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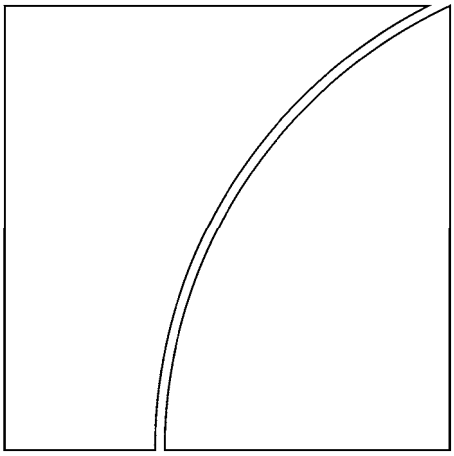

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by Gabriele Galati and Richhild Moessner

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Macroprudential policy – a literature review[1]

Gabriele Galati
De Nederlandsche Bank

Richhild Moessner
Bank for International Settlements

Abstract

The recent financial crisis has highlighted the need to go beyond a purely micro approach to financial regulation and supervision. In recent months, the number of policy speeches, research papers and conferences that discuss a macro perspective on financial regulation has grown considerably. The policy debate is focusing in particular on macroprudential tools and their usage, their relationship with monetary policy, their implementation and their effectiveness. Macroprudential policy has recently also attracted considerable attention among researchers. This paper provides an overview of research on this topic. We also identify important future research questions that emerge from both the literature and the current policy debate.

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Macroprudential policy – a literature review

Gabriele Galati and Richhild Moessner

1 Introduction

The recent financial crisis has highlighted the lack of analytical frameworks to help predict and cope with the global build-up of financial imbalances whose sudden unwinding turned out to have severe macroeconomic consequences. With the benefit of hindsight, there has been a fundamental lack of understanding of system-wide risk[2]. In particular, there has been a failure to appreciate how aggressive risk-taking by different types of financial institutions – against the background of robust macroeconomic performance and low interest rates – supported a massive growth in balance sheets in the financial system. Overconfidence in the self-adjusting ability of the financial system led to underestimate the consequence of the accumulation of growing stocks of debt and leverage, which resulted from booming credit and asset prices – most notably in the housing sector – and were reflected in historically low levels of asset price volatility and risk premia. There was also insufficient recognition of the role of financial innovation and financial deregulation in magnifying both the boom and the unwinding of financial imbalances and their consequences on the real economy.

In terms of policy, the recent financial crisis has highlighted the need to go beyond a purely micro-based approach to financial regulation and supervision. In recent months, the number of policy speeches, research papers and conferences that discuss a macro perspective on financial regulation has grown considerably. There is a growing consensus among policymakers that a macroprudential approach to regulation and supervision should be adopted:

> *"[…] we need a new set of macro-prudential policy tools which will enable the authorities more directly to influence the supply of credit […]. These tools are needed because credit/asset price cycles can be key drivers of macroeconomic volatility and potential financial instability […]." (Chairman of the UK Financial Services Authority, Adair Turner, 2010).*
>
> *"To this microprudential base policymakers are adding a macroprudential overlay to address systemic risk. This overlay has two important dimensions. First, it seeks to ensure the stability of the financial system over time […]. And second, the macroprudential overlay addresses the stability of the financial system at each point in time […]." (Deputy General Manager of the BIS, Herve Hannoun, 2010).*

Standard-setting committees have been tasked with working on macroprudential tools:

> *"Basel III represents a fundamental strengthening - in some cases, a radical overhaul - of global capital standards. Together with the introduction of global liquidity standards, the new capital standards deliver on the core of the global financial reform agenda, and will be presented to the Seoul G20 Leaders Summit in November.*
>
> *The implementation of Basel III will considerably increase the quality of banks' capital and significantly raise the required level of their capital. In*

[2] See e.g. Catte et al (2010).

addition, it will provide a "macroprudential overlay" to better deal with systemic risk. Lastly, the new package will allow sufficient time for a smooth transition to the new regime." (Caruana, 2010a).

"[…] Taken together, the enhanced Basel II and the macroprudential overlay form the Basel III framework." (Deputy General Manager of the BIS Herve Hannoun, 2010).

The policy debate is focusing in particular on the usage, implementation and effectiveness of macroprudential tools, as well as their impact on macroeconomic outcomes and their relationship with monetary policy. Until recently, only limited research and analytical tools was available to inform decisions on a macroprudential policy framework. In the wake of the financial crisis, however, macroprudential policy has attracted considerable attention among researchers, and the research literature is now growing fast. This paper provides an overview of this line of research. The focus of our paper is on the macroeconomic implications and aspects of macroprudential policy tools. Such macroeconomic aspects are relevant for designing effective macroprudential tools, and for the setting of macroeconomic policy, especially of monetary policy. Our paper does not focus on primarily microeconomic issues or issues regarding banks individually.[3] The aim of our paper is to help guide researchers in identifying policy-relevant research questions that can inform policy decisions on the design and implementation of macroprudential policy tools going forward and on the interaction with monetary policy, and to provide information for policymakers on existing research which can inform their current policy debates.

In the paper, we draw parallels with the research literature on monetary policy, which over the past decades has informed the evolution of monetary policy frameworks and strategies. In particular, we look at policy objectives, intermediate targets, instruments and the transmission mechanisms. The crisis has highlighted important shortcomings of the literature on monetary policy, and in particular big gaps in modeling the nexus between the real economy, the financial system, and monetary policy. New research on monetary policy is trying to fill this gap. Monetary policy and macroprudential policy seem to be at the same cross-road.

The remainder of the paper is organised as follows. Section 2 provides a brief historical overview of the usage of the term "macroprudential". Section 3 discusses the objectives of macroprudential policy, Section 4 goes on to discuss macroprudential policy tools, and Section 5 covers the analytical underpinnings and the transmission mechanism. The effectiveness of macroprudential tools, including empirical analysis, is dealt with in Section 6. Section 7 covers coordination of macroprudential policy with monetary policy, as well as governance issues. Finally, Section 8 identifies future research questions based on our review of the existing literature and current policy concerns.

2 Some history

As documented carefully by Clement (2010), the origin of the term "macroprudential" can be traced back to unpublished documents prepared in the late 1970s – minutes of a meeting of the Cooke Committee (the precursor of the present Basel Committee on Banking Supervision) and a document prepared by the Bank of England. During this period, the term generally denoted a systemic orientation of regulation and supervision linked to the macroeconomy (see Borio, 2009). Public references to macroprudential policy surfaced only in the mid-1980s. BIS (1986) discussed it as a policy aimed at supporting "the safety and

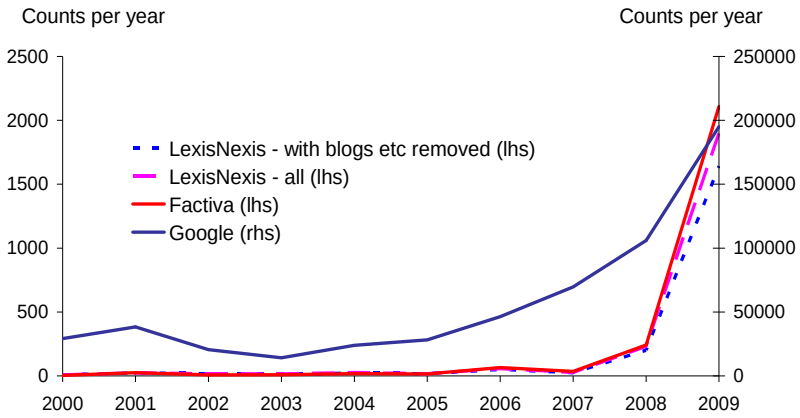
[3] Gorton and Winton (2003) provide a detailed survey of this literature.

soundness of the financial system as a whole, as well as payments mechanism". George Blunden, the first chairman of the Basel Committee on Banking Supervision, highlighted in a speech how a systemic view could imply curbing banking practices that would appear to be prudent from an individual bank's perspective (Blunden, 1987).[4]

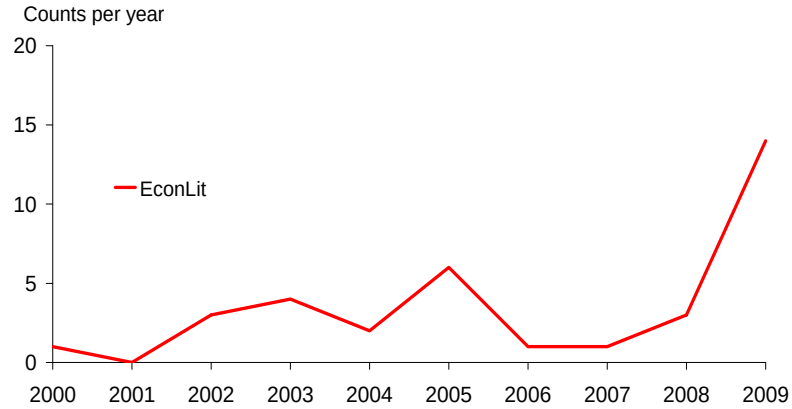
In the early 2000s, the notion of a macroprudential approach to regulation and supervision received new impetus, particularly through an influential speech by Andrew Crockett, at the time General Manager of the BIS (Crockett, 2000).

The use of the term macroprudential became much more common in the current financial crisis (see Graph 1). Many recent speeches on lessons from the crisis discuss macroprudential policy in detail (e.g. Shirakawa, 2009, Nijathaworn, 2009, Tumpel-Gugerell, 2009, Bini-Smaghi, 2009, Kohn, 2009, and Brouwer, 2010). Over the past two years, there has also been a visible increase in research related to macroprudential policy, although the number of published papers, as measured by search results on the term "macroprudential" in EconLit, has remained small (Graph 2). This reflects a dearth of research focusing explicitly on macroprudential policy, but is also partly due to lags in the publication process.

Graph 1
Usage of the term "macroprudential"



Graph 2
Usage of the term "macroprudential" in academic publications



[4] See Tucker (2009). For an early review of prudential policies, with a focus on responses to the build-up of risk from rising leverage, see McCauley et al. (1999).

3 Objectives of macroprudential policy

Over the past two decades and until the crisis erupted, the literature on monetary policy has seen a broad convergence of views on the policy objective.[5] Monetary policy should be geared towards price stability – defined over a horizon of no longer than two years – and, if there is a dual mandate as for example in the case of the Federal Reserve, maximum sustainable employment. Operative objectives were typically defined in terms of CPI inflation or some type of core inflation.

The literature on macroprudential policy is still far from such a consensus on its objectives. Broadly speaking, macroprudential policy is seen as aiming at financial stability but there is no commonly shared definition of financial stability. The different views can be broadly assigned to two groups. The first defines financial stability in terms of robustness of the financial system to external shocks (e.g. Allen and Wood, 2006; Padoa-Schioppa, 2003). The second emphasizes the endogenous nature of financial distress and describes financial stability in terms of resilience to shocks originating within the financial system (e.g. Schinasi, 2004) or the vulnerability to financial distress in response to normal-sized shocks rather than large shocks (Borio and Drehman, 2009a).

In terms of the specific goals of macroprudential policy, the general view is that it is all about limiting the risks and costs of systemic crises, although there are differences in language and emphasis. Brunnermeier et al. (2009) argued that one key purpose of macro-regulation is to act as a countervailing force to the natural decline in measured risks in a boom and the subsequent rise in measured risks in the subsequent bust.

Bank of England (2009) noted that in general terms, it should aim at the stable provision of financial intermediation services – payment services, credit intermediation and insurance against risk – to the economy, trying to avoid the type of boom-bust cycles in the supply of credit and liquidity that were manifested during the recent financial crisis. Macroprudential policy should instead not be geared to avoiding bubbles and imbalances in general, since – as the dot.com bubble illustrated – these can sometimes not be associated strongly with shifts in (bank) credit supply. Landau (2009) instead argued that avoiding bubbles is a possible mandate for macroprudential supervision that would be both pragmatic and legitimate.

An alternative view defined the goal of macroprudential policy as limiting the risk of episodes of system-wide distress that have significant macroeconomic costs (Borio and Drehmann, 2009a). A useful starting point in understanding the nature of macroprudential policy according to this view is the distinction between the macro- and the microprudential perspectives to regulation (Crockett, 2000). Borio (2003) suggested the following stylized characterisation of the different nature of the two perspectives:

[5] See e.g. Borio et al (2003) and Orphanides and Williams (2010) for a discussion of the evolution of views on monetary policy objectives.

Table 1

Macro- versus microprudential perspectives

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

Source: Borio (2003).

A more specific characterization of this view, which refers to the issues in the time and cross-sectional dimensions more explicitly, was provided recently by the general manager of the BIS. Caruana (2010b) described the objective of macroprudential policy as "to reduce systemic risk by explicitly addressing the interlinkages between, and common exposures of, all financial institutions, and the procyclicality of the financial system" (Caruana, 2010b).

Perotti and Suarez (2009a) viewed macroprudential policy as aiming to discourage individual bank strategies which cause systemic risk, a negative externality on the financial system.

Hanson et al (2010) start from the observation that microprudential regulation aims at forcing banks to internalize losses on their assets in an attempt to protect deposit insurance funds and mitigating moral hazard. They discuss how capital regulation and the principle of prompt corrective action (PCA) do not distinguish whether troubled banks react to shocks by raising new capital or shrinking their assets. In their view, macroprudential policy instead aims at controlling the social costs of a generalized reduction of assets in the financial system. Hanson et al (2010) distinguish credit crunches and fire-sales of assets as primary costs of such a balance sheet shrinkage and emphasize that the perimeter of macroprudential regulation should go beyond deposit-taking institutions.

4 Macroprudential tools

In the literature on monetary policy, there is a clear-cut consensus on the role of different instruments. The policy rate is seen as the primary instrument, with communication generally playing a supporting role (Blinder et al, 2008). The use of non-conventional tools, which have recently attracted much attention in the policy debate and the research literature (e.g. Bernanke and Reinhart, 2004; Gertler and Karadi, 2009; Motto et al, 2009; Curdia and Woodford, 2009; Lenza et al, 2010), are confined to extreme situations where policy rates are close to the zero bound.

While the crisis has sparked an extensive policy debate, as well as a number of research initiatives in academia and research task forces of policy fora, a comparable consensus is

still missing in the literature on macroprudential policy.[6] A range of possible macroprudential measures have been investigated without identifying a primary instrument nor a standard taxonomy of instruments.

One important distinction in the debate is between macroprudential tools – defined as prudential tools set up with a macro (in the sense of system-wide/systemic) lens – and other macroeconomic tools that can support financial stability such as fiscal policy (see e.g. Blanchard et al, 2010; Borio, 2009). Table 2, adapted from Hannoun (2010), gives an overview of alternative sets of tools geared towards financial stability. Caruana (2010b) argues that financial regulatory policies are an essential part of the solution but they alone will not suffice to address systemic risk in all its complexity.

Table 2

Alternative sets of tools to foster financial stability

Tool set	Goal	Instruments
Prudential policy: Microprudential	limit distress of individual institutions	e.g. quality/quantity of capital, leverage ratio
Prudential policy: Macroprudentia	limit financial system-wide distress	e.g. countercyclical capital charges
Monetary policy	Price stability	policy rate, standard repos
	Liquidity management	Collateral policies; interest on reserves; policy corridors
	Lean against financial imbalances	policy rate; reserve requirements; mop-up of liquidity; FX reserve buffers
Fiscal policy	Manage aggregate demand	Taxes; automatic stabilizers; discretionary countercyclical measures
	Build fiscal buffers in good times	e.g. measures to reduce debt levels; taxes/levies on the financial system
Capital controls	Limit system-wide currency mismatches	e.g. limits on open foreign exchange positions; constraints on the type of foreign currency assets
Infrastructure policies	Strengthen the resilience of the infrastructure of the financial system	e.g. move derivative trading on exchanges

Source: Adapted from Hannoun (2010).

Especially for emerging market economies, the macroprudential toolkit could also include measures to limit system-wide currency mismatches, which aim at stemming the domestic financial consequences of capital inflows. Examples are limits on open foreign exchange positions and constraints on the type of foreign currency assets (Turner, 2009). Borio and Shim (2007) document how the build-up of financial imbalances was often accompanied by a growing share of net foreign-currency financing.

By contrast, market-based regulations designed to reduce the incentives for capital inflows (Mohanty and Scatigna, 2005; Ghosh et al., 2008; CGFS, 2009) and other tools aimed at controlling large capital inflows that may fuel domestic credit booms are not seen as

[6] The ESCB recently launched a macroprudential research network (Mars) aimed at establishing conceptual frameworks, models and tools that would improve macroprudential supervision in the EU (Constâncio, 2010).

macroprudential tools per se but rather as measures that can buttress prudential regulations (Ostry et al, 2010). One example of such tools is the Pigouvian taxation of international borrowing proposed by Jeanne and Korinek (2010), which forces borrowers to internalize the costs that currency mismatches on their balance sheets can generate in terms of asset price deflation.

The contributions to the literature on specific macroprudential instruments can be categorized in various – in part overlapping – ways. Table 3 provides an example of a taxonomy of macroprudential tools, taken from BIS (2008).

The literature has highlighted several important distinctions. One important distinction is between tools geared towards addressing the time-series dimension of financial stability – i.e. the procyclicality in the financial system – and tools that focus on the cross-sectional dimension – i.e. on how risk is distributed at a point in time within the financial system/contributions to systemic risk of individual institutions. The time series dimension captures the evolution of risk over time, i.e. the procyclicality of risk (BIS, 2001; Borio et al., 2001; Danielsson et al., 2001; Borio and Zhu, 2008; Brunnermeier et al, 2009, Brunnermeier and Pedersen, 2009; Shin, 2009).[7]

Saurina and Trucharte (2007) and Repullo et al. (2009) examined the procyclicality of capital requirements. Shin (2010) discusses how countercyclical capital requirements, together with forward-looking statistical provisioning schemes, can mitigate the harmful effects of securitization on risk concentration in the financial system. Kashyap and Stein (2004) show how time-varying capital requirements are optimal in a model where the objective of the social planner comprises both protecting the deposit insurance fund and maintaining credit creation during recessions. Hanson et al (2010) argue that one problem with this approach is that at times of distress, the regulatory constraint on bank capital might be insufficient to convince markets to continue funding troubled banks. They therefore argue in favor of minimum capital ratios in good times that substantially exceed the standards that markets might impose in bad times.[8]

The literature has highlighted several other sources of procyclicality and suggested instruments geared towards them. The first is the interaction between practices concerning the valuation of collateral and loan-to-value ratios, which can be addressed through maximum loan-to-value (LTV) ratios. Borio et al (2001) provide an in-depth discussion of this interaction and an overview of the regulators' experience with LTV ratios.

The second is loan loss provisions, an important channel through which a misassessment of risk can weaken banks' balance sheets and amplify the financial cycle. Borio et al (2001) argue that accounting practices, tax constraints and the methodologies used to measure risk cause provisions to increase during business cycle downturns. Fernandez de Lis et al (2000) discuss how forward-looking provisioning would limit the observed strong procyclicality of loan provisions. Jimenez and Saurina (2006) suggest that forward-looking loan loss provision should take into account the credit risk profile of banks' loan portfolios along the business cycle.

[7] The literature on the procyclicality of the capital framework known as Basel II is surveyed in ECB (2009).

[8] See also Turner (2000) for a discussion of whether regulatory ratios should be procyclical.

Table 3

Macroprudential instruments

1. Risk measurement methodologies	**Examples**
By banks	Risk measures calibrated through the cycle or to the cyclical trough
By supervisors	Cyclical conditionality in supervisory ratings of firms; Develop measures of systemic vulnerability (e.g. commonality of exposures and risk profiles, intensity of inter-firm linkages) as basis for calibration of prudential tools; Communication of official assessments of systemic vulnerability and outcomes of macro stress tests;
2. Financial reporting	
Accounting standards	Use of less procyclical accounting standards; dynamic provisions
Prudential filters	Adjust accounting figures as a basis for calibration of prudential tools; Prudential provisions as add-on to capital; smoothing via moving averages of such measures; time-varying target for provisions or for maximum provision rate
Disclosures	Disclosures of various types of risk (e.g. credit, liquidity), and of uncertainty about risk estimates and valuations in financial reports or disclosures
3. Regulatory capital	
Pillar 1	Systemic capital surcharge; Reduce sensitivity of regulatory capital requirements to current point in the cycle and with respect to movements in measured risk; Introduce cycle-dependent multiplier to the point-in-time capital figure; Increased regulatory capital requirements for particular exposure types (higher risk weights than on the basis of Basel II, for macroprudential reasons)
Pillar 2	Link of supervisory review to state of the cycle
4. Funding liquidity standards	Cyclically-dependent funding liquidity requirements; Concentration limits; FX lending restrictions; FX reserve requirements; currency mismatch limits; open FX position limits
5. Collateral arrangements	Time-varying Loan-to-value (LTV) ratios; Conservative maximum loan-to-value ratios and valuation methodologies for collateral; Limit extension of credit based on increases in asset values; Through-the-cycle margining
6. Risk concentration limits	Quantitative limits to growth of individual types of exposures; (Time-varying) interest rate surcharges to particular types of loans
7. Compensation schemes	Guidelines linking performance-related pay to ex ante longer-horizon measures of risk; back-loading of pay-offs; Use of supervisory review process for enforcement
8. Profit distribution restrictions	Limit dividend payments in good times to help build up capital buffers in bad times
9. Insurance mechanisms	Contingent capital infusions; Pre-funded systemic risk insurance schemes financed by levy related to bank asset growth beyond certain allowance; Pre-funded deposit insurance with premia sensitive to macro (systemic risk) in addition to micro (institution specific) parameters
10. Managing failure and resolution	Exit management policy conditional on systemic strength; Trigger points for supervisory intervention stricter in booms than in periods of systemic distress

Source: Adapted from BIS (2008).

The third is haircut-setting and margining practices in securities financing and over-the-counter derivatives transactions.[9] CGFS (2010a) highlights the system-wide impact of these practices during the financial crisis, and discusses policy options for reducing the procyclical effects of those practices on financial markets. These include countercyclical variations in margins and haircuts, and higher and relatively stable through-the-cycle haircuts for securities financing transactions.

The cross-sectional dimension focuses on the distribution of risk in the financial system at a point in time, and in particular the common exposures that arise owing to balance sheet interlinkages, similar exposures and associated behavioral responses. In the process, macroeconomic dynamics are taken as exogenous. There is a rich literature on which analysis of the cross-sectional dimension can draw, such as studies of systemic aspects of risk management (see e.g. Hellwig, 1995) or theories of systemic risk (e.g. Acharya, 2009). Important elements within this perspective include market failures (e.g. Rabin, 1998; Calomiris, 2009) and propagation channels (e.g. Jensen, 1986; Calomiris and Khan, 1991).

Most of the macroprudential tools discussed pertain to the regulation of banks' capital. At the same time, the large share of short-term debt in banks' liabilities has been identified as a major source of banks' vulnerability (Brunnermeier, 2009; Gorton, 2009; Shin, 2009; Hanson et al, 2010). These vulnerabilities are often modeled as idiosyncratic shocks amplified through spillovers across the system, as in the studies that focus on credit chains, payment and settlement system links or runs triggered by the inability to distinguish solvent from insolvent institutions (e.g., Kiyotaki and Moore, 1997; Allen and Gale, 2000; Rochet and Tirole, 1996a,b; Freixas and Parigi, 1998; McAndrews and Roberds, 1995; Aghion et al, 1999). Martin et al (2010) showed within an extended Diamond-Dybvig (1983) framework how financial institutions that are funded by short-term borrowing and hold marketable assets can be subject to runs similar in nature to the "traditional" runs on bank deposits. Stein (2010) developed a theoretical model that shows that in the absence of regulation, money creation by banks can lead to an externality in which they issue too much short-term debt and make the financial system excessively vulnerable to costly crises.

All these considerations have focused researchers' attention on instruments that distinguish the maturity structure of banks' balance sheets. The most prominent examples of such tools are the net stable funding ratio or a liquidity coverage ratio (BCBS, 2009), which have an element of procyclicality. One way to overcome procyclicality, proposed by Perotti and Suarez' (2009a,b, 2010), is to affect banks' incentives through liquidity risk charges that penalize short-term funding. Brunnermeier et al (2009) argued in favor of capital requirement surcharges that proportional to the size of the maturity mismatch.

As in monetary policy, another distinction is between rules (built-in stabilizers) and discretion in calibrating the tools of macroprudential policy (Borio and Shim, 2007). Both the historical experience of monetary policymaking and the academic literature have highlighted the importance of rules for accountability, transparency and efficacy of monetary policy. As the literature on time consistency shows, discretion-based solutions, which would be first-best in terms of agents' utility, are time inconsistent (Kydland and Prescott, 1977). In models where rational, utility-maximizing agents act strategically, rules can ensure at least a second-best solution. At the same time, there is a common recognition that to be successful, monetary policy has to be flexible, and that discretion is needed in special circumstances.

By analogy, rule-based macroprudential tools – e.g. automatic stabilizers – appear appealing (Goodhart, 2004). Loan loss provisions, capital requirements/capital surcharges, or loan-to-value ratios can for example be designed in a rules-based way. One important built-in stabilizer are risk management practices that internalize the risk of the build up of financial imbalances and their unwinding (Borio and Shim, 2007).

[9] For a discussion of margins, see Borio (2004).

Contingent instruments can be seen as a form of rule-based tools that are state-dependent. A number of papers have examined the design and usefulness of contingent capital instruments.[10] Hanson et al (2010) distinguish two types of such instruments – "contingent reversibles" and "capital insurance". The former are debt securities that automatically convert into equity if the bank's regulatory capital (or its stock-market value) falls below a fixed threshold (Flannery, 2005; French et al, 2010; Pennacchi, 2010). The latter is an insurance policy that a bank can purchase which pays off in a bad state of the world, according to a prespecified trigger (Kashyap, Rajan and Stein 2008).

While rule-based tools are generally viewed as important, the policy debate has highlighted that discretionary tools like supervisory review or warnings are also likely to play an important role, not least because the next crisis is likely to take a different form from the current one. One commonly used discretionary tool is to issue warnings – e.g. in speeches or Financial Stability Reports – about the build-up of risk in the system. A drawback of warnings is that they may have adverse effects if they turn into self-fulfilling prophecies (Libertucci and Quagliariello, 2010). Other discretionary tools that could play an important role include supervisory review pressure or quantitative adjustments to the various prudential tools (e.g. Hilbers et al, 2005).

One can also distinguish tools based on quantity restrictions and those based on price restrictions. Perotti and Suarez (2010) provide a theoretical treatment of price vs. quantity based tools based on the model by Weitzman (1974), who shows that in the presence of externalities the two types of policy instruments can have different welfare outcomes if there is uncertainty about compliance costs. Price-based tools (taxes) fix the marginal cost of compliance and lead to uncertain levels of compliance, while quantity-based tools fix the level of compliance but result in uncertain marginal costs. Perotti and Suarez (2010) compare the performance of Pigovian taxes aimed at equating private and social liquidity costs to that of quantity regulations such as net funding ratios. They show that when regulators cannot target individual bank characteristics, the industry response to regulation depends on the composition of bank characteristics. Hence, depending on the dominant source of heterogeneity, the socially efficient solution may be attained with Pigovian taxes, quantity regulations or a combination of both.

Among quantity restrictions, Hanson et al (2010) make the further distinction between ratios and absolute values in the context of their discussion of PCAs targeted at bank capital. They argue in favor of an approach that targets incremental amounts of new capital for troubled banks instead of increases in its capital ratio. The idea is that the former would avoid inducing banks a shrink their assets and hence induce procyclical behavior. As a possible application, Hanson et al (2010) propose to design capital ratio requirements in terms of the maximum of current and lagged assets.

Some studies also distinguish the context in industrial and emerging market countries. McCauley (2009) argued that emerging market central banks have been regular practitioners of macroprudential policy, without calling it by this name. As an example, he cited the Reserve Bank of India's decision to raise the Basel I weights on mortgages and other household credit in 2005 (RBI, 2005).[11] Borio and Shim (2007) and CGFS (2010b) provide an overview of emerging market economies' experience with macroprudential instruments. Agénor and Pereira da Silva (2009) examined the cyclical effects of capital requirements for banking sectors in developing countries, with a view to understanding the cyclical effects of Basel regulations in the prevention and/or amplification of the financial crisis.

[10] See Sundaresan and Wang (2010) for an overview.

[11] Caruana (2010) highlighted Asian central banks' efforts to implement various macroprudential tools before and following the experience of the 1997 crisis.

5 Analytical underpinnings

Over the past two or three decades, the literature on monetary policy has provided a common conceptual framework. In particular – at least until recently – there was a consensus on the definition of price stability, the measurement of inflation, and the advantages and limitations of commonly used economic models. Theoretical work within this framework generally assumes forward looking, homogenous, rational agents, and analyzes dynamics near the steady-state. These models typically incorporate frictions that result from rigidities in product and labor markets and asymmetric information that affect financing conditions. A long tradition of empirical research investigated monetary authorities' reaction functions, the monetary transmission mechanism, etc. The main challenge for research on monetary policy highlighted by the crisis is to build macro models that incorporate in a meaningful way the behavior of the financial system and feedback effects to the macroeconomy.[12]

In contrast to the monetary policy literature, research on macroprudential policy is still in its infancy and appears far from being able to provide an analytical underpinning for policy frameworks. This may be due to three main reasons. First, as discussed above, the macroprudential approach has come to play a visible role in policy discussions only very recently and pinning down the definition of financial stability and goal of macroprudential policy is much less obvious.[13] Secondly, we lack a thorough understanding and established models of the interaction between the financial system and the macroeconomy. Thirdly, there is no clear consensus on the relationship and delineation between microprudential policy and macroprudential policy.[14]

5.1 Financial (in)stability and systemic risk

As discussed above, there is no commonly shared definition of financial stability, towards which macroprudential policies would be geared. In terms of analytical paradigms for alternative views on financial instability, one can follow Borio and Drehmann (2009a) and distinguish three types of models. The first comprises models of self-fulfilling equilibria generated by exogenous shocks, in the sense of Diamond and Dybvig, 1983. The second refers to models with negative shocks – which can be idiosyncratic or systematic (Allen and Gale, 2004) – and an amplification mechanism (e.g. contagion shaped by informational and balance sheet linkages as in Rochet and Tirole, 1996b). The third consists of representation of the "endogenous cycle view of financial instability" in the spirit of Minsky (1982) and Kindleberger (1996).

The notion of financial stability is often discussed in terms of the concept of systemic risk and its sources. There is a rich literature on this concept, which is surveyed in de Bandt and Hartmann (2000) and de Bandt et al. (2009), and for which again there is no consensus definition.[15] De Bandt and Hartmann (2000), for example, define systemic risk in terms of the risk of experiencing systemic events where institution(s) affected in the second round or later actually fail as a consequence of the initial shock, although they have been fundamentally solvent ex ante. A similar argument applies if the market(s) affected in later rounds also

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[12] Recent work by Brunnermeier and Sannikov (2009) – who model heterogeneous agents and derive full equilibrium dynamics, not just near the steady state – points to a very useful approach to filling this gap.

[13] See e.g. Tucker (2009) and Borio (2009).

[14] An analogy from economic theory might be the aggregation problem concerned with the relationship between microeconomic theory and macroeconomic theory. Peston (1959) suggests that macrotheory and microtheory should be seen as complements, not substitutes, suggesting that "since […] it is not necessarily possible to make a logically rigid distinction between macro and microvariables, a distinction between the two sorts of theory may not always be easy to make, or even be worth making".

[15] Bullard et al (2009) provide an overview of systemic risk in the context of the current financial crisis.

crash and would not have done so without the initial shock. Along similar lines, Perotti and Suarez (2009b) interpret systemic risk as propagation risk, when shocks spread beyond their direct economic impact, resulting in diffused distress and disruption of the real economy.

A different view of systemic risk starts from the point that the origin of financial instability does not lie so much in contagion but in the exposures to the evolution of systematic risk through time, which is intimately linked to the business cycle (Borio, 2003). According to this view, risk is fundamentally endogenous, and reflects the mutual interaction between the financial system and the real economy that results in overextension in booms, and which in turn sows the seeds of the subsequent downturn and financial strains. Note that this notion is dynamic in the sense that risk builds up over time (during the boom) and then materializes as the imbalances unwind in the downturn.

A somewhat related view by Danielsson et al. (2009) emphasizes the endogeneity of risk, in the sense that the risks impacting financial markets result from market participants' behavior, which in turn depends on perceived risk. They view risk in equilibrium as the fixed point of the mapping of perceived risk to actual risk, and go on to solve a dynamic asset pricing model where equilibrium risk is derived as such a fixed point.

In research on systemic risk that arises within the financial system, one can identify two different strands. The first focuses on measuring systemic risk, while the second aims at assessing the systemic importance of individual financial institutions.

5.1.1 Quantifying financial instability and systemic risk

A variety of empirical approaches have been used to quantify financial instability, which so far have had more limited value in informing policy decisions. These tools can be broadly classified into four categories: indicators of financial distress based on balance sheet and market indicators, early warning indicators, indicators based on Vector Autoregression Models (VARs), and macro stress tests.[16]

Over the past decade, a growing literature has identified indicators of financial distress based on balance sheet indicators (Carson and Ingves, 2003; Bordo et al, 2000) – most notably the Financial Soundness indicators whose development was coordinated by the IMF (Moorhouse, 2004; IMF, 2008) – and market indicators, typically based on equity and credit-default-swap (CDS) or other derivative instruments (Illing and Liu, 2006; Tarashev and Zhu, 2006, 2008). While these indicators are increasingly used, they have important limitations (e.g. Fell, 2007). Most balance sheet indicators – such as loan loss provisions or non-performing loans – are typically backward looking or at most contemporaneous indicators of financial distress (Bongini et al, 2002). Ratings of individual institutions are in principle forward-looking but in practice tend to incorporate new information only with a lag. Moreover, they are micro in nature and thereby fail to highlight vulnerabilities at the level of the whole financial system.

There is a rich literature on early warning indicators, which has documented virtues and drawbacks of alternative types of such indicators for banking crises.[17] These studies tend to predict events that happen in the very near future, and moreover do not reflect an underlying model of how the real economy and the financial sector interact. They appear therefore ill-suited to informing macroprudential policy decisions.

A more promising avenue of research on early warning indicators relies on indicators based on credit and asset markets (Borgy et al, 2009; Borio and Lowe, 2002; Borio and Drehman,

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[16] See Borio and Drehmann, 2009a.

[17] See e.g. Hutchinson and McDill, 1999; Kaminsky and Reinhart, 1999; Bell and Pain, 2000; Demirguç-Kunt and Detriagache, 2005; Davis and Karim, 2008; Dell'Arricia et al., 2008; Von Hagen and Ho, 2007. The large body of studies on early warning indicators of currency crises (e.g. Kaminsky et al, 1998) is beyond the scope of this paper.

2009b; Gerdesmeier et al, 2009; Alessi and Detken, 2009; Fornari and Lemke, 2009). These indicators perform relatively well in predicting – even out-of-sample – episodes of financial distress over somewhat longer horizons (one to four years), and reflect a view of financial instability that is based on endogenous cycles (Borio and Drehmann, 2009a). According to this view, excessively strong growth in credit and financial asset prices – and, especially in emerging market countries, a marked real exchange rate appreciation – reflects the build-up of financial imbalances that have the potential to unwind in a disruptive fashion with large negative macroeconomic consequences (Borio and Lowe, 2002).

A third set of tools for measuring financial (in)stability and capturing financial distress comprises VARs (Drehmann et al, 2006; Misina and Tessier, 2008). These empirical models are flexible tools for forecasting and allow tracing the transmission of shocks through the economy. At the same time, they offer only very stylized descriptions of the dynamics of the financial sector, and of the feedback to the macroeconomy. One variant of this approach consists in modeling the underlying joint dynamics of output growth and indicators system-wide financial risk through a factor-augmented VAR (FAVAR) model (De Nicolo' and Lucchetta, 2009). Stress-tests of these indicators can then be carried out by computing impulse responses to structural shocks identified by standard macroeconomic and banking theory.

The fourth approach consists of macro stress tests, which can be used to trace the response of the financial system to unusually large exogenous shocks.[18] Macro stress tests are by nature forward-looking and highlight the transmission of shocks within the system. They rely explicitly on an underlying view of the forces that can drive financial distress. Similarly to other methodological approaches, however, these models generally fail to capture feedback effects between the financial system and the macroeconomy.[19] They also fail to capture the key aspect of financial distress that small shocks can have very large effects (Borio and Drehmann, 2009a). Existing macro stress tests failed to identify vulnerabilities ahead of the current crisis. Similarly, Alfaro and Drehmann (2009) document that a large fraction of historical banking crises is not preceded by weak domestic macroeconomic conditions, showing that current stress testing models are not able to replicate the dynamics of many past crises. He argues that this could be a result of stress tests considering the wrong risk factors and missing those that were the actual drivers of crises.

5.1.2 Assessing the systemic importance of individual financial institutions

A recent line of research investigates the systemic impact resulting from the problems of an institution or a market, and highlights the role of size, interconnectness and the availability of substitutes.

One important contribution to this line of research is the concept of CoVaR work introduced by Adrian and Brunnermeier (2009), which measures the value at risk (VaR) of the financial system conditional on institutions being under distress. They define an individual financial institution's marginal contribution to systemic risk as the difference between CoVaR and the financial system VaR. This measure crucially depends on leverage, size, and maturity mismatch. One main problem of this measure is that it is not additive, in the sense that individual contributions do not add up to the aggregate measure of systemic risk (Tarashev et al, 2010).

Buiter (2009a) suggests two further conceptual problems with this CoVaR measure. First, it uses correlation to measure spillover, with the latter implying causation, while the former does not necessarily imply causation. Secondly, the CoVaR measure, like the VaR measure, is likely to behave very differently in a crisis than in a normal period over which the

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[18] Surveys of the macro stress testing literature are provided by Sorge (2004) and Drehmann (2009).

[19] Recent work by Aikman et al (2009) is an important exception.

correlations are measured. Moreover, the CoVaR is still a bilateral measure, in the sense that it does not take indirect effects into account.

Segoviano and Goodhart's (2009) proposed an alternative approach to measuring the systemic impact of individual institutions, by looking at the conditional probability of having at least one extra bank failure given a particular bank fails.

Zhou (2010) extended this measure to a multivariate context and proposed a "systemic importance index", which measures the expected number of bank failures in the banking system given one particular bank fails. He also considered a reversed measure – the probability of a particular bank failure given that there exists at least one another failure in the system (the so-called "vulnerability index").

Zhu (2009) constructs market-based systemic risk indicators, defined as the insurance premium for a hypothetical protection on liability losses when the financial system as a whole is in distress.

Zhu et al. (2009b) provide an alternative method to allocate systemic risk contributions at bank level. The definition is along the same lines as the CoVaR or Zhou's vulnerability index. Zhu et al. (2009b) define it as the losses from a particular bank conditional one the banking system being in distress. It has the same additive property (i.e. systemic risk contribution of individual banks add up to the system's risk) as using the Shapley Value approach. And also differently from CoVaR or the approach of Zhou (2010), Zhu et al. (2009)'s measures incorporate size weight information and LGD information in the simulation.

Gauthier et al. (2010) use data on individual banks' loan books, risk exposures, and on interbank linkages including OTC derivatives for the Canadian banking system to compare alternative mechanisms for allocating the overall risk of a banking system to its member banks. They explicitly take into account that overall risk as well as each bank's risk contribution change once bank capital requirements change. Gauthier et al. (2010) consider five different ways to compute contributions to systemic risk, namely component VaR, incremental VaR, two kinds of Shapley values, and CoVaRs. They find that macroprudential capital allocations can differ by as much as 50% from observed capital levels. They find that all five risk allocation mechanisms give similar results in terms of improving financial stability due to macroprudential capital buffers based on them.

One literature strand on the interconnectedness of financial institutions that has recently received increasing attention models the financial system as a complex system. This research focuses explicitly on the degree of complexity, interconnection, non-linearity, diversity and uncertainty (Hommes 2006, 2008, 2009; Hommes and Wagener, 2009; LeBaron and Tesfatsion, 2008). These models are based on heterogeneous agents with bounded rationality, and whose learning process influences the aggregate dynamics of the system.

A related line of research analyses the financial system as a complex dynamic network of agents, which are connected directly through mutual exposures in the interbank market and indirectly through holding similar portfolios or sharing the same mass of depositors.[20] van Lelyveld and Liedorp (2006), for example, investigated contagion risks in the Dutch interbank market by estimating the actual extent of bilateral and foreign exposures, and hence the actual structure of the network. They find that the Dutch interbank market only seemed to carry systemic risks if a large bank failed, and even in this extreme and unlikely event not all of the remaining banks were affected. Gai and Kapadia (2008) and Nier et al. (2008) construct artificial homogeneous networks of banks and analyze the effect of an idiosyncratic shock on the resilience of the network. Both find non-linear effects of net worth and network connectivity (the probability that one bank has lent to another bank) on contagion. These results illustrate that the financial system is likely to have a robust-yet-fragile tendency, i.e.

[20] Allen and Babus (2008) provide a survey of this literature.

while the likelihood of contagion may be reduced by greater connectivity the potential impact of a shock has a much larger scale.[21]

A related approach starts from a measure of systemic risk and then identifies the contributions of individual institutions to this measure (Tarashev et al, 2009a, 2009b). These contributions can inform the design and calibration of policy tools aimed at preventing that systemic stress can originate in these institutions (Huang et al, 2009).

Acharya et al. (2009) start from measuring systemic cost – a negative externality of the financial sector – as the return to the financial sector being "sufficiently bad", i.e. below a certain percentile of its distribution.[22] In their paper, the contribution of each individual financial institution to this cost is proportional to its size and to the percentage loss or negative return it suffers when the market is below this threshold. They propose a "tax" to be imposed on each institution depending on the average of this contribution (its Marginal Expected Shortfall, MES) multiplied by its (dollar) weight in the economy. In other words, MES of a financial institution can be interpreted as the per dollar systemic risk contribution of that institution.

5.2 Understanding the interaction between the financial system and the macroeconomy

In this field of research, the contrast with research on monetary policy is striking. In the latter, there exists a large body of literature that models the link between policy instruments and goals. These models are routinely employed both to produce forecasts of target variables and to conduct policy simulations.[23] By contrast, both theoretical and empirical work linking the financial sector to the macroeconomy is far from a stage where it can be operationalized and used for risk analysis and policy simulations.

In recent years ahead of the financial crisis, central banks increasingly relied on DSGE models to inform their setting of monetary policy (Sbordone et al., 2010). There are three main drawbacks of standard DSGE models more generally. First, they do not model financial frictions in a meaningful sense (Bean, 2009). For example, the Bank of England developed a DSGE model to help the Monetary Policy Committee in producing economic projections, which does not include financial intermediation or financial frictions (Harrison et al., 2005). Second, DSGE models generally assume complete markets and analyze deviations from steady state (with a steady state independent of financial regulation), and are not able to model financial booms and busts (see Buiter, 2009b and Tovar, 2008). Third, they have until recently implicitly assumed that defaults do not occur (Goodhart et al., 2009).

It is possible to identify two relevant strands of the literature based on DSGE models which try to overcome these limitations.[24] The first, recent strand looks at monetary policy in DSGE models augmented with financial frictions related to credit constraints of *non-financial borrowers* (Curdia and Woodford, 2009; Christiano et al., 2008, Christiano et al., 2010, Gerali et al., 2009; Dellas et al., 2010.), building on the financial accelerator mechanism of

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[21] In related work, Chan-Lau (2010) uses balance sheet-based network analysis and bank-level data for Chile to evaluate empirically the interconnectedness risk in banking systems. For an overview of researchers that uses counterfactual simulations to estimate the danger of contagion owing to exposures in the interbank loan market, see Upper (2007).

[22] See also Acharya et al (2010).

[23] Nelson (2008) surveys the use of such models in central banks.

[24] A discussion of the finance literature on the relationship between the term structure of interest rates and macroeconomic factors is beyond the scope of this paper. Rudebusch (2010) provides a careful survey of this literature and distinguishes three strands: papers that add macroeconomic variables to a canonical arbitrage-free finance representation of the yield curve; papers on bond pricing and bond risk premia in a canonical macroeconomic DSGE model; papers that develop a new class of arbitrage-free term structure models that are empirically tractable.

Bernanke et al. (1999). Some papers explicitly use these models to examine the interaction between monetary policy and the macroeconomy during the crisis. Del Negro et al. (2010) for example introduce a model with credit frictions of the form suggested by Kiyotaki and Moore (2008), as well as nominal wage and price frictions to show that the non-standard monetary policies followed by the Federal Reserve during the crisis prevented a repeat of the Great Depression in 2008-09.

Kannan, Rabanal and Scott (2009) present simulations that show how a strong reaction of monetary authorities to accelerator mechanisms that drive credit growth and asset prices can foster macroeconomic stability. In addition, a macroprudential instrument designed specifically to dampen credit market cycles would be useful. They also find that invariant and rigid policy responses raise the risk of policy errors that could lower, not raise, macroeconomic stability. When studying the implications of credit frictions for monetary policy, Vlieghe (2010) suggests that a reallocation of productive resources away from the most productive agents due to credit frictions should be taken into account in setting monetary policy.

The drawback of such models is that they mainly model financial frictions related to non-financial borrowers, not to lenders, whereas financial frictions in the recent financial crisis mainly originated from within the financial intermediation sector. Consequently, such models are not very useful in understanding the recent financial crisis.

The second strand investigates frictions related to *financial intermediaries*, and studies the role of bank capital in the monetary transmission mechanism. Goodfriend and McCallum (2007) include a banking sector and money in a DSGE model, which leads them to distinguish the role of different interest rates – the collateralized loan rate, the uncollateralized loan rate, the Treasury bill rate, the net marginal product of capital and a pure intertemporal rate. By calibrating their model to US data, they conclude that ignoring these differences could lead to substantial policy mistakes. Recent work on incorporating financial intermediaries within DSGE models includes Cohen-Cole and Martinez Garcia (2008), who introduce a bank lending channel in a model with the financial accelerator mechanism. Gertler and Karadi (2009) model financial intermediation within a quantitative monetary DSGE model that allows for financial intermediaries which face endogenous balance sheet constraints. Gertler and Kiyotaki (2009) focus on disruption in financial intermediation, building on Gertler and Karadi (2009)'s modeling of financial intermediation and on Kiyotaki and Moore (2008)'s modeling of liquidity risk. However, Gertler and Kiyotaki (2009)'s model is a purely real model, without nominal frictions, so that the effect of conventional monetary policy cannot be studied within this approach; but the effect of credit policies can be studied within it. In related work, Jeanne and Korinek (2010) show how the interaction between debt accumulation and asset prices amplifies credit booms and busts. The idea of their model is that borrowers do not internalize their contribution to aggregate volatility and as a result take on excessive leverage, thereby leading to boom-bust cycles. To reign in excessive leverage, Jeanne and Korinek (2010) propose a Pigouvian tax on borrowing that induces agents to internalize their externalities they generate.

The implications of capital regulation for bank behavior and macroeconomic outcomes have been studied theoretically in the following papers. Covas and Fujita (2009) use a general equilibrium model to quantify business cycle effects of bank capital requirements. They focus on the interaction between entrepreneurs' moral hazard and liquidity provision by banks as analyzed by Holmstrom and Tirole (1998). They find that output volatility is significantly larger (and household welfare smaller) in the presence of procyclical capital requirements as in Basel II. Zhu (2008) develops a stochastic dynamic model to examine the impact of capital regulation on banks' financial decisions. He finds that compared to a flat-rate capital rule, a risk-sensitive capital standard leads to much higher capital requirements for small and riskier banks, and much lower requirements for large and less risky banks. He also shows that the negative co-movement of risk-based capital requirements with the business cycle does not necessarily lead to a reinforcement of the credit cycle. Repullo and Suarez (2009) build a model that endogenously determines capital buffers and equilibrium loan rates, and use it to analyze recently advocated countercyclical adjustments to capital requirements. As an

illustration, they show that small cyclical adjustments in the confidence level of the IRB approach in Basel II would substantially reduce the incidence of credit rationing over the business cycle without compromising the long-run solvency targets implied in the original regulation. N'Diaye (2009) finds that binding countercyclical prudential regulations can help reduce output fluctuations and reduce the risk of financial instability. In particular, countercyclical capital adequacy rules can allow monetary authorities to achieve the same output and inflation objectives but with smaller adjustments in interest rates. Moreover, these rules can help reduce swings in asset prices and the magnitude of the financial accelerator process. Van den Heuvel (2008) embeds the role of liquidity creating banks in an otherwise standard general equilibrium growth model, and studies the impact of capital requirements on welfare. Meh and Moran (2008) construct a DSGE model in which the balance sheet of banks affects the propagation of shocks. They find that economies whose banking sectors remain well-capitalized experience smaller reductions in bank lending and less pronounced downturns. Bank capital thus increases an economy's ability to absorb shocks and therefore affects the conduct of monetary policy.

Macroeconomic Assessment Group (2010) and Basel Committee on Banking Supervision (2010) study the macroeconomic impact of stronger capital and liquidity requirements proposed under Basel III, via coordinated research for a number of countries, with the former focusing on transitional costs, and the latter on long-term costs and benefits. Macroeconomic Assessment Group (2010) mainly consider macroeconomic models without a financial sector: the effect of stronger capital and liquidity requirements is mainly assessed by first modeling their effect on credit spreads, economy-wide lending volumes and lending standards, and then modeling the effect of these on macroeconomic outcomes using standard semi-structural macroeconometric models or DSGE models without a banking sector; but some DSGE models in which financial intermediaries and their balance sheets are modeled explicitly were also employed in the study. In Basel Committee on Banking Supervision (2010) thirteen models were considered, of which eight models incorporated a role for bank capital, and five for both bank capital and bank liquidity. For the models that do not include a role for bank capital or liquidity, Basel Committee on Banking Supervision (2010) also first models the effect of higher capital and liquidity on lending spreads, and subsequently the impact of these spreads on macroeconomic outcomes. The effect of a macroprudential overlay in the form of countercyclical capital buffers proposed under Basel III has not yet been analyzed

Angeloni and Faia (2009) explicitly address macroprudential policy within a DSGE framework. They integrate banks into a standard DSGE model and examine three important issues: the role of banks in the transmission of shocks; the effects of monetary policy when banks are exposed to runs; and the interplay between monetary policy and Basel-like capital ratios. They find that tighter monetary policy reduces bank leverage and risk, while a productivity or asset price boom increases it. They document that procyclical capital ratios are highly destabilizing, regardless of how monetary policy is conducted. In their model the optimal outcome is achieved by a combination of "mildly anticyclical" capital ratios and a monetary policy rule that responds to bank leverage or asset prices. Angelini et al. (2010) develop a DSGE model of the euro area that incorporates a banking sector and investigate whether a countercyclical capital requirements policy can usefully interact with monetary policy in achieving an inward shift of the output-inflation volatility trade-off. They find that conditional on supply or financial shocks that destroy bank capital, policymakers' active management of capital requirements would improve the stabilization of economic activity.

More detailed models of the banking sectors, but incorporating less detailed macroeconomics, have been constructed by Goodhart et al. (2005, 2006) and Uhlig (2009). De Walque et al. (2008, 2009) are attempts to bridge a macroeconomic model with a more elaborate model of the banking sector, and in particular the interbank market, building on the model of Goodhart et al. (2005) by embedding it into a DSGE framework. Similarly, de Walque and Pierrard (2009) embed that same model into a DSGE model and examine the implications for monetary policy. They find that Taylor rules directly targeting some banking variables may perform better than standard Taylor rules targeting output.

Following a very different set-up with respect to DSGE macro models, a number of recent studies have tried to bridge the gap between macro models and models of the financial system. One such approach introduces macroeconomic factors in elaborate models of cycles in financial intermediation. Brunnermeier and Sannikov (2009) integrate macroeconomic factors and the financial system in an analysis that is not confined around the steady state. Within a dynamic equilibrium model, they show that the financial sector does not internalize all the costs associated with excessive risk taking, and hence leverage and maturity mismatch are excessive. Securitization allows the financial sector to offload some of the risk but exacerbates excessive risk-taking.

Related work examines the impact of monetary policy and funding liquidity on credit supply. Brunnermeier and Pedersen (2009) emphasize the impact of cheap funding liquidity. They show that market liquidity and funding liquidity can be mutually reinforcing, leading to liquidity spirals, and that market liquidity can suddenly dry up and co-moves with the market. Adrian and Shin (2008) examine the link between funding conditions and fluctuations of leverage of market-based financial intermediaries. They show that balance sheet quantities of market-based financial intermediaries can be important macroeconomic state variables for monetary policy. Adrian and Shin (2009) show how low interest rates can influence how banks evaluate the risk of their lending activity through their impact on valuations, incomes and cash flows.[25] Geanakoplos (2010) analyze the determinants and implications of leverage in a general equilibrium model with heterogeneous beliefs. The link between monetary policy and interbank markets subject to sudden freezes is also examined in Freixas (2009), Freixas and Jorge (2008), and Ongena and Popov (2009).

An important line of research on the interaction between real and financial factors focuses on the monetary transmission mechanism. Borio and Zhu (2008) review both the theoretical and empirical contributions on the role of bank capital in the monetary transmission mechanism. They highlight the role of the "risk taking channel", which they view as a family of possible mechanisms through which monetary policy decisions can influence risk perceptions or risk-tolerance – in other words, the price of risk – which in turn influence the degree of risk in portfolios, the pricing of assets, and the price and conditions of the supply of funding. Borio and Zhu (2008) discuss three main ways in which changes in interest rates can influence the price of risk. The first works indirectly through the impact of interest rates on valuations, incomes and cash flows. The second captures the "search for yield" effect (Rajan, 2005). The third is related to the impact of communication policies of a central bank and perceptions of its reaction function on risk-taking. One possibility is that central banks are perceived to behave asymmetrically – not responding directly to signs of the build-up of risk but just to the emergence of stress – thereby providing a sort of ex ante insurance (see Diamond and Rajan, 2009; Farhi and Tirole, 2010).

Dubecq et al. (2009) provide a theoretical model of how a risk taking channel may emerge in the form of underestimation of risk on the part of investors. In their model underestimation of risk is larger the lower the level of the risk-free real interest rate; but they do not provide a quantitative evaluation of how important this channel might be in practice. Disyatat (2010) proposes a reformulation of the bank lending channel which operates via the effect of monetary policy on risk perception and on the strength of banks' balance sheets.

A number of recent papers have empirically investigated the risk taking-channel of monetary policy. Adrian and Shin (2009) find that short-term interest rates are important in influencing the size of financial intermediary balance sheets. Most of the empirical work focuses mainly on the impact of changes in interest rates on lending terms, generally not trying to distinguish between the various channels described above. Maddaloni et al. (2008), Ioannidou et al. (2008) and Jimenez et al. (2009) find empirical support for the hypothesis that lower interest

[25] This work is related to Brunnermeier (2001), who shows that under asymmetric information, low returns on risk-free securities can prompt financial players to take on more risk and invest in higher yielding, riskier assets.

rates have induced banks to take higher risk, with lower interest rates leading to an increase in credit supply to riskier borrowers. This effect has been found to be reinforced by financial innovation (Rajan, 2005). Altunbas et al. (2009a) find that unusually low interest rates (compared with a Taylor rule and the natural rate) over an extended period of time cause an increase in banks' risk taking, by leading to a reduction in the perceived risk of default by banks (see also Gambacorta, 2009).

Moreover, Taylor (2009) examines the behavior of interest rates, macroeconomic and financial variables and finds that the Federal Reserve's excessively expansionary monetary policy contributed to the housing boom in the years preceding the crisis. By contrast, Dokko et al. (2009) find that monetary policy was not a primary factor in the US housing bubble in these years.

6 Effectiveness of macroprudential tools

There is to date only very limited empirical analysis of the effectiveness of macroprudential tools employed so far, which could guide the design of macroprudential tools going forward (see also Turner (2010)).

A compilation of authorities' assessments of the effectiveness of macroprudential tools in a number of countries is given in Borio and Shim (2007). In Spain, the effect of provisioning has been found to have had only a small impact on credit growth, while being useful in building up countercyclical buffers that help strengthen the solvency of banks (Caruana, 2005, Saurina, 2009a). Saurina (2009b) finds that dynamic provisions, while providing no guarantee that they will be enough to cope with all the credit losses of a downturn, have proved useful in Spain during the current financial crisis, by enhancing the resilience of both individual banks and the banking system as a whole. Jimenez and Saurina (2006) find empirical evidence of more lenient credit standards during boom periods, both in terms of screening of borrowers and collateral requirements. Motivated by this evidence, they suggest forward-looking loan loss provision that take into account the credit risk profile of banks' loan portfolios along the business cycle as a regulatory tool. Fillat and Montoriol-Garriga (2010) investigate the hypothetical need for government TARP funds by US commercial banks if they had followed the Spanish dynamic provisioning system, and find that about half of these banks would not have needed TARP support.

Keys et al. (2009) find that in US states with more stringent laws on mortgage brokers, lending standards were loosened to a lesser degree as a result of securitization than in other states in the United States. Analysis by Nadauld and Sherlund (2009) of US subprime mortgage-backed securitization deals suggests that raising capital requirements might limit the growth of a bubble. They show that after the Security and Exchange Commission reduced capital requirements on certain broker dealers in 2004, five large deal underwriters disproportionately increased their purchasing activity relative to competing underwriters in areas with the highest realized rates of house price appreciation but lower average credit quality, with these loans subsequently defaulting at marginally higher rates.

The lack of established models of the interaction between the financial system and the macroeconomy is exacerbated by the difficulty in obtaining data that are needed to conduct empirical work on macroprudential tools. Until now there has been very little analysis in the literature on data needs for macroprudential policy purposes. Regarding the United States, Lo (2009) proposes that a new independent agency should collect data on the market prices of both on- and off-balance sheet assets and liabilities of US financial firms, including in the shadow banking sector, in order to be able to monitor leverage and liquidity conditions in the US banking system, the correlation of asset prices, and portfolios' sensitivity to changes in economic conditions. Sibert (2010) suggests that an agency in the euro area should collect similar data. However, Sibert (2010) also points out that such data would only be of limited use, since it would measure symptoms, rather than causes, of financial instability, since systemic risk is not well understood, and there would be difficulties in interpretation of the

data, and in measuring interconnectedness and network effects. In order to allow researchers and regulators to analyze systemic risk exposures, Brunnermeier at al. (2010) propose a regular (quarterly) collection of data on partial equilibrium risk sensitivities (both of market and idiosyncratic risk) and liquidity sensitivities from regulated financial institutions. Researchers could then use this data in models in order to calibrate system risk and general equilibrium effects.

Using data on individual banks' loan books, risk exposures, and on interbank linkages including OTC derivatives for the Canadian banking system, as mentioned above, Gauthier et al. (2010) find that macroprudential capital allocation mechanisms reduce default probabilities of individual banks as well as the probability of a systemic crisis by about 25%, suggesting that macroprudential capital buffers can substantially improve financial stability.

One important open issue is how one can deal most effectively with the international dimension. Monetary policy has grappled with this dimension in the context of high capital mobility and asynchronous business cycles. For macroprudential policy, a main problem is the asynchrony of financial cycles – and in particular credit cycles – across economies. The risk is that regulatory arbitrage – for example through lending via foreign branches or direct cross-border lending – erodes the effectiveness of macroprudential instruments.[26] For the Eurosystem, this is a particularly relevant issue, which has driven much of the discussions on the European Systemic Risk Board.

Another issue is whether foreign currency liquidity risk should be limited by employing macroprudential tools. Allen and Moessner (2010) discuss the provision of international liquidity via central bank swap networks in the financial crisis of 2008-09, and relate it to a measure of foreign-currency liquidity shortages in both advanced and emerging economies. They conclude that several countries were saved from a serious financial instability by the willingness of the Federal Reserve to make very large amounts of dollar liquidity available at very short notice, and that monetary authorities are likely not to be willing to accept in the future the same amount of foreign currency liquidity risk which they accepted in the past.

Korinek (2010) provides a welfare-theoretic analysis for risk-adjusted capital flow regulations. In his framework agents undervalue the social cost of repayments in crisis states and take on too much systemic crisis risk in their ex-ante financing decisions. Based on historical data for Indonesia, Korinek (2010) finds that optimal Pigovian taxes range from approximately zero for FDI flows to 1.54% for foreign currency-denominated debt. Within a two-sector DSGE-small open economy model with occasionally binding endogenous credit constraints calibrated to emerging markets, Bianchi (2009) finds that a social planner can mitigate the downward spiral in the real exchange rate during a crisis and make all consumers better off by reducing the amount of debt (denominated in the international unit of accounts) ex-ante. According to Bianchi (2009), a tax on debt can implement the constrained social optimum, and the tax should be charged in relatively tranquil times to discourage leverage and decrease the vulnerability to financial crises. Benigno et al. (2010) study overborrowing in production and endowment small open economies subject to an occasionally binding borrowing constraint, giving rise to sudden stops in foreign capital inflows. By contrast, Benigno et al. (2010) find no clear rationale to prefer ex-ante prevention over intervention in a crisis, but in a model which does not consider issues of moral hazard arising from the effect of policies on agents' behavior.

[26] For a detailed analysis of this issue, see Bank of England (2009).

7 Coordination with monetary policy and governance

7.1 How might macroprudential tools interact with monetary policy?

One key issue in the design of a framework for macroprudential policy is how it interacts with monetary policy, since ultimately both types of policy target macroeconomic stability and affect real economic variables. This interaction depends to an important extent on whether financial imbalances play a role in the monetary policy framework.

Before the crisis erupted, the consensus was that monetary policy should not be geared towards anything but price stability, which was defined over a horizon of around two years – and, if there is a dual mandate as for example in the case of the Federal Reserve, maximum sustainable employment.[27] A minority of researchers instead supported the possibility of using a tightening of monetary policy to lean against the build-up of financial imbalances (e.g. Kent and Lowe, 1997; Borio and White, 2004; Filardo, 2004).[28]

The crisis has rekindled the debate on whether monetary policy should be used to counter the accumulation of financial imbalances. As noted by Trichet (2009), there appears to be a shift in favor of the adoption of some form of leaning against the wind both in the policy debate and in the academic literature. In a recent speech, Bernanke (2010) suggested that in exceptional circumstances monetary policy may have to go beyond targeting macroeconomic stability.

Loisely et al. (2009) study the interaction between monetary policy and asset prices using a simple general equilibrium model in which asset-price bubbles may form because of herd behavior in investment in a new technology whose productivity is uncertain. In this model, monetary policy can influence the cost of resources for entrepreneurs and thereby firms' investment in the new technology if and only if they have received a favorable private signal. In doing so, policymakers reveal this signal and can therefore prevent herding behavior and the formation of asset bubbles. The paper identifies conditions under which such a monetary policy intervention is socially desirable.

What does a leaning-against-the-wind approach imply in terms of the monetary policy stance, compared to an approach that is exclusively focused on price stability at a horizon of two years? Agur and Demertzis (2009) examine the interaction between optimal monetary policy and endogenous bank risk and find that leaning-against-the-wind will on average lead to tighter monetary policy. The idea is that banks' risky projects are relatively illiquid and raise the probability of default. If a monetary authority puts sufficient weight on preventing defaults, it follows a V-shaped policy: during downturns, rates are cut more deeply but for a shorter period than under a Taylor rule. Interest rates are raised to limit excess risk-taking during booms.

Borio and Drehmann (2009a) not only support the use of monetary policy to address financial imbalances, but also stress that relying only on macroprudential policy to address (the time-dimension of) financial instability would burden it too much.

The challenge of coordinating monetary policy and macroprudential policy, since they both affect real economic variables, is similar to the challenge faced in attempts to coordinate

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[27] The standard references are Bernanke and Gertler (2001), Goodfriend (2002), and, for an overview of the arguments, Giavazzi and Mishkin (2006).

[28] Cecchetti et al. (2000) argue that monetary authorities should at times react to asset prices in order to stop bubbles from getting out of hand. Assuming that the central bank can observe that an asset bubble is in progress, they conclude that pricking the bubble will lead to better macroeconomic outcomes. A somewhat more nuanced view is found in Bean (2003, 2004, 2007, 2009) and Detken and Smets (2004). Bean (2003) argues that a forward-looking flexible inflation targeting central bank should bear in mind longer-run consequences of asset price bubbles and financial imbalances on macroeconomic variables in the setting of current interest rates, without a need for an additional response of monetary policy.

monetary and fiscal policy. While economic outcomes would be superior if monetary and fiscal policy were coordinated, governance issues and a lower frequency of fiscal policy decisions have led in practice to fiscal policy being the Stackelberg leader, with monetary policy decisions at higher frequency taking fiscal policy as given.[29] Lambertini and Rovelli (2003) find in a theoretical model of fiscal-monetary policy interaction that each policy maker prefers to be the second mover in a Stackelberg game. They find that both Stackelberg solutions are preferable, for each policymaker, to the Nash solution. They argue that there is a natural way to choose among the two Stackelberg games, implying that the government should act as the Stackelberg leader and adopt a fiscal policy rule based on the minimization of a loss function, which internalizes also the objective of price stability. Similarly, the problem might be addressed by monetary policy taking macroprudential policy as given when setting short-term interest rates, given that the frequency of decisions on macroprudential policy is likely to be lower than on monetary policy decisions.

Within a simple static macroeconomic model including banks, Cecchetti (2009) finds that coordination between monetary policy and capital adequacy policy is essential, since they can act as substitutes: the more monetary policy is used for stabilization purposes, the less capital adequacy policy needs to be used, and vice versa. Bean et al. (2010) study how the use of macroprudential policy tools might affect the conduct of monetary policy within a New-Keynesian DSGE model adapted from Gertler and Karadi (2009). As macroprudential tool they consider a lump-sum levy or subsidy on the banking sector, which can be used to affect the amount of capital that banks carry forward. Their results suggest that "to the extent that movements in bank capital and leverage are key factors driving risk taking and aggregate lending, the deployment of macro-prudential policy is likely to be more effective than trying to 'lean against the wind' using monetary policy". Their results also suggest that monetary policy and macroprudential policy should be coordinated, since they are not merely substitutes, but they mention that the issue of coordination needs to be studied further.

Within DSGE models, the impact of financial regulation on the steady state has until recently not been studied. If new financial regulation should affect the steady state, the question arises whether monetary policy should accommodate a transition to a potentially new steady state.

Within a monetary union, macroprudential policy instruments set at the national level can be used to affect national credit growth at a time when policy rates are no longer controlled nationally. The introduction of dynamic provisioning in Spain in July 2000 allowed the Bank of Spain to use this instrument to build up buffers after entering EMU when the power to set policy interest rates was passed to the ECB (Fernández and García Herrero, 2009).

7.2 Institutional set-up and governance issues

There is no consensus in the literature on whether the monetary policy and the banking regulation and supervisory functions should be combined in a central bank, or performed by separate institutions (Lastra, 2003). Goodhart and Schoenmaker (1995) find no overwhelming arguments for either model. Blanchard et al. (2010) discuss how coordination is achieved between monetary and regulatory authorities, and whether the central bank should be in charge of both. They argue that for three main reasons, the past trend toward separating decision making for these two policies may well have to be reversed. First, their advantage in monitoring macroeconomic developments makes central banks an obvious candidate as macroprudential regulators. Second, centralizing macroprudential responsibilities within the central bank would avoid problems of coordinating the actions of

[29] Since fiscal policy employs taxpayers' money, democratic governance implies that fiscal policy decisions should be taken by elected politicians, rather than by unelected officials at independent central banks. In practice, inflation targeting regimes often take fiscal policy as given in their inflation forecasting models, as is the case for example at the Bank of England.

separate agencies during a crisis such as those highlighted during the bailout of Northern Rock. Third, monetary policy decisions have potential implications for leverage and risk taking.

Another important question in implementing macroprudential policy is how committees deciding on macroprudential policy instruments should be composed. Usually, memberships of committees dealing with monetary and financial stability issues at central banks are not identical, although there may be overlap. An interesting counterexample is provided by the Riksbank, where one committee, the Executive Board, decides on both monetary policy and financial stability issues. Previous literature on committee decision making has mainly focused on monetary policy decision making (see Blinder, 2008). Eslava (2006) studies the potential effects of collective decision-making and government appointments on the choices of individual central bankers in monetary policy committees; some of these results might be useful for designing committees deciding on macroprudential policies. Sibert (2010) proposed to have macroprudential policy being conducted by a committee consisting of five members – a macroeconomist, a microeconomist, a research accountant, a financial engineer and a practitioner – composed of members outside of government bodies and international organizations. She stressed that the board should not include supervisors and regulators. The idea is that this composition would favor objective and independent judgment.

8 Conclusions – Topics for future research

The recent financial crisis has highlighted the need to go beyond a purely micro-based approach to financial regulation and supervision, and there is a growing consensus among policymakers that a macroprudential approach to regulation and supervision should be adopted. However, the current urgent drive for decisions on macroprudential policy has occurred against a background of only limited research and analytical tools and data available so far that could inform these policy decisions in a meaningful way. Based on our review of the existing literature, and in light of current policy concerns, we identify the following questions as important future research questions that would be particularly useful to address in order to aid in the implementation of macroprudential policy instruments.

The first set of research questions is to study the effectiveness of macroprudential tools, including quantifying the effect of macroprudential policy instruments on credit growth, leverage, asset prices, and asset price bubbles; evaluating the practicality of proposed macroprudential measures derived from theoretical considerations, such as CoVaRs; an assessment of data that should be collected to allow a meaningful analysis of macroprudential policy to be carried out; and empirical analysis of the effectiveness of macroprudential tools in avoiding financial instability, including historically where macroprudential measures have been employed.

The second set of research questions is to study how monetary policy and macroprudential policy should be coordinated, including the question of the interaction between macroprudential policy and monetary policy; and modeling of financial intermediation and frictions therein in macroeconomic models used for monetary policy purposes, including away from the steady state.

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