Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 544

Diciembre 2009

TOWARDS AN OPERATIONAL FRAMEWORK FOR FINANCIAL STABILITY: "FUZZY" MEASUREMENT AND ITS CONSEQUENCES

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BANCO CENTRAL DE CHILE

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Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
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Resumen

En la última década, la inestabilidad financiera se ha convertido en un problema prioritario para las autoridades. A pesar de los esfuerzos desplegados, todavía están lejos de desarrollar un marco operativo que sea satisfactorio. La gran complicación surge de que la medición de la inestabilidad financiera resulta difusa. Aquí revisamos las metodologías disponibles y mostramos varias debilidades. En particular, advertimos contra la práctica común entre las autoridades de confiar en la generación actual de las pruebas de tensión macroeconómica, con el argumento de que pueden dar una falsa sensación de seguridad. Sin embargo, argumentamos que la naturaleza difusa de las mediciones no impide avanzar hacia un marco operativo, siempre que se tome como lo que es. Algunas de las características que dicho marco debe tener son: que fortalezca la orientación macroprudencial de la regulación y supervisión financiera; que aborde en forma más sistemática la prociclicidad del sistema financiero; que se apoye tanto como sea posible en estabilizadores automáticos antes que en factores discrecionales, aliviando así la tarea de medir los riesgos de inestabilidad financiera en tiempo real; y que establezca acuerdos institucionales que potencien la experiencia relativa de las distintas autoridades responsables de preservar la estabilidad financiera, tales como supervisores financieros y bancos centrales.

Abstract

Over the last decade or so, addressing financial instability has become a policy priority. Despite the efforts made, policymakers are still a long way from developing a satisfactory operational framework. A major challenge complicating this task is the "fuzziness" with which financial (in)stability can be measured. We review the available measurement methodologies and point out several weaknesses. In particular, we caution against heavy reliance on the current generation of macro stress tests, arguing that they can lull policymakers into a false sense of security. Nonetheless, we argue that the "fuzziness" in measurement does not prevent further progress towards an operational framework, as long as it is appropriately accounted for. Crucial features of that framework include: strengthening the macroprudential orientation of financial regulation and supervision; addressing more systematically the procyclicality of the financial system; relying as far as possible on automatic stabilizers rather than discretion, thereby lessening the burden on the real-time measurement of financial stability risks; and setting up institutional arrangements that leverage the comparative expertise of the various authorities involved in safeguarding financial stability, not least financial supervisors and central banks.

This paper was prepared for the 12th Annual Conference of the Banco de Chile, "Financial stability, monetary policy, and central banking", Santiago, 6-7 November 2008. This version has not been up-dated since. We would like to thank Marjorie Santos and Philippe Hainaut for excellent research assistance, Janet Plancherel for superb editorial support and Kostas Tsatsaronis for very helpful comments. Several ideas on financial stability measurement were initially developed when Mathias Drehmann was working for the ECB. He benefited from many discussions with colleagues and is particular thankful to John Fell and Philipp Hartmann. The views expressed in this paper are those of the authors, and do not necessarily represent those of the Bank for International Settlements.

Introduction

Over the last decade or so, addressing financial instability has risen to the top of national and international policy agendas. Policymakers in general, and central banks in particular, have been allocating increasing resources to the monitoring of potential threats to financial stability and to the elaboration of frameworks to address them effectively. In part, this trend has been driven by the emergence of episodes of financial distress that have derailed, or threatened to derail, the real economy. The major financial earthquake that has engulfed the global financial system since the summer of 2007 is bound to strengthen this trend further (eg, Borio (2008a)).

Despite the efforts made, policymakers are still a long way from developing a satisfactory operational framework. Tellingly, in the financial stability sphere there is nothing like the well established apparatus employed in the pursuit of price stability (Goodhart (2006)).[1] For price stability, over the years central banks have succeeded in establishing a set of procedures and institutional arrangements that command a broad consensus (eg, Nelson (2008)). By contrast, there is no equivalent agreement on the analytics of financial stability and on how best to secure it. Policymakers are still looking for a reliable compass.

A widely recognised challenge in developing an operational framework for financial stability is measurement: can financial stability or its converse, instability, be adequately measured? Can the risk and cost of future financial distress be measured with sufficient confidence? Measurement influences all the elements of the framework. It translates the definition of the goal into an operational yardstick. It shapes the strategy that maps the goal into the instruments. And it has major implications for the institutional set-up that implements the framework, most notably for the governance structure that ensures the accountability of policymakers. In particular, the precision or "fuzziness" with which the goal can be measured is crucial.

Taking the measurement challenge seriously, this paper highlights the key issues faced in the elaboration of an operational framework for financial stability and suggests an outline of the most promising way forward. In order to keep the paper manageable, we focus exclusively on crisis prevention, rather than crisis management and resolution, and on the architecture of prudential arrangements. We thus do not consider several other policies can have a first-order impact on financial stability, notably monetary, fiscal and accounting policies.

Our main conclusion is that, while the measurement challenge is a tall one, it does not prevent policymakers from edging closer towards an effective operational framework. In the process of reaching this conclusion, we highlight a number of points.

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[1] To be sure, challenges in the pursuit of price stability should not be underestimated; and indeed, some of the hardest ones are closely related to financial stability (Borio (2006)).

First, analytically, it is useful to distinguish financial instability from financial distress (or a financial crisis). We define *financial distress* as an event in which substantial losses at financial institutions and/or their failure cause, or threaten to cause, serious dislocations to the real economy. We define *financial instability* as a situation in which normal-sized shocks to the financial system are sufficient to produce financial distress, ie in which the financial system is "fragile". *Financial stability* is then the converse of financial instability.

Second, it is important to distinguish the two quite distinct roles that measurement performs in an operational framework. One is to help ensure the accountability of the authorities responsible for performing the task. The other is to support the implementation of the strategy in real time to achieve the goal. These two roles place different demands on measurement. The former calls for *ex post* measurement of financial instability, ie for assessments of whether financial instability prevailed or not at some point in the past. The latter puts a premium on *ex ante* measurement, ie on assessing whether the financial system is fragile or not today. Both *ex ante* and *ex post* measurement are fuzzy, but the challenges of *ex ante* measurement are tougher. For *ex post* measurement, the *past* occurrence of financial distress can provide irrefutable evidence of instability; for *ex ante* measurement, it is more important to identify the likelihood and costs of *future* financial distress. Failure to appreciate this distinction can lead to misleading conclusions about the feasibility and structure of an ideal operational framework.

Third, the performance of *ex ante* measures of financial instability is generally rather poor, although some are more useful than others. Most techniques provide thermometers rather than barometers of financial distress, ie do not permit its identification with a sufficient lead and confidence. Given current technology, while potentially promising, macro stress tests may actually risk lulling policymakers into a false sense of security. By contrast, leading indicators rooted in the "endogenous cycle" view of financial instability appear better suited to identify *general* risks of financial distress. These indicators draw on the Minsky-Kindleberger tradition, which sees the gradual build-up of vulnerabilities associated with aggressive risk-taking as sowing the seeds of subsequent strains. The corresponding indicators take market signals as *contrarian* signals of the likelihood of distress, eg unusually low risk premia or unusually strong asset prices and credit expansion are taken as harbingers of future financial distress (Borio and Lowe (2002a,b)).

Fourth, any operational financial stability framework would have a "macroprudential", as opposed to "microprudential", orientation (Crockett (2000), Borio (2003a)). This orientation is defined by two features that follow from the nature of financial instability. One is a focus on the financial system as a whole as opposed to individual institutions, paying particular attention to the costs of instability in terms of the real economy. The other is relying on a notion of risk that stresses the potentially destabilising effects of the collective behaviour of economic agents, ie what might be termed the "endogenous" nature of risk. It is precisely this feature that underlies the amplifying mechanisms that generate financial distress in

response to normal-sized shocks. To varying degrees, these two elements are shared by all the analytical approaches to the modelling of financial instability.

Fifth, strengthening the macroprudential orientation of financial regulatory and supervisory arrangements has implications for the calibration of policy tools with respect to both the cross-sectional and time dimensions of aggregate risk in the financial system. In the cross section, ie with respect to the treatment of risk at a point in time across firms, it calls for increasing the weight on common exposures relative to institution-specific exposures (ie, on systematic relative to idiosyncratic risk). At present, no such distinction is formally made. In the time dimension, ie in relation to the evolution of aggregate risk over time, it calls for addressing systematically the so-called "procyclicality" of the financial system. The term "procyclicality" refers to the amplifying ("positive feedback") mechanisms that operate within the financial system and between the financial system and the real economy and that can cause financial instability. While most analytical approaches to financial instability point to such mechanisms, the "endogenous cycle" view highlights their operation in both bad *and* good times. As a result, it also stresses the need to restrain the build-up in risk-taking during the expansion phase. A more countercyclical orientation of prudential arrangements would be a key way of limiting procyclicality.

Finally, fuzzy measurement shapes a number of features of the operational framework. Given the difficulties in *ex ante* measurement, the framework should rely as far as possible on rules rather than discretion. Rules put less weight on the real time measurement of the likelihood and cost of future financial distress and can act as more effective precommitment devices for policymakers. In addition, fuzzy measurement, together with the possibility that for long periods the system may be unstable *without financial distress actually emerging*, also put a premium on transparent institutional set-ups. These need to be based on clear mandates that can help ensure the accountability of the authorities in charge.

The paper is organised as follows. The first section explores the definition of financial stability and analytical approaches to the modelling of instability. The second section discusses in detail the role of measurement, including its purposes, the tools available, and their strengths and weaknesses, illustrating them with the help of simple examples. The third section outlines the most promising way forward for the design of frameworks and highlights the most pressing outstanding analytical questions. In doing this, we draw lessons from the current financial crisis. An Annex examines in more detail the recent performance of leading indicators rooted in the endogenous cycle view of instability.

I. Financial (in)stability: definition and analytical perspectives

Definition

Ever since financial stability as a public policy objective has risen to prominence, efforts to define it have multiplied. Even so, a generally agreed definition that could be the basis for an operational framework has remained elusive.

Most definitions of financial stability share three useful elements. First, they focus on the financial system as a whole, as opposed to individual institutions. Second, they do not consider the financial system in isolation, but ultimately measure the economic (welfare) benefits and costs in terms of the "real economy" (economic activity). Third, they make an explicit reference to financial instability, the converse of stability, which is more concrete and observable.

At the same time, differences abound. Some definitions are very broad, including any allocative distortions arising from financial "frictions" relative to an ideal benchmark (Haldane (2004)); others are more restrictive, focusing on the absence of episodes of acute distress and significant disruptions to the functioning of the system (eg, Mishkin (1999)). Some highlight the robustness of the financial system to external shocks (eg, Allen and Wood (2006), Padoa-Schioppa (2003)); others cover the possibility that the financial system may itself be a source of shocks (eg, Schinasi (2004)). Some tie the definition closely to the equally common but elusive notion of "systemic risk" (eg, Group of Ten (2001), De Bandt and Hartmann (2000)); others avoid it.

For the purposes of developing an operational framework some definitions are more helpful than others. Broad definitions unnecessarily widen the objective to be pursued by the authorities and hinder accountability. And, as will be argued below, definitions that rule out the possibility of the financial system being a source of shocks, at least as normally identified, risk being too restrictive and misleading.

In this paper we will use the following terminology. We define *financial distress/a financial crisis* as an event in which substantial losses at financial institutions and/or the failure of these institutions cause, or threaten to cause, serious dislocations to the real economy, measured in terms of output foregone. We define financial *in*stability as a set of conditions that is sufficient to result in the emergence of financial distress/crises in response to normal-sized shocks. These shocks could originate either in the real economy or the financial system itself. Financial stability is then defined as the converse of financial instability.

While the definition is only very rough, it provides a reasonable starting point for our analysis. Three characteristics of this definition are worth noting.

First, it is pragmatic. This is why the scope is narrowed to the performance of financial institutions. It goes without saying that large fluctuations in asset prices and the exchange rate or problems in the balance sheets of governments, households and non-financial enterprises can *by themselves* have a sizable

impact on output, even if the financial sector is not seriously disrupted. Pure sovereign and exchange rate crises can be examples of the genre. But including them would arguably broaden the definition too much from an operational perspective. Financial stability *mandates* are probably best defined narrowly in terms of the financial sector so as to avoid broadening the scope of regulation too far.[2]

Second, the definition distinguishes episodes of financial distress as *events* from financial instability/stability as *properties* of the financial system. By their nature, properties are harder to identify than events, as they may involve the appeal to a counterfactual. For example, the system can be unstable even if no financial distress materialises for quite some time (see below).

Finally, it is crucial that distress is generated in response to a shock that is not of extraordinary size as it is unreasonable to expect the financial system to function effectively regardless of the size of *exogenous* shocks that hit it (eg, Goodhart (2006)). Moreover, as discussed next, the analytical approaches to financial instability share this characteristic, ie a normal-sized shock can generate financial distress through the amplifying mechanisms in the system.

Analytical perspectives

Analytical approaches to the modelling of financial instability vary widely. They thus have different implications for how to set up operational frameworks to address it. For present purposes, it is useful to distinguish approaches along three dimensions. The dimensions are defined in terms of whether financial crises/episodes of financial distress are seen as (i) self-fulfilling or driven by "fundamentals"; (ii) the result of endogenous financial cycles or of exogenous negative "shocks" amplified by the system (the "endogenous cycle" versus "exogenous shock-amplification" views) and (iii) reflecting mainly shocks to systematic risk factors or idiosyncratic shocks amplified through spillovers across the system.

The first distinction, between crises seen as self-fulfilling or fundamentals-driven, has a long pedigree. One of the most influential models of banking crises sees them as self-fulfilling (eg, Diamond and Dybvig (1983)). In this model, runs on banks are driven by the belief that others will run, given that a deposit contract satisfies customers on a first-come, first-served basis. Illiquidity leads to insolvency: banks engage in maturity transformation and assets can be liquidated only at a cost. Multiple equilibria exist, one in which the crisis occurs and one in which it does not, without any basis for choosing between them.[3] In other models, a crisis can occur only if the value of the assets falls below a certain threshold, and is in this

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[2] This, of course, does not imply that authorities should not consider carefully the implications of developments outside the financial sector for its stability. Far from it! Moreover, the broader macroeconomic consequences of strains in the balance sheets of other sectors that do not impinge of the financial sector's stability can be taken into account through other policies, not least monetary policy.

[3] Technically, the equilibrium is chosen based on the artificial notion of "sunspots", which act as coordinating devices for beliefs.

sense driven by "fundamentals" (threats to solvency) (eg, Gorton (1988), Chari and Jagannathan (1988)). Unique equilibria can be achieved, for instance, by restricting the beliefs of agents (eg, Morris and Shin (1998), Rochet and Vives (2004)).

The second distinction, between the endogenous cycle and exogenous shock-amplification views of financial instability, is equally long-standing. The prevailing formal literature on financial instability falls overwhelmingly in the shock-amplification category. The models assume a probability distribution for exogenous "shocks" that, given the rest of the structure of the economy, may result in financial distress if the realisation is sufficiently *negative* (eg, a bad harvest, a fall in productivity). By contrast, an older intellectual tradition sees financial distress as the natural result of the build-up in risk-taking over time, owing to self-reinforcing feedback mechanisms within the financial system and between it and the real economy. These mechanisms lead to the build up of financial disequilibria, or imbalances, that at some point inevitably unwind, thereby generating an endogenous cycle. Minsky (1982) and Kindleberger (1996) are the authors most closely associated with this view. The "model" is fundamentally dynamic and the financial system itself plays a key role in generating what may *appear* as the exogenous "shock" triggering distress (eg, a fall in asset prices from unsustainable levels). In fact, the true shock may well have occurred a long time before and would have been *positive* (eg, a perceived productivity improvement or a financial reform), triggering a boom-bust cycle in the economy. The actual trigger for the unwinding of the imbalances may be exceedingly small and unobservable (eg, a change in mood), given the fragility built up in the system. While the precise timing of the unwinding is unpredictable, its occurrence is not.

To our knowledge, no formal micro-founded model able to capture satisfactorily the endogenous cycle view of instability has as yet been developed. At the same time, several models incorporate elements of the overall picture. These range from those that explain "bubbles" in asset prices[4] to those that explore the amplification mechanisms that operate within the financial system and between the financial system and the real economy, as a result of the "financial frictions" inherent in financial contracts. A notable example is the mutually reinforcing link between credit and asset prices that arises from the use of "collateral" (Kiyotaki and Moore (1997) and Bernanke et al (1999)).[5]

The third distinction, between shocks to systematic risk factors – by definition affecting exposures that are common across institutions – and idiosyncratic shocks amplified through spillovers, relates to the channels

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[4] The literature on bubbles is vast. See Allen and Gale (2000a) for a model that highlights the role of credit in that context. For a recent overview, see Brunnermeier (2001).

[5] General equilibrium models with financial frictions that explore the welfare properties of these amplification mechanisms normally dispense of financial intermediaries altogether, considering only the interaction between entrepreneurs and households. Similarly, these models generally do not generate endogenous cycles, but highlight the build-up in risk-taking that makes the system fragile to exogenous shocks that lead to much tighter financing constraints, thereby amplifying business fluctuations. On both of these aspects, see, eg Lorenzoni (2007), Korineck (2008) and references therein. For an alternative approach that generates endogenous cycles, see Suarez and Sussman (1999).

through which the crisis propagates; it is also less clear-cut than the other two. In models that assume that the financial sector is a single entity, as many do, no such distinction exists.[6] In those that assume multiple intermediaries, it is sometimes assumed that the original deterioration occurs in a specific institution and is then transmitted elsewhere through knock-on effects, as a result of the balance sheet and/or behavioural connections that keep the financial system together. This is the case, for instance, of approaches that stress credit chains, payment and settlement system links or runs triggered by the inability to distinguish solvent from insolvent institutions (eg, Kiyotaki and Moore (1997), Allen and Gale (2000b), Rochet and Tirole (1996a,b), Freixas and Parigi (1998), McAndrews and Roberds (1995), Aghion et al (1999)). By contrast, other approaches highlight a joint deterioration owing to shared exposures, such as through the holdings of the same assets (eg, Cifuentes et al (2005), Allen and Gale (2004)). The distinction is less clear-cut than the other two, however, since shared exposures to risk factors can be both *direct*, through similar claims on the non-financial financial sector, and *indirect*, through balance sheet interlinkages within the financial sector itself.

Beyond the obvious differences, two common characteristics stand out.

First, all the approaches stress how aggregate risk is endogenous with respect to the collective behaviour of economic agents. This view of aggregate risk contrasts sharply with the way individual market participants regard and measure risk, treating it as exogenous with respect to their actions. Given the assumed structure of the financial system, this collective behaviour can amplify small disturbances and generate instability, ie result in strong non-linearities in the response of the system. This amplification is the essence of what has come to be known as the "procyclicality" of the financial system, denoting a situation in which the financial system, rather than acting as a shock absorber acts as a shock amplifier, exacerbating business fluctuations (Borio et al (2001), Borio (2003a)). In models that fall in the negative shock-amplification paradigm, these mechanisms by necessity operate only to reduce output; moreover, the existence of asymmetries associated with the bankruptcy constraints means that they are especially powerful. In models in the spirit of the endogenous cycle paradigm, or in which financial frictions are always present, they operate also during the expansion phase.

Second, two types of fundamental sources of instability are at work in the various models, either of which is sufficient to produce it. One source is errors in the elaboration of the information available to agents, ie the assumption that expectations are not "rational" or "model consistent".[7] Most approaches rule out this possibility, given the popularity of the rational expectations assumption in modern economics. By contrast, such errors are clearly implicit, but not required, in variants of the endogenous cycle view, such as those

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[6] This would apply, for instance, to the "systemic" interpretation of Diamond and Dybvig (1985), ie thinking of their bank and a whole banking system, rather than interpreting the model as one of runs on individual banks.

[7] Strictly speaking, the issue is undefined in the case of self-fulfilling crises. In this case, agents obviously do not form expectations over the likelihood of the two types of equilibria.

of Minsky and Kindleberger. Rationality of expectations, for example, is one, though not the only, reason why financial accelerator mechanisms have persistence-enhancing effects on shocks rather than having a larger, non-linear impact on output of the boom/bust variety. The other source of instability is the wedge between individually rational and collectively desirable (welfare-enhancing) actions.[8] Its specific manifestations vary with assumptions concerning the information available to economic agents and the types of financial contacts and markets in which they transact. Relevant notions here are coordination failures, (rational) herding and prisoner's dilemmas. These are, for instance, the types of mechanism that explain runs on financial institutions, distress sales, or excessive risk-taking in the expansion phase of the financial cycle (eg, Rajan (1994 and 2005)).[9]

From a practical perspective, the various approaches have implications for the broad contours of an operational framework. Some are common to all. In particular, all of them suggest strengthening the robustness of the financial system to shocks. An uncontroversial way of doing so is strengthening the payment and settlement infrastructure – an aspect which is often taken for granted in the models. Another possibility is to improve the information available to economic agents. This could reduce the possibility of errors in its elaboration and/or limit the risk of unwarranted contagion. Yet another one would be to improve "buffers" in the system, although their characteristics would very much depend on the details of the models (eg, insurance, capital and liquidity).

Other implications vary more substantially. The approaches differ significantly in terms of the ability to measure the risk of financial distress in real time. Taken literally, this is impossible if crises are self-fulfilling.[10] And an assessment may be conceptually easier in endogenous-cycle models than in those that stress the exogenous shock-propagation paradigm. The approaches also differ in terms of the weight to be placed on different factors in that context, including liquidity or solvency, interlinkages in the financial system or direct common exposures to systematic risk, separate from those linkages. And they also differ in terms of the most promising areas for policy action. Thus, by comparison with shock-propagation approaches, the endogenous-cycle perspective highlights more the desirability of restraining risk-taking in the expansion phase.

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[8] Note, however, that in some models financial instability is actually welfare enhancing, given the assumptions made. On this, see Allen and Gale (1998). The assumptions concerning the information available to investors/depositors can be key here. For instance, depending on the quality of the signal received, wholesale depositors may either induce effective market discipline (desirable liquidations) or not (inefficient ones) (compare Calomiris and Kahn (1991) and Huang and Ratnovski (2008)).

[9] See Borio et al (2001) for a more detailed discussion and references to the literature.

[10] More precisely, the likelihood of distress is impossible to measure; the cost given distress is not.

II. Financial (in)stability: measurement

Role of measurement

Any operational framework designed to secure financial stability requires a mapping of the definition of the goal into a measurable, or at least observable, yardstick. Measurement performs two quite distinct roles. One is to help ensure the accountability of the authorities responsible for performing the task. The other is to support the implementation of the chosen strategy to achieve the goal in real time. The former calls for *ex post* measurement of financial instability, ie for assessments of whether financial instability prevailed or not at some point in the past. The latter relies on *ex ante* measurement, ie on assessments of whether the financial system is fragile or not today. While both *ex ante* and *ex post* measurement are "fuzzy", the challenges in supporting strategy implementation are tougher.

As a means of ensuring accountability, it is in turn important to distinguish two cases, depending on whether an episode that may qualify as financial distress occurs or not during the relevant period.

If such an episode does take place, *ex post* measurement difficulties are challenging but manageable. In order to conclude that the system was unstable policymakers should be able to (i) recognise financial distress *ex post*; and (ii) reach a judgement that the distress was out of proportion with the original exogenous (unavoidable) "shock", ie that financial distress was the result of financial instability rather than extreme shocks. Clearly, even this assessment can involve considerable fuzziness. How "large" should be the losses among financial intermediaries and the associated costs for the real economy before the episode can qualify as one of "financial distress"? How large should the "shock" be? By definition, the answers to both of these questions can only be given with reference to a model, however rudimentary, of the economy. Moreover, where should one draw the line between crisis prevention and crisis management? For example, if the authorities intervene in response to the first signs of strain to manage the situation and thereby avoid the failure of institutions (eg, through early recapitalisations or the issuance of guarantees), is that distress or its prevention (see Annex 1)? But overcoming this "fuzziness" should not be too hard.

By contrast, if financial distress has not emerged, *ex post* measurement is harder. The main drawback is that the system may actually be unstable (fragile) even if no financial distress has materialised. Episodes of financial distress are rare and the window during which the system may be fragile *without experiencing a financial crisis* may last years. As a result, it can be hard to judge how well the authorities are performing for quite a long time. Judging whether the system was unstable during any given recent *tranquil* period requires policymakers to answer the same *kind* of counterfactual as for real time implementation, and hence for *ex ante* measurement: what *would have happened* had the system been hit by a shock? Or, in the endogenous cycle view of financial instability, were imbalances building up that simply happened not to unwind during the period? In effect, during tranquil periods, the demands on *ex ante* and *ex post*

measurement are qualitatively equivalent, although requirements in terms of frequency of observation, lead time and accuracy are lower for the *ex post* variant.

As a means of implementing the chosen strategy in real time, the requirements on measurement are, on balance, more demanding than for accountability, since *ex ante* measurement is inevitable. By the time financial distress emerges, it is too late, as the damage is done. The requirements are especially demanding as a basis for *discretionary* measures designed to take preventive action. In this case, it is necessary to measure the likelihood and cost of future episodes of financial distress in real time *with a sufficient lead and confidence*. They are less demanding, however, as a basis for the calibration of *built-in* stabilisers, such as through the indexing of prudential tools. In this case, measurement can be less ambitious. It can be based on less precise proxies of risks of financial distress as long as the basic *direction* of the measures is correct. For instance, it would be sufficient to relate prudential measures to rough estimates of the financial cycle, based on some long-term averages (see next section).

Another way of highlighting the challenges in *ex ante* measurement is to consider its implications for the properties of measures of financial instability. *Ex ante* measurement calls for good leading, as opposed to contemporaneous, measures of episodes of financial distress, ie for good *barometers* rather than *thermometers* of distress. Given the lead-lag relationships involved, such measures would also be good thermometers of financial instability; that is, they would be able to capture the financial system's fragility *before* financial distress actually emerges. As we shall see, a key challenge here is what might be called the "paradox of instability": the financial system can appear strongest precisely when it is most fragile. This puts a premium on the policymakers' ability to read the "tea leaves" correctly (eg, Knight (2007)).

A taxonomy

In considering the possible range of measurement tools, it might be helpful to start from what an ideal measure would be. This measure would be the output of a fully structural model of the economy mapping instruments into the goal. More precisely, it could be written as follows:

$$M \leftarrow f(X, I, u)$$

where the measure of financial (in)stability M is some transformation of the output of a structural model of the economy, f(.), linking a set of variables X to policy instruments I and exogenous shocks u. Such a model would permit the *ex post* identification of financial instability by decomposing the past into "shocks" and the endogenous response of the system. It could also be used to generate the *ex ante* probability distribution of outcomes, and hence of financial distress, through the simulation of the shocks or, alternatively, to generate scenarios (ie trace the behaviour of the system conditional on specific shocks). And it could be relied upon to design appropriate policies, by seeing how the system would behave under different configurations of the instruments. For example, the tools would ideally generate an "expected cost of financial distress" metric over a specific horizon, combining the likelihood of financial distress with its cost in terms of economic activity. The authorities could then use this measure as the basis for the

calibration of both automatic stabilisers and discretionary actions aimed at keeping it within a desired range.

Reality falls well short of this ideal. In fact, it falls well short even of the less ambitious but more realistic set-up that characterises the world of monetary policymaking, to which those working on financial stability often aspire (eg Goodhart (2006)). In monetary policy, the quantitative side of the job is much more developed. Policymakers have models that link instruments to the goal (some varying combination of inflation and output) and use them to make forecasts and carry out policy simulations (Nelson (2008)). Typically not just one, but a variety of such tools are employed, exploiting their relative strengths and weaknesses in forecasting and policy analysis. The tools are quite helpful in disciplining the inevitable and crucial role of judgement. And they can be used to keep measures of price stability, such as a point-estimate for inflation over a given horizon, within desired ranges. This is what is typically done in inflation-targeting regimes.

The picture is quite different in financial stability analysis. There are no satisfactory models of the economy as a whole linking balance sheets in the financial sector to macroeconomic variables. Even the *empirical* modelling of financial instability *within* the financial sector, for given (exogenous) macroeconomic factors, is often very primitive, hardly going beyond rather mechanical exercises with very limited behavioural content (eg, Upper (2007)).[11] And if an instrument is included at all in the model, this is the interest rate, whose primary function is to achieve price stability. All this makes it virtually impossible to do meaningful risk analysis and policy simulations within a single framework. Policymakers need to fall back on to a variety of much more limited quantitative tools that put little discipline on judgement.

In surveying the landscape of such tools, it is useful to classify them along three dimensions. First, how far do the models provide leading, as opposed to contemporaneous, measures of episodes of financial distress? In other words, how far do they act as barometers rather than thermometers of financial distress? This is important for the use to which those measures can be put. Second, how far do the tools take into account, directly or indirectly, the behavioural interactions that underlie episodes of financial distress? Failure to capture such interactions, ie the endogenous nature of aggregate of risk with respect to collective behaviour, can easily underestimate the likelihood of financial distress. Third, how far do the

[11] The work stream by Goodhart et al (2004, 2006 a,b) provides an interesting exception. These papers theoretically derive general equilibrium models with incomplete markets, heterogeneous agents and in which endogenous default can occur. Ultimately, however, calibrating and finding computational solutions for the model are the major difficulties. So far this has only been tried for the UK (Goodhart et al (2006b)) and Colombia (Saade et al (2007)). In both cases, it was only possible to implement a highly stylised model with three different banks, two states of the world (stress and no stress) and two time periods. Even in this case, calibration proved difficult. As Saade et al (2007) explain, some parameters such as policy variables are observed, some can be calibrated using econometric methods and others, which are at the heart of the model, can only be arbitrarily imposed. Moreover, these models are based on "endowment" economies, which rule out feedback effects on output.

models actually "tell a story" about the transmission mechanism of financial distress?[12] Being able to tell a convincing story can influence their effectiveness in communicating risks and possibly give more confidence in the outputs. However, sometimes a trade-off may exist between the granularity and degree of detail needed for story telling and accuracy in measurement.[13]

We focus on tools that are actually used at present in policy institutions. We start with a variety of indicators, ranging from traditional balance sheet variables, at one end, to more ambitions early warning indicators (EWIs), at the other. We then discuss vector autoregressions (VARs), which amount to very simple representations of the economy and could, in principle, perform both risk and policy analysis. We finally consider current system-wide multi-module measurement models, with macro stress tests being the prime example in this category. We illustrate the performance of these tools with some representative examples.

From balance sheet to market price indicators

The simplest type of indicator comprises statistics based on *balance sheet items*. These would include, for example, measures of banks' capitalisation, non-performing loans, loan loss provisions, items of the balance sheets of households and corporations, etc. Most of the so-called "Financial Soundness Indicators" listed by the IMF fall in this category (IMF (2008)). National authorities would also have, in addition, data for individual institutions at a more granular level.

Clearly, at best, these variables can be used as inputs into a richer analysis of vulnerabilities.[14] Crucially, given accounting rules, variables such as loan loss provisions, non-performing loans and levels of capitalisation are rather backward looking and, at best, contemporaneous rather than leading indicators of financial distress, ie thermometers rather than barometers. Indeed, profits tend to be rather high, and provisions low, when risk is taken on; the recent experience has been no different in this respect (Graph II.1). The same is true for variables such as balance sheet and income leverage. In order to become useful from a forward-looking perspective, they need to be embedded in a "theory" of the dynamics of

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[12] This is close to the distinction between structural and reduced form models. The term structural model is often used to refer to models whose parameters are invariant with respect to policy interventions ("deep parameters"), so that policy simulations can be properly carried out. Given the state of modeling of financial stability, this would simply mean setting the bar too high. We return to this issue in the next section, where we discuss briefly the implications for monetary policy of the inability to model financial distress satisfactorily.

[13] For example, It is well known in econometrics that simple models, such as autoregressive specifications, may even outperform the true model of the data generating process in forecast performance (Clements and Hendry (1998)). However, autoregressive specifications are certainly not granular enough for policy evaluation or communication.

[14] A typical process is well described in Carson and Ingves (2003) through a so-called transmission map, which traces the impact of possible macro and financial shocks through the non-financial sector on the financial system as well as the feedback onto the real economy. See also Gadanecz and Jayaram (2008), who provide an overview of the use of indicators in current financial stability reports.

instability, such as the endogenous cycle view, that links them explicitly to future episodes of financial distress (see below).

By construction, similar limitations apply to *indices* which combine balance sheet variables into a single number to generate an index of stress, possibly together with other variables.[15] These indices have the advantage of summarising a wide set of information into one statistic, which can then be used as an input into a more refined assessment. At the same time, they are not very transparent.

Ratings for individual borrowers go one step beyond balance sheet variables. The ratings could be issued by credit rating agencies or by supervisory authorities, based on more confidential information. Relative to balance sheet variables, ratings have the advantages of combining information into a single statistic and of being designed to be forward-looking. Specifically, they are estimates of the probability of default or expected loss.

At the same time, they have a number of limitations. The most important one is that they relate to individual institutions taken in isolation. Thus, a measure of the strength of the financial system as a whole requires the bottom-up aggregation of ratings that do not take systematic account of common exposures and interactions. Questions also arise regarding their reliability as truly leading indicators of financial distress, at least for credit agencies' ratings. In practice, downgrades tend to be rather "sticky" compared with the arrival of information. To a considerable extent, this reflects the fact that such ratings seek to filter out the influence of the business cycle, ie to be "through-the-cycle" rather than "point-in-time" estimates of default. As a result, they are more helpful in assessing the structural and idiosyncratic determinants of default than its evolution over time.[16]

An alternative procedure is to build indicators of financial distress from *market prices*. There are various possibilities. At one end, raw indicators can be considered in isolation, or combined, with little or no theoretical restrictions. Typical variables include volatilities and quality spreads. More ambitiously, by imposing some structure, prices of fixed income securities and equities can be used to derive estimates of probabilities of default or expected losses for individual institutions and sectors. To do so, one needs to rely on a pricing model that "reverse engineers" the various inputs, based on some assumption. For example, so-called expected default frequencies (EDFs, in effect probabilities of default) can be obtained

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[15] Bordo et al (2000) were among the first to aggregate indicators into a single index. Their index is based on four annual series: the bank loan charge-off rates, business failure rates, the (ex-post) real interest rate and the quality spread. To aggregate, they first compute a standardised distance from the median for each variable. The average of the standardised distances is then split into five buckets, from "severe distress" to "euphoria", to generate an "index of financial conditions". Similarly, Hanschel and Monnin (2005) build a stress index for Switzerland aggregating balance sheet variables, such as provisions or capital levels, with market data for banks and confidential supervisory information on the number of "problem" banks.

[16] In addition, most rating agency assessments include the probability of external support, including government support, in the assessment. From a policy perspective, this should be filtered out. Some ratings seek to do precisely that (eg, Fitch Ratings "individual" ratings and Moody's "financial strength" ratings).

from equity prices, recalling that equity can be regarded as a call on the firm's assets just as its debt is a put on them (Merton (1974)). Once again, these individual inputs can then be aggregated, based on some estimates of correlations across the firms' assets, so as to obtain a measure of distress for the corresponding sector.

On the face of it, such indicators have a number of advantages over those discussed so far. They are forward-looking measures that incorporate all the information available to market participants at a particular point in time, ie they are comprehensive, point-in-time measures of risk. They therefore also implicitly embed views about any common exposures and interactions that may exist within the sector covered. They are also available at high frequencies.

At the same time, they may have drawbacks too. Depending on the characteristics of the financial system, their coverage may be too narrow (eg, few institutions may be publicly quoted). Another problem is distinguishing between the market's view of future cash flows and the price it assigns to them, ie the risk premium. If the purpose is to identify *future* distress, rather than the "price" attached to it or to measure current conditions, the influence of the risk premium should be filtered out. This requires several assumptions and is hard to do with any confidence. More importantly, though, any biases in the market's assessment would be embedded in the estimates. If, as some analytical approaches suggest, excessive risk-taking is the source of financial instability, then estimates of risk derived from market prices would tend to be unusually *low* as vulnerabilities build up and would tend to behave more like contemporaneous indicators of financial distress.[17]

Available evidence tends to confirm that the lead with which market prices point to distress is uncomfortably short for policy. For example, unusually low volatilities and narrow spreads prevailed across a broad spectrum of asset classes until the turmoil started in the summer of 2007, when they then rose sharply (BIS (2007) and Graph II.2). Graphs II.3 illustrate this point based on two representative indices of stress, which differ with respect to the degree to which they are constrained by theoretical priors. Graph II.3 (left-hand panel) shows an index of stress for the United States and the euro area based on the methodology developed by Illing and Liu (2006) and first applied to Canada. In essence, the index is a weighted sum of market based indicators for the banking sector, debt markets, equity markets and liquidity measures. Graph II.3 (right-hand panel) plots the "price of insurance against systemic distress" developed by Tarashev and Zhu (2008); based on banks' CDS spreads, the index calculates the premium that needs to be paid for insurance against losses that exceed a certain threshold in terms of overall assets of the

[17] This would reflect a combination of high risk appetite and excessively benign views about future cash flows. To quote Greenspan (2005): "history has not dealt kindly with the aftermath of protracted periods of low risk premiums".

banks covered with a given probability.[18] As can be seen, both indicators start going up sharply only once the turmoil in financial markets erupted in the second half of 2007.[19]

EWIs

One possible way of overcoming these limitations is to develop formal *early warning indicators* (EWIs) of financial distress. These are specifically designed to identify episodes of financial distress in advance. There has been a growing literature on EWIs. Although most of it was initially concerned with exchange rate and sovereign crises (eg, Berg and Pattillo (1998)), banking crises have been attracting growing attention (eg, Bell and Pain (2000), Demirguc-Kunt and Detragiache (2005), Davis and Karim (2008)). The basic approach consists in using reduced-form relationships linking a set of explanatory variables to a "financial distress" index. [20] This is generally a zero/one variable, except in Misina and Tkacz (2008) who forecast the Canadian stress index developed by Illing and Liu (2006) (see the discussion above) using measures of credit and asset prices.

Potentially, EWIs have some attractive features. They represent statistically rigorous attempts to identify basic relationships in the historical data. They are explicitly forward-looking. They implicitly capture any interactions that have existed in previous episodes. And as long as their structure is not purely data-driven but inspired by some analytical view of distress, they might be able to help frame broad stories about the factors behind distress. True, by construction they can only provide an estimate of the likelihood of distress, not of its costs. But some rough idea of the costs can be derived from those associated in the past with the episodes of distress used in the calibration.

Their performance so far, however, has also revealed a number of shortcomings. The forecasting horizon in often quite short, more relevant for investors than policymakers (eg, typically not exceeding one year and sometimes as short as one month). The prediction may include information that is actually not available at the time the prediction is made (eg, Kaminsky and Reinhart (1999)). The choice of

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[18] Avesani et al (2006) derive a similar indicator, seeking to estimate the likelihood that more than one bank defaults, based on a latent factor model for an nth to default CDS basket. As in the case of Tarashev and Zhu (2008), the indicator refers to risk-neutral probabilities, ie probabilities weighted by agents' risk aversion. Thus, care should be taken when drawing inferences. An alternative approach is to derive stress indicators based on Merton models for banks (eg Segoviano and Goodhart (2007)) or the whole economy (eg, Gray et al (2006)). Other market based measures of the likelihood of co-distress among banks have been estimated by applying extreme value theory to stock prices (Hartman et al, (2005)), the conditional co-movement of large abnormal bank stock returns (Gropp and Moerman (2004)), co-movements in VaRs (Adrian and Brunnermeier (2007)). The basic message highlighted in the text would also apply to these indicators. Some of these measurement approaches have also been run in a stress-testing mode (eg Xin et al (2008)); see below.

[19] Researchers have also developed indicators based on combinations of balance sheet and market price data (eg, Bordo et al (2000)). Depending on the precise combination and calibration procedures, their properties would lie somewhere in between the two types.

[20] The statistical methodology varies. They range from threshold models calibrated based on noise-to-signal ratios (Kaminsky and Reinhart (1999) to multivariate regressions (eg, Demirguc-Kunt and Detragiache (1998 and 2005)). Mixtures of the two are also possible (Borio and Lowe (2004)).

independent variables may be excessively data driven, so that the "story" is not obvious and there may be a risk of overfitting at the cost of out-of-sample performance. They have a tendency to produce too many "false positives", ie to predict crises that do not occur, and their performance tends to be rather poor (Bell and Pain (2000)). More generally, they are open to the criticism that there is no guarantee that past relationships will hold in the future.[21]

In research with colleagues we have sought to develop simple indicators that overcome some of these limitations (eg, Borio and Lowe (2002a, b)). The indicators aim to predict banking crises over horizons that, depending on the calibration, range from 1 to 4 years ahead. They rely exclusively on information that is available at the time the predictions are made, ie they are truly real-time. They are quite parsimonious, relying on two or at most three variables, as they draw heavily on the endogenous cycle view of financial instability. The basic idea is that the *coexistence* of unusually rapid credit expansion and asset price increases points to the build-up of financial imbalances that at some point are likely to unwind. The indicators are intended to measure the co-existence of asset price misalignments with a limited capacity of the system to absorb the asset price reversal. Misalignments are simply captured by deviations of asset prices from a (one-sided) trend; the absorption capacity of the system by deviations of the ratio of private sector debt to GDP from a similar trend, both exceeding certain thresholds. The precise timing of the unwinding is impossible to predict, hence the use of flexible, long horizons.

In sample, the performance of these indicators is encouragingly good, with comparatively low noise-to-signal ratios despite their parsimony, alleviating the "false positive" problem. As a result, Fitch Ratings (2005) is now using a variant of this methodology to implement a top-down assessment of systemic risks, complementing its bottom-up approach based on individual banks' ratings.

But how would those indicators have performed more recently? In the Annex we take a first, preliminary shot at this question. In order to do so, with the benefit of additional data, we extend the previous indicators to incorporate explicitly property prices. We estimate the indicators for a sample of industrial countries over the period 1970 to 2003 and we do an out-of-sample forecast.

A number of conclusions stand out. First, the indicator does identify with a lead of at least a couple of years the emergence of problems in the United States, the country at the epicentre of the crisis. Second, it picks up most of the countries that have taken measures to prop up their banking systems, but it misses those where the problems have originated in foreign exposures, in this case to strains in the United States. This highlights an obvious limitation of the indicator in an increasingly globalised world: it is implicitly based on the assumption that the banks resident in one country are only exposed to financial

[21] Likewise, they cannot be used consistently to generate counterfactual stories based on alternative policy responses, as they normally do not include instruments. In fact, changes in policy regimes may be one reason why past relationships need not hold in future.

cycles in that country. Third, there are "only" a couple of cases in which false positive signals are issued, in countries that have seen sizable booms but as yet no financial distress. At the same time, this also depends on the specific definition of what constitutes a "crisis", which is especially ambiguous in real time when governments decide to take measures pre-emptively aimed at forestalling insolvencies and/or avoid their systems to be at a competitive disadvantage. The global response to the current crisis is quite unique in this regard. Overall, we conclude that despite its obvious limitations, this approach is rather promising as a way of identifying *general* vulnerabilities associated with credit and asset price booms.

Single-module measures: VARs

In the absence of structural econometric models, a potentially useful tool to carry out stability analysis could be VARs. VARs are largely data-driven representations of the economy, with few theoretical restrictions. Typically, a rather small set of variables are allowed to interact dynamically, with the dynamics ultimately driven by a set of exogenous shocks. In principle, if financial distress could be defined in terms of some of those variables (eg, as financial institutions' losses exceeding a certain threshold), the tool could be rather versatile. Through simulations, it can generate a probability distribution of outcomes for the endogenous variables and hence a measure of the probability of distress over any given horizon. For example, the tool could be used to calculate a value-at-risk (VaR) metric for the variable of interest. Alternatively, conditional on an assumed set of shocks, it could generate the implied value for the variable of interest. If the chosen shocks are outside the typical range observed in the sample, this procedure is akin to carrying out a stress test.

In theory, VARs are quite appealing. Depending on the horizon over which the forecasts are made, they can truly act as barometers rather than as thermometers of financial distress, providing a rich representation of the range of potential outcomes. They take into account interactions between variables and hence feedback effects. And they can provide the basis for some story telling, tracing the impact of propagation of shocks through the system, although the parameters of the VAR are not amenable to a structural interpretation.

In practice, however, VARs fall well short of this promise. The variables typically used to capture financial distress are rather rudimentary, such as non-performing loans or defaults in the corporate sector, and poorly modelled. Data limitations are a problem. The representation of the financial sector is cut to the bone and the range of possible shocks is quite limited, as the models have to be kept manageable for estimation and often exclude asset prices, which beyond a general equity price index are hard to incorporate. The lack of structure implies that the models have very little to say about the dynamics of distress. And the assumptions on which the models are built make it very hard to detect any fundamental

non-linearities associated with financial distress.[22] By construction, given their very nature and the estimation methods, the models capture average relationships among the data series, rather than how the series interact under stress, and are unable to incorporate boom-bust cycles.

This is illustrated in Graph II.5 and II.6, which show the results of a simple but representative exercise. Following Hoggarth et al (2005), who carried out the analysis for the United Kingdom, we replicate it for the United States. The VAR consists of the output gap, non-performing loans, inflation and the short-term (3 month) interest rate.[23] Two points stand out. First, as indicated by the impulse response functions, the macro-financial linkages are poorly modelled (Graph II.4). Non-performing loans respond little to economic slack or inflation and only to the interest rate. The response of output to non-performing loans is short lived, as an easing of monetary policy appears to attenuate the blow. Non-performing loans are largely determined by their own lagged behaviour.[24] Second, just as tellingly, even using an extreme stress test scenario, we cannot replicate the actual experience with non-performing loans (Graph II.5). We assume that a one-off unexpected inflationary shock hits the economy in Q1 2007 raising inflation in that quarter from below 2% to 6%. This is a level last experienced in early 1989. Inflation more than triples within one quarter, compared with an increase of at most 75% in any one quarter in the sample starting in 1970. Arguably, such a scenario would never have been run as a "severe, yet plausible" one, something stress tests aim to do. Notwithstanding the severity of the scenario, following an initial rise, non-performing loans start to drop back to the baseline after one year, given the properties inherent in the VAR model. This type of behaviour and results are quite typical for VARs and may explain why, to our knowledge, no central bank uses VARs on their own for a regular assessment of vulnerabilities.

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[22] Specifically, the models generally assume that the underlying relationships interact in a (log)linear fashion, so that, say, a three standard deviation shock has exactly the same impact as three times a one standard deviation shock. This assumption would be acceptable if the underlying data generating process was linear or the VAR was used to study the impact of small shocks around the equilibrium of the process. However, stress tests do not consider small shocks, and it is not likely that the relevant data generating processes are all log-linear over the relevant range. Drehmann et al. (2006) explore the log-linearity assumption and the impact of large macro shocks on aggregate liquidation rates in the United Kingdom. Whilst they find that non-linear models behave significantly different, they cannot provide strong evidence of feedback effects in their study.

[23] The VAR is estimated using quarterly data for the US from Q1 1990 to Q1 2008 with a lag-length of 4. The ordering is non-performing loans, growth, inflation and interest rates. Impulse response functions are derived using a Cholesky decomposition. Different unit root tests gave different messages concerning whether non-performing loans are stationary or not. For the purpose of this analysis, we assume that they are. As a robustness check we used growth rates in non-performing loans. In this case the shape of the impulse response functions is similar but the effects are even less significant.

[24] Hoggarth et al (2005) found some effect of growth on their measure of financial stability (write offs) but no effect in the opposite direction. Also in a VAR set-up, Carlson et al (2008) find that for the United States a higher median EDF for the banking sector depresses the profitability and investment of non-financial firms. Aspachs et al (2007) look at a panel VAR of 7 countries and find that their measures of financial fragility decrease GDP.

Multiple-module measures: Macro stress tests

The absence of fully-fledged structural models and the limitations of VARs have encouraged the use of multiple-module approaches to the assessment of financial distress: so-called macro stress tests generally fall in this category. By analogy with the stress tests for the portfolios of individual institutions, macro stress tests are designed to form a view of how the system as a whole would behave under exceptional but plausible adverse circumstances, ie in response to negative "shocks" drawn from the tail of the underlying probability distribution (eg, IMF and World Bank (2003)).[25] These measures are thus inspired by the "negative exogenous shock-amplification" view of financial instability. They effectively seek to replicate for the financial system the stress tests individual firms carry out on their portfolios.

Despite considerable differences, all macro stress tests share some characteristics (Drehmann (2008a)).[26] A macro engine, be this a VAR (eg, Pesaran et al (2006)), a traditional macro model (eg, Bunn et al (2005)) or a macro model linked to market risk drivers (Elsinger et al (2006)), is used to generate the shock and/or to trace out a scenario for macroeconomic variables, ie the change in the assumed "systematic risk factors". These are then used to shock the balance sheets of the relevant sector so as to assess more precisely their impact on its financial strength, measured in a variety of ways (Cihak (2007)). The analogy with banks' own stress tests is obvious.[27] Box 1 illustrates in more detail a couple of examples representative of the range of more advanced practices.

Box 1: Multi-module measures: some sophisticated examples

One of the earliest multi-module measurement models was developed by Elsinger et al. (2006) for the Austrian banking sector. It is still the most sophisticated model that is actually fully operational and is used to support both regular and ad-hoc financial stability assessments. The model integrates market risk, credit risk, interest rate risk and counterparty credit risk in the interbank sector. The model is able to use a credit register that has a very extensive coverage of on-balance sheet exposures. The model outputs can be represented by loss distributions for the whole financial sector or particular banks or as aggregate VaRs. The model can also be run in stress testing mode. Importantly, given the information about interbank exposures, the model can trace out how a default of one or more banks can spread through the system.[1] As banks are assumed not to adjust portfolios in reaction to the shocks, the model is always run with a one-quarter (single period) horizon.[2]

In a stress testing exercise that integrates credit and interest rate risk in the banking book, Drehmann et al (2008) are the first to model assets and liabilities simultaneously. This ensures that banks' balance sheets balance at each point in time during the simulation horizon. Whilst this is a basic accounting identity, it is something all other stress testing models ignore. Given its granularity, the

[25] This view can take the form of a point forecast conditional on some unusually large shocks or of a whole probability distribution, with its tail representing the outcomes of interest (eg, a Value-at-Risk (VaR) measure)

[26] For surveys of the range of practices, see Sorge (2004) and Drehmann (2008a,b).

[27] Thus, just as VARs or macro models draw on the financial accelerator literature, stress tests follow banks' approaches to risk management, which in turn is based on statistical approaches in the tradition of the actuarial sciences (Summer (2007)).

model provides a suitable framework to explore the impact on banks' profits and losses of different behavioural rules about the investment behaviour of banks once assets mature or profits accumulate. Alesandri et al (2008) take this model as one basic building block for a financial stability measurement model for the United Kingdom that also captures, albeit in a very rough way, both market risk and counterparty credit risk in the interbank market. Interestingly they also include a simple market liquidity component à la Cifuentes et al (2005) as an additional feedback channel.[3] Even though the model structure could offer an interesting starting point, changes in the investment behaviour of banks are not yet linked back to the macroeconomy, so that macroeconomic feedbacks cannot be analysed.

Macroeconomic feedbacks are the focus of the work by Jacobson et al (2005), who propose a reduced form approach for Sweden consisting of an aggregate VAR model that includes the average default frequency of companies as a measure of financial stability, a model linking macro and balance sheet specific factors to defaults of companies, and a module linking the evolution of balance sheets in response to macro factors. By integrating these three building blocks they show that there are significant feedback effects from financial stability back to the real economy. Given the non-linear nature of the model, they can also show that the impact of shocks is state dependent. For example, monetary policy seems to be more potent in recessions than in booms. De Graeve et al (2008) use the same methodology but can proxy financial stability more directly, as they model the default probably of banks in Germany. They find that bank capitalisation has significant implications for the transmission mechanism of shocks to banks' balance sheets and back.[4]

Whilst all these models make important contributions to the stress testing literature, none is so far able to combine all elements because of enormous technical difficulties and a lack of data. Important components missing so far are off-balance sheet items and funding liquidity. The former reflect serious data limitations. As for the latter, combining macro stress tests with a market-wide liquidity stress test in line with van den End (2008) could be an interesting starting point, even though it is doubtful that extreme reactions as currently observed can ever be captured.

[1] Elsinger et al (2006) find that second round effects associated with counterparty risk in the interbank market are of second order importance in their model. Joint defaults of banks are mostly driven by common exposures, ie exposures to systematic risk factors. [2] A recent version (Boss et al (2008)) extends the horizon to 3 years and a makes the assumption that all profits are immediately distributed to shareholders. No other reactions are allowed for. [3] The authors show that these feedback effects can be sizable, but this requires very strong and arguably unrealistic assumptions about the market risk component of the model. [4] In particular, they find that the impact of a monetary policy shock can be 6 times larger when the banking system is weakly capitalised.

Just like the stress tests for individual institutions, macro stress tests have become quite popular. They are explicitly forward-looking. They have the potential to cover a broad range of scenarios, not constrained by the probability distributions derived in estimation. They are quite helpful in tracing the propagation mechanism from shock to outcome and hence in story telling and communicating concerns. Above all, they can be much more granular than other approaches, relating scenarios to features of individual balance sheets. For example, information about interlinkages in the banking sector can be used to calculate knock-on effects from losses at individual institutions (Elsinger et al (2006)). The ultimate measures of distress, therefore, are closer to those that capture the concerns of policymakers, such as the erosion in the degree of capitalisation in the banking system.

Even so, their limitations should not be underestimated. Some of these have to do with the shortcomings of the individual modules. As already discussed, the macroeconomic modules do a very poor job of

incorporating financial variables, hardly ever going beyond equity prices and interest rates, regardless of whether VARs or other macroeconomic models are used.[28] Given that the macro model is the source of all shocks in these applications, episodes of distress that are not driven by macro factors cannot be simulated. This restricts the use considerably, as events, like the current crisis, cannot be captured. The relationship between macro risk factors and credit risk proxies is also often poorly modelled. And the balance sheets of the financial sector generally exclude important items. For example, given the enormous data requirements, current models are not able to account for off-balance sheet commitments, an item that has been at the heart of the recent crisis.

Other limitations relate to how the modules are linked. For one, the modular structure can easily result in internal inconsistencies, both conceptual and empirical, such as those that can arise from piece-wise estimation.[29] Moreover, there is a clear danger of excessive complexity, undermining robustness and ease of communication, both within the organisation and with the public. And most importantly, greater granularity and relevance are bought at the expense of ruling out interactions and feedback effects. After all, it is these interactions, within the financial system and between the financial between and the real economy, that lie at the heart of the dynamics of financial distress. This is especially serious when the horizon of the simulation exceeds one period, as it realistically should. The very fact that unusually *large* shocks are needed to produce any action suggests that the current generation of macro stress tests is missing essential elements of financial instability. As a result, there is a serious risk that, as carried out now, macro stress tests may underestimate the likelihood of financial distress and its potential magnitude.[30]

This is consistent with recent experience. To our knowledge, all the macro stress carried out before the recent financial turmoil failed to anticipate it as a possible relevant outcome. The tests indicated that the capital buffers in the system were perfectly adequate, and yet they came under considerable strain once the turmoil erupted.[31]

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[28] Thus, typical shocks would include changes in output, inflation or, less often, oil prices.

[29] An easy to make mistake would for example be to treat interest rates as I(1) variable in one module but I(0) in another.

[30] Moreover, from the perspective of the endogenous cycle view of financial instability, macro stress tests could at best capture the end-game, since by construction they trace out the impact of *negative* shocks. While this may be very useful in understanding the interaction in the financial system during a crisis and the potential costs, it may be less suited to identifying potential problems with a sufficient lead time for policy makers to react.

[31] In principle, one could envisage a highly complementary use of EWIs and macro-stress tests (eg, Borio (2003a)). The former can be used to measure the likelihood of distress, the latter its cost conditional on distress. As the previous analysis suggests, however, the inconsistencies between the two types of tools does not as yet make this feasible.

Box 2: Financial liberalisation and innovation – a problem for measurement models

All measurement models discussed rely on historical data to uncover the embedded behavioural relationships. Given this constraint and typical estimation methods, the models capture mainly average past relationships among the data series, rather than how the series interact under stress. The reliance on past data also implies that these models are not well suited to capture innovations or changes in market structure. And yet, innovations – be they financial, such as structured credit products, or "real", such as the invention of railways – are often at the centre of the build-up of imbalances and the following distress. Similarly, it is not uncommon for financial liberalisation episodes to trigger a boom that may prove unsustainable while at the same time changing the certain characteristics of the economy.[1]

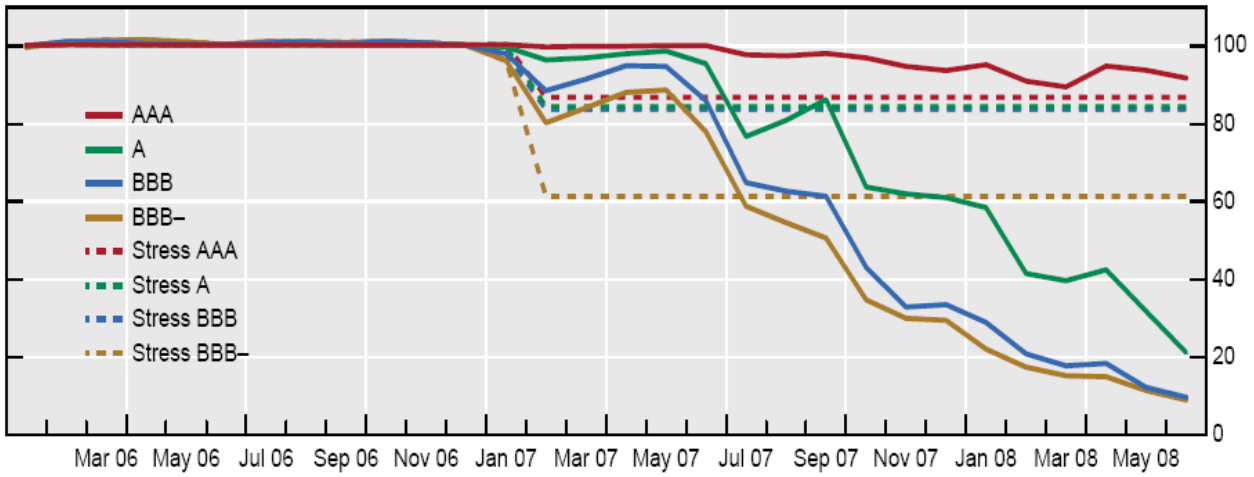
Even though this is rarely done, stress tests can help to challenge the projected risk characteristics of new products where limited or no historical data are available.[2] However, assumptions about the behaviour of new products have to be made. In practice, this implies that the characteristics of new products may be approximated by those of others for which historical information is available. This process involves potential pitfalls.

To illustrate this point we implement a micro stress test for a portfolio of asset-backed securities (ABS) exposures, following a procedure that was not uncommon prior to the crisis. The typical assumption was to proxy the default characteristics of ABS by those of corporate bonds of the same rating category. Based on this assumption, we implement a severe stress test scenario starting in February 2007.[3] An unspecified shock is assumed to lead to defaults in each rating category equal to the highest default rates ever observed for corporate bonds in that category. Essentially, these are default rates from the Great Depression. In addition, non-defaulted exposures experience a drop in prices which is three times the worst annual return on corporate bond indices for the various ratings over the period 1990 to the beginning of 2007.

Graph B2.1

Stress testing new products[1]

A simple stress test proxying ABS with corporate bonds[2]



[1] Solid lines: actual market prices for ABS index from JP Morgan for 2006.1 vintage for different ratings. Dotted lines: Impact of the hypothetical stress test for different ratings. Impact for BBB ratings worse than for A, but hard to distinguish in the graph. [2] ABS tranches are assumed to behave like bonds of the same rating category. Stress test scenario starts in February 2007. An unspecified shock is assumed to lead to defaults in each rating category equal to the highest default rates ever observed for corporate bonds in that category. In addition, non-defaulted exposures experience a drop in prices which is three times the worst annual return on corporate bond indices for the various ratings over the period 1990- beginning of 2007.

Source: JP Morgan; BIS calculation.

Only for AAA ratings is the outcome of this stress test worse than actual developments, while the impact for all other categories is much more benign. Admittedly, more appropriate pricing models should have fared better. But to replicate actual price developments, given the typical assumptions used at the time, it is likely that rather extreme scenarios would have been needed – something which is arguably not consistent with the stress tests' focus on "severe yet plausible" scenarios.

A more general point is apparent from eyeballing the graph. By definition, only limited data is available for new products and none of that would be taken from a crisis. Understanding the "true" statistical properties is therefore difficult, if not impossible, from an ex-ante perspective. Arguably, measurement models built on these statistical relationships will break down in precisely those scenarios that they aim to capture beforehand – a problem which is present for many financial times series more generally (see also Danielsson (2008)).

[1] The EWIs discussed in Box 1 are also subject to the criticism that they rely on historical relationships to predict future crises. However, they seek to focus on those factors that past experience indicates have been invariant across policy regimes and periods of financial innovations. [2] See Bunn et al (2005) for how this can be done in the context of macro stress testing. [3] Actual price levels are based on the ABX index from JP Morgan for the 2006.1 vintage for different ratings. The treatment of correlations is crucial for the pricing and evolution of structured credit products (eg Fender et al (2008)). This stress test implements a very simplistic correlation structure. It assumes that defaults occur independently but price changes are fully correlated.

An overall assessment

The discussion of quantitative measurement tools points to a number of conclusions.

First, the technology to measure the likelihood of financial distress in real time is still rather rudimentary. The tools generally provide little comfort in the estimates. And, with rare exceptions, the lead with which distress is assessed is insufficient to take remedial action. Most behave more like thermometers than true barometers of distress and/or risk lulling policymakers into a false sense of security. At the same time, those EWIs that draw on the endogenous cycle perspective on financial instability appear comparatively more promising.

Second, to our mind, the reasons for this unsatisfactory performance reflect a mixture of factors. For one, financial distress is an inherently rare event. Inevitably, this makes estimation with any degree of confidence very hard, even if the processes at work do not change fundamentally over time. Sufficiently long data series may not be available. And when they are, they typically span different economic structures, adding further to the uncertainty surrounding inferences. The very fact that financial innovation or regime shifts such as financial liberalisation are common features of crises adds uncertainty (Box 2). Relying on *other* countries' experience may help, but can also generate further doubt. Moreover, the available tools do a very poor job in capturing the interactions and non-linearities that lie at the heart of financial instability. They are unable to capture its very essence, namely outsized responses to normal-sized shocks. And there is considerable disagreement on what is the best analytical framework to guide the analysis.

Finally, all this implies that available quantitative tools do not impose sufficient discipline on the judgemental assessments of vulnerabilities routinely carried out in national and international fora (Borio and Shim (2007)). On the one hand, there has been an excessive tendency to "look at everything" without

a good sense of "how" to look at everything. On the other hand, there is still too much room for quasi-philosophical priors concerning the strength of the stabilising or destabilising nature of market forces to influence the final judgements.

III. Towards an operational framework: a way forward

The previous discussion indicates that the analytical basis for an operational financial stability framework is not very satisfactory. The definition of financial (in)stability has a number of agreed elements but is not very precise. There is no unified analytical framework that commands a broad consensus. The state of quantitative measurement is poor. As a result, measurement is fundamentally fuzzy.

At the same time, the shortcomings of this analytical basis should not be overstated, especially once the dual role of measurement is acknowledged. Rather, the operational framework should recognise both what we know and what we do not know. Overall, the analysis does point to a number of desirable features that any such framework could have and, by implication, to helpful steps forward. Some of the features are independent of the specific view one may have of the nature of financial instability, others call for more of a stand on this issue.

Desirable features: from microprudential to macroprudential

We highlight six desirable features.

First, any operational financial stability framework would have a macroprudential, as opposed to microprudential, orientation (Crockett (2000), Borio (2003a), Knight (2006) and Table III.1). It would focus on the financial system as a whole as opposed to individual institutions. The failure of individual institutions, regardless of their implications for the system, does not amount to financial instability. And it would explicitly treat aggregate risk as endogenous with respect to the collective behaviour of institutions rather than as exogenous, as individual economic agents would tend to do. This would help to address the wedge between actions that are rational for individual agents but that, collectively, do not result in desirable outcomes.

Second, while within the financial sector distinctions are hard to make, some institutions deserve more attention than others. If institutions are highly leveraged and/or engaged in substantial liquidity transformation, they are more vulnerable. And if they have large liabilities outstanding, are highly interconnected, play key roles (eg, wholesale payment services, market making in important derivatives

markets), their failure would be particularly disruptive for the system as a whole. [32] At the same time, a broad coverage is critical. For example, even if individually small, a large set of institutions could raise serious risks for the system as a whole if they are exposed to similar common risk factors. Moreover, the features that make institutions especially relevant for financial stability hardly apply to banks only.

Third, in the cross-section at a point in time, a macroprudential approach highlights the importance of common exposures across financial firms, ie exposures to systematic risk.[33] This holds true regardless of whether these exposures are direct, arising from claims on the non-financial sector, or indirect, reflecting exposures to each other. Other things equal, the higher the exposure to systematic risk, the higher is the threat to the financial system as a whole, as the institution is likely to incur losses *at the same time* as the others, making it harder to absorb them.[34] This is also bound to strengthen the endogenous amplifying mechanisms that generate financial distress and increase its cost for the real economy. As a result, a key principle of the approach is to calibrate prudential tools so as to increase the weight on systematic risk relative to idiosyncratic risk: at present, prudential requirements are generally set based on the overall risk profile of individual institutions, without making any distinction between the two.

Fourth, in the time dimension, the key principle of a macroprudential approach is to dampen the procyclicality of the financial system. This means encouraging the build-up of buffers (eg, in terms of institutions' capital and funding liquidity) in good times, during the expansion phase, so that they can be run down, in a controlled way, as harder times materialise and financial strains threaten to emerge. The build-up would strengthen the resilience of the system to the emergence of incipient distress as long as the buffers were allowed to operate as such. Crucially, this implies a willingness to allow them to be run down, since otherwise they act as minima and from shock absorbers turn into shock amplifiers. In addition, to the extent that it behaved as a kind of "dragging anchor", the build-up of buffers could also restrain risk-taking and any balance sheet overextension during the expansion. This, in turn, could mitigate the influence of any incentives to take on risk resulting from the anticipation of public support in the event of systemic distress ("moral hazard").[35]

Fifth, the operational framework would rely as far as possible on built-in (automatic) stabilisers rather than discretion. This would help address the limitations in the measurement of aggregate risks in real time,

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[32] The general point, also noted by Morris and Shin (2008), is that institutions whose "systemic impact factor" in terms of impact on others deserve special attention/tighter standards owing to the implications of their distress for the system as a whole.

[33] For theoretical analyses that explore some of the implications for the prudential framework of the distinction between systematic and idiosyncratic risk, including for issues such as diversification, see in particular Acharya (2001) and Wagner (2008a, b).

[34] See, in particular, Hellwig (1995) for the exploration of the pitfalls encountered in assessing the soundness of institutions in isolation as opposed to in a system context.

[35] See Acharya and Yorulmazer (2007) for a formalisation of this point.

which can make discretionary action error-prone. And it would limit the danger that, even when risks are correctly identified, action may not be taken at all, for fear of going against the manifest view of markets. The widespread failure to anticipate the recent credit crisis and, *even when general risks were identified*, to take remedial action, has hammered this message home.[36] Once in place, automatic stabilisers do not require continuous justification, and hence can act as an effective pre-commitment device. And provided they are linked to robust aspects of the financial cycle and are not too ambitious, they leave less room for policy error. Importantly, the corresponding measure need not track system-wide risk perfectly, but just provide a rough gauge. For example, it would be sufficient that the evolution of the stabilisers is related to some robust aspects of financial conditions measured relative to average historical experience (see below).

At the same time, automatic stabilisers and discretionary measures should not necessarily be seen as mutually exclusive. Discretionary measures could complement automatic stabilisers if the latter faced design limitations. Likewise, they might be more easily tailored to the nature of the build-up in risk-taking and vulnerabilities as long as these are identifiable in real time. They may also be harder to arbitrage away, as circumvention becomes easier over time. The key issue would be how to constrain and discipline any such discretion.

Finally, institutionally, any operational financial stability framework would also align as far as objectives with the control over relevant instruments and the know-how to use them. This is difficult. Financial stability is a task on which a whole range of policies have a bearing, well beyond prudential policies. And even within prudential arrangements, in many cases the institutional setup is not particularly conducive to an effective implementation of the macroprudential orientation. Not least, mandates tend to have a microprudential orientation. In particular, the presence of depositor/investor protection elements in the statutes of some supervisory authorities is not easily reconcilable with a system-wide perspective. And even when the instruments are available,[37] the embedded culture and expertise may not be quite sufficient. This may be less of an issue where central banks are in charge of supervision, given their natural comparative advantage in macroeconomic issues. But it could be a more relevant consideration elsewhere, where legal and accounting backgrounds are the rule.

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[36] To be sure, signs of building vulnerabilities were not hard to detect, especially if seen from the perspective of the endogenous cycle view of instability. And several observers, including in the official sector, did not hold back warnings to that effect, albeit sometimes in "coded" or at least rather guarded language (eg, BIS (2005, 2006 and 2007), Knight (2007), IMF (2007), ECB (2007), Bank of England (2007), Geithner (2007). Even so, there was a general tendency to overestimate the ability of the system to withstand shocks and to take comfort from what, on the surface, appeared to be strong levels of capitalisation and better risk management practices. And actual policy action to rein in risk-taking was limited, not least out of a concern that a tightening of prudential standards would inevitably be seen as going against the manifest view of markets.

[37] Control over instruments is often imperfect or limited. This is especially the case when other types of authorities are involved, such as those responsible for accounting and taxation.

Next steps

What might be the most promising next steps to edge closer to an effective operational financial stability framework? We consider three aspects in turn: improving the measurement of risk; strengthening the architecture of prudential arrangements; and putting in place an institutional set-up that supports the framework. As already noted, we focus only on prevention.

Measurement of risk

The overall objective in *risk measurement* would be to improve the way low-frequency, system-wide risks are evaluated. Better risk measures could not only be used for the calibration of policymakers' tools but also as inputs in firms' own risk assessments.

Our previous analysis would suggest a set of priorities in this area.

First, analytically, major steps are needed to develop better models of financial instability, marrying micro and macro aspects. A priority is to incorporate explicitly endogenous amplifying mechanisms. At present, no such operational models exist. Without them, for instance, there is a serious danger that macro stress tests will lull policymakers into a false sense of security.[38]

Second, for monitoring and calibration purposes, it is important to develop better information about the interlinkages and common exposures that exist in the financial system. As some of this information is bound to be regarded as confidential, it would have to be reported to the authorities and not disclosed publicly (Borio and Tsatsaronis (2004 and 2006)).

Finally, for the immediate future, working on EWIs appears more promising than on macro stress tests. We expect improvements in macro stress tests to require considerable time, owing to the analytical and informational demands involved. As long as EWIs are not too ambitious, they can help to highlight *general* risks to the financial system. Arguably, as suggested by recent empirical evidence, developing indicators that draw on the endogenous cycle view of financial instability is the most fruitful route. These indicators could be refined through better measures of financial system leverage and risk-taking, based on either price or balance sheet information.[39]

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[38] These limitations extend to models used for monetary policy. Despite confidence in their performance, it is obvious that their inability to capture the build-up of financial instability and the consequences of the materialisation of financial distress can lead policymakers astray (eg see Borio (2006)).

[39] Our analysis also points to a potentially serious limitation of this work as an input into individual firms' own risk assessments. Relative to those of policymakers, these assessments are even more vulnerable to two shortcomings (Borio et al (2001), Lowe (2002)). They make no attempt to endogenise risk with respect to the collective behaviour of economic agents. And they tend to focus on short horizons; in the case of banks, for instance, horizons range from a few days for trading books to at most one year for their loan books, making it more likely to assume the continuation of current conditions. These shortcomings can easily lead to highly procyclical risk measures that underestimate system-wide risk and its repercussions on the firms' own balance sheets. The problem here is that even if improvements in risk measurement technology were achieved, distortions

Architecture of prudential arrangements

The overall objective in structuring prudential arrangements would be to strengthen their macroprudential orientation, both in the cross-sectional and time dimensions. Consider each in turn.

In the cross-section, there are a number of ways of calibrating prudential tools so as to increase the weight on systematic risk relative to idiosyncratic risk. One could deliberately seek to estimate separately the exposures of individual institutions to the two sources of risk; alternatively, simpler proxies could be used based on the composition of balance sheets.[40] Similarly, for a given exposure to systematic sources of risk, institutions whose distress had a larger impact on the system as a whole would also be subject to tighter standards, given their importance as sources of indirect exposures in the system. Size is one relevant factor.[41] Building on existing arrangements, the increased weight on systematic risk could be achieved through transparent adjustments in the calibration of current prudential tools specifically designed to capture this aspect (what might be termed a "macroprudential overlay").

In the time dimension, there are several options to address the procyclicality of the financial system through the offsetting behaviour of prudential cushions. As this has been extensively discussed in other work (eg, Borio et al (2001), Borio (2003a), Borio and Shim (2007)), we highlight only a number of general considerations here.

First, a holistic approach is needed. A broad range of policies have an impact on the procyclicality of the system. Thus, the required adjustments in the prudential framework will depend on the characteristics of other policies and on any adjustments made to them. For example, the current trend towards fair value accounting is likely to add to procyclicality by making valuations more sensitive to the economic cycle, as it embeds evolving estimates of future cash flows and risk premia in the accounting figures (eg, Borio and Tsatsaronis (2004), Goodhart (2004), Adrian and Shin (2008)). Other obvious examples potentially having a first-order effect on procyclicality include the characteristics of deposit insurance schemes, of resolution procedures and of the monetary policy regime in place.[42]

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in incentives of individual firms would remain. They would hinder the lengthening of the horizon and could induce them to target levels of risk tolerance and risk-taking that, from the perspective of the system as a whole, could be inappropriate.

[40] An example of the former comprises statistical techniques designed to measure the sensitivity of an institution's return on assets to common risk factors. An example of the latter includes balance sheet exposures to sectors/industries (eg, real estate) and types of particularly cyclically-sensitive activities (eg, LBOs). For example, tighter prudential standards or concentration limits could be applied on that basis.

[41] To some extent, these arrangements are already in place in a number of jurisdictions (see Borio (2008b)).

[42] By comparison with pre-funded deposit insurance schemes, unfunded (survivor pays) ones increase procyclicality in the face of system-wide strains, by requiring payments precisely when capital is more scarce for institutions. See, for instance, Kashyap et al (2008) for a proposal to set up systemic insurance schemes activated by aggregate losses in the system. The same can be true of resolution procedures that are not conditional on the degree of stress in the financial system as a whole. And monetary policy frameworks that focus narrowly on the pursuit of price stability over short horizons may unwittingly accommodate the build-up of financial imbalances if

Second, within prudential arrangements, while a lot of attention has been devoted to capital requirements, several other possibilities are also worth considering. As a preliminary step, "prudential filters" can be applied to accounting figures to offset undesirable features, such as loan provisioning rules that are not sufficiently forward-looking and prudent (see below). As the availability of funding liquidity is procyclical, funding liquidity standards that rely on quantitative minimum requirements that are invariant to the state of the economy risk exacerbating financial strains once they emerge, by acting as shock amplifiers rather than shock absorbers.[43] Increasing variation margins when volatility spikes can have a similar effect (CGFS (1999), Borio (2003b)). High minimum-loan-to-value ratios can add to procyclicality by increasing the sensitivity of the supply of credit to the assets used as collateral (Borio et al (2001)). Arrangements could therefore be adjusted in all of these areas.

Third, at the same time, given their central role and far-reaching effects, capital standards remain a key potential area for adjustment. The spectrum of options for regulatory capital ranges from reducing its cyclical risk sensitivity to deliberately introducing elements of countercyclicality within the existing framework. There are various ways in which this can de done (eg, Gordy and Howells (2006)). Examples include: strengthening the through-the-cycle orientation of minimum capital requirements; setting the corresponding risk parameters based on smoothed outputs of financial institutions' internal risk models; and adding a countercyclical adjustment to the minima based on measures of the financial cycle (a form of "macroprudential overlay"). The adjustments could be hardwired to the minima (Pillar 1 in Basel II) or encouraged through the supervisory review process (Pillar 2).

Fourth, there a number of areas in which automatic stabilisers could be considered. In the area of collateral requirements, possibilities include seeking to implement through-the-cycle margining requirements (Geithner (2006)) and enforcing minimum loan-to-value ratios that are comparatively low and/or based on valuations that are less sensitive to market prices. Similarly, supervisors may consider that accounting standards do not allow for sufficiently forward-looking or prudent provisions, such as not permitting through-the-cycle provisions for loans, sometimes known as "dynamic provisions", based on average historical experience, in place until recently in Spain (Fernandez de Lis et al (2001)). In that case, they can add the difference between what they find appropriate and the accounting figures to minimum

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these take place when inflation remains low and stable (eg, Borio and Lowe (2002a), Borio and White (2004), Borio (2006)).

[43] For a discussion of liquidity standards that take a system-wide perspective into account, see Borio (2003b) and Morris and Shin (2008). Note that while Morris and Shin talk about putting in place "liquidity requirements" they presumably mean "liquidity buffers", since state or time (state) invariant liquidity requirements would act as amplifiers at times of stress. For a discussion of the interaction between market and funding liquidity, see Borio (2003b), for its theoretical modelling, Brunnermeier and Pedersen (2007) and, for a survey, Shim and von Peter (2007).

capital requirements.[44] Importantly, adjustments to capital standards within the existing framework could be made based on specific rules rather than discretion. A possibility worth examining would be to index the macroprudential overlay to some measure of the financial cycle. For example, one could tie capital standards *inversely* to measures of risk premia or indicators of market perceptions of financial institutions' strength, exploiting their thermometer characteristics. Alternatively, one could tie them *positively* to aggregate credit growth or asset prices relative to trend, exploiting their barometer features.

Finally, regardless of specifics, for arrangements to be successful they will need to constrain the room for regulatory arbitrage, both across countries and as between the regulated and unregulated sectors. Across countries, this raises thorny issues of coordination between home and host authorities.[45] The harder challenge, however, is how to constrain behaviour outside the regulated sector. To the extent that an indirect approach based on restrictions on the regulated institutions proved insufficient, the extension of the coverage of prudential instruments would need to be considered.

Institutional set-up

Two key issues that need to be addressed in the institutional set-up for the implementation of the framework are the needs to ensure accountability and to align objectives with the available know-how.

Accountability calls for a clear mandate, transparency and effective processes to hold policymakers responsible. Accountability is especially important to discipline any reliance on discretion that complements automatic stabilisers. It can generally be enhanced by making sure that the measures used are as simple and transparent as possible. One could imagine a set-up similar to the one now being employed for monetary policy. At the same time, given the lags involved and the inevitable "fuzziness" in definition and measurement, it would be unrealistic to expect that an equivalent degree of accountability and transparency is feasible.

Addressing the imperfect alignment between goals, instruments and know-how in the institutional set-up is a difficult and controversial task. At a minimum, a financial stability framework with a macroprudential orientation requires close cooperation between a broad range of authorities with respect to both its

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[44] Admittedly, this is less effective than adjustments directly made to accounting standards. Even if publicly disclosed, such "prudential provisions" may be less effective in reducing procyclicality than if dynamic provisions were allowed for accounting purposes: since they are not charged against current income, prudential provisions forgo the disciplinary effect that operates through the market's focus on the earnings (bottom line) figure. Even so, they can help constrain dividend payments during expansions, thereby increasing the size of the capital buffers, and they release buffers when losses materialise, and accounting provisions spike.

[45] Financial and real conditions may and do differ across countries. For institutions with international operations, this would suggest calibrating instruments with respect to their individual consolidated exposures to the corresponding country's conditions rather than based on the nationality/residence of the firm. These exposures could derive from cross-border lending or direct operations in host countries.

development and implementation. The close bearing on financial stability of a wide range of policies, under the responsibility of authorities with very different perspectives, requires this.

At the same time, a key ingredient of success is to leverage the comparative advantage of the various authorities involved. This is especially important for monetary and prudential authorities. Monetary authorities have an edge in understanding the nexus between the macro-economy and the financial system and the functioning of financial markets. Prudential authorities have an edge in understanding the risk management practices of the regulated institutions. For instance, one could set up special committees involving these types of authority charged with implementing those macroprudential overlays in regulatory and supervisory tools executed on a discretionary basis.

Conclusion

The measurement of financial (in)stability is fundamentally "fuzzy". This reflects a number of factors: a lack of consensus on the most appropriate analytical framework; the infrequent incidence of episodes of financial distress; and limitations in the available measurement tools. These tools are very poor at capturing the feedback effects that are at the heart of financial instability and that operate both within the financial system and between the financial system and the real economy. At their best, they can provide indications of the general build-up in risks. As a result, there is always a danger that policymakers may be lulled into a false sense of security.

No doubt these shortcomings are serious: there is a urgent need for further analytical and empirical work to address them. We have suggested what the most promising directions might be. But notwithstanding them, there is still ample scope for progress in establishing a more effective operational framework for financial stability as long as these shortcomings are fully taken into account.

We have argued that progress can be made in several ways: by strengthening the macroprudential orientation of financial regulation and supervision; by addressing more systematically the procyclicality of the financial system; by relying as far as possible on automatic stabilisers rather than discretion while disciplining the use of any such discretion; and by setting up institutional arrangements that leverage the comparative expertise of the various authorities involved in safeguarding financial stability, not least financial supervisors and central banks. The global credit crisis that has engulfed financial systems since the summer of 2007 provides a unique opportunity for steps in this direction.

Annex 1: Endogenous cycles and EWIs

This annex is a first, preliminary attempt to update and extend the EWIs developed by Borio and Lowe (2002a,b and 2004) and to assess how they would have fared prior to the current crisis. It refines the previous indicators by introducing property prices alongside equity prices.

As discussed in the main text, Borio and Lowe's approach is grounded in the endogenous cycle view of financial instability. They argue that the coexistence of unusually rapid credit growth and asset price increases indicates the build-up of financial imbalances that raise the likelihood of subsequent financial distress. They develop EWIs drawing on a large set of industrial and emerging market countries. Their proxy for misaligned asset prices is an asset price gap (measured by the deviation of inflation-adjusted (real) equity prices from their long term trend); and that for credit booms is a credit gap (measured by deviations of the ratio of private sector credit to GDP from its trend). The trends are calculated on the basis of one-sided Hodrick-Prescott filters. They assess various combinations and thresholds and find that for industrial countries the EWI has the best performance in terms of low noise-to-signal ratio as well as the percentage of crises predicted when a warning signal is issued if the credit gap exceeds 4 percentage points and the equity price gap is greater than 40%.[46] Flexible horizons are incorporated by analysing forecast intervals that vary in length, from 1 to 3 years ahead.[47]

One drawback of that analysis, as already pointed out at the time, is that property prices were not included in the indicator. With the benefit of a few more observations, here we extend the analysis to include them. This is critical to make proper inferences in the current episode, where the lag between the peak in equity and property prices has been considerably longer than in the previous episodes (Borio and McGuire (2004)). The exercise is carried out for 18 industrial countries.[48]

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[46] The noise-to-signal ratio is the ratio of the fraction of Type II errors (ie the number of (false) positive signals issued relative to non-crises periods) over 1 minus the fraction of Type I errors (ie the number of instances in which no signal was issued relative to the number of crises observed). Several studies minimise the noise-to-signal ratio and thereby weigh both types of error equally (eg Kaminsky and Reinhart (1999)). Borio and Lowe argue that for practical policy purposes equal weighting is not appropriate and they apply judgment to derive what constitutes the best threshold, giving more weight to Type I error.

[47] They assume that that the signal is correct if a crisis occurs in *any* of the years included in the horizon. For example, for a 3 year horizon, a correct signal is given if the credit gap and the equity gap jointly exceed their corresponding thresholds least in one of the 3 years prior to a crisis.

[48] The countries included in the sample are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States. We use annual data. Our sample size is restricted by the property price indices, which combines retail and commercial property indices, and that for most countries are available only from 1970 onwards. All gaps are measured as percentage deviations from a one-sided Hodrick-Prescott trend (with lambda=1600), which only uses information that is available at the point in time the prediction is made. A gap is only calculated if at least 10 years of data are available. Therefore, the sample used for the calibration of the thresholds is from 1980 until 2003. In this period 13 crises occur. The timing of crisis is based on Borio and Lowe (2002a) and extended based on Laeven and Valencia (2008).

We construct a credit gap, an equity gap and a property price gap. The property price gap combines both residential and commercial property prices, with weights that are rough estimates of their shares in private sector wealth. We then assess the performance of the EWI in terms of the percent of crises predicted and the noise-to-signal ratio for different thresholds, estimating the best indicators through a grid search. We carry out the analysis "in sample", ie up to 2003, and then forecast out of sample, over the remaining years, ending in 2007, the last full year for which we have data, and in 2008 for the information concerning the crises. Table A.1 summarises the results.

In sample, we find that the best performance is achieved if the credit gap exceeds 6% and at the same time either the equity gap exceeds 60% or the property gap exceeds a threshold that ranges from 15 to 25%. Especially for horizons of up to 2 years, a threshold of 15% is relatively attractive, as it predicts a high proportion of crises (some 70%), albeit it produces a higher percentage of false alarms. For a horizon of up to three years, a higher threshold is preferable, as financial distress does eventually emerge and the noise-to-signal ratio is lower. As expected, the predictive power increases and the noise-to-signal ratio decreases as the horizon is lengthened, confirming that the timing of the reversal of the financial imbalance is very hard to predict. Comparing the different thresholds it is apparent that a higher threshold implies lower predictive power but also a lower noise-to-signal ratio.

Table A.1

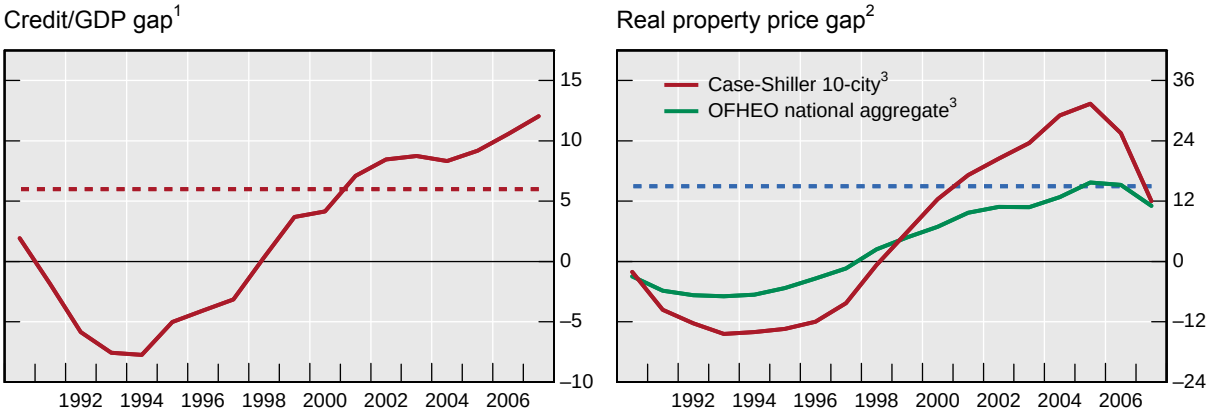
Horizon	In sample		Out of sample (Definition 1)		Out of sample (Definition 2)	
	% crises predicted	Noise/signal	% crises predicted	Noise/signal	% crises predicted	Noise/signal
(**property gap>15**% or equity gap> 60%) and credit gap >6%						
1	46	0.23	67	0.53	50	0.65
2	69	0.13	67	0.53	50	0.69
3	69	0.11	67	0.53	64	0.52
(**property gap>20%** or equity gap> 60%) and credit gap >6%						
1	31	0.21	33	0.53	21	0.82
2	54	0.11	33	0.50	29	0.97
3	69	0.07	33	0.47	36	0.70
(**property gap>25%** or equity gap> 60%) and credit gap >6%						
1	31	0.18	33	0.24	7	1.40
2	46	0.11	33	0.19	7	1.62
3	62	0.06	33	0.13	7	2.33

Note: A gap is measured as percentage points from an *ex ante*, recursively calculated Hodrick-Prescott trend (lambda=1600). Thresholds are given in percent. A signal is correct if a crisis takes place in any one of the years included in the horizon ahead.

How do the indicators perform in the more recent period? As an illustration, Graph A.1 plots the credit and property gaps for the Unites States, the epicentre of the crisis. We do not plot the equity price gap, since it was exceeded at the time of the dotcom boom but, subsequently, turned negative.

Graph A.1

Estimated gaps for the United States



Gaps are estimated using a rolling Hodrick-Prescott filter with lambda set to 1600. The horizontal dashed lines refer to the threshold values that define the existence of a boom. 6% for Credit/GDP gap; 15% for real property price gap.

[1] In percentage points. [2] In per cent; refers to combined residential and commercial property prices. [3] Refers to the residential property price component.

Source: BIS calculations.

The graph indicates that the indicator would have picked up the vulnerabilities. Taken at face value, signs of vulnerabilities began to emerge as far back as 2001, as both the credit gap and the property price gap started to exceed the critical threshold jointly, at least if the residential component of the property price index is measured by the Case-Shiller 10-city index. If the less variable OFHEO index is used, the threshold is reached only in 2005.[49]

A more formal out-of-sample exercise covering all the industrial countries for which data are available is harder to perform at this early stage, in the midst of the turmoil. At least two problems emerge. First, given that the flexible horizon extends up to three years, we can only fully assess the predictive content of the signals issued in 2004; for subsequent ones the full horizon has not yet materialised. Second, and more importantly, defining which country is in distress is not unambiguous. This highlights some of the issues raised in assessing financial instability, especially in real time.

To address the ambiguity in the identification of the crisis, we adopt two definitions, going from the more to the less restrictive:[50]

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[49] The gap based on property prices using the Case-Shiller aggregate index is in between the other two and breaches the critical threshold in 2003. The in-sample estimates presented in Table A.1 are unaffected by the choice of the property price measure for the United States.

[50] The cut-off date for this analysis was 20 October 2008 and depending on future developments the classifications of which country is in turmoil may change. For simplicity, we assume that crises start in 2007, even though most policy measures were adopted in 2008. We also used the alternative assumption that all crises started in 2008. In this case one problem is that for four countries (Belgium, Canada, Denmark and the United Kingdom) residential

Definition 1: Countries where more than one large bank failed or had to be supported by the government in an emergency operation.[51]

Definition 2: Countries that undertook at least one of the following policy operations: extend deposit insurance guarantees beyond the household sector, buy assets or undertake capital injections.[52]

Based on Definition 1, only 3 countries have faced a crisis, viz. the United States, the United Kingdom and Belgium. Based on Definition 2, 14 out of the 18 countries have faced distress.

On balance, the performance of the indicator is encouraging, although far from perfect and a function of the definition used. Clearly, the variant of the indicator based on the lowest threshold for property prices (15%) performs best: the others fail to pick a significant number of cases. And while the noise-of-signal ratio increases considerably compared with the in-sample estimates, a look behind the aggregate numbers is quite revealing. If Definition 1 is used, it picks 2 out of 3 cases independent of the forecast horizon; the one missed is Belgium. If Definition 2 is used, the three year indicator picks 9 out of the 14 crises; those missed are Germany, Switzerland, Belgium, Canada, and the Netherlands At the same time, only two false positive signals are issued for Denmark and New Zealand.

The results suggest a number of observations. First, while the indicator does identify distress in the country that has been at the epicentre of the crisis, the United States, it fails to pick the international transmission of the problems. In particular, it does not capture those cases in which banks have run into trouble as a result of losses on their international exposures in the absence of signs of financial imbalances in the domestic economy, most notably in Germany and Switzerland.[53] This is no surprise, since by construction the indicator assumes that banks in any given country are exposed only to the financial cycle in that country. Obviously, this is an aspect that calls for improvement and has implications

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and/or commercial property prices are not available for 2007, so that the property gap cannot be fully estimated. Based on judgmental estimates, we found comparable results, except that also the crisis in Belgium can be successfully predicted. For exploratory reasons we also used two additional definitions of crises: Definition 2(a) is similar to Definition 2 except that it identifies a crisis if countries adopted at least two of the policy measures. Results are very similar to those for Definition 2. Definition 2(b) is the least restrictive, as it includes any of the policy measures listed in Definition 2 as well as an expansion of the coverage of deposit insurance for retail deposits. As all countries except for Japan have implemented at least one of these policies, the noise-to-signal ratio drops to zero since our EWI correctly predicts that Japan is not a crises country.

[51] The countries which are in a crisis according to this definition are: the United States, the United Kingdom and Belgium.

[52] We take account of policy actions which have been announced but may not yet be fully implemented. The countries which are in a crisis according to this definition are: Australia, Belgium, Canada, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States.

[53] Canada and the Netherlands exceed the threshold in terms of either credit growth or property prices but not both. In Belgium, the property price gap in 2006 was 14.45, just below the threshold. Furthermore, in 2007, the credit gap was above 10. Even though data are only available until mid-2007, they suggest that the property price gap in this year would also have been greater than 15.

for the calibration of prudential arrangements (see main text). Second, the countries for which the indicator issues false positive signals include two that have exhibited sizable booms and in at least one of them, Denmark, one institution has already failed. We may need to wait longer to see exactly how the indicator performs.

A broader issue is also apparent. Which definition of distress is more appropriate? Definition 1 excludes preventive policies designed to deal with the threat of imminent distress; Definition 2 includes them. Conceptually, Definition 2 is arguably more appropriate. We take the view that the extraordinary measures included in the definition are forms of crisis *management* rather than *prevention*: the system should be capable of being stable without them. At the same time, this ambiguity does highlight the grey area that exists when the authorities try to intervene quite early in the game, before more obvious signs of insolvency are apparent. These ambiguities are compounded when actions are taken partly to address the spill-over effects of policies taken in other countries. The extension of guarantees to prevent a drain of funding in the domestic market is an obvious example. Would distress fail to materialise without them? This type of "policy contagion" is quite novel in recent experience and reflects the global nature of the crisis when several highly interdependent financial systems are facing incipient strains simultaneously.

Overall, we conclude that the recent credit crisis confirms the usefulness of the family of indicators rooted on the "endogenous" cycle view of financial instability. At the same time, it also highlights some of their limitations and the potential scope for improvement.

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Table

Table III.1*
The macro- and microprudential perspectives compared

	Macroprudential	**Microprudential**
Proximate objective	limit financial system-wide distress	limit distress of individual institutions
Ultimate objective	avoid output (GDP) costs linked to financial instability	consumer (investor/depositor) protection
Characterisation of risk	Seen as dependent on collective behaviour ("endogenous")	Seen as independent of individual agents' behaviour ("exogenous")
Correlations and common exposures across institutions	important	irrelevant
Calibration of prudential controls	in terms of system-wide risk; top-down	in terms of risks of individual institutions; bottom-up

* As defined, the two perspectives are intentionally stylised. They are intended to highlight two orientations that inevitably *coexist* in current prudential frameworks.

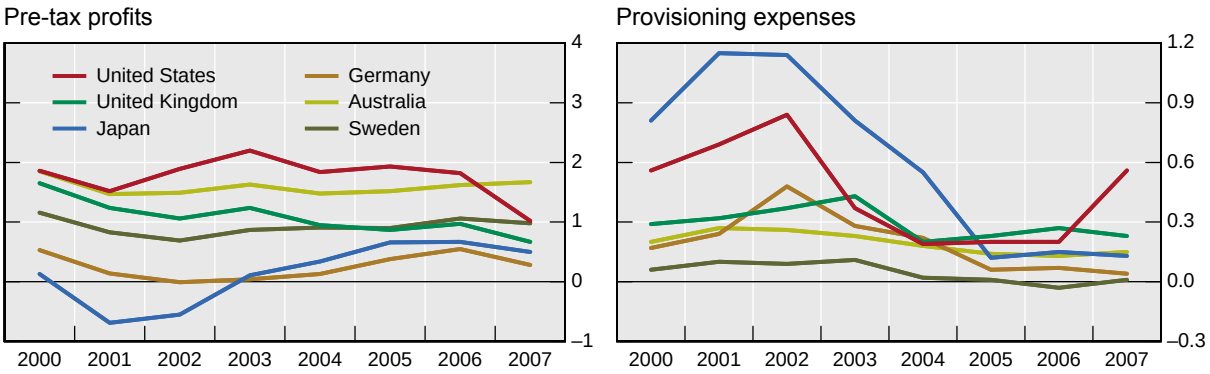
Source: Borio (2003).

Graphs

Graph II.1

Profits and provisioning

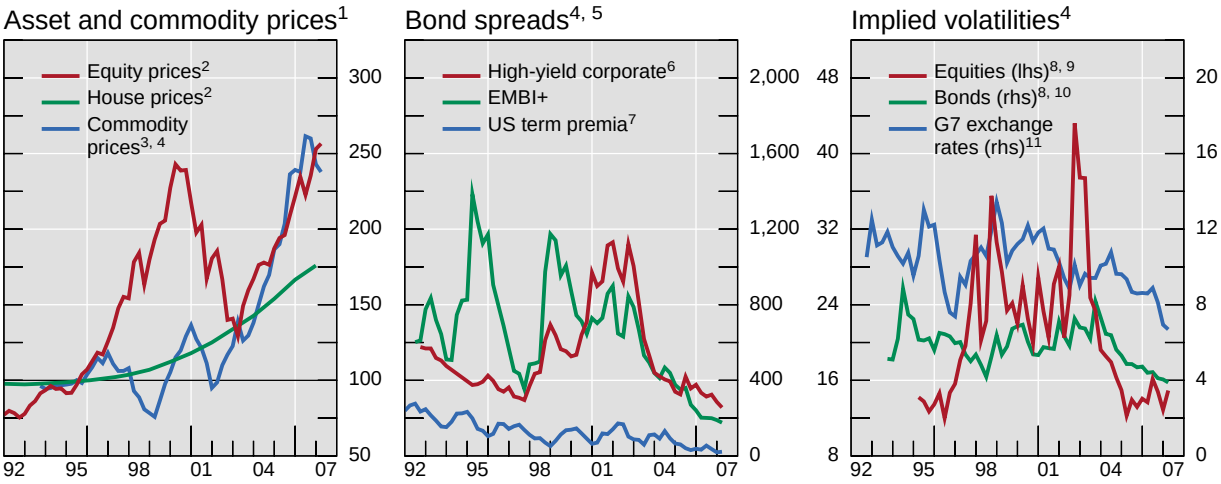
As a percentage of total assets



Source: BIS annual reports from 2003 to 2008.

Graph II.2

Buoyant asset markets

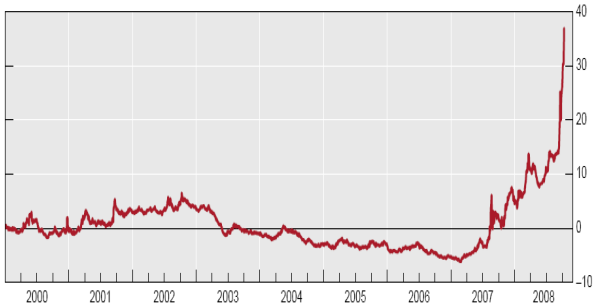


[1] 1995 = 100. [2] Sixteen OECD countries; weighted averages based on 2000 GDP and PPP exchange rates. [3] Goldman Sachs Commodity Index, in US dollar terms. [4] Quarterly averages. [5] In basis points. [6] As from December 1997, simple average of US and euro area high-yield indices, otherwise only US. [7] Estimated for 10-year zero coupon Treasuries. [8] Simple average of US and Germany. [9] Derived from the price of call option contracts on stock market indices. [10] Price volatility implied by the price of call options on 10-year government bond futures contracts. [11] JPMorgan benchmark index for the level of G7 currencies' implied volatility.

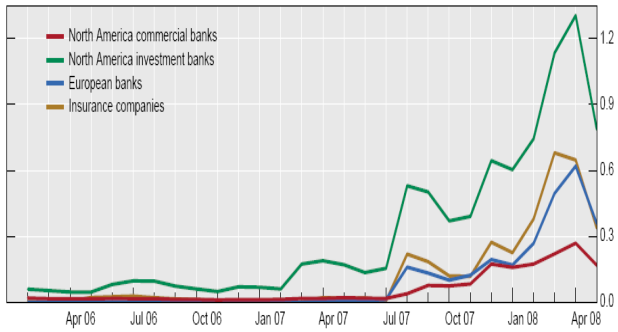
Sources: Bloomberg; Datastream; Merrill Lynch; JPMorgan Chase; OECD; national data.

Graph II.3
Market indices of stress

Financial stress index for the United States[1]



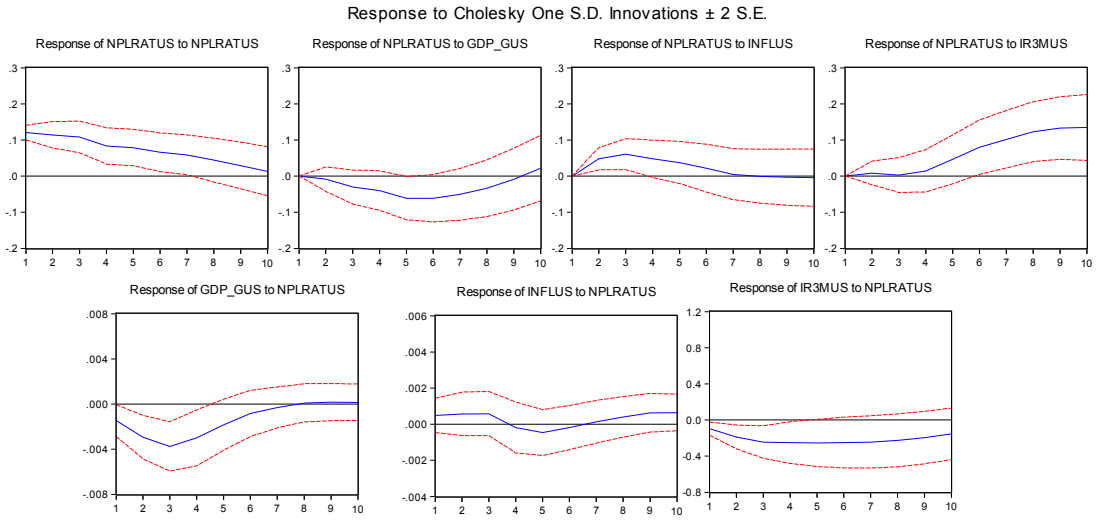
Price of insurance against systemic distress by financial segment[2]



[1] Demeaned variance-weighted average (from 1995) of the following indicators: bank bond spread (banks' long-term bond yield against US Treasuries), corporate bond spread (corporate long-term bond yield against US Treasuries), liquidity spread (3-month USD Libor against T-bills), interest rate spread (long-term US Treasury bond yield against 3-month T-bills), banks' beta (covariance between bank and total market equity returns / variance of total market returns) and CMAX of equity (index current value / one-year high). For more detailed definitions of individual indicators and different weighting methods, see Illing and Liu (2006). [2] In per cent. Based on credit default swap (CDS) spreads for 10 commercial and eight investment banks headquartered in North America, 16 universal banks headquartered in Europe and 14 insurance companies headquartered in the United States and Europe. Risk neutral expectation of credit losses that equal or exceed 15% of the corresponding segments' combined liabilities in 2006 (per unit of exposure to these liabilities). Risk neutral expectations comprise expectations of actual losses and preferences.

Sources: Bankscope; Datastream; national data; Markit; BIS calculations.

Graph II. 4
Impulse response functions of a FS VAR for the US[1]

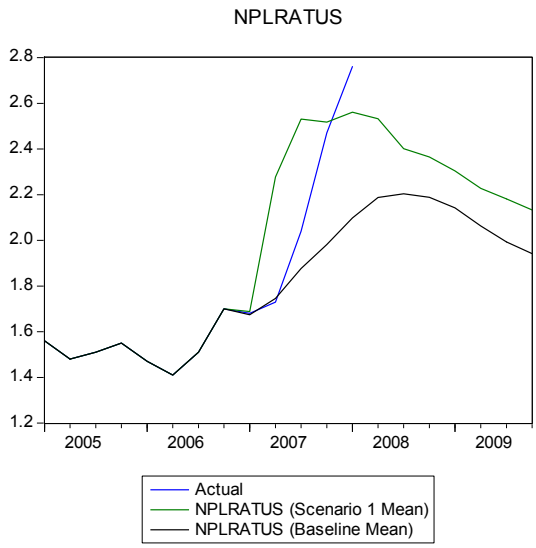


[1] GDP_GUS: the annual growth rate of real GDP; INFL_US: annual CPI inflation; IR3MUS: 3 month risk free nominal interest rate; NPLRATUS: the ratio of non-performing loans to total loans. Impulse response functions are derived using a Cholesky decomposition.

Source: National data; BIS calculations.

Graph II. 5

A simple stress test of non-performing loans for the US[1]



[1] NPLRATUS: ratio of non-performing loans to total loans. *Baseline Mean* is the mean forecast of NPLRATUS assuming no shock, starting in Q1 2007. *Scenario 1 Mean* is the mean forecast of NPLRATUS assuming a one-off inflationary shock raising inflation to 6% in Q1 2007. *Actual* is the actual development of NPLRATUS.

Source: National data; BIS calculations.

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