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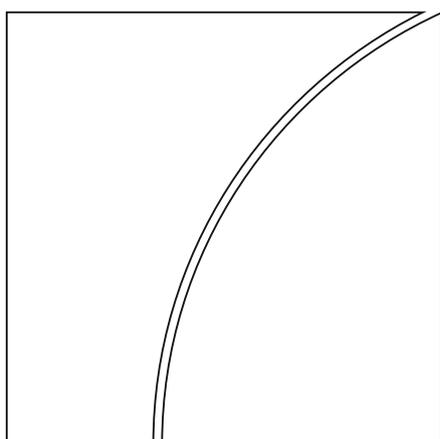
### Experiences with the ex ante appraisal of macro- prudential instruments

Report submitted by a Study Group established by the  
Committee on the Global Financial System

The Group was chaired by Anne Le Lorier, Bank of France

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## Preface

Macroprudential policy is actively practised, with instruments being introduced and operated in many jurisdictions. Yet the lack of an established analytical framework remains a challenge for the assessment of benefits and potential negative side effects of these instruments.

The Committee on the Global Financial System (CGFS) has an ongoing interest in the conceptual and practical aspects of macroprudential policymaking. It mandated a Study Group chaired by Anne Le Lorier (Bank of France) to provide an overview of central banks' experiences in assessing the benefits and possible adverse implications of macroprudential tools. The objective was to provide a stocktake of these approaches, derive lessons from these experiences and identify areas where further analytical development would be particularly useful.

The following report summarises the Group's main findings. It provides an overview of the experiences of central banks with approaches and methodologies used in appraisals as well as of how the appraisals are used in operational decision-making. The Study Group found that there is a definite trend towards more quantitative analysis in ex ante appraisals, but expert judgment retains a very important role in the setting of policy. This is particularly the case in assessing the influence of policy on market participants' behaviour and expectations. A key message of the report is that governance arrangements should promote wider cooperation in conducting appraisals because these exercises require a diverse set of skills and depend on the setting of other policies.

I hope that this work can contribute to the better understanding of the operationalisation of macroprudential policymaking, and can serve as a resource for policymakers interested in the practicalities of ex ante appraisals of macroprudential instruments.

William C Dudley

Chair, Committee on the Global Financial System  
President, Federal Reserve Bank of New York

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## Executive summary

In the wake of the global financial crisis, macroprudential policy practice has moved ahead of associated theory. The crisis spurred policymakers' interest in tools that can address system-wide vulnerabilities. New macroprudential instruments have been introduced and existing ones have been recalibrated with a macroprudential perspective. This policy making has taken place despite the fact that the conceptual and analytical underpinnings of macroprudential policy remain at an early stage of development.

This gap between the conceptual framework and the practical requirements of policymaking presents challenges to authorities. One such challenge is related to the appraisal of policy effectiveness ahead of deployment of instruments ("ex-ante appraisals"). Appraisals refer to the quantitative analysis of how the deployment of an instrument may help achieve financial stability objectives and how this benefit balances against any adverse economic and financial side effects.

This report provides an overview of the experiences central banks have gathered with ex ante appraisals of macroprudential instruments and identifies areas where further analytical development would be particularly useful. It starts with a description of different approaches policymakers have used to produce quantitative and operational objectives for macroprudential policy, and a classification of the analytical methodologies employed in appraisals. The main part of the report discusses how these different methodologies have been used in practice to assess the impact of macroprudential instruments in different stages of practical decision-making such as: the assessment of risks and vulnerabilities as well as the selection of the appropriate instrument, the timing of the activation of the instrument, and the calibration of the intensity of the instrument. In all cases the discussion is illustrated with actual experiences in different jurisdictions.

The overview suggests that often policy has to devise new analytical methodologies and explore (or create) novel data sources to conduct appraisals. Consequently, no single preferred approach has (yet) emerged. The relative advantages of any particular approach depend on a range of factors, including: the nature of the instrument under consideration; the macro-financial structural and conjunctural characteristics of the jurisdiction applying the instrument; the level of familiarity with analytical methodologies; the availability of data; and governance arrangements. Another important factor in driving this decision relates to the ease of communication of the results to key stakeholders.

That said, two general messages can be drawn from the overview of experiences. They relate to the importance of inclusive governance in the conduct of appraisals and the relative role of quantitative analysis and judgment.

**Governance arrangements should promote wider cooperation in conducting appraisals.** Ex ante appraisals of macroprudential instruments require expertise in a number of areas: how regulation impacts financial institutions, how financial markets react to structural changes, how monetary and microprudential policy may interact with macroprudential policy, how the real and financial sectors interact, etc. These skills are unlikely to be all available within the same organisational unit. Furthermore, when instruments are best activated, and how they are calibrated, may depend on the setting of other policies. Hence, cooperation across organisational units and/or policy authorities is essential.

**Macroprudential policymaking relies increasingly on quantitative analysis, but this does not obviate the reliance on judgment.** The wealth of quantitative approaches employed attests to a growing tendency to enhance the analytical support of policymaking. If anything, this trend is likely to continue.

However, independently of the approach taken to appraisals, expert judgment retains an overriding role. One reason is that data and analytical tools are not as developed. Another reason is the influence of policy on market participants' behaviour and expectations. The responses of expectations and behaviour is a key factor for the impact of deploying the policy instrument but at the same time it is an area in which quantitative approaches so far offer little guidance. Continued improvement of models and of data sources at the household and firm level would be beneficial to further progress in this area.

An ancillary conclusion of this report, and a suggestion implicit in the Study Group's discussions, is the value of a continued exchange of views and experiences among those involved in promoting research and fostering the analytical support to macroprudential policy.

# 1. Introduction

In the wake of the global financial crisis, macroprudential policy practice has moved ahead of associated theory. The crisis spurred policymakers' interest in tools that can address system-wide vulnerabilities. Consequently, new macroprudential instruments have been introduced or existing ones have been recalibrated with a macroprudential perspective despite the fact that the conceptual and analytical underpinnings of macroprudential policy are at an early stage of development.

This gap between the conceptual framework and the practical requirements of policymaking presents challenges to authorities. One such challenge is related to the appraisal of policy effectiveness ahead of deployment of instruments and the evaluation of policy success after implementation. Lack of well-established and easily measurable objectives of policy, or a generally accepted analytical paradigm for the assessment of policy impact on financial stability and the economy at large, imply that often policy has to develop new practical approaches to appraisals. These approaches may relate to the analytical methodologies used and/or to novel data sources.

The CGFS mandated a Study Group to provide an overview of the experiences central banks have gathered with ex ante appraisals of macroprudential instruments. The motivation is to provide a stocktake of these approaches, derive lessons from these experiences and identify areas where further analytical development would be particularly useful. Appraisals refer to the quantitative analysis of how the deployment of an instrument may help achieve financial stability objectives and how this benefit balances against any adverse economic and financial side effects. They provide valuable input to the policymakers' decision-making regarding the effectiveness and limitations of the instrument. Publication of the analysis can enhance the communication of policy.

This report presents the findings of the Study Group.<sup>1</sup> It builds on contributions of its members as well as on the information gathered in a workshop held on 26 January 2016. It provides an overview of the experiences of central banks with approaches and methodologies used in appraisals as well as of how the appraisals are used in operational decision-making. The primary focus of the report is on analysis that supports the design and deployment (ie timing of activation and calibration) of instruments. It also touches upon, albeit in a less systematic manner, two other areas in policy instrument evaluation linked with ex ante appraisals: the use of quantitative assessments in deciding which instrument to use in cases when several are available; and the ex post evaluation of instrument effectiveness where analytical methods can be used that are similar to those applied in ex ante appraisals.

The rest of this report is organised in five sections. Section 2 describes how overall macroprudential objectives have been made sufficiently concrete to be quantified. Section 3 presents a brief overview of methods that have been used in ex ante appraisals. Section 4 is the core of the report; it describes how ex ante appraisals are conducted in practice. Section 5 discusses the role of communicating appraisals, both within authorities and to the wider public. Section 6 concludes and delivers preliminary key messages. The Annex contains a list of key terms used in the report

<sup>1</sup> See the Annex for the Study Group membership.

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## Case studies: Overview

Table 1

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Case study	Coverage of case study
Sectoral risk weights (Brazil)	Objective setting; risk assessment and instrument selection; activation; calibration; communication
Loan-to-value ratio caps (Netherlands)	Objective setting; activation; calibration; phasing-in; communication
Capital surcharges for domestic systemically important institutions (Germany)	Application of international guidelines
Countercyclical capital buffer (France, Italy, US)	Application of international guidelines (Italy); activation (France); calibration (France, US)
Debt service-to-income ratio caps (Singapore)	Objective setting; risk assessment and instrument selection
Large exposure limits (Mexico)	Calibration
Specific issues arising when releasing macroprudential instruments (Hong Kong)	Application of international guidelines; calibration

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and a description of selected models that Study Group members have used for their appraisals. A number of case studies serve to illustrate the Study Group members' experiences with different parts of the appraisal process (Table 1).

## 2. Operationalising objectives

The appraisal of policy instruments needs to compare the positive impact from their application with potential negative side effects. Thus the first challenge to the appraisal framework relates to measuring the benefits that derive from the implementation of the tool against a yardstick in the form of the objective against which the impact of policy will be judged. Emphasis on quantitative assessment implies that these objectives must be made quite specific: they need to be operationalised.

There are a number of definitions of the term "macroprudential policy". Many definitions put the emphasis primarily on limiting financial system instability. An example is provided in BCBS-FSB-IMF (2011): "a policy that uses primarily prudential tools to limit systemic or system-wide financial risk, thereby limiting the incidence of disruptions in the provision of key financial services that can have serious consequences for the real economy". Some jurisdictions complement this objective with ones relating to the improvement of macroeconomic outcomes, the promotion of competition or the enhancement of financial market efficiency. For example, the mandate of the Bank of England's Financial Policy Committee includes a secondary objective "to support the economic policy of the Government, including its objectives for growth and employment". Typically, these overall objectives are not explicitly ranked.

The key issue from the perspective of this report relates to how the high-level objectives of macroprudential policy are translated into a set of quantifiable, lower-level objectives so as to set the analytical framework for instrument appraisal.

In many cases, authorities proceed in two steps in setting operational objectives for macroprudential policy. In a first step, they translate the high-level (overarching) objectives of policy into a handful of intermediate, not necessarily quantitative, targets that capture specific aspects of the overall objective. For example, the European Systemic Risk Board (ESRB) recommended including intermediate objectives relating specifically to: the prevention of the build-up of excessive leverage, of maturity mismatches and of exposure concentrations; the reduction of moral hazard; and the strengthening of financial market infrastructures.<sup>2</sup> In a second step, these intermediate objectives are in turn translated into quantifiable targets that can be used to numerically evaluate the potential impact of individual instruments. This second step can take the form of defining risk indicators that measure the extent to which the intermediate objective has been reached, and selecting threshold levels for these risk indicators.

The connection between the overall policy objective and the specific quantifiable objectives in this two-step approach becomes less immediate (less tight) the greater the constraints imposed by different practical and conceptual limitations, which include:

- **Limitations in the availability of data.** For a variety of reasons, the data necessary for quantification may not be readily available. For instance, data coverage may be too short and not cover periods of financial distress within the given jurisdiction; relevant data may be too costly to collect; or there may be concerns about the confidentiality of relevant data (as is often the case with institution-specific regulatory data).
- **Limitations of the analytical framework.** In the absence of an analytical framework linking a given instrument to the policy objectives (including the channels of transmission through the financial system), the quantified objective is typically defined closer to the instrument at hand. For example, confidence in the quantitative links between the level of a ceiling on mortgage loan-to-value (LTV) ratios and metrics of banks' and households' balance sheet resilience may be more robust than between the LTV ceiling and broader metrics of financial stability.
- **Limitations imposed by the governance of macroprudential decision-making.** This can influence not only data availability, as noted above, but also the type of quantifiable objectives that should be evaluated. For example, if a number of agencies are involved in the decision-making process, there might be a case for taking these agencies' specific objectives into account when operationalising macroprudential policy.

The significance of those limitations varies considerably across jurisdictions, across types of instrument and, arguably, over time. This diversity implies that, in practice, policymakers use a wide variety of ways to formulate quantitative objectives depending on the instrument and the jurisdictional characteristics. Those formulations can be broadly grouped into three general categories, depending on the type of inputs they use and/or the analytical techniques they employ:

1. **Quantification using aggregate (macro) variables.** Frequently, this focuses on the level, growth and volatility of GDP, or of credit to the economy. This approach is usually light on data requirements, but places heavy demands on the analytical

<sup>2</sup> European Systemic Risk Board (2013).

methods (mostly macroeconomic models) that link the policy instrument (eg setting capital requirements or calibrating LTV limits at exposure level) to the macro objective. For example, the appraisal of the economic impact of Basel III capital requirements was based on the analysis of their impact on GDP and credit, over the medium- and longer-term horizons.<sup>3</sup> Similarly, the measure introduced by Korea setting prudential limits to the ratio of gross debt to disposable income for households was introduced with the objective of reducing the rate of growth of the stock of household debt.<sup>4</sup>

2. **Quantification using system-wide metrics of risk.** The objective here is defined in terms of system-wide metrics of distress (such as the likelihood of joint bank failures or of large declines in aggregate capital buffers). This approach also makes heavy use of models, but of a different type. These are mainly portfolio credit risk models, often involving simulations, that link the calibration of the instrument to the robustness of individual institutions and then to that of the system as a whole.
3. **Quantification using granular variables.** These approaches to objective formulation are based on variables that relate readily to sources of vulnerability for individual firms or sectors. For example, frequent choices include measures of the riskiness of banks' assets (such as distributions of LTV ratios of mortgages) and aspects of banks' systemic importance (such as their exposures to other banks). Similarly, for the non-financial sector, such variables can be metrics of households' and firms' debt servicing capacity out of current income or earnings. Box 1 provides a number of examples.

The three categories represent different trade-offs between the availability of data and the analytical link between instrument setting and objectives. The connection between macroprudential instruments and the quantified objective is arguably easiest to establish in the third category and most challenging in the first. On the other hand, the data challenges become increasingly severe as one moves from the first to the third category. In practice, the third approach tends to be chosen most frequently in situations where a specific type of exposure (such as excessive exposure of banks to foreign exchange-denominated funding, or excessive risk-taking when granting a specific type of loan to households) is generally understood to represent a risk to financial stability even without articulating a fully specified link between the exposure and the broad macro or system-wide metrics of stability.

Clear, quantifiable objectives also provide a benchmark when assessing the instrument's effectiveness.

In summary, how the overall objective of macroprudential policy is operationalised depends on the instrument under consideration, the availability of data and analytical methods, and aspects of the governance of macroprudential decision-making.

<sup>3</sup> See Basel Committee on Banking Supervision (2010a) and Macroeconomic Assessment Group (2010).

<sup>4</sup> According to the press release issued in February 2015, as part of its more comprehensive measures to deal with household debt, the Korean government set the goal of reducing the level of household debt-to-disposable income by 5 percentage points until the end of 2017.

## Case studies: Objective setting

### Risk weights (Brazil)

Against the background of heightened concerns about lending standards for some forms of consumer credit, the Central Bank of Brazil conducted an appraisal of the impact of raising the risk weights for auto loans with high loan-to-value ratios and long maturities in 2010.<sup>①</sup> The primary objective of the measure was to increase the resilience of the banking sector, with a secondary objective not to impede corporate investment. Auto loans represented a significant share of the assets of the Brazilian financial system (25% of outstanding loans to households). These objectives are not expressed in quantitative terms in contrast to the operational target of the policy, which was stated in terms of a reduction of the flow of loans granted to households at high LTVs and long maturities.

### LTV limits (Netherlands)

In 2012, the Netherlands introduced a statutory loan-to-value ceiling on mortgages set at 106% that would gradually decline to reach 100% in 2018. The government stated that a further reduction looked desirable in due course and asked the Dutch Financial Stability Committee (FSC) to discuss the level to which the cap should be lowered and the speed at which it should be phased in. At the request of the FSC, the Netherlands Bank conducted an appraisal of a further reduction of the LTV limit.<sup>②</sup>

The LTV cap was seen as a structural measure aiming to improve financial stability. The primary objective was to enhance the resilience of both banks (by reducing their credit risk exposure) and households (by increasing new borrowers' ability to withstand income and house price shocks). Other possible positive effects include the dampening of cyclical house price movements as well as volatility in the aggregate consumption expenditure by capping the degree to which households can extend their financial resources through leverage.

### Debt service-to-income limit (Singapore)

The Monetary Authority of Singapore introduced, in 2013, a unified standard for calculation of the debt service ratio for property loans granted by financial institutions, the Total Debt Servicing Ratio (TDSR), and set a maximum threshold for that ratio.

The TDSR has two objectives. The first is to increase the resilience of households by encouraging financial prudence among borrowers. The second is to increase the resilience of financial institutions by standardising and at the same time strengthening the underwriting standards for mortgage loans.

<sup>①</sup> See Afanasieff et al (2015) for a detailed description of the appraisal. <sup>②</sup> See Netherlands Bank (2015).

## 3. Analytical methods for ex ante appraisals

This section provides an account of analytical tools that are employed in the ex ante appraisals of macroprudential instruments, including some that are still under development. The tools include a variety of frameworks, some consisting of fully specified models, others being approaches built as suites of methodologies aimed at providing a comprehensive picture of the effect of policy instruments on financial stability. While some jurisdictions make use of the entire range of these methods, others may rely on a subset or less formal approaches. The next section (Section 4) will discuss how these approaches are used to inform different stages of practical policy decision-making.

The various methodologies are grouped in two categories reflecting the origins of their analytical development, which also relates to the type of inputs they use. The first category refers to methods that can assess policies against targets set in terms of macroeconomic variables, while the second category refers to methods that help assess policies against targets set in terms of granular (micro-level, institution-specific or exposure-specific) variables. Descriptions of models that Study Group members have used or are intending to use in their appraisal process are collected in the Annex.

Several lessons emerge from this overview. First, there is no unique or perfect methodology for ex ante appraisals. The relative advantages of using one or the other method are likely to depend on a range of factors, including: the instrument under consideration; the macro-financial characteristics of the jurisdiction; and the degree of development and expertise in specific methodologies. Second, many promising analytical methods have been developed only very recently or are still under development, implying that practices and applications are likely to evolve relatively quickly in line with progress in developing the underlying methodology. Third, possibly reflecting the uncertainties implied above, there is considerable variation in the use of these methods and in some cases several are used in a combined manner to take advantage of their complementarity. Similarly, while the use of models is an indication that macroprudential policymaking is relying increasingly on quantitative analysis, expert judgment remains an important component of decision-making (see discussion in Section 4).

## Methods using macroeconomic data

The methods that rely on aggregate (macroeconomic and system-wide) data have their analytical origins in macroeconomics and have sometimes been developed and used by central banks for other analytical purposes. They are stylised depictions of the economy, with varying degrees of granularity in their depiction of the financial sector, varying attention to the treatment of economic agents' expectations about financial variables, and varying clarity in the modelled interactions between decision-makers (policymakers, households, firms etc). In this section, we distinguish between three such types of methodologies used in appraisals of macroprudential instruments.

### Structural macroeconomic models

This class of models has been the workhorse of central bank macroeconomic analysis since the late 1960s. The original versions of these models were large-scale, multi-equation structural models with a fairly elaborate description of the real sector but very stylised financial sector. Gradually, these models have acquired a more detailed description of finance, and of banks' balance sheets in particular, in order to capture the interactions between the real and financial sectors of the economy. Occasionally, large-scale models are complemented by so-called satellite components, which are purpose-built to capture aspects of the financial sector. They often also include estimated or calibrated decision rules that describe reinvestment rules and feedback loops resulting from common exposures and contagion via large interbank exposures.<sup>5</sup>

<sup>5</sup> See eg Kawata et al (2013) for a comparison of macroprudential policies within the framework of a large-scale macro-financial model. Burrows et al (2012) and Bank of Korea (2012) explain how these models are used in the context of stress testing.

One version of structural models is the class of dynamic stochastic general equilibrium (DSGE) models. The main analytical advantage of DSGE models derives from a coherent depiction of decision-making by economic agents (eg banks, households or firms) that lends itself more readily to the analysis of policy interventions.<sup>6</sup> The drawback of this approach, however, is that, for the analysis to take place, the policy instrument under consideration must be explicitly modelled. As the analytical complexity of these models grows very fast with the number of agents' decisions that are explicitly accounted for within the framework, the users have to resort to shortcuts and simulations to obtain answers to the policy questions. Yet different instrument settings or even alternative instruments can be assessed by comparing the net gains (in terms of households' utility or in terms of GDP) that they generate in the model.

### Reduced-form macroeconomic models

Reduced-form macroeconomic models describe the observed relationship between economy-wide variables of interest (for example, the likelihood of stress in financial markets, or GDP or variations in bank capital) without linking them to explicit decisions by households and firms. They exploit time series correlations of the variables involved over different horizons and enable the analyst to consider variables that closely measure the setting of the macroprudential instrument under consideration, perhaps even the policy variable itself.<sup>7</sup>

The price of the greater flexibility in depicting dynamic relationships among variables compared to structural models is the difficulty to track agents' reactions to fundamental shifts in policy. Without the structure imposed by modelling behavioural rules of consumers, firms and financial intermediaries, the identification of the transmission of policy shifts on the macro (or system-wide) outcomes becomes more tenuous. Also, without the restrictions imposed by structural macroeconomic models, the reduced-form empirical models require a longer history of data to separate the impact of past policy shifts from other possible influences on macro variables. Such data sets may not be always available, and even when they are, they are likely to include important structural changes in terms of the underlying economic relationships. A rich set of variables is likely necessary to disentangle the transmission channels in this case.

### Indicator-based approaches

Indicator-based approaches link specific aggregate variables with episodes of financial distress or actual crises. They are aimed at identifying statistical patterns that signal the build-up of financial vulnerabilities and act as an early warning for incipient stress. While describing these approaches as "models" stretches the definition of the term, they are based on macro (aggregate) data, as are the other approaches in this group, and exploit the statistical link between those aggregates and historical episodes of financial instability. The approaches are largely atheoretical and impose no economic structure on the variables. Yet for this reason, they are used extensively in the macroprudential analysis. They are flexible, can accommodate comparisons

<sup>6</sup> See the Annex for a list of DSGE models used by central banks.

<sup>7</sup> See eg Behn et al (2015), Gross et al (2015) and Wong et al (2015).

across countries more easily, and permit conclusions to be drawn from a broader set of experiences across time and jurisdictions.

Similarly to reduced-form models, indicator approaches lack the economic structure that allows the analysis of the reaction of economic agents to policy decisions. In addition, lacking a dynamic statistical (time-series) structure they tend to have mixed predictive performance as regards the exact timing of episodes of distress. They are quite useful, however, in pointing to vulnerabilities that can lead to systemic distress over a horizon (interval) without being specific as to the exact date. This matters for macroprudential policymaking because an alarm signal from the indicator should come with sufficient time for authorities to take appropriate corrective action. Recent advances reduce the prediction error that results from model uncertainty by selecting early warning models on the basis of their ability to predict stress.<sup>8</sup>

### General issues with the use of macroeconomic models

A number of difficulties can arise when appraising macroprudential instruments with models.

First, models have to be selective in what detail of the economy they incorporate to remain tractable. However, there is no consensus on the key model ingredients. For example, the precise nature of market imperfections (which financial friction or externality generates inefficiencies, and potentially risk) is key for what policy instrument is optimal according to the model. For example, if amplification mechanisms for risk in the model are linked to the capitalisation of banks in the model, then capital requirements are likely to turn out to be a suitable instrument for reducing systemic risk.

Second, it is difficult to incorporate default risk – a key aspect of systemic risk – into these models.<sup>9</sup> Progress in this area has only very recently been made, such that there is only limited experience with models incorporating defaults. Tail risks have only very recently been analysed within DSGE models.

Third, introducing heterogeneity – for example, different types of banks or households – increases substantially the complexity of a model and renders the analysis more challenging.<sup>10</sup> This means that fully specified models with many different decision making agents do not lend themselves easily to the study of contagion, an important driver of systemic risk.<sup>11</sup> The relative shortage of empirical analysis of the behavioural responses to prudential policy shifts by financial market participants and financial intermediaries compounds this lack of guidance by theory. In fact macroprudential policy appraisals are generally weak in dealing with the micro-economic responses of banks, markets and other agents to policy shifts.

<sup>8</sup> See eg Coudert and Idier (2015), described in the Annex.

<sup>9</sup> An example of a model that includes several layers of default risk is Clerc et al (2015).

<sup>10</sup> See eg Gerali et al (2010).

<sup>11</sup> The study of contagion within these models is nevertheless feasible. See, eg, Benes, Laxton and Mongardini et al (2016), Carvalho and Castro (2015, described in the Annex), and Carvalho, Castro and Costa et al (2014).

## Methods using granular data

These methods are based on disaggregated information that relates to individual financial institutions, individual exposures and other micro data. They can be grouped into three general categories: stress tests, micro-econometric (panel) models and network models of interconnections between institutions.

### Stress testing

Stress testing is a forward-looking technique that attempts to measure the sensitivity of a portfolio, an institution or even an entire financial system to hypothetical scenarios that may have a small probability of occurring but will have significant impact if they do occur. Microprudential supervisors have been routinely using stress testing to assess the impact of adverse scenarios on individual banks' liquidity and solvency.<sup>12</sup> Over time, the testing methodologies have started to incorporate feedback effects through contagion between firms, or through the interaction of the financial to the real sectors of the economy.<sup>13</sup> Stress tests are also used to quantify the impact of a specific scenario on individual banks' balance sheets in terms of equity losses and the results used in calibrating capital requirements. Simulations based on counterfactuals can also help assess the impact of specific policy measures on banks' (or the system's) resilience to the shocks described in the scenario.

In the context of ex ante appraisals of macroprudential instruments, **stress tests of portfolios** of loans can be useful for assessing how the likelihood of default, and loss-given-default, of a given class of loans impacts individual banks' solvency.<sup>14</sup> This can help provide a starting point for the calibration of macroprudential instruments whose impact is concentrated on a specific class of loans, such as additional capital requirements for high-LTV mortgages, or LTV ratio caps. Stress tests of the finances of households and non-financial firms can help provide rough but plausible estimates of likelihoods of default and loss-given-default.<sup>15</sup>

Similarly, **stress testing of banks' funding**, for instance by estimating how long a bank would be able to serve its obligations if it were unable to roll over short-term debt, can inform the calibration of prudential liquidity requirements.

### Panel data models

Empirical analysis based on micro-level data (for instance balance sheet items of individual institutions, or the performance of individual loans) that are available over a longer time horizon, can inform the appraisal of instruments. Panel data econometric methods can be used to isolate the likely impact of changes in regulatory requirements on lending. To the extent that they capture the key factors relevant for agents' decisions, they can play an important role in assessing the behavioural impact

<sup>12</sup> Stress tests have also been described as a macroprudential instrument in themselves: eg the Comprehensive Capital Analysis and Review (CCAR) in the United States.

<sup>13</sup> See eg Bank of England (2015) and Henry and Kok (2013) for how these might be used to inform macroprudential policymaking. For a critical discussion, see eg Borio et al (2012).

<sup>14</sup> See eg Afanasieff et al (2015).

<sup>15</sup> For microsimulation models that allow stressing of the financial conditions of, respectively, households and firms, see Michelangeli and Pietrunti (2014) and De Socio and Michelangeli (2015). Both are described in the Annex.

of policy changes, including changes to the structure of markets and the degree of contestability (ie the ability of firms to affect pricing of their products) and the possibility that leakages may occur as the private sector attempts to arbitrage the regulatory intervention.<sup>16</sup>

The methodologies offer the promise of rigour in estimating the reaction of financial institutions, households and firms, as it is identified in responses to previous shifts of similar nature. They can then usefully provide a detailed analysis of potential policy impact. However, they also have shortcomings. One is that the required data are not always available over a long enough period to permit the identification of responses to the particular policy intervention being appraised. Another is that the models are typically purpose-built and geared towards addressing specific questions. As such, it may be hard to adapt existing models to the specific needs of the appraisal or demanding to build new ones for the purpose.

### Network models

Networks of bilateral exposures between financial institutions can give rise to system-wide risk, measured by the likelihood of the failure of multiple institutions through domino effects and through contagion.<sup>17</sup> Network models explicitly account for mutual exposures and trace the impact of an adverse shock to one institution (a node in the network) to the capitalisation of others exposed to it directly or indirectly. Some network models also attempt to capture additional risks arising from common exposures to particular risks factors.

While network models provide a structure to the analysis of interconnections, they may be unreliable predictors of systemic episodes if the network of exposures can change very fast as in the case of derivative exposures. In practice, financial institutions are likely to attempt to reduce their exposures to institutions that appear vulnerable, giving rise to additional dynamics. Introducing these behavioural responses has proven to be complex, however; there might also be arbitrariness in formulating rules for behavioural responses without describing individual institutions' objectives and decision-making processes.

## 4. Using ex ante appraisals in decision-making

This section provides a discussion of practical experiences with the appraisal of macroprudential instruments. It first discusses the role of systemic risk assessments in shaping the appraisal process as well as that of guidelines offered by international standard setting bodies. It then presents examples of how quantitative methods are used in two stages of policy-making: the decision of when to activate an instrument, and the decision of how to calibrate its intensity.

Two lessons emerge from the following overview. First, a multitude of different methods are used in the appraisal process. Ex ante appraisals of macroprudential instruments require expertise in a large number of areas, including: how regulation impacts financial institutions; how financial markets react to structural changes; how

<sup>16</sup> See eg Aiyar et al (2014) and Bridges et al (2014).

<sup>17</sup> Eg Gabrieli et al (2015), Idier and Piquard (2016), Fink et al (2015) and Bank of Mexico (2011).

monetary and microprudential policies may interact with macroprudential policy; and how the real and financial sectors interact. These skills are unlikely to be all available within the same organisational unit. Furthermore, when instruments are best activated, and how they are calibrated, may depend on the setting of other policies. Hence, cooperation across organisational units and/or policy authorities is essential for effective policymaking.

The second lesson is that a key challenge for the analysis of the impact of policy is its effect on market participants' behaviour and expectations. Section 3 showed that only some models explicitly describe expectations formation and few of them are able to take into account multiple equilibria or herding behaviours, which are arguably at the source of financial instability. There is therefore little guidance from analytical frameworks regarding the impact macroprudential policy has on market participants' behaviour.

### Risk assessment and instrument selection

Risk analysis narrows down the nature of risk that the financial system faces. In conjunction with the operationalised objectives of macroprudential policy, risk analysis typically provides sufficient information to select a single instrument, instrument, or a combination of instruments, out of those available to the macroprudential authority, reducing the need to conduct a full appraisal of each candidate instrument.

Risk analysis can draw from a number of sources and use a range of methods. One form of risk analysis is based on indicators. Critical indicator levels then trigger a more in-depth analysis of where exactly the risk lies, which factors give rise to it, and which instruments might be appropriate for addressing the risk. Some jurisdictions complement the information gained from indicators with the output of early warning models.

If the underlying data are readily observable, it may be possible to automate the calculation and aggregation of the indicators and represent them visually in a way that – if guided by expert judgment – is easily understood. “Risk dashboards” and especially “heat maps”, in which colours reveal the risk signalled by the level of each indicator, are frequently used to that end.<sup>18</sup> The scarcity of data on crises, changes in the type of risk and the structure of the financial system, and the availability of new data sources can make it desirable to update at regular intervals both the set of indicators that are monitored and the definition of critical thresholds.

Jurisdictions typically rely on supervisory data, for example resulting from stress tests, or insights from market participants to further narrow down the risk the financial system faces.<sup>19</sup> The experience from Singapore (Box 2) underlines the benefits of close cooperation between microprudential and macroprudential risk assessment in

<sup>18</sup> See eg Mencia and Saurina (2016). The authors associate a risk scale for each of over 100 indicators and weigh the indicators taking into account their capacity to anticipate periods of stress in Spain. The resulting heat map illustrates, at different levels of aggregation, the likely sources of risk in the financial system.

<sup>19</sup> See eg Bank of England (2015) and Pérez-Montes and Trucharte (2013) for how results from stress tests might be used by the macroprudential authority.

## Case studies: Risk assessment and instrument selection

### Risk weights (Brazil) – continued

For purposes of risk assessment, the central bank considered aggregate indicators such as credit-to-GDP ratios; and indicators of lending standards, such as loan-to-value ratios, the term of the loan at origination, the interest spread charged, and through-the-cycle estimates of the share of non-performing loans.

An adjustment of risk weights specifically on high-LTV, long-maturity auto loans (while exempting, for example, loans that financed the purchase of trucks) appeared to be the appropriate instrument for addressing the objective. Imposing an LTV was considered to be overly interventionist: as long as high-LTV, long-maturity loans were backed by sufficient capital, banks ought to have been in a position to grant those loans.

Confining the measure to auto loans, and specifically to those with a high LTV and long maturity at origination, followed an assessment that the standard 75% risk weight imposed by the Basel II framework appeared insufficient for this class of loans but not in general for banks' lending to households. In addition, the likely increase in banks' funding costs for this class of loans could lead to a reduction in their supply relative to other types of loans without materially affecting aggregate lending. Exempting some types of loans that supported corporate investment (eg loans that financed the purchase of trucks) helped achieve the secondary objective of not impeding corporate investment. Finally, the central bank also thought that a targeted measure would have a stronger signalling effect, encouraging banks to improve their lending standards where it was most needed.

Variables that mattered for risk assessment were also used for assessing the instrument's effectiveness ex post. The method used for ex post evaluation took advantage of a design feature of the regulation: the exclusion of some types of auto loans (eg loans that financed the purchase of trucks were exempted). After the instrument had been deployed, the share of targeted auto loans fell from 74% to 60% of all auto loans within a year. Difference-in-difference estimations helped identify the policy impact, by separating the change in origination of targeted auto loans from that which simply co-moved with auto loans unaffected by the instrument.

### Debt service-to-income caps (Singapore) – continued

Microprudential supervision and macroprudential surveillance complemented each other in the risk assessment underlying the TDSR. Bank supervisors observed that housing loan tenures were trending upwards. A thematic review revealed that, while banks generally had sound practices and processes in place, lenders employed uneven practices when computing and evaluating debt service-to-income ratios of mortgage loan applicants. On the macroprudential surveillance front, rising household debt and strong growth of housing loans were observed in an environment of low interest rates and search for yield.

The choice and design of the instrument took account of existing regulatory requirements. As an example, the TDSR would not have been as effective without the limits on housing loan tenures that were already in place, since borrowers could have then stretched their loan tenures to reduce the monthly repayments.

To achieve the financial prudence objective for households, all outstanding debt obligations were taken into account when calculating the TDSR. Debt obligations include all property-related loans and non-property-related loans such as auto loans, credit card loans and other secured or unsecured loans.

this regard. Box 2 also shows how indicators, in conjunction with supervisory information, helped inform the choice between different macroprudential instruments in Brazil.

A number of jurisdictions aim to design stress tests with a macroprudential perspective to improve their ability to inform the setting of macroprudential

instruments.<sup>20</sup> For example, the United Kingdom has, for the first time in 2016, linked the severity of the stress explicitly to the assessment of system-wide risks that also underlies the calibration of the countercyclical capital buffer.<sup>21</sup>

Some authorities use large-scale macro-financial models to complement their understanding of how stress can be amplified by feedback effects between the real and the financial sector.<sup>22</sup>

Indicators used for risk assessment are also relevant for the evaluation of the effectiveness of the macroprudential instrument after it has been deployed. The evaluation of the imposition of minimum risk weights on auto loans in Brazil (Box 2) provides one example. Another example is the assessment of risks in the housing market by the Bank of England's Financial Policy Committee (FPC). A marked rise in the share of mortgages extended at high loan-to-income multiples prompted the FPC to recommend that lenders should not extend more than 15% of their total number of new residential mortgages at loan-to-income ratios at or greater than 4.5. In its annual evaluation of this recommendation, there is a focus on household debt-to-income both in aggregate and broken down into the number of households at particular loan-to-income levels. For example, the tail of households with debt-to-income ratios greater than 4.0 indeed fell in early 2015.<sup>23</sup>

## Guidelines resulting from appraisals by international committees

For two key macroprudential instruments with the potential for cross-border spillovers, ex ante appraisals have been conducted by international committees: the countercyclical capital buffer and the capital buffer for systemically important institutions. These appraisals included assessing the design of the instruments as well as behavioural responses; estimating the transitional and final costs and the long-run benefits of introducing them; and evaluating various risk indicators for their usefulness in providing guidance for activating and calibrating the buffers.<sup>24</sup>

The guidance that emerged from these ex ante appraisals, complemented by others,<sup>25</sup> focuses on recommending risk indicators and threshold values that could be useful in the activation and calibration of the macroprudential instrument. Many jurisdictions use these recommendations as the basis of their own ex ante appraisals, often complementing or adapting them to take account of data availability and idiosyncratic aspects of the structure of their economy.

Adopting (or complementing) the recommendations involves an appraisal process of its own. For example, in the case of the countercyclical capital buffer, it

<sup>20</sup> See Jobst et al (2013) for the IMF's framework for using macroprudential bank solvency stress testing in the context of risk assessment.

<sup>21</sup> See Bank of England (2016).

<sup>22</sup> See Bank of Japan in the Annex, and Kawata et al (2013) for an example of how these models can also inform the choice between macroprudential instruments.

<sup>23</sup> See Bank of England (2014a).

<sup>24</sup> See eg Macroeconomic Assessment Group (2010, 2011).

<sup>25</sup> See eg BCBS (2010b, 2014), EBA (2014) and Detken et al (2014).

## Case studies: Use of guidelines

### Capital surcharges for systemically important institutions (Germany)

The Bundesbank used a two-step method to identify domestic systemically important banks (D-SIBs). In the first step, it followed the uniform scoring model that the European Banking Authority (EBA) had proposed.<sup>①</sup> This provides guidance on how to measure and to aggregate information about the bank's size, its importance in domestic payments and private sector deposits and lending, its complexity and its interconnectedness. In the second step, this information was complemented by a selection of the supplementary indicators that the EBA had proposed, balancing the desire to keep the designation method parsimonious with the need to capture aspects relevant specifically for the German banking sector. Selected complementary indicators included the number of banks for which the bank under consideration served as settlement bank in the euro area's large-value payment system, TARGET2, as well as the number of domestic payment transactions processed by the bank. Finally, the list of designated institutions was reviewed in the light of expert judgment.

The results of this indicator-based approach were checked for plausibility using a network model of the German banking sector.<sup>②</sup> The model uses bilateral data on banks' large exposure to each other to simulate the effect of a single bank's default. The essential feature of the model is that direct contagion effects can be disentangled from indirect effects, thus delivering a more intricate view of interconnectedness than one that would emerge from the mutual direct exposures alone. The plausibility check confirmed the results of the scoring method, as those banks with high scores also contributed to a potentially high banking system loss.

For the calibration of the buffer rate, the identified institutions were then allocated to certain capital buffer categories using a cluster analysis to form homogeneous groups of institutions based on the variation of their indicator scores. The resulting four groups of institutions were then assigned to four different capital buffer buckets. The highest buffer was set at 2% Common Equity Tier 1 capital per total risk exposure in accordance with the statutory maximum of the D-SIB buffer.<sup>③</sup>

### Countercyclical capital buffer (Italy)

Following guidelines set by the European Systemic Risk Board, the Bank of Italy has developed a country-specific framework for the purpose of appraising the countercyclical capital buffer.<sup>④</sup> The aim was to complement the standard methodology proposed by the Basel Committee for Banking Supervision (BCBS) to better capture the specific features of the Italian financial cycle.

The first step compared two methods for smoothing the time series that enter the computation of a key indicator of the financial cycle, the credit-to-GDP ratio. Compared with the one-sided version of the Hodrick-Prescott filter proposed for that purpose by the BCBS, the two-sided version appeared to better smooth the estimate of the credit cycle in Italy and improved the real-time estimation of the Italian financial cycle.<sup>⑤</sup>

The second step developed a quantitative framework to select additional macro-financial indicators to improve the credit-to-GDP gap's ability to guide the activation and calibration of the countercyclical capital buffer. For that purpose, a principal component analysis helped identify the combinations of indicators that best explain financial cycles in Italy. A regression analysis tested how closely correlated these factors are with a measure of risk in the banking system, the share of bad loans.

### Countercyclical capital buffer (Hong Kong)

The Hong Kong Monetary Authority (HKMA) supplements the credit-to-GDP gap proposed by BCBS (2010b) with indicators on local property prices and rents to reflect the importance of the real estate market for financial stability. The resulting composite indicator, the Composite CCyB Guide, provides an initial reference point for the setting of the countercyclical capital buffer.

Two further indicators of banking sector stress improve the composite indicator's ability to point to a necessary release of the countercyclical capital buffer. These are the spread between the Hong Kong interbank market rate and the corresponding risk-free rate at the three-month maturity, and the quarter-on-quarter change in the share of loans with at best a "substandard" likelihood of being repaid.<sup>⑥</sup> The former indicator appears more relevant during sudden, acute stress episodes; the latter when systemic risks play out more gradually. Together, the two indicators form the basis for calculating an indicative cap on the countercyclical capital buffer, the Indicative CCyB Ceiling.

Many other indicators (eg credit default swap spreads, impairments of mortgage securities, sovereign credit spreads, bankers' sentiment or opinion surveys) may help capture more specific aspects of risk in the banking system. The two above-mentioned indicators were chosen as primary stress indicators for two reasons. First, they can be seen as general symptoms expected to be associated with a wide variety of underlying banking sector problems, including those that may not have been experienced in previous crises. Second, they are currently not considered to be particularly susceptible to manipulation.<sup>⑦</sup>

① See the EBA's guideline EBA/GL/2014/10, Annex 1, Table 1. ② Fink et al (2015). ③ Article 131(5) of the European Union's Capital Requirements Directive, CRD IV. ④ European Systemic Risk Board (2014). ⑤ Alessandri et al (2015). ⑥ See the "Loan Classification System" entry in the Guide to Hong Kong Monetary and Banking Terms, [http://www.hkma.gov.hk/gdbook/eng/loan\\_classificat\\_sys.shtml](http://www.hkma.gov.hk/gdbook/eng/loan_classificat_sys.shtml). ⑦ For a detailed description of the HKMA's approach to implementing the CCyB, see HKMA (2015).

involves deciding whether the guidelines that the Basel Committee on Banking Supervision (BCBS) issued for measuring the credit-to-GDP gap are appropriate for the domestic economy, and what other indicators should be evaluated.<sup>26</sup> The Reserve Bank of India, for example, uses the credit-to-GDP gap proposed by the BCBS to facilitate its decisions regarding the countercyclical capital buffer, but may include other indicators – for example, those related to credit quality. The same arguments apply for the activation and calibration of buffers for systemically important institutions, for which international fora have developed an indicator-based method.<sup>27</sup>

Box 3 contains three examples of how guidelines were used in the appraisal process. The Deutsche Bundesbank, building on guidelines by the European Banking Authority, chose additional indicators to identify systemically important banks, balancing the desire to keep the designation method parsimonious with the need to capture aspects relevant specifically for the German banking sector. To help inform the setting of the countercyclical capital buffer, the Bank of Italy used statistical techniques to build summary indicators that better capture the specific features of the Italian financial cycle than the standard indicators proposed by the BCBS. In order to help inform specifically the release of the countercyclical capital buffer, the Hong Kong Monetary Authority complemented the indicators proposed by the BCBS with two variables of banking system stress. These provide an indication of the maximum level which the countercyclical capital buffer should not exceed during periods of stress.

<sup>26</sup> See eg Alessandri et al (2015), Castro et al (2014, 2016) and Giese et al (2014).

<sup>27</sup> BCBS (2014) and EBA (2014).

## Activation (timing)

Activation is the choice of when an instrument is used (or not). Part of this choice is how much time firms should be given to comply with a policy change.

The approach to deciding when to use an instrument varies across countries, with only some countries having adopted a model-based approach. The structural models described in Section 3 that allow risk to respond dynamically to changes in macroprudential instrument settings tend not (yet) to be used in the appraisal process. An exception are two macroeconomic models – one empirical, the other structural – used by the ECB as part of a regular ex ante appraisal of decisions on the activation of the countercyclical capital buffer, taken by jurisdictions in the Single Supervisory Mechanism area.<sup>28</sup>

Most authorities rely instead on the results of reduced-form models and risk assessment (eg indicator-based models or early warning models) – see the example of the Bank of France’s activation of the countercyclical capital buffer in Box 4. New supervisory insights, together with the desire to complement previously deployed instruments, were important factors behind the Monetary Authority of Singapore’s decision to implement the debt service ratio policy.

Box 4 also illustrates that different considerations may be relevant for the activation of structural and cyclical macroprudential instruments. By definition, structural measures are atemporal in the sense that there is no intention a priori to vary their level with the financial cycle. This also means that implementation periods can be lengthened relative to the case of cyclical instruments: longer transition periods can reduce the costs associated with deploying the instrument. Nevertheless, other considerations may argue in favour of a short implementation period. For example, the minimum risk weight that the Brazilian authorities imposed on auto loans became effective immediately after its announcement precisely to prevent front-running. In contrast, Dutch authorities’ decision to further tighten the LTV ratio by 1 percentage point per year was mainly motivated by the need to avoid a sharp drop in house prices that could have been the consequence of more aggressive tightening. Another motivation was the ability to communicate the further tightening as a continuation of the ongoing tightening to 100%. The speed at which tightening occurred was too small to give rise to front-running.

These approaches to appraising the activation decision also inform the calibration of the instrument once it has been activated. For both activation and calibration, authorities tend to assess risks more broadly than what the instrument is specifically designed to address. For example, the Bank of Spain complements instrument-specific indicators (eg the credit-to-GDP gap in the case of the countercyclical capital buffer) with composite indicators that summarise information about a wide range of risks in different categories.<sup>29</sup> Evaluating these broader-based composite indicators helps assess interactions across instruments and between different sources of systemic risk.

<sup>28</sup> See Section 3: the GVAR model by Gross et al (2016) and the DSGE model by Darracq Pariès et al (2016). Both are described in the Annex.

<sup>29</sup> See eg Mencia and Saurina (2016).

## Case studies: Activation

### Risk weights (Brazil) – continued

No international guidelines were available for activating and calibrating this policy. The activation decision was made against the background of a decline in interest rate spreads that exceeded that in comparable loan categories, perhaps reflecting stronger competition among the banks supplying auto loans. The minimum risk weight became effective immediately after announcement to prevent front-running. However, a 7-month phase-in period for the calculation of capital requirements was allowed for banks to adapt their internal controls to the new system.

### LTV limits (Netherlands) – continued

The LTV cap was thought of as a structural rather than a cyclical instrument. The conjunctural situation therefore only mattered insofar as it appeared compatible with the tightening of the instrument. More important was the policy context: the ongoing tightening phase (from 106% to 100%) was scheduled to end in 2018, and there was a desire to consider the possibility to further tighten LTV caps as early as possible to reduce regulatory uncertainty. Moreover, other prudential policies, such as an amortisation requirement and a loan-to-income cap, appeared insufficient to achieve the above objectives.

While the appraisal investigated the implications of an immediate tightening of the LTV cap, it focused on the case where the speed of the ongoing tightening (1 percentage point per year) would be maintained. This was mainly motivated by the need to mitigate the effect on house prices. Another motivation was the ability to communicate the further tightening as a continuation of the ongoing tightening to 100%. Even though this meant that the policy would be introduced over 10 years, front-running was not perceived to be a risk. The steps appeared to be too small to induce households to bring forward home purchases, and there was no evidence of significant front-running in the ongoing tightening phase.

### Countercyclical capital buffer (France)

As from 1 January 2016, France, along with all other members of the European Union, decides on a quarterly basis whether to activate and how to calibrate the countercyclical capital buffer (CCyB). In France, the Haut Conseil de Stabilité Financière (HCSF) is responsible for the CCyB and made its first decision regarding its activation in December 2015.

The appraisal complemented the guidelines provided by the BCBS with a wider set of relevant indicators. Based on the same type of methodology as the standardised credit-to-GDP, the Bank of France uses, for example, a narrow bank credit-to-GDP gap, for which credit is defined as the total credit (loans and debt securities) of French banks to the French private non-financial sector. By focusing on banks' credit, this indicator seems more relevant than the standardised gap to assess the efficiency of the CCyB for dampening credit growth, since the CCyB affects only banks. Moreover, the narrow bank credit-to-GDP gap also provides information regarding the momentum of banks' credit risk-taking.

In addition to the computation of alternative credit gaps, the basket of indicators has been expanded to include the main sources of risks the CCyB may address: credit, macro, market and bank risks. To go beyond a simple "level reading" strategy, an early warning system has been set up to derive critical thresholds for indicators that indicate, once reached, a significant probability of facing a banking crisis within one to three years. Since September 2015 this analytical tool has been supporting the HCSF's decision-making every quarter, and it is complemented with expert judgment.

### Debt service ratio limit (Singapore) – continued

The TDSR framework is intended to be structural in nature. The TDSR complements other measures that were put in place earlier, including housing LTV caps and maximum loan tenures. The thematic review by microprudential supervisors (see risk assessment) provided additional reasons for activating the TDSR cap.

In practice, **judgment** plays a key role in the activation decision, in particular when it comes to behavioural responses to the policy decision. Apart from operational constraints (the time firms need for the development of relevant computer systems, training of staff, adjustment of their asset portfolio and funding structures), a number of factors appear important:

- **The extent to which regulated institutions might continue, or accelerate, behaviours that give rise to systemic risk.** For example, allowing a long implementation period for an LTV cap on the flow of new mortgages might encourage banks to accelerate granting mortgages with LTVs above that cap while the regulation is not yet in force (front-running strategies). However, this risk might be low when the implementation schedule is very gradual, or when front-running is effectively discouraged by the supervisor.
- **Announcement effects and behavioural responses.** If risks appear to have reached very high levels, immediate action may appear more attractive. However, the risk of triggering undesired behavioural consequences may argue against immediate actions. For example, stretched balance sheets might, at first glance, suggest that instrument settings should be tightened immediately – for example, by increasing capital requirements. However, if the policy announcement triggers an adverse market reaction, risks may materialise even before institutions were able to raise capital.

Similarly, markets might become unsettled if authorities choose an action that could be wrongly interpreted as reflecting that the macroprudential authority has knowledge of imminent risks. Careful communication could help reduce that risk.

- **The economic environment.** It may be easier to tighten macroprudential instrument settings in an economic environment where risks are comparatively low and macroeconomic growth positive and stable. This is because any negative impact the tightening may have on economic growth is then more easily absorbed, and the risk of undesired announcement effects is small. Many authorities therefore aim to deploy macroprudential instruments early, before substantial imbalances have emerged.

That said, the macroprudential authority may find it more difficult to justify its policy action vis-à-vis its stakeholders in those circumstances. This is also because any negative impact of tighter instrument settings is likely to be noted immediately (indeed, any negative impact may be larger in the short run than in the long run), whereas the gain, in the form of a reduced likelihood and impact of financial crises (ie essentially the absence of an event), only becomes apparent in the longer term. Regulated institutions, as well as the general public, might be more easily convinced of the need for activation in situations where heat maps glow orange and red, signalling critical risk levels.

Linking the activation decision to a widely accepted set of indicators with the ability to predict crises in the longer term reasonably well could help an authority justify action to its stakeholders. On the other hand, expert judgment may be needed for cases where decisions are based on thresholds, for instance for the designation of D-SIBs and global systemically important banks (G-SIBs). Convincing stakeholders may also be easier when the authority is acting early enough to be able to calibrate an instrument in a preventive way such that it is,

at the time of deployment, not binding.<sup>30</sup> Communication may help in this respect: for example, widely announcing the reasons for setting CCyB to zero during a low credit cycle may make it politically easier to activate the instrument at times of fast-growing credit.

- **Interactions with other prudential instruments.** A number of macroprudential instruments are being developed and deployed simultaneously at the moment. Some, like the countercyclical capital buffer and the capital buffer for systemically important financial institutions, operate on the same part of banks' balance sheets – their equity – and therefore have very similar effects on them in the short run. At the same time, new microprudential capital and liquidity requirements are still being phased in.

For example, D-SIBs represent around 70% of total lending in Spain. Consequently, the D-SIB buffer is expected to have a similar effect to increasing the countercyclical capital buffer in the short run, particularly if markets tend to front-run phase-in arrangements. Similar situations are likely to occur in other countries with highly concentrated banking sectors.

- **Interactions with other policy areas.** Macroprudential policy is not the only policy affecting financial stability. The tax treatment of debt influences households' and firms' (privately) optimal combination of debt and equity funding. Competition policy influences the degree of concentration in the financial system, and thereby the extent to which systemically important institutions emerge. Monetary policy influences the cost of funding and thereby debt levels for households and firms.

The governance arrangements for macroprudential policy can be important for the degree to which activation decisions take into account these interactions – for example, whether the same institution is responsible for macroprudential and monetary policy, or the degree to which the ministry of finance is involved in macroprudential policy decisions.<sup>31</sup>

## Calibration

Calibration is the choice of the instrument's setting (its intensity). Jurisdictions use a number of approaches to calibrate macroprudential instruments, depending on the risk that is of primary concern, the type of instrument, the structure of their domestic economy and cyclical developments. The following paragraphs distinguish two approaches. The first often coincides with the choice of microeconomic variables to operationalise objectives; the second with that of macroeconomic variables.

**One approach to calibration focuses on the impact on financial stability.** This approach to calibration is often used when the macroeconomic impact of the chosen instrument is judged to be small. This could be the case when the instrument is targeted towards a specific set of loans or types of funding of banks.

<sup>30</sup> This approach to calibration is adopted relatively frequently; see, for example, the Bank of England's calibration of a limit on loan-to-income ratios for mortgages (Bank of England (2014b, Box 5)).

<sup>31</sup> For an example of how governance arrangements may influence macroprudential policymaking, see Shakir and Tong (2014), who explain how the committees responsible for macroprudential and monetary policy at the Bank of England interact.

## Case studies: Calibration

### Risk weights (Brazil) – continued

The calibration followed the Basel II IRB approach. The key ingredients were the loss-given-default (LGD) and the probability of default (PD) on auto loans, for different loan-to-value ratios and terms at origination. These were estimated using loan-level data. The PD was taken from observed default rates. For the LGD, estimates yielded a relatively wide range of plausible values, partly because there was a lack of data about the quality of the collateral that secured the defaulted loan. The decision was then made to use the risk weight that would appear appropriate when applying the higher estimates of the LGD.

Leakages to other institutions did not appear to be an issue because all suppliers of household loans would fall under the new regulation. Leakages in the form of unsecured top-up loans could be dealt with by increased supervision, including the possible threat to impose additional capital buffers under Pillar 2 of the Basel II framework, taking advantage of data obtained from credit registries.

### Debt service ratio limit (Singapore) – continued

The calibration of the instrument covered not only the headline threshold for the TDSR (set to 60%), but also the various aspects of how debt and income streams should enter the computation of the TDSR. For example, the calibration required financial institutions to apply specified haircuts to different types of income to take account of their respective riskiness. The calibration also specified a medium-term interest rate in the computation of the TDSR with sufficient regard to longer-term debt servicing ability.

The thematic review by banking supervisors (see risk assessment) had revealed uneven practices when computing and evaluating debt service-to-income ratios of mortgage loan applicants. The practices that supervisors observed formed the basis for the calibration of the TDSR framework. The TDSR threshold was set to achieve the objectives of strengthening the resilience of financial institutions and encouraging financial prudence among households, while having regard to housing affordability.

### Limit to large intragroup exposures (Mexico)

During the financial crisis, Mexican authorities became concerned about the size and the volatility of exposures between domestic banks and their foreign parents. During 2008 and 2009, some Mexican subsidiaries provided funding to their foreign parents, leading to a large increase in their net exposure to their parents' default. The situation reversed later, when foreign parents attempted to benefit from the higher interest rates offered in Mexican pesos than in their currencies.

Against this background, the Bank of Mexico in 2010 considered whether the existing limit for intragroup exposures should be reduced from 50% of Tier 1 capital, and whether intragroup transfers of assets or liabilities should be limited. The objective was to limit contagion risk without unduly restricting the ability of global financial groups to manage their assets and liabilities. The result was a regulation proposal that the National Banking Commission published in 2011.

The calibration focused on contagion risk. A key input was a thorough analysis of the network of interbank exposures, on a daily basis, for a number of years including the financial crisis. For each day, the Bank of Mexico ran a counterfactual exercise in which it investigated the worst impact should one bank's foreign interbank exposure materialise, taking account not only of the initial impact on the bank itself but also the contagion among the banks' creditors. This counterfactual exercise revealed that, on some days, the capital adequacy of up to nine domestic banks, accounting for 25% of total domestic banking assets, might have fallen below regulatory minima. It also revealed that intragroup exposures of domestic subsidiaries were among the largest losses in the domestic banking system. ①

The decision to reduce the existing limit for intragroup exposures from 50% to 25% of Tier 1 capital as a soft limit where any amount in excess of the limit has to be deducted from regulatory capital reflected the results of this network analysis and the experience that exposures were subject to large swings. The new threshold value was not set to bind

in normal times: in fact, the counterfactual exercise suggested that, in the years after the crisis, when domestic subsidiaries had typically become debtors of their foreign parents, bank failures would have been very rare even if the worst-case exposure had materialised and the threshold had not been lowered. Instead, the threshold was lowered to prevent the build-up of excessive exposures. Reducing the threshold could also serve as a signalling device, encouraging international banking groups to better manage exposures arising between group members.

In contrast, no quantitative limit was imposed on the transfer of assets and liabilities between group members. The reason was that a uniform limit appeared to be unable to adequately reflect the heterogeneity of banks. Requiring authorisation should transfers exceed 25% of Tier 1 capital within a year appeared to be the more flexible measure, and might again positively influence intragroup risk management. This measure was also put in place in 2011.

① For details, see Bank of Mexico (2010).

The starting point for the calibration decision is typically the risk assessment. Box 5 illustrates this, continuing the case studies of the appraisals of a minimum risk weight in Brazil and a debt service-to-income ratio in Singapore. In the Brazilian case, the minimum risk weight was calibrated on the basis of the Basel II internal ratings-based (IRB) formula but using values for the likelihood of default, and for the loss to the lender should the loan default, that appeared to be appropriate from a macroprudential perspective. In the case of the debt service-to-income ratio, an important part of the calibration was to ensure that all banks use the same, high, standards when computing the debt service ratio after a supervisory exercise had revealed discrepancies among banks. The third example is the appraisal undertaken by the Bank of Mexico of a limit to intragroup credit exposures.

**Another approach jointly assesses the impact of an instrument on financial stability and on the wider economy.** One variation uses **separate sets of models to assess different links in the transmission of macroprudential instruments**: the impact of variations in instrument settings on (a) the likelihood and macroeconomic costs of financial crises and (b) on the cost of funding for the banking sector, the width of the spread between risk-free rates and the cost of funding for households and corporates; and the impact of wider spreads on GDP. The appraisal then joins these links to an overall, quantified, transmission chain, informing policymakers' choice of the desired instrument calibration.

This approach has been employed in the calibration of bank capital requirements under Basel III, and is used by a number of authorities to calibrate macroprudential instruments.<sup>32</sup> Its advantage is that the models in each link of the transmission chain are readily available, comparatively simple and well understood, making it easy to analyse the impact of varying key parameters. This can be useful when macroprudential policy committees are composed of members with materially different views about aspects of financial intermediation. A disadvantage is that the approach is fragmented and the reconciliation of different models can be challenging. In particular, linking different models that make different behavioural assumptions may increase model uncertainty. Furthermore, it becomes more difficult to assess feedback effects from the later to earlier links in the transmission chain.

<sup>32</sup> See eg Brook et al (2015) and Arregui et al (2013).

## Case studies: Calibration II

### LTV limits (Netherlands) – continued

The analysis considered both benefits and costs of tightening the LTV caps. A simple stress test based on loan-level data implied that, had an 80% LTV ratio cap been imposed at the origination of mortgages to first-time buyers during 2004–12, none of these mortgages would have been in negative equity at the time of the analysis, as opposed to just under 50% in the presence of a 100% LTV cap. A 90% LTV cap would still have reduced this share to about 15%. Estimates of the response of household consumption to changes in home equity suggested that annual consumption growth had been held back by as much as 1.5% in the aftermath of the 2007–09 crisis, implying a sizeable benefit from reducing the volatility of housing equity. Finally, the policy was estimated to somewhat reduce house price growth. Estimates for the impact of house prices were derived using a number of macroeconomic models, which also delivered predictions on consumption and GDP growth (next paragraph).

Several models were used to assess the policy's impact on macroeconomic variables. The first, the standard macroeconomic model of the Netherlands Bank (DNB), did not include a variable related to LTVs but included mortgage credit, residential investment and private consumption. The appraisal linked these variables to the LTV cap via the effect the policy would have on the number of household transactions. The fall in transactions was determined by the share of households that would be unable to provide a sufficiently high deposit as required under a tighter LTV cap, estimated from household-level wealth statistics. A survey on housing, which contained information such as whether potential first-time buyers lived rent-free with their parents, helped assess the time it might take for these constrained households to accumulate sufficient savings. This provided information about the response of private consumption. The effect on transaction volumes was assessed using information about the length of the chain of transactions that a first-time buyer triggers. This estimate was based on, among other sources, a housing survey. Transaction volumes were translated into mortgage credit and residential investment. The DNB's standard macroeconomic model was then used to study the dynamic impact of shocks to mortgage credit, residential investment and private consumption on the economy.

A key variable to which the analysis proved to be quite sensitive was the extent to which constrained households would receive transfers from their family in order to top up the deposit they would be able to pay using their own means.

Similar approaches were taken to translate the policy variable into variables that were integrated in two empirical models (S-VARs). One of the two models was purpose-built in order to cut the number of steps that needed to be taken in this respect. Because LTV caps had not been in place for long, the choice fell on the average LTV of first-time buyers' mortgages at origination.

The appraisal made no formal attempt to aggregate the likely costs and benefits of the policy. While the ingredients of such an aggregation were largely in place (with the exception of linking greater stability in the banking sector and in household finances to the likelihood of sharp declines in GDP and the associated welfare costs), the DNB had not been requested to balance costs and benefits – instead, this assessment was due to be made by the Dutch Financial Stability Council.

### Countercyclical capital buffer (France) – continued

To guide the calibration, the Bank of France considers two approaches: a “structural” and a “hybrid” approach. The structural approach relies on dynamic equilibrium (DSGE) models (see Section 3) that capture several macro-financial variables that are important in France. The central bank's aim is to calibrate a rule according to which the setting of the countercyclical capital buffer responds to macroeconomic developments. This rule is the outcome of a maximisation of either a model-consistent measure of welfare, or of an objective function that is chosen to directly reflect declared macroprudential objectives.

The second approach is “hybrid” in the sense that it combines a stress test module to model the response of bank capital to a relevant macroeconomic scenario with a DSGE model.<sup>33</sup> The DSGE model provides a consistent framework for evaluating the impact of different calibrations of the countercyclical buffer on key economic variables, such as GDP and credit, and thereby helps inform simultaneously the benefit of a higher calibration (in the form of a reduced impact on GDP over the medium-term of the capital shock identified in the stress test module) and the cost (in terms of the reduced growth of GDP when the buffer is introduced).

The two approaches complement each other. The hybrid approach better fits the data, while the structural approach provides a more unified description of how the introduction of a rule-based variation of the countercyclical buffer affects economic agents’ decisions.

In principle, **structural macroeconomic models** offer a more coherent approach. However, so far, only a few authorities have been using them to inform their calibration decision. Some authorities use structural macroeconomic models developed for monetary policymaking to assess the impact that macroprudential instrument settings have on the real economy. These models rarely describe the affected sectors (banks, households, corporations) in sufficient detail to directly evaluate the impact of different macroprudential instrument settings. The example of the calibration of the LTV ratio cap in the Netherlands illustrates that, in this case, instrument settings typically first have to be translated into variables that are already incorporated in the model (Box 6).

Moreover, structural macroeconomic models that incorporate a more detailed description of the banking sector have only recently been developed.<sup>34</sup> While they are actively researched by many authorities, their early stage of development means that few authorities have used them in the policymaking process. If at all, authorities use them for broad-based macroprudential instruments. This may be because targeted macroprudential instruments are more challenging to model and have less of an influence on the real economy, reducing the benefits of using models whose primary benefit is to help assess feedbacks between the real and the financial sector. In addition, broad-based instruments are more easily translated into variables that are incorporated in the model. For example, the ECB, the Bank of France and the Federal Reserve use DSGE models as part of their assessment of the impact of different calibrations of the countercyclical capital buffer on the economy.

Few authorities have used large-scale structural models that include behavioural responses and calibrated decision rules directly for the purpose of calibrating instruments, despite the potential benefits that these models offer by attempting to incorporate feedback effects and behavioural responses. A reason may be that they have been only relatively recently developed, similarly to DSGE models that incorporate a banking sector, such that their properties are not as well understood as those of more established models. One exception is the Federal Reserve, which has used such a model to assess the scope of migration of activity as part of the calibration of the countercyclical capital buffer.

Some authorities use **reduced-form macroeconomic models** in the calibration process. For example, when calibrating LTV ratio caps for mortgages, the Netherlands Bank used a model that included real estate transactions, a variable not included in

<sup>33</sup> See Anido et al (2016).

<sup>34</sup> See eg Clerc et al (2015)

its structural model. Directly including prudential instruments in empirical models requires some history of policymaking using that instrument.

Box 6 continues the case studies for the appraisal of LTV limits in the Netherlands and of the countercyclical capital buffer in France to illustrate how models have been used to inform the calibration of macroprudential instruments.

Methods used for activation and calibration can typically also be used for evaluating policy success – for example, by using newly available data to assess whether indicators of risks, or predicted likelihoods of crises, have changed.

As with the decision to activate an instrument, **judgment** is key to interpreting and aggregating the various sources of information that inform the calibration decision. This is illustrated by the appraisal of the countercyclical capital buffer in the United States (Box 7). Factors that authorities consider include:

- The desire not to interfere excessively in financial markets. For example, setting too low limits for large interbank exposures may reduce the ability of banks to efficiently intermediate funds in the financial system. Setting too restrictive LTV limits may have detrimental distributive effects in countries where mortgages predominantly finance first house acquisitions.
- Uncertainty regarding medium-term behavioural responses of regulated institutions and economic agents to the introduction of the instrument. For example, it is not clear whether, in response to additional capital requirements, banks respond by rationing certain types of credit or by uniformly increasing the cost of credit. Similarly, the macroeconomic cost of tightening an LTV limit on mortgages depends on the extent to which potential first-time buyers are constrained by the lower limit. Box 6 illustrated the various approaches the Netherlands Bank took to assess potential first-time buyers' ability to increase savings – for example, by living rent-free with parents.
- Uncertainty regarding the extent of likely migration of activity. Some of this migration may be desired – for example, foreign suppliers of mortgages to Dutch households appeared deterred by the high LTV ratios prevalent in mortgage lending in the Netherlands. Lowering the LTV cap for mortgages could help encourage foreign lenders to become more active in the Dutch mortgage market, thereby increasing competition and household welfare.<sup>35</sup>

Uncertainty is likely to be higher where institutions to whom the macroprudential instrument applies have only a comparatively small market share. Cooperation between different regulators, and careful design of the instrument, can help reduce this type of uncertainty. For example, reciprocity agreements in the countercyclical capital buffers are designed to reduce migration of activity from domestic to foreign banks and regulatory arbitrage (eg in the form of cross-border banking groups restructuring subsidiaries, to which the macroprudential instrument would apply, to branches, to which the same instrument might not apply).

<sup>35</sup> See Verbruggen et al (2015).

## Case studies: Calibration III

### Countercyclical capital buffer (United States)

In order to inform the activation and calibration of the countercyclical capital buffer (CCyB), the Federal Reserve Board regularly monitors and assesses threats to financial stability by synthesising information from a comprehensive set of financial sector and macroeconomic indicators, supervisory information, surveys, and other interactions with market participants.<sup>①</sup>

Empirical models that translate a manageable set of quantitative indicators of financial and economic performance into potential settings for the CCyB are an additional input to the Federal Reserve Board's judgmental assessment. Such models include those that rely on small sets of indicators – such as the credit-to-GDP ratio, its growth rate, and combinations of the credit-to-GDP ratio with trends in the prices of residential and commercial real estate – which some academic research has shown to be useful in identifying periods of financial excess. Such models also include those that consider larger sets of indicators, which have the advantage of representing conditions in all key sectors of the economy, especially those specific to the financial condition of large banks.

However, no single or fixed set of indicators can adequately capture all the key vulnerabilities in the US economy and financial system. Moreover, adjustments in the CCyB that were tightly linked to a specific model or set of models would be imprecise due to the relatively short period for which some indicators are available, the limited number of past crises against which the models can be calibrated, the uneven coverage of data on different sectors of the US financial system, and limited experience with the CCyB as a macroprudential tool. As such, these models represent an input into the comprehensive judgmental assessment for setting the buffer.

<sup>①</sup> See eg Adrian et al (2014).

- Heterogeneity among households and financial firms. Regulation would be overly complex if it attempted to take account of all forms of heterogeneity in the economy. Important forms of heterogeneity, such as a borrower's commitment to repay a loan, or their attitude to risk, are not observable at all.

This means that some prudential measures penalise households or firms whose behaviour would not have been any riskier under a less tight instrument setting.

One possible way to address this is to leave banks with some flexibility in applying rules – for example, by requiring only a certain share of the portfolio of mortgages to abide by a loan-to-value ratio limit. This approach was taken by the United Kingdom when deploying a loan-to-income ratio cap.<sup>36</sup> Another approach is to select an instrument that leaves banks more flexibility. This consideration influenced, for example, the decision by Brazilian authorities to increase the risk weights on auto loans rather than to impose an LTV limit (Box 2).

- Distributional effects. Deploying macroprudential instruments is likely to redistribute wealth and income between different groups of the population. For example, a macroprudential instrument can affect the distribution of wealth between banks' creditors and their shareholders, via its effect on the composition of banks' liabilities; between taxpayers and bank creditors and shareholders, by

<sup>36</sup> See Bank of England (2014b).

## Case studies: Calibration IV

### Releasing cyclical macroprudential instruments (Hong Kong) – continued

Whereas imbalances in credit and property markets typically build slowly, their unwinding is rarely orderly. That being so, the HKMA's experiences suggest that macroprudential instrument settings would be tightened early but at a gradual pace when imbalances build up, whereas their release would have to balance the desire to respond quickly and aggressively with the aim to avoid acting prematurely. The following paragraph illustrates the factors that affect how the balance is struck in the release phase for the countercyclical capital requirement and property-related measures.

If financial imbalances unwind in a disorderly fashion, the Indicative CCyB Ceiling (Box 3) is likely to signal that credit constraints might become excessive if the CCyB is not released in a timely manner. The final decision on a buffer reduction would of course be made based on well informed expert judgment. In particular, the HKMA is mindful of the risk that a premature release may delay a much needed downward correction and consequently subject banks to further systemic risks.

If financial imbalances unwind without triggering banking system stress, there may be at least two other key reasons for releasing the buffer by less than what the credit-to-GDP gap and housing market indicators suggest. First, the downward cycle might accentuate later despite the release of the CCyB, removing an important cushion for banks' losses. Banks should therefore not be encouraged to expand their loan portfolio when the down-cycle (especially one led by the residential property market) has just started because of significant latent risk.

Second, the cost of policy reversals might be significant. It is difficult to distinguish a temporary consolidation from the early stage of a genuine down-cycle, particularly for small-and-open economies whose financial cycle is more determined by external factors (eg quantitative easing in major advanced economies). When the uncertainty is high, the best strategy might be to wait for more evidence of a genuine down-cycle and consider a bigger batch of CCyB releases later when the down-cycle is more certain.

The considerations for relaxing property-related macroprudential measures are broadly similar to those for the CCyB. Since it is difficult to model behavioural responses in small-and-open economies with relatively large foreign participation, the HKMA tends to tighten property-related macroprudential measures in small steps and modify measures based on the developments over the extended up-cycle in the residential property market. Similarly, the relaxation of property-related macroprudential measures during the down-cycle would not follow any mechanical formula. Instead it would depend on the nature of the down-cycle and rely very much on well informed expert judgment.

transferring a larger share of the cost of bank failure to the latter; and, more broadly, between those owning assets whose prices are impacted by regulation, and those who do not own these assets (eg homeowners versus renters). The latter effect was considered by the Dutch central bank as part of its appraisal of the impact of tighter LTV caps on mortgages.<sup>37</sup>

Given that two key macroprudential instruments – capital buffers for systemically important institutions, and the countercyclical capital buffer – have only recently been introduced, experiences with releasing macroprudential instruments are scarcer than those with tightening them. One exception is the Reserve Bank of India, which has used time-varying risk weights and provisioning norms since 2004 to mitigate disproportionately higher growth to specific sectors, including residential housing and commercial real estate. Some of these measures were relaxed in the second half of 2008 and tightened again in late 2009, when credit growth began to recover.

<sup>37</sup> See Verbruggen et al (2015).

A number of other authorities have substantial experiences with varying in particular housing market tools.

While there appear to be broad similarities between the approaches taken when appraising instruments in both situations, the weight that different factors have when judgment is exercised may differ considerably. Box 8 illustrates this with the experiences of the Hong Kong Monetary Authority.

## 5. Communication of ex ante appraisals

Communication of the results represents a distinct challenge of the policy appraisal process. The groundwork for ex ante appraisals is done at expert working level within policy institutions, but the results must be communicated to the level where policy decisions are taken and, often, also made available to the wider set of stakeholders externally. This section discusses practices and experiences of central banks with the communication of appraisals both within the institution and to a wider audience outside the central bank.

### Internal communication to policymakers

Ex ante appraisals conducted at the working level need to be explained to the bodies in charge of deciding the deployment of macroprudential instruments. The background and the composition of these bodies could influence how results are communicated and, by extension, also the type of appraisal methods used as well as how their results are evaluated.

Not all methods are easily communicated. At one end of the spectrum, analysis based on risk indicators – presented, for example, in the form of heat maps – is relatively easy to understand even for decision-makers without a technical background. At the other end of the spectrum are complex structural models (see Section 3) that have been constructed explicitly to allow the transmission mechanism of macroprudential instruments to be studied.

More generally, the governance structure of decision-making for macroprudential policy can present a trade-off between using methods that are easy to communicate but somewhat simplistic, and methods that are more sophisticated but harder to grasp intuitively. One possibility to deal with this trade-off has been to use more complex methods to confirm messages that arise from an analysis based on methods that are easier to communicate. This parallels a practice in monetary policy analysis in which forecasts are obtained using traditional econometric approaches but a narrative is provided using structural models.

### External communication to a wider audience

Most jurisdictions publish aspects of their ex ante appraisals. Legal requirements, best practice standards, and a general trend towards greater openness in policymaking set the framework for authorities' publications policy. For example, in the EU, authorities setting the level of the countercyclical capital buffer are required to publish the credit-to-GDP gap. In addition, the ESRB recommends publishing a set of supporting

## Case studies: External communication

### Risk weights (Brazil) – continued

To avoid triggering a surge in auto loans ahead the enactment of the policy, the measure was not discussed with the financial industry. At the time of enactment, the central bank used various communication channels: press statements and its financial stability report emphasised concerns over rapid household credit growth and auto loans in particular, and the need for macroprudential policy to support tightening measures undertaken by monetary and fiscal policy. This communication was at a high-level and did not include the technical aspects of the appraisal.

The communication of risks associated with long-term, high-LTV auto loans appeared to discourage the supply of those loans even after the measure had been replaced by a simpler version, in which the risk weight depended only on the term of the loan, not on the LTV. The appraisal process was published in detail a few years later (Afanasieff et al (2015)).

### LTV limits (Netherlands) – continued

The appraisal was conducted during 2014/–15 and published together with the subsequent recommendation of the Financial Stability Council (FSC) to further tighten the LTV cap to 90%. The DNB published the appraisal in detail and used press releases and a newspaper interview by its president to explain it. This was not primarily to enhance accountability: the government, not the central bank, would decide on the policy. However, the DNB president chaired the FSC, and the presentation of the relative costs and benefits of the policy, as well as the language used in its report, suggested that it favoured tightening the LTV cap. This was the opposite conclusion to that reached by a contemporaneous study that was conducted by the Netherlands Bureau for Economic Policy Analysis (CPB) and published separately.

indicators. In the US, the Federal Reserve Board updates Congress twice a year on developments pertaining to the stability of the US financial system, thereby providing information about the setting of the countercyclical capital buffer. Publication of policymakers' rationale behind specific measures increases the transparency of the policy process and enhances the accountability of the decision maker. It also reduces regulatory uncertainty and strengthens the expectations channel of macroprudential policy.

Many jurisdictions target specific audiences via different communication channels. To reach the general public, for which simplicity and practical implications of the message are key, policymakers use press releases, conferences, speeches, interviews, and articles in non-technical publications. For more specialised audiences they might enlist the help of external economic researchers in validating and improving ex ante appraisals by publishing the models and data used in discussion papers and professional journal articles, or by presenting them in academic conferences. A suggestion along these lines has, for example, been issued by the German Financial Stability Committee in the context of its recommendation to introduce borrower based instruments, albeit for ex post evaluations of these instruments.

The level of detail that central banks publish varies. Confidentiality concerns and contractual arrangements with data providers limit authorities' ability to publish granular data, in particular when it comes to institution-specific information. Publications typically contain only aggregated data and assessments of impact. For example, the Bank of England makes the value of key indicators available on its

website that its Financial Policy Committee uses to assess stability in the housing market and to calibrate the countercyclical capital buffer and sectoral capital requirements. Even when some of the information is available from other sources, the publication by the authority in charge of macroprudential policymaking helps reduce search costs for others.

There might also be elements of the ex ante appraisals that authorities might not wish to publish. This would include conjectures about possible behavioural responses to variations in instrument settings. This could, for example, be the case for the assessment of leakages or the extent of front-running. One possibility to convey information about this part of the appraisal might be to publish different scenarios for behavioural changes, covering the range of possible responses. This approach was used in the context of assessing changes to banks' credit supply in response to higher capital requirements.<sup>38</sup> For some macroprudential instruments, authorities might only publish information about the appraisal after the policy was enacted in order to avoid that market participants front-run the forthcoming change in instrument settings. This was, for example, a motivation for the Central Bank of Brazil to only publish its appraisal of higher risk weights with a delay (Box 9).

## 6. Conclusions and key messages

The above overview presents a range of practical approaches that policymakers have used in the appraisal of macroprudential instruments. The breadth of this range implies that there is no single preferred approach to ex ante appraisals. Instead, the relative advantages of any particular approach depend on a range of factors, including: the nature of the instrument under consideration; the macro-financial structural and conjunctural characteristics of the jurisdiction applying the instrument; the level of familiarity with analytical methodologies; the availability of data; and governance arrangements.

That said, there are two general messages to be drawn from this overview of experiences with appraisal methodologies. They relate to the importance of inclusive governance in the conduct of appraisals and the relative role of quantitative analysis and judgment.

**Governance arrangements should promote wider cooperation in conducting appraisals.** Almost by definition, ex ante appraisals of macroprudential instruments require expertise in a number of areas: how regulation impacts financial institutions, how financial markets react to structural changes, how monetary and microprudential policy may interact with macroprudential policy, how the real and financial sectors interact, etc. These skills are unlikely to be all available within the same organisational unit. Hence, cooperation across organisational units and/or policy authorities is essential.

Furthermore, when instruments are best activated, and how they are calibrated, may depend on the setting of other policies, and the governance structure can influence how these other policy paths are taken into account.

<sup>38</sup> See eg BCBS (2010a).

**Macroprudential policymaking relies increasingly on quantitative analysis, but this does not obviate the reliance on judgment.** The wealth of quantitative approaches employed to support various facets of design and implementation of instruments attests to a growing tendency to enhance the analytical support of policymaking. If anything, this trend is likely to continue.

However, independently of the approach taken to appraisals, expert judgment retains an overriding role. One reason is that data and analytical tools are not as developed. Information on holdings, exposures, and liabilities are hard to obtain and expensive to process. But aside from data-related issues, quantitative analysis offers limited help. The influence of policy on market participants' behaviour and expectations is a key factor for the impact of deploying the policy instrument but at the same time it is an area in which quantitative approaches so far offer little guidance. Continued improvement of models and of data sources at the household and firm level would be beneficial to further progress in this area. The reliance on expert judgment is not unusual for policymaking. But the role of judgment may be larger in macroprudential policy than in closely related areas in which there is more practical experience, important data is more readily available, and the analytical framework more developed.

An ancillary conclusion of this report, and a suggestion implicit in the Study Group's discussions, is the value of a continued exchange of views and experiences among those involved in promoting research and fostering the analytical support to macroprudential policy.

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## Annex

### List of key terms used for the purposes of this report

Key terms	
Term	Characterisation
Uses the countercyclical capital buffer as an example.	Table 2
Macroprudential instruments	All policy measures that have been undertaken with a macroprudential purpose in mind. This may include measures such as amortisation limits, or reserve requirements.
Design of an instrument	The process of defining the characteristics of an instrument (eg the fact that the countercyclical capital buffer applies to risk-weighted assets and to domestic exposures, is subject to reciprocity).
Timing of an instrument	When an instrument is used (or not); when the instrument setting is changed (or not). For the countercyclical capital buffer, this would be, for example, triggering the release phase.
Calibration of an instrument	The choice of the instrument's intensity. For the countercyclical capital buffer, this would be whether to set it at 1% or 2% etc.
Deployment of an instrument	Choice of timing and calibration of an instrument, ie choosing an instrument setting and the time at which it should apply.
Ex ante appraisal of an instrument	An analysis exploring the economic impact of deploying a given macroprudential instrument. Could cover the work during the design of the instrument and/or the analysis that backs its activation.

### Examples of models used in the appraisal process

This Annex contains a description of models (in alphabetical order) that Study Group members have used or are intending to use in their appraisal process for macroprudential instruments. Table 3 shows what macroprudential issue each paper aims to inform.

Examples of models: Overview	
Issue	Relevant models described in this annex
Calibration of capital requirements (general)	Bank of Japan, Bank of Italy, Behn et al (2015), Carvalho and Castro (2015), Clerc et al (2015), Darracq Pariès et al (2015), Gabrieli et al (2015), Gerali et al (2010), Gross and Garcia (2015), Idier and Piquard (2016).
Deployment of countercyclical capital buffer	Alessandri et al (2015), Castro et al (2016), Central Bank of Luxembourg, Coudert and Idier (2015), Federal Reserve Board.
Housing market and household vulnerability	Gross et al (2015), Ciocchetta et al (2016), Michelangeli and Pietrunti (2014), Nobili and Zollino (2012).
Firm vulnerability	De Socio and Michelangeli (2015).

### **Alessandri et al (2015): “A note on the implementation of the countercyclical capital buffer in Italy”**

This is a statistical assessment of the credit-to-GDP gap that is meant to inform the activation and calibration of the countercyclical capital buffer (CCyB).

The analysis proposes an operational framework that, within the degrees of freedom allowed by the Basel approach and European regulation, aims to address the challenges related to the application of the CCyB in Italy. First, it studies the credit cycle using the longest time series of credit and GDP available in Italy. Second, it proposes a way to improve the real-time estimation of the state of the financial cycle (the credit-to-GDP gap) by using information retrieved from all the observations available (two-sided Hodrick-Prescott filter). Third, it proposes an approach to selecting a set of additional macro-financial indicators that should complement the credit-to-GDP gap in guiding decision-making on the CCyB.

The next steps envisaged are the development of a more comprehensive framework for the real-time estimation of the financial cycle and a refinement of the analysis of the additional indicators in a forecasting framework.

### **Bank of Italy: “The quarterly model of the Italian economy”<sup>39</sup>**

This is a large-scale macroeconomic model. The Bank of Italy’s quarterly econometric model describes the interactions between the main macroeconomic aggregates of the Italian economy, providing medium-term projections of macroeconomic variables. It is made up of about 800 equations, of which nearly 100 are stochastic, with a broad specification of the economic sectors, including the public sector and the banking sector. The mechanisms that govern the evolution of the main variables are Keynesian in the short term (with economic activity mainly influenced by the evolution of aggregate demand and rigidities in the adjustment of prices and wages), while in the long term, as in the neoclassical model, economic growth is the result of investment, productivity and demographic dynamics.

The model has not been used yet to simulate “shocks” stemming from macroprudential policies but might be used, for instance, to gauge the interaction between a capital requirement policy and the wider economy and especially non-financial sectors. Equations from the banking sector block of the model might allow assessment of how banking sector income affects the banks’ capital or how higher capital requirements affect the interest rate spread applied to the non-financial sector. The banking sector block is currently under review.

### **Bank of Japan: Financial macro-econometric model<sup>40</sup>**

This is a large-scale econometric model covering 115 banks and 258 cooperative regional financial institutions as well as households and the firm sector, and explicitly estimates a set of behavioural equations for the banks it includes. It has two notable features. First, it estimates a bank’s behaviour, such as lending, for each bank, using confidential granular data collected from banks.

Because the key parameters governing banks’ behaviours, including pass-through rates and the laws of motion governing the rating transition matrix, are bank-specific, it is possible to gauge a loss under a stress scenario or reactions to a certain

<sup>39</sup> For a description of the model, see Busetti et al (2005).

<sup>40</sup> This model is discussed in Ishikawa et al (2012), Kitamura et al (2014), and Kawata et al (2013).

macroprudential instrument not only for an aggregate economy but also for each bank. Second, the model explicitly addresses interaction between the real economy and the banking sector. For instance, macroeconomic variables such as GDP and stock prices are modelled as a function of aggregates of a bank's lending volume, and a bank's lending volume is modelled as a function of GDP and stock prices.

The model is used for two purposes. First, stress testing. Both scenario formation and estimation of banks' loss under stress scenarios are conducted using this model. Both scenarios and estimation results are published as a part of the *Financial System Report* that is released biannually by the Bank of Japan. Second, it serves the analysis of the effectiveness of macroprudential policy instruments.

**Behn et al (2015): "Assessing capital-based macroprudential policy using an integrated Early Warning GVAR model"**

This is an early warning model, combined with a GVAR. The framework links the costs and benefits of macroprudential actions. Costs are estimated as the short-term loss in credit and GDP following the activation of a macroprudential measure as identified using sign restrictions within the GVAR model. Benefits are computed through a reduction of the probability of a crisis; costs are estimated using the average GDP loss of a crisis (as in Laeven and Valencia (2012)).

The paper aims to inform the calibration of capital buffers, in particular the countercyclical capital buffer.

**Carvalho and Castro (2015): "Foreign capital flows, credit growth and macroprudential policy in a DSGE model with traditional and matter-of-fact financial frictions"**

This is a DSGE model. The framework incorporates consumer, commercial and housing loans, all of which facing default risk. Consumer loans are granted based on expected future labour income. Housing loans have seniority over consumer loans and credit origination in that the segment faces an LTV-type constraint in addition to a DTI constraint. Banks also grant working capital loans to exporters. Banks optimise a dynamic balance sheet allocation problem, facing liquidity targets and macroprudential regulatory constraints. The model is estimated with Bayesian techniques using data from Brazil.

The model can be used to inform the calibration of Pillar 1 and 2 capital requirements, the Pillar 3 countercyclical capital buffer, reserve requirements on heterogeneous deposit accounts and heterogeneous risk weights. Intended developments include the addition of public banks as part of a heterogeneous banking system.

**Castro et al (2016): "The countercyclical capital buffer in Spain: an analysis of key guiding indicators"**

The paper assesses a range of indicators for guiding the CCyB's activation in Spain. It finds that a relatively small set of indicators, comprising economic developments typically associated with excessive credit growth periods – namely, strong credit growth, increased debt service in the private sector, house price appreciation and external imbalances – can usefully complement the credit-to-GDP gap in setting the CCyB. Structural estimates of the long-run trend for those indicators in "gap format", including the credit-to-GDP gap, are also considered.

On the specific indicators proposed, the authors find that indicators of "credit intensity" (the ratio of changes in credit-to-GDP), property prices (structural house

price gap), external imbalances (headline or structural current account as a percentage of GDP) and private sector debt sustainability (the cyclically adjusted debt burden ratio for the non-financial private sector) can help to identify periods of excess credit growth associated with an increase in systemic risks.

#### **Central Bank of Luxembourg<sup>41</sup>**

This is an econometric model designed to inform the activation and calibration of the countercyclical capital buffer (CCyB).

Following BCBS (2010b), the HP filter with a lambda of 400,000 is used to compute the credit-to-GDP gap. A narrow credit definition is favoured. This approach is complemented with multiple additional indicators. In addition to the BCBS approach, the European Systemic Risk Board's CCyB Recommendation has been followed (based on Detken et al (2014)), along with the parametric/non-parametric AUROC approaches. A panel of 28 European countries is used – including Luxembourg, for which a vulnerability variable is defined based on an index developed in Rouabah (2007). The indicators considered are the year-on-year real growth rate of credit and the credit-to-GDP ratio. Credit covers both broad, narrow and mortgage credit definitions. Policymakers' preferences are taken into account via a loss function. Model output can also be used to define three levels of vulnerability (high, medium and low).

Intended developments include the specific application of the model to the calculation of the CCyB; and a risk assessment analysis in terms of excess credit in the economy.

#### **Ciocchetta et al (2016): “Assessing financial stability risks arising from the real estate market in Italy”**

This paper presents three early warning models to provide guidance to policymakers in the operationalisation of macroprudential instruments for the real estate sector: (i) a standard binary logit model; (ii) a multinomial logit model; and (iii) Bayesian model averaging.

The best set of early warning indicators for banking vulnerability related to households comprises the household credit-to-GDP ratio, the value added of the construction-to-GDP ratio, the gap between the number of house sales and its long-term trend, the growth rate of nominal residential prices, and the growth rate of the number of house sales. For construction and real estate firms, the best-performing set includes long-term government bond yields, the gap between the value added of the construction-to-GDP ratio and its long-term trend, the price-to-income ratio, the growth rate of credit granted to construction and real estate firms, and the growth rate of the number of house sales.

#### **Clerc et al (2015): “Capital regulation in a macroeconomic model with three layers of default”**

This DSGE model aims to inform the long-term calibration of total capital buffers (Pillar 1, Pillar 2 and macroprudential buffers). The framework links households, firms and banks and explicitly models the possibility of default by all agents as a consequence of aggregate and idiosyncratic shocks. In the model, bank defaults imply costly liquidations and cause welfare losses that agents fail to internalise

<sup>41</sup> This is a description of a method the Central Bank of Luxembourg uses to inform its setting of the CCyB; it has not been written up as a paper.

because of the existence of deposit insurance, which provides an implicit subsidy to lending. Higher capital requirements reduce loan supply and tighten lending standards but can increase economic activity and social welfare, as they reduce the implicit subsidy to banks and depositors provided by government as a consequence of limited liability and deposit insurance. The ability of higher capital requirements to increase the welfare of both savers and borrowers is, however, limited, as after a threshold level the benefits from a lower incidence of bank defaults are outweighed by the costs imposed on borrowing households by higher credit spreads.

The model is being applied to the calibration of the countercyclical capital buffer (see also C Mendicino, K Nikolov, J Suárez and D Supera, "Designing capital regulation in a quantitative macroeconomic model", work in progress).

**Coudert, and Idier (2015): "An early warning system for macroprudential policy in France"**

This paper aims to inform risk monitoring and the activation of the countercyclical capital buffer. The authors construct a new early warning system for detecting risks of banking crises in the euro area with the aim of it being used for conducting macroprudential policy in France, mainly for the activation of the countercyclical capital buffer. The authors rely on a two-step strategy.

In a first step, the authors select a set of economic indicators among a large number of candidates for their signalling properties; to do this, they pick the series that outperforms a random walk in predicting crises both over the euro area panel and over the French sample.

In a second step, the authors aim to select the best logit models using three of these indicators as explanatory variables along with a measure of the credit gap. Among all the possible models, they retain those with all coefficients significant at the 95% level. Then, they average their fitted values using several options for weighting their results and fixing the thresholds according to their relative performance, either at the French or at the euro area level. This method, aimed at mitigating the risk incurred by using one single model, is assessed both in and out of the sample.

The results show that averaging models and selecting an overall optimal threshold outperforms a strategy based on only one model, both for the euro area panel taken as a whole and for France. The model might be used to design financial instability scenarios.

**Darracq Pariès et al (2015): "Macroeconomic propagation under different regulatory regimes: using an estimated DSGE model for the euro area"**

This is a DSGE model for the euro area with financially constrained households and firms and embedding an oligopolistic banking sector facing capital constraints. The model includes monetary policy and various financial frictions to credit supply and demand. Furthermore, bank capital is explicitly modelled.

It is intended to study the real economic implications of increasing capital requirements and of introducing risk-sensitive capital requirements, and the effects of the implementation schedule of new regulatory requirements.

**De Socio, A and V Michelangeli (2015): "Modelling Italian firms' financial vulnerability"**

This is a microsimulation model of firms' financial vulnerability. The model uses microeconomic (firm-level) data to take into account the heterogeneity of firms and their demography and complement these data with macroeconomic forecasts in order to estimate earnings before interest, taxation, depreciation and amortisation (EBITDA), interest expense and financial debt for each individual firm over a two-year horizon. In this way, the model yields a projection of the share of vulnerable firms (those with negative EBITDA or whose interest expense-to-EBITDA ratio is above 50%) and of their debt well in advance of the availability of actual data.

The model has not been used yet to simulate "shocks" stemming from macroprudential policies. In this model, a CCyB decision might affect firms' vulnerability, eg through its impact on interest rates on new loans. Also, sector-specific measures might be appraised.

### **Federal Reserve Board: Estimation and calibration of Iacoviello (2015), Clerc et al (2016) and Kiley and Sim (2015)**

For the purpose of assessing the effects of the countercyclical capital buffer for overall fluctuations in credit and economic activity, Iacoviello (2015) and Kiley and Sim (2015) are estimated using US data; Clerc et al (2015) is calibrated.

In Iacoviello (2015) and Clerc et al (2015), banks face an exogenous borrowing constraint, interpreted as a capital requirement. The CCyB tightens banks' binding capital constraint, banks rely on inside equity and do not pay dividends (or repurchase shares), and banks cannot raise outside equity; as a result, a change in the CCyB forces banks to reduce lending to accumulate inside equity.

In Kiley and Sim (2015), investors in bank debt limit overall leverage to limit the risk of default. The CCyB is additionally adopted and is assumed to be tighter than the leverage constraint imposed by investors. In contrast to Iacoviello (2014) and Clerc et al (2015), banks can raise outside equity, although this is costly if following adverse earnings shocks. These features suggest that the model will imply that the CCyB has little effect on lending.

### **Gabrieli et al (2015): "Cross-border interbank contagion in the European banking sector"**

For the purpose of assessing contagion risk, this network model allows analysis of the effect of financial interconnections between European banking groups on the risk of contagion. It features the interaction of three contagion channels: (i) exposures to a common risk factor (eg to the market price of some assets); (ii) exposures to credit and counterparty risk in the interbank market; and (iii) exposures to short-term liquidity risk (inability to roll over a loan overnight or with a seven-day maturity).

Following the failure of one institution, the spread and consequences of financial contagion are measured by the number of banks in default and the capital losses suffered. So far, the analysis has relied on bilateral interbank exposures in the euro money market (estimated from TARGET2 payments) and on balance sheet data for 73 European banking groups; behavioural responses are taken into account in the modelling of short-term liquidity risk, whereby the larger the losses incurred, the more a bank is reluctant to provide liquidity to other banks.

The tool is currently being revised in order to improve the modelling of contagion mechanisms and to exploit newly available data on interbank exposures. An impact study of reforms aimed at limiting the concentration of exposures (or the

centrality of some market participants), or at raising regulatory capital and liquidity requirements, is also under consideration within this modelling framework.

**Gerali et al (2010): “Credit and banking in a DSGE model of the euro area”**

This is a DSGE model with financial frictions and an imperfectly competitive banking sector. Banks issue collateralised loans to both households and firms, obtain funding via deposits, and accumulate capital out of retained earnings, aiming to keep their capital-to-assets ratio as close as possible to an exogenous target level. Banks enjoy some market power, as loan margins depend on the banks’ capital-to-assets ratio and on the degree of interest rate stickiness. Banks face costs of adjusting retail rates, and the pass-through to loan and deposit rates of changes in the policy rate is incomplete. Balance sheet constraints establish a link between the business cycle, which affects bank profits and thus capital, and the supply and cost of loans. The model is estimated with Bayesian techniques using data for the euro area.

The model has been used to show the potential impact of a CCyB measure within a research project by Angelini et al (2011). It is intended to be re-estimated on Italian data.

**Gross and Garcia (2015): “Assessing the efficacy of borrower-based macroprudential policy using an integrated micro-macro model for European households”**

This microsimulation paper develops an integrated micro-macro model framework that is based on household survey data for a subset of the EU countries. The model can be used to assess the efficacy of borrower-based macroprudential instruments, namely loan-to-value (LTV) ratio and debt service-to-income (DSTI) ratio caps. The simulation results from the model can be attached to bank balance sheets and their risk parameters to derive the impact of the policy measures on households’ capital position.

The framework also allows quantification of the macroeconomic feedback effects that would result from the policy-induced reduction of demand for mortgage loans. The model provides an answer to the question of which of the two measures – LTV or DSTI caps – is the more effective, with respect both to their ability to reduce household loss rates and to their impact on the economy. It is intended to inform the calibration of borrower-based measures.

**Gross et al (2016): “The impact of bank capital on economic activity – evidence from a mixed-cross-section GVAR model”**

This is a reduced-form multi-country GVAR model used to combine 28 EU economies and a sample of individual banking groups to study the propagation of bank capital shocks to the economy.

Various simulations with the model assess how capital ratio shocks influence bank credit supply and aggregate demand. The authors distinguish between contractionary and expansionary deleveraging scenarios, and confirm the intuitive result that, only when banks choose to achieve higher capital ratios by shrinking their balance sheets, would economic activity run the risk of contracting.

The model can be used to establish ranges of impact estimates for capital-related macroprudential policy measures, including countercyclical capital buffers, systemic risk buffers and G-SIB buffers, also with a view to assessing the cross-country spillover effects of such policy measures.

### **Idier and Piquard (2016) “Pandemic crises in financial systems: a simulation-model to complement stress-testing frameworks”**

This model presents a simulation framework of pandemic in financial system composed of banks, asset markets and interbank markets. This framework aims at complementing the usual stress-test strategies that evaluate the impact of shocks on individual balance-sheets without taking into account the interactions between several components of the financial system. We build on the network model of Gourieroux, Héam, and Monfort (2012) for the banking system, adding some asset market channels as in Greenwood, Landier, and Thesmar (2012) and interbank markets characterized by collateralized debt as in Brunnermeier and Pedersen (2009). We show that rather small shocks can be amplified and destabilize the entire financial system. In our framework, the fact that the system enters in an adverse situation comes from first round losses amplification triggered by asset prices depreciation, interbank contraction and bank failures in chain. From our simulations, we explain how the different channels of transmission play a role in weakening the financial system, and measure the extent to which each channel could contribute to the probabilities of default of banks.

This framework thus provides first evaluation of second round losses when all banks suffer shortfalls against a given scenario, but also at the extreme, quantify the impact of a bank default on the entire bank network.

### **Mencía and Saurina (2016): “Macroprudential policy: objectives, instruments and indicators”**

This paper uses a broad set of indicators that enables macroprudential risks to be monitored through risk mapping. The resulting heat map is a tool for visualising possible sources of systemic risk and for monitoring how they evolve over time.

The methodology comprises two stages. In the first stage, a level of alert (a risk scale) is associated with each available indicator (more than 100 currently). The second stage consists of aggregating all the information from the indicators. The aggregation procedure aims to minimise redundancies and to take into account the indicators' capacity to anticipate periods of stress in Spain.

The resulting heat map has been structured around a series of categories that provides a better arrangement of the data: (i) credit growth and leverage; (ii) transformation of maturities and market illiquidity; (iii) concentration; (iv) incentives and moral hazard; and (v) macroeconomic imbalances. Lastly, a separate category capturing actual conditions in the economy and in the banking sector is also included.

### **Michelangeli and Pietrunti (2014): “A microsimulation model to evaluate Italian households' financial vulnerability”**

Household-level data from the Survey on Household Income and Wealth (SHIW) are complemented with macroeconomic forecasts on debt and income to project the path of households' indebtedness and debt service ratio. Households' vulnerability can be assessed at a higher frequency and in a timelier manner than by using household data alone. The framework allows different definitions of financial vulnerability.

First, households are distinguished according to their income class. For each class, the parameters of the income process are estimated using historical microeconomic data and allowing for different income realisations, while ensuring

consistency with the growth in nominal income from macroeconomic projections. Second, indebted households repay their mortgage according to a French amortisation schedule. Mortgage originations are retrieved from microeconomic estimates, readjusted to match the macroeconomic data on mortgage debt growth. By combining projections of income, debt and repayments, the projected share of vulnerable households over time can be computed.

The model has not been used yet to simulate “shocks” stemming from macroprudential policies. In this model, a CCyB decision might affect households’ vulnerability, eg through its impact on interest rates on new mortgages and the quantity of new mortgages.

**Nobili et al (2012): “A structural model for the housing and credit markets in Italy”**

This is a structural system of simultaneous equations for the housing market in Italy, which takes into account the multifold link with bank lending to both households and construction firms. Shocks in the economy affect the equilibrium in the housing sector through their effects on housing demand (captured by house prices) as well as on housing supply (captured by changes in residential investments). The model allows the house supply to vary in the short run and the banking sector to affect the equilibrium in the housing market, through its effect on housing supply and demand. As far as the banking sector is concerned, the model encompasses two credit segments that might potentially affect the house market equilibrium, namely mortgage loans to households and loans to construction firms. Both might be affected by “pure-supply factors”.

This model is currently used in macroeconomic projections as a “satellite model” of the quarterly econometric model. It has not been used yet to simulate “shocks” stemming from macroprudential policies but might be used to assess the impact of policies (and notably real estate-directed policies) on the real estate market.

The model is currently being improved, in order to shorten the lags in the dynamic of the response variables, to model the agents’ expectations and the effect of real estate taxation, and to allow for non-linear disequilibrium on the credit market, with a view to simulating credit crunch outcomes on quantity of credit, in addition to cost-of-credit effects. Data gaps regarding the real estate market are also being filled.

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