worst case scenario.

Ultimately, however, the choice of assessment methodology is likely to depend on the possible policy applications. For example, macro-prudential policy aimed at the internalization of the costs imposed on others by the failure of systemically important institutions requires a different measure than macro-prudential policy with the purpose of institutions paying an insurance premium to cover their own losses in the case of a systemic event; whereas in the first case, a measure of systemic importance is required to determine the individual institutions' contributions, in the second case, the appropriate measure would be one of systemic fragility. However, referring to this measure of systemic fragility as a measure of systemic importance would be a misnomer. It is exactly the existence of this type of misnomers and the lack of a solid conceptual background that clearly defines systemic importance and how it differs from the concept of systemic risk that may generate confusion among market participants and supervisors when discussing and comparing macro-prudential policy tools.

References

Acharya V., L. Pedersen, T. Philippon, and M. Richardson (2009), Regulating Systemic Risk, in Restoring Financial Stability: How to Repair a Failed System, ed. Acharya, V. and M. Richardson.

Adrian T. and M. Brunnermeier (2009), CoVaR, Federal Reserve Bank of New York Staff Reports No. 348.

Annaert J., M. De Ceuster, P. Van Roy and C. Vespro (2010), What Determines Euro Area Bank CDS Spreads?, National Bank of Belgium Working Paper, 190.

Azizpour S. and K. Giesecke (2008), Self-Exciting Corporate Defaults: Contagion vs. Frailty, mimeo.

Claessens S. and K. Forbes (2001), International Financial Contagion, Kluwer Academic Publishers, Boston.

de Bandt O. and P. Hartmann (2000), Systemic risk: A survey, ECB Working Paper No. 35.

Elsinger H., A. Lehar and M. Summer (2006a), Systemically important banks: an analysis for the European banking system, International Economics and Economic Policy, 3 (1): 73-89.

Elsinger H., A. Lehar and M. Summer (2006b), Using market information for banking system risk assessment, International Journal of Central Banking, 2 (1): 137-165.

European Central Bank (2006), Identifying large and complex banking groups for financial system stability assessment, Financial Stability Review, December 2006: 131-139.

European Central Bank (2009), The concept of systemic risk, Financial Stability Review, December 2009: 134-142.

Financial Services Authority (2009), A regulatory response to the global banking crisis: Systemically important banks and assessing the cumulative impact, Turner Review Conference Discussion Paper DP09/4.

Gauthier C., A. Lehar and M. Souissi (2010), Macroprudential Regulation and Systemic Capital Requirements, Bank of Canada Working Paper 2010-4.

Geluk J., L. De Haan and C. De Vries (2007), Weak and strong financial systemic fragility, Tinbergen Institute Discussion Paper, TI 2007-023/2.

Giesecke, K. and B. Kim (2009), Systemic risk: What defaults are telling us, mimeo.

Hartmann P., S. Straetmans and C. De Vries (2005), Banking system stability: A cross-Atlantic perspective, ECB Working Paper No. 527.

Huang X., H. Zhou and H. Zhu (2009a), A framework for assessing the systemic risk of major financial institutions, forthcoming Journal of Banking and Finance.

Huang X., H. Zhou and H. Zhu (2009b), Assessing the systemic risk of a heterogeneous portfolio of banks during the recent financial crisis, Federal Reserve Board Finance and Economics Discussion Series No 2009-44.

Koyluoglu U. and J. Stoker (2002), Honour your contribution, Risk, April.

International Monetary Fund (2009), Global Financial Stability Report, April 2009.

International Monetary Fund/Bank for International Settlements/Financial Stability Board (2009), Guidance to assess the systemic importance of financial institutions, markets and instruments: initial considerations, Report to G20 Finance Ministers and Governors.

Lando D. and M. Nielsen (2009), Correlation in corporate defaults: Contagion or conditional independence?, mimeo.

Lehar A. (2005), Measuring systemic risk: A risk management approach, Journal of Banking and Finance, 29 (10): 2577-2603.

McNeil A., R. Frey and P. Embrechts (2005), Quantitative Risk Management: Concepts, Techniques and Tools, Princeton University Press.

Merton R. (1974), On the pricing of corporate debt: the risk structure of interest rates, Journal of Finance, 29 (2): 449-470.

Praet P. (2010), Macro-prudential and financial stability statistics to improve financial analysis of exposures and risk transfers, mimeo.

Segoviano M. and C. Goodhart (2009), Bank stability measures, IMF Working Paper WP/09/4.

Tarashev N., C. Borio and K. Tsatsaronis (2009a), The systemic importance of financial institutions, BIS Quarterly Review, September 2009: 75-87.

Tarashev N., C. Borio and K. Tsatsaronis (2009b), Allocating systemic risk to individual institutions: Methodology and policy applications, mimeo.

Tasche D. (2000), Risk contributions and performance measurement, mimeo.

Thomson J. (2009), On systemically important financial institutions and progressive risk mitigation, Federal Reserve Bank of Cleveland, Policy Discussion Papers No 27.

Zhou C. (2009), Are banks too big to fail?, DNB Working Paper No 232.