OPERATIONALISING A MACROPRUDENTIAL REGIME: GOALS, TOOLS AND OPEN ISSUES

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1 Introduction

Since the early 1970s, the probability of systemic crises appears to have been rising. The costs of systemic crises have risen in parallel. The incidence and scale of systemic crises have risen to levels never previously seen in financial history [Reinhart and Rogoff (2011)]. It has meant that reducing risks to the financial system as a whole – systemic risks – has emerged as a top public policy priority.

The ongoing financial crisis is the most visible manifestation of this trend. Five years on from its inception, the level of real output in each of the major industrialised economies remains significantly below its pre-crisis path (Chart 1). In cumulative terms, crisis-induced output losses have so far reached almost 60 %, over 40 % and over 30 % of annual pre-crisis GDP in the UK, Euro-area and US respectively.[1]

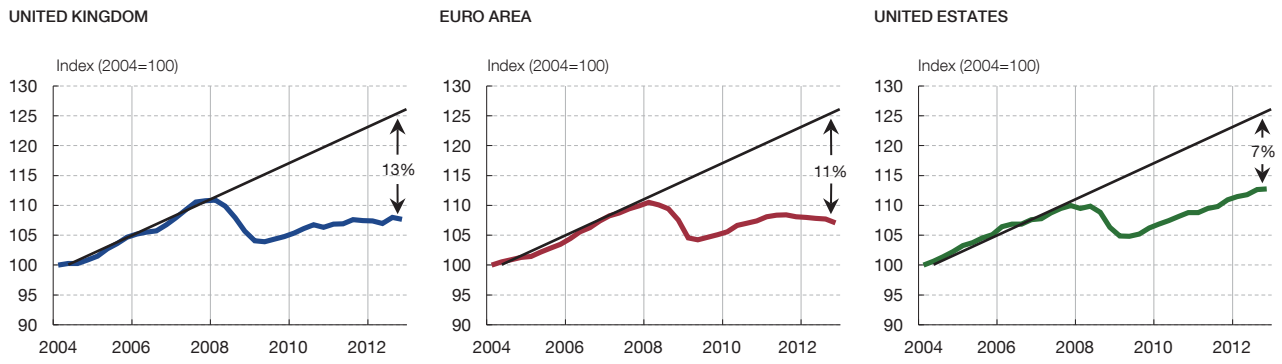
With the benefit of hindsight, the pre-crisis policy framework was ill-equipped to forestall the build-up in systemic risk which generated these huge costs. Monetary policy internationally was aimed at balancing nominal demand in line with the supply capacity of the economy. And microprudential regulation meanwhile focused on the health and conduct of individual financial institutions. This approach appeared to work well for some time – we entered a "Great Moderation".[2] Certainly, demand and inflation were stable and there were few failures of financial institutions.

But at the same time, something dramatic was happening within the financial sector. Global banks' balance sheets doubled between 1990 and 2007. In some countries, such as the UK and Spain, the ballooning of balance sheets was more dramatic still. As financial exuberance took hold, credit became too cheaply priced. Latent financial vulnerabilities began to emerge.

To some extent, these emerging fault-lines reflected fundamental weaknesses in the microprudential regime. In particular, regulatory limits on banks' leverage ratios were set

1 It could plausibly be argued that these output costs are an overstatement of the damage caused by the financial crisis as the pre-crisis level may have been unsustainable.
2 See Blanchard and Simon (2001) and Bernanke (2004).

THE SEVERE AND PERSISTENT REAL COSTS OF FINANCIAL CRISES — CHART 1



SOURCE: Authors' calculations.

A SELECTION OF SYSTEMIC RISK FRAMEWORKS AROUND THE WORLD TABLE 1

	Governance Structure	Mandate	Powers
United Kingdom Financial Policy Committee (FPC)	– Chair: Governor of the Bank of England – 10 voting members (5 from BoE, including head of prudential regulator; head of conduct regulator; 4 external members), one non-voting HM Treasury representative – Meets quarterly	– Protect and enhance the resilience of the UK financial system – Subject to this, support the government's economic objectives including for growth and employment – Cannot take actions that would be detrimental to medium-to-long term growth	– Direction powers over Countercyclical Capital Buffers and Sectoral Capital Requirements – Comply-or-explain Recommendation powers over prudential and conduct regulators – Recommendations (not comply-or-explain) to other bodies (eg on regulatory perimeter) – Measures cannot be directed at individual institutions
United States Financial Stability Oversight Council (FSOC)	– Chair: US Secretary of the Treasury – 10 voting and 5 non-voting members from Federal Reserve and supervisory agencies – Meets at least quarterly	– Identify and respond to emerging threats to financial stability – Promote market discipline, eliminate bailout expectations	– Recommendations to the supervisory authorities on heightened prudential standards – Designation of systemically important non-bank financial institutions and financial market utilities – Reporting to Congress on regulatory gaps
European Union European Systemic Risk Board (ESRB)	– Chair: ECB President – 37 voting members, including central bank governors, and 28 non-voting members from supervisory agencies – Meets quarterly	– Prevent or mitigate systemic risks to the EU financial system – Contribute to smooth functioning of the internal market and sustainable financial sector growth	– Systemic risk warnings and non-binding recommendations to European member states
Germany German Financial Stability Commission (Ausschuss für Finanzstabilität)	– Chair: The Federal Minister of Finance (or deputy) – Three representatives from the Ministry of Finance, three from the Deutsche Bundesbank; and three from the BaFin. Non-voting role for the chairman of the FMSA – Meets quarterly	Tasks of the Commission include: – Consideration of decisive issues for financial stability – Strengthening cooperation in a crisis between institutions represented on the Commission	– Warnings and recommendations to the German government, the BaFin, or any other public sector institution within Germany. Recipients obliged to respond within an appropriate timeframe. – Legal right to request data (forthcoming) both from reporting entities and other public authorities
France Financial Stability Council (Conseil de stabilité financière CSF)	– Chair: Finance Minister – 9 members (Banque de France Governor, the Secretary General and deputy of the prudential supervisor (ACP), the head of the markets regulator, the head of the accounting standards authority and three external independent members)	– Maintain the stability of the financial system and guaranteeing that the financial sector makes a sustainable contribution to economic growth – Ensure co-operation and exchange of information among its members	– Recommendations to institutions represented on the CSF (which may be published) to prevent threats to financial stability. Recipients must inform the CSF of the actions taken in response – At the proposal of the Governor of the BdF, defining capital requirements on exposures in France and outside the EEA – At the proposal of the Governor of the BdF, stipulating criteria or conditions for loans issued by banks
Switzerland	– The Swiss National Bank has the right to submit proposals to the Federal Council, following consultation with the Swiss Financial Market Supervisory Authority (FINMA) – Decision-making power rests with the Federal Council	– Increase the resilience of the banking sector and the overall economy against risks posed by excessive credit growth – Counter excessive credit growth and price rises	– Sector-specific countercyclical capital buffer targeting residential mortgage lending
Sweden Council for cooperation on macroprudential policy	– Chair: Governor of the Riksbank – 6 members (a Deputy Governor of the Riksbank and its Head of Financial Stability, the Director General, Chief Economist and Chief Legal Council of Finansinspektionen, the microprudential supervisor) – Meets at least twice a year	– Discuss both authorities' assessments of systemic risks, appropriate prevention measures and issues relating to development of macroprudential policy in general	Not defined

SOURCES: Bank of England, Financial Stability Oversight Council, European Systemic Risk Board, Bundesbank, Banque de France, Swiss National Bank and Riksbank.

at levels which, with hindsight, were far too low.[3] But there are also limits to what prudential regulation could reasonably achieve as long as it was static and calibrated to institution-specific balance sheets. With this focus, the build-up of leverage and

3 See Wellink (2011) for a summary of weaknesses in the pre-crisis microprudential regime. Consistent with regulatory definitions, this paper defines leverage ratios by dividing the relevant measures of capital by assets (e.g. a leverage ratio of 4%) rather than the reverse (e.g. a leverage ratio of 25 times). But the discussion uses the standard English language interpretation of associating rising levels of leverage with greater indebtedness – under the definition used here, this is equivalent to a falling leverage *ratio*.

maturity mismatch across the financial system, and growing interconnectedness within it, was under-emphasised.

In response, a broad consensus has emerged internationally over the past few years on the need to introduce *macroprudential* regulation.[4] In essence, this new approach seeks to ensure that regulatory rules are attuned to risks arising across the financial system as a whole. Put differently, it aims to plug the gap between macroeconomic policy on the one hand and micro-prudential regulation on the other – a gap through which the largest crisis in a generation fell.

New macroprudential regimes are being put in place around the globe. For example, in the United Kingdom, the Financial Services Act (2012) creates a Financial Policy Committee (FPC) at the Bank of England, with broad powers to make "comply-or-explain" recommendations and control over a set of specific macroprudential tools. In the US, the Financial Stability Oversight Council (FSOC) and in the Euro-area the European Systemic Risk Board (ESRB) have been set up with broadly similar objectives. Macroprudential frameworks are being established in a number of other countries too, including in Switzerland, France and Germany to name but a few. Table 1 summarises a selection of them.[5]

In this paper, we provide an overview of the progress made in making macroprudential regimes operational. Section 2 sets out an analysis of the sources of systemic risk. Section 3 uses this as the basis for a taxonomy of potential macroprudential policy instruments. Section 4 provides a case study of how one such instrument – the countercyclical capital buffer – might be made operational. The material in this section draws heavily on the analysis presented in Bank of England (2013). Section 5 concludes with a discussion of open issues, of which there are many.

2 Fundamental sources of systemic risk

In designing a public policy framework for tackling systemic risk, a natural first step is to identify potential sources of such risk. In this respect, economists have often found it analytically convenient to distinguish two manifestations:[6]

— First, *time-varying or cyclical risks* whose magnitude at any point in time depends on the amount of risk the financial system as a whole takes, relative to its available capital and liquidity resources; and

— Second, *cross-section or structural risks* whose magnitude depends on the network of connections between financial institutions and the distribution of risk across financial market participants.

2.1 TIME-VARYING OR CYCLICAL RISKS

There is a strong collective tendency for financial firms, companies and households to overexpose themselves to risk in the upswing of a credit cycle and to become overly risk-averse in a downswing. This pro-cyclicality has a variety of underlying behavioural causes, including myopia about risk[7] and herding in financial markets.[8] The result is a feast-or-famine problem, with credit plentiful when times are good, but severely rationed when they are bad.

4 See *inter alia* Bank of England (2009, 2011), FSB-IMF-BIS (2011), De Larosière (2009), Van Rompuy (2012), G30 (2010), HM Treasury (2011), CGFS (2010), IMF (2011), Hanson, Kashyap and Stein (2011).

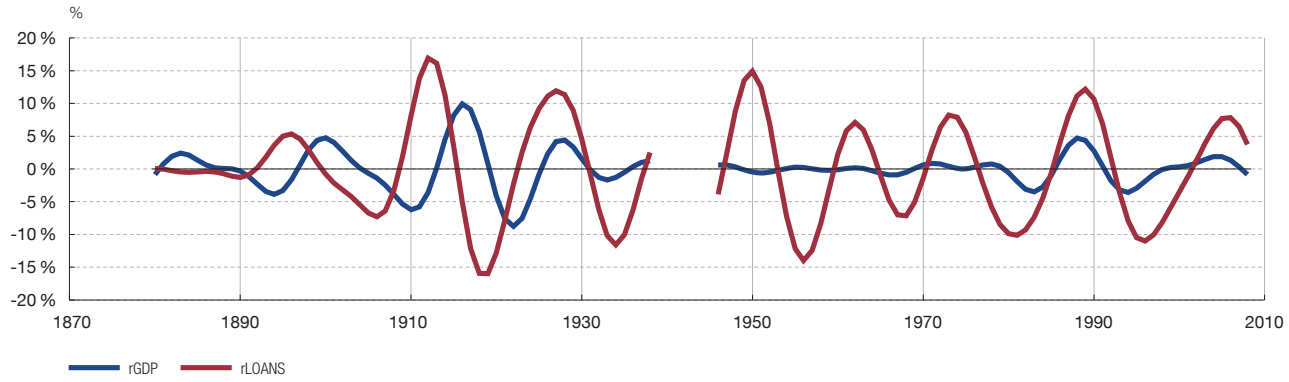
5 Nier *et al.* (2011) set out some of the strengths and weaknesses of alternative institutional frameworks for conducting macroprudential policy.

6 This distinction draws on Borio and Crockett (2000) and is consistent with those adopted by others in the literature, including Bank of England (2009, 2011), CGFS (2010), Group of Thirty (2010), IMF (2011) and FSB/IMF/BIS (2011).

7 See Guttentag and Herring (1986), Herring (1998), Haldane (2009a), Gennaioli, Schleifer and Vishny (2012).

8 On the theory of herding in financial markets, see Avery and Zemsky (1998); Lakonishok *et al.* (1992) test its empirical relevance. Bikhchandani and Sharma (2001) provide an overview of the literature.

MEDIUM-TERM CYCLE IN REAL GDP AND REAL CREDIT FOR THE UNITED KINGDOM CHART 2



SOURCE: Aikman, Haldane and Nelson (2010).

This credit cycle is not just disruptive in its own right. Historically, it has also tended to propagate crises. Credit booms have sown the seeds of subsequent credit crunches for many centuries. The work of Minsky (1986) and Kindleberger (1989) were both attempts to make sense of these regular patterns in the relationship between credit growth and crises, drawing on detailed case studies of past financial crises.

Schularik and Taylor (2012) have recently provided some econometric support for this link between credit and crises. The authors compile a dataset of financial variables from 12 developed economies over almost 140 years. They find credit growth to be the single best predictor of financial instability over this period. For example, according to their estimates, a one standard deviation change in real loan growth raises the probability of a crisis by between two and three percentage points, relative to an in-sample crisis frequency of just under 4 per cent. Dell'Ariccia *et al.* (2012) report similar findings using a dataset of 170 countries back to the 1960s. They find that roughly two-thirds of all credit booms are followed either by a banking crisis or by a period of sub-par economic growth.[9]

Aikman, Haldane and Nelson (2010) use the Schularik and Taylor dataset to document the empirical properties of credit cycles. As Chart 2 illustrates for the UK, bank credit exhibits a remarkably regular pattern of cyclical swings. A broadly similar pattern is evident in most other countries. Relative to the typical business cycle, two features of the credit cycle stand out. First, its average duration is over 10 years, far longer than the typical business cycle. This makes it harder to distinguish structural and cyclical shifts in credit: a lengthy cyclical credit boom may look like a permanent technological shift, as during the run-up to the present crisis.

Second, credit cycles are also distinct from business cycles in their amplitude. The amplitude of credit cycles is roughly five times that of fluctuations in GDP at conventional business cycle frequencies. Cycles in asset prices have higher amplitude still. Drehmann, Borio and Tsatsaronis (2011) report similar findings. This suggests that pro-cyclicality in the financial sector may be an important amplifier of the business cycle.

The recent credit cycle has been particularly severe and synchronised internationally. In 2006, private sector credit across the United Kingdom, United States and Euro-area rose by around 10 %. In some sectors, such as real estate, it was larger still. In the United Kingdom,

9 See also Borio and Lowe (2002), Mendoza and Terrones (2008), Reinhart and Rogoff (2009).

the stock of credit extended to commercial real estate companies doubled between 2002 and 2008; in Spain and Ireland, construction accounted for 20 per cent of the level of GDP in 2007. When the bubble burst, the flow of private credit collapsed.

These credit booms and busts tend, historically, to have been amplified by four factors, all of which were present in the current crisis. First excessive **leverage**, especially in the banking system. When a credit boom is funded by banks operating at low levels of capital, the consequence is a heightened risk of subsequent banking sector distress when imbalances unravel. Leverage was a very important amplifier of both the recent credit boom and bust. A comparison with the late-1990s technology bubble is instructive here. The collapse of dotcom shares led to significant market volatility, but it was the wave of defaults on telecom debt that threatened banking stability.[10]

A second factor that intensifies credit booms and busts is **maturity transformation**. Funding long-term assets with short-term liabilities can be socially efficient and welfare-improving.[11] But taken to excess, this can expose banks to the risk of runs and the possibility that they might need to contract wholesale lending, hoard liquidity or sell assets at depressed market prices to meet actual or prospective withdrawals. Prior to the crisis, many banks reduced their holdings of liquid assets and became increasingly reliant on funding at shorter maturities. This amplified the credit cycle, with the growth of bank balance sheets highly correlated with the proportion of funding sourced from short-term wholesale deposits.[12] When the crisis hit, flighty sources of funding disappeared, putting further pressure on banks' liquidity and solvency.

A third factor is **intra-financial system activity**. Links between financial institutions can help manage risk and distribute funds to where they can be most efficiently deployed. But cyclicality in such interconnectedness can also fuel credit booms. For example, in the pre-crisis period, securitisation was perceived to have dispersed risk around the system. But it reduced incentives for banks to screen and monitor lending, exacerbating over-borrowing.[13] It also lengthened the intermediation chain, masking a significant increase in leverage and maturity transformation across the system.[14]

Fourth, the credit cycle can be amplified by a relaxation of the **terms and conditions** on transactions in financial markets. In the pre-crisis period, lending spreads fell for both the household and corporate sectors, while the share of new mortgages extended at high LTV and LTI ratios rose sharply.[15] This contributed to the bubble in real estate lending in a number of countries, including the US, UK and Spain. Terms in wholesale borrowing markets also became progressively more lax, as did margining requirements on secured financing and derivatives transactions. The reversal of these trends was a major contributory factor to the collapse in interbank markets and the credit crunch.

2.2 CROSS SECTION OR STRUCTURAL RISKS

The systemic consequences of shocks to asset prices and activity also depend importantly on structural features of the financial sector. These include the distribution or concentration

10 See Mishkin (2008).
11 See Diamond and Dybvig (1983).
12 Financial Services Authority (2009).
13 Consistent with this, Keys *et al.* (2010) observe that low documentation subprime mortgage loans with FICO scores just above 620 defaulted 20% more frequently than their counterparts with scores just below 620 – the former category were significantly easier to sell to investors via securitisations than the latter.
14 See Hellwig (1995).
15 For example, in the United States typical LTV ratios rose prior to the crisis, with higher LTV ratios subsequently associated with higher default rates.

of risk across the financial system and the opacity (lack of information) and complexity (difficulty of assessing information) of financial products, institutions and the connections between them. All of these ingredients were important in the run-up to the crisis.

When risk is concentrated in a small number of institutions or markets, or when the provision of financial services is highly concentrated, the system is likely to be more vulnerable than if risks and the provision of services are more evenly distributed. As illustrated by the experiences of AIG and Lehman Brothers in the current crisis and Long-Term Capital Management and Credit Anstalt further back in history, distress or failure of a **systemically important entity** that is "too big to fail" can trigger spillovers to financial institutions or the wider economy which far exceed the contagion generated by the collapse of peripheral players.[16] In other words, there are network externalities associated with the failure of key nodes in the financial system.

These externalities arise because individual institutions or infrastructure providers typically fail to take sufficient account of the effects of their own actions, or failure, on others within the system. This leads to under-insurance against systemic risk. Systemic significance may also give rise to expectations of state support, which further distort perceptions of risk by lowering the cost of funding that such institutions face.[17] This supported rapid balance sheet expansion in the lead-up to the crisis. When such institutions subsequently failed during the crisis, they were provided state support to cushion their contagious consequences. In the UK, US and the Euro-area, state support of various types to financial institutions peaked at over 50 % of GDP.

Systemic risk can also be generated by the **opacity** and **complexity** of institutions, markets and financial instruments. These factors hinder the effective operation of market discipline to limit risk and potentially contribute to perception-driven contagion. Complexity also makes financial institutions more difficult to resolve. Pre-crisis, financial innovation spawned many examples of such complexity. For example, uncertainty over off-balance sheet exposures and banks' widely differing valuations of the same complex structured products led investors to lose faith in published balance sheets and to reduce their appetite for complex financial products and institutions.

Innovation linked to complex trading strategies may also contribute to market stress. For example, high-frequency trading strategies have been highlighted for their role in amplifying the 6 May 2010 US "flash crash". There is evidence that such strategies can drive withdrawals of liquidity, amplifying stress. More generally, algorithmic trading strategies can lead to destabilising feedback loops, which in turn may lead to sharp price falls, possibly across a wide range of market venues.

3 Tools to tackle systemic risk

Given these different sources of systemic risk, a range of different types of macroprudential tools may be needed to tackle them.[18] Prospective macroprudential tools can be roughly categorised three ways:[19]

— Those that operate on financial institutions' balance sheets;

— Those that affect the terms and conditions on financial transactions;

— Those that influence market structures.

16 See Haldane (2009b), Gai *et al.* (2011) and Arinaminpathy *et al.* (2012).
17 Noss and Sowerbutts (2012) quantify the value of this implicit subsidy for UK banks.
18 See also Hanson, Kashyap and Stein (2011) and Berntsson and Molin (2012).
19 See Bank of England (2011).

POTENTIAL MACROPRUDENTIAL INSTRUMENTS

TABLE 2

Key Amplification Channels/ Tools	Time-varying risk			Cross-sectional risk: distribution of risk; opacity; complexity
	Leverage	Intra-financial system activity	Maturity transformation	
Balance-sheet tools	– Countercyclical capital buffers – Maximum leverage ratios – Limits on exposures to particular asset classes		– Time-varying liquidity buffers (e.g. Liquidity Coverage Ratios; Net Stable Funding Ratios; Core Funding Ratios; loan-to-deposit ratios) – Sectoral liquidity buffers – Limits on particular sources of funding or funding instruments	– Capital/liquidity add-ons for systemically important financial institutions (SIFIs) – Large exposure / liability limits – Institutional structure (e.g. ring-fencing)
	– Sectoral capital requirements targeted at real economy lending – Dynamic provisioning – Stress testing	– Sectoral capital requirements targeted at intra-financial system activity – Time-varying or sectoral liquidity buffers		
Terms and conditions of transactions	– Loan-to-value, loan-to-income and debt-to-income restrictions	– Haircut / margin restrictions		
Market structures	– Remuneration practices	– Use of central counterparties		– Use of central counterparties – Design and use of trading venues (including 'circuit breakers')
	– Disclosure requirements			

SOURCE: Bank of England (2011).

The first two of these are primarily designed to tackle cyclical risks. The corresponding tools are likely to be time-varying in nature, ie tightened during periods of exuberance and relaxed when risks have receded or crystallised. The third category of tools is primarily geared towards cross-sectional risks and so would tend to be permanent, or at least durable, in nature. Table 2 lists some frequently discussed tools which fall into these various categories.[20]

Balance sheet tools include maximum leverage ratios, countercyclical capital and liquidity ratios and dynamic provisioning frameworks. These tools influence the aggregate level of leverage and maturity mismatch in the financial system. As such, they might be used to contain generalised risks arising across the financial sector. For example, the counter-cyclical capital buffer (CCB) under Basel III is intended to temper aggregate leverage over the credit cycle. Sectoral capital or liquidity requirements could, by contrast, have a role to play in targeting emerging risks in particular asset or liability classes.

Some balance sheet tools may have a more structural dimension. For example, additional capital and/or liquidity requirements for systemically important institutions might be used to tackle cross-sectional risks, by lowering their probability of failure. Institutional reform, such as the structural separation or ring-fencing of investment and retail banking activities as proposed in the UK [by ICB (2011)], in the EU [by Liikanen (2012)] and in the US [by Volcker (2011)] operate instead by lowering the losses felt across the system in the event of failure, in part by enhancing the "resolvability" of large, complex banks.

Tools that influence the terms and conditions in financial transactions include the ability to restrict the quantity of, or the capital requirements on, lending at high LTVs. These macroprudential tools have been deployed by a number of emerging market countries over the past few years, including China, Hong Kong and Korea. Macroprudential policy could also operate on minimum margining requirements on secured financing or derivative

20 See also CGFS (2010) and Bank of England (2011) for closely related analyses.

transactions within the financial system – the wholesale market equivalent of minimum LTV ratios [CGFS (2009)].

The third category of macroprudential tools – market structure – includes a variety of interventions aimed at altering the topology of the financial network. For example, targeted disclosure requirements can be used to reduce uncertainty about specific exposures or interconnections, which may amplify cyclical or structural risks. The structure of remuneration practices could be used to influence risk-taking incentives by managers of financial firms. And the design and use of organised trading platforms and/or obligations to clear trades through central counterparties could bolster the resilience of markets that are central to the smooth functioning of the financial system.

4 Case study: operationalising countercyclical capital buffers in the UK

How might macroprudential policy be operated in practice? In this section, we consider the tasks involved in operationalising one particular macroprudential tool: the countercyclical buffer (CCB). [21] The CCB introduces a time-varying capital buffer over and above normal microprudential standards in relation to banks' domestic exposures. It can be raised during periods of exuberance and subsequently reduced.[22] The implementation of this tool requires: a) a risk assessment process; b) a procedure for reaching decisions, explaining those decisions to the public, coordinating with other relevant bodies – including systemic risk authorities in other countries – and enforcing decisions with firms; and c) an assessment of the possible impact of those decisions on financial stability and growth. In what follows, we describe progress in the UK towards developing a framework for carrying out each of these steps. The material in this section draws heavily on the analysis presented in Bank of England (2013).

4.1 RISK ASSESSMENT AND INDICATORS TO GUIDE DECISION-MAKING

There are many different approaches for identifying threats to the financial system. Many authorities use indicator dashboards or cobwebs, including the European Systemic Risk Board, the Office of Financial Research in the United States, the World Bank, the Reserve Bank of New Zealand and the Norges Bank.[23] Stress testing aims to explore the resilience of the financial system under various adverse scenarios.[24] Other modelling approaches include early-warning leading indicator models, composite indicators of systemic risk, and Merton-based models of systemic risk that use contingent claims analysis.[25]

Given the complexity and state-contingency of signals from indicators and models, it would not make sense to tie movements in the CCB mechanically to any specific set of indicators or models. At the same time, the Bank of England's new Financial Policy Committee (FPC) has identified a relatively short list of core financial and economic indicators that it will routinely review to help guide decisions to adjust the CCB. These are intended to help anchor policy actions, provide some consistency to decision-making and give a basis for explaining actions to an external audience. They help enhance the predictability of the regime and reinforce the signalling channel of macroprudential policy.

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21 See Juks and Melander (2012) for a similar analysis for the case of Sweden.

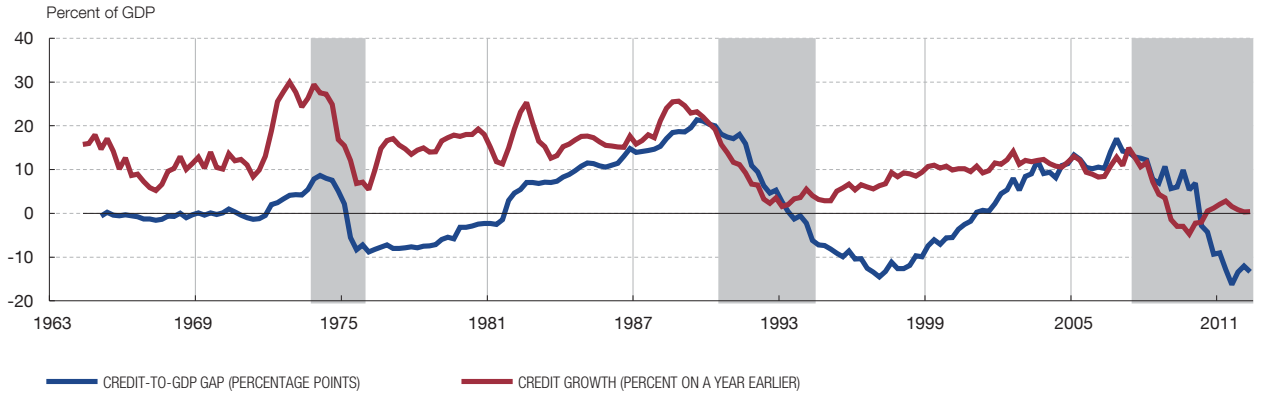
22 The design features of the CCB are prescribed in some detail in Basel III and, in Europe, the forthcoming CRDIV/CRR. For further details on the specification of this tool in the United Kingdom, see Bank of England (2013).

23 For the US, see section 3 of the OFR Annual Report (2012). The ESRB's Risk Dashboard' is published on the web (see http://www.esrb.europa.eu/pub/rd/html/index.en.html). On the cobweb approach used in New Zealand and Norway, see Bedford and Bloor (2009) and Dahl *et al.* (2011), respectively.

24 See Aikman *et al.* (2009), Burrows *et al.* (2012) and Kapadia *et al.* (2013) for a discussion of the Bank of England's approach to stress testing and its "RAMSI" model.

25 On early warning indicator models, see Kaminsky and Reinhart (1999), Drehmann *et al.* (2011), Borio and Lowe (2002, 2004) and Barrell *et al.* (2010). On composite indicator models, see Illing and Liu (2006) and Holló *et al.* (2012). On contingent claims models, see Gray *et al.* (2008) and Gray and Jobst (2011).

UK CREDIT GAP AND CREDIT GROWTH (a) (b) (c) CHART 3



SOURCES: ONS, Bank of England and Bank calculations.

a Credit is defined here as debt claims on the UK private non-financial sector. This includes all liabilities of the household and not-for-profit sector and private non-financial corporations' loans and debt securities excluding derivatives, direct investment loans and loans secured on dwellings. ONS data are not available before 1990. Before then, stable relationships between the ONS household and private non-financial corporation debt data and Bank of England household and private non-financial corporation lending data are assumed and the ONS household and private non-financial corporation debt series is assumed to grow at the same rate as the Bank of England household and private non-financial corporation lending series.
b The credit-to-GDP gap is calculated as the percentage point difference between the credit-to-GDP ratio and its long-term trend, where the trend is based on a one-sided HP filter with a smoothing parameter of 400,000.
c Twelve-month growth rate of nominal credit.

The full set of indicators is discussed in detail in Bank of England (2013); a brief overview is given below. Particular emphasis is placed on simple, high-level indicators rather than more complex metrics. As well as being important for transparency and accountability reasons, some empirical evidence and case studies suggest that simple indicators can often out-perform more complex alternatives in their predictive power due to their greater robustness in the face of uncertainty.[26]

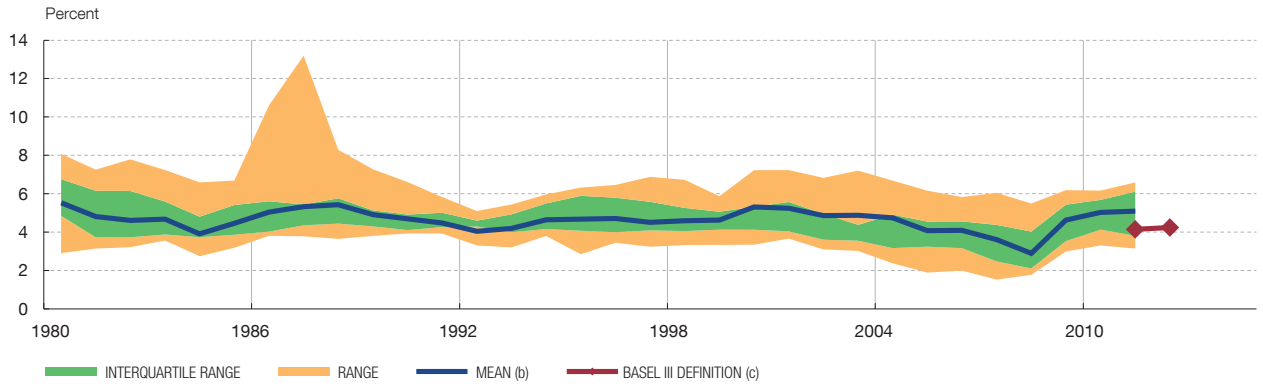
A natural starting point is the so-called **"credit-to-GDP gap"**, defined as the deviation of the ratio of household and corporate indebtedness to GDP from its long term trend. This is given particular prominence in Basel III. It has been found to be a useful leading indicator of past crises in many countries within sample.[27] In the United Kingdom, it performed well in signalling emerging vulnerabilities in advance of each of the last three major episodes of financial distress (Chart 3). Prior to the current crisis, it would have suggested activating the CCB as early as 2002. It also would have suggested activating the CCB ahead of the UK secondary banking crisis in the 1970s and the small banks' crisis in the early 1990s.[28]

As discussed by Bank of England (2013, Box 2) and Giese *et al.* (2013), however, it is important to augment the information in the credit-to-GDP gap with a range of complementary indicators. This partly reflects its poorer ability to signal the possible need to reduce the CCB in the face of deteriorating credit conditions (Chart 3). The indicator also fails to account for the absolute level of credit and is agnostic on the sources or quality of credit.

To meet these concerns, it is helpful to monitor a wider set of indicators reflecting bank and non-bank balance sheet stretch. **Aggregate risk-based capital ratios** and **leverage ratios** reflect the amount of capital that the financial sector has available to absorb losses on its

26 See Haldane and Madouros (2012) and Aikman *et al.* (2013).
27 See Borio and Lowe (2002), Alessi and Detken (2009) and Drehmann, Borio and Tsatsaronis (2011). Barrell and Karim (2012), however, find little evidence that the indicator signals crises in OECD countries, although they find some role in emerging market economies. Repullo and Saurina (2012) also criticise this indicator on the grounds of its negative correlation with GDP growth in many countries.
28 See Giese *et al.* (2013).

UK BANKS LEVERAGE RATIOS (a) CHART 4



SOURCES: Published accounts, FSA supervisory data and Bank calculations.

a The mean and ranges shown are based on the simple leverage ratio defined as the ratio of shareholders' claims to total assets based on banks' published accounts (note a discontinuity due to introduction of IFRS accounting standards in 2005, which tends to reduce leverage ratios thereafter). Data exclude Northern Rock from 2008.
b Weighted by total assets.
c The 'Basel III leverage ratio', from end-2011 onwards, is calculated as aggregate peer group Tier 1 capital over aggregate leverage ratio exposure, according to the proposed Basel III definition. However, Tier 1 capital includes some 'grandfathered' instruments which will no longer be eligible after the full transition in 2019. The Basel III sample includes Barclays, HSBC, Lloyds Banking Group, RBS, Nationwide, Santander UK and Co-operative bank. Last data point is October 2012.

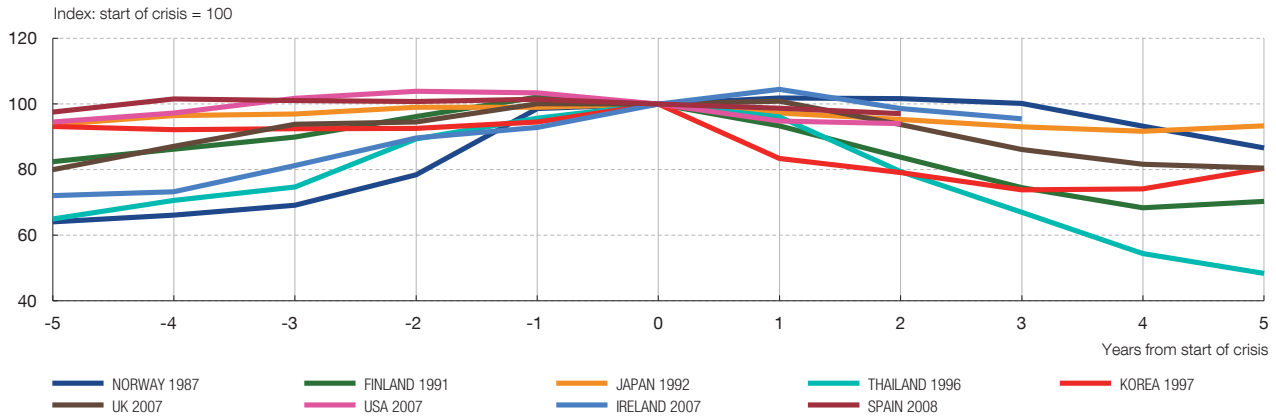
assets, on a risk-weighted and unweighted basis respectively. A rapid build-up in leverage (i.e. a fall in leverage ratios) in the major UK banks was an important driver of the current financial crisis (Chart 4). Risk-based capital ratios tended to provide poorer signals before this crisis, particularly for larger banks[29] ; their failure to signal impending problems reflected a secular decline in **average risk weights**. Some studies from earlier episodes, however, have tended to find a more positive role for risk-based standards in predicting bank failure.[30] Going forward, there is likely to be value in monitoring both metrics in determining whether banks have sufficient buffers to absorb future losses during periods of stress. And since profits are the first line of defence against losses, simple measures of the core profitability of the banking system, such as the **pre-tax return on assets**, are also likely to be useful in such circumstances.

Another helpful indicator of banks' balance sheet stretch is the **loan-to-deposit ratio**, which provides a signal of whether the provision of credit has become too reliant on unstable funding sources. Rising loan-to-deposit ratios were evident in many countries prior to this crisis. This indicator also performed well in signalling impending distress in East Asia in 1997-98 (Chart 5).

Market-based metrics can provide corroborative evidence on perceptions of banking sector health. Spreads on bank debt, such as **subordinated debt spreads** and **CDS on senior unsecured debt**, indicate financial market participants' assessment of the likelihood of bank failure. The views of equity market investors, meanwhile, can be gauged by considering **banks' price to book ratios** and **market-based leverage ratios**. But these indicators need to be interpreted with caution. In periods of exuberance, they may be subject to significant mispricing or indeed even a "volatility paradox": times of low volatility may be associated with a build up of leverage, which increases systemic risk.

29 Haldane and Madouros (2012).
30 See Avery and Berger (1991 and Estrella, Park and Peristiani (2000).

LOAN-TO-DEPOSIT RATIO BEFORE AND AFTER MAJOR CRISES (a) (b) CHART 5



SOURCES: World Bank, published accounts and Bank calculations.

a The years beside the country names give the dates of the first year of a banking crisis, based on Reinhart and Rogoff (2009).
b The UK measure is major UK banks' customer lending as a percentage of customer funding, where customer refers to all non-bank borrowers and depositors. Where disclosed, repurchase agreements are excluded from loans and deposits. The measure for all other countries is the 'Bank credit to bank deposits' series from the World Bank Global Financial Development database. In their measure of credit, the World Bank include the financial resources provided to the private sector by domestic money banks.

Moving beyond banks, movements in national balance sheet indicators such as the **current account** provide a natural indicator of balance sheet stretch in the wider economy. Large and persistent current account deficits and high and rising external indebtedness have tended to precede past crises. For example, these factors were observed prior to the Latin American debt crisis of the 1980s, the East Asian crisis of 1997-98, and the more recent crises in the United States and some euro area economies.

These balance sheet metrics can be complemented by monitoring indicators of terms and conditions in financial markets. For example, conditions in global capital markets can be indicative of overall levels of risk appetite, as reflected in metrics relating to equity markets (such as the **VIX** which captures expectations of stock market volatility) and debt markets (such as **global spreads** over risk-free rates, for example on corporate bonds or on collateralised and securitised debt). Signals of strong risk appetite, combined with low or falling **long term real interest rates**, may indicate a "search for yield".

4.2 DECISION-MAKING, COORDINATION AND IMPLEMENTATION

The UK's FPC meets quarterly to assess the information in the core indicators, alongside a wider set of information including from stress testing and other models, and from market and supervisory intelligence. Having reached a decision on whether to alter the CCB, the rationale for the FPC's decisions is communicated externally through some combination of a press release, a Record of the meeting (published approximately two weeks afterwards) and the Bank of England's twice-yearly *Financial Stability Report.*

For the CCB, international coordination is ensured by the reciprocity arrangements enshrined in Basel III. In particular, overseas regulators are expected to apply the CCB rate chosen by the FPC for their banks' UK exposures and vice versa. This should help to enhance the effectiveness of macroprudential policy by reducing the likelihood of international leakages. Such leakages are likely to be substantial if policies are uncoordinated – for example, Aiyar *et al.* (2012) find that one third of the impact of higher Pillar 2 capital requirements on UK banks may be offset by increased lending by foreign branches.

For other macroprudential actions, it will also be important to consider possible cross-country spillovers when reaching macroprudential decisions. The forthcoming Capital Requirements Directive and Regulation will institutionalise a coordination process within the EU to assess such spillovers, including the potentially negative spillovers from *failing* to act in a timely fashion to mitigate domestic systemic risks – it is important to balance policy coordination with a need to avoid inaction bias.

Once policy action on the CCB has been agreed, banks will typically have twelve months to meet any increase in the CCB – although a shorter implementation period may be recommended to the regulators in exceptional circumstances. Banks that fail to meet the buffer level in the required time, or breach it subsequently, will be subject to automatic restrictions on dividends and discretionary bonuses and will be required to prepare a plan explaining how they will meet the buffer level within an appropriate timeframe.[31] It will be the responsibility of the microprudential authority to monitor compliance and to impose further supervisory measures if needed. A decision to *decrease* the CCB can take effect immediately.

4.3 IMPACT ANALYSIS

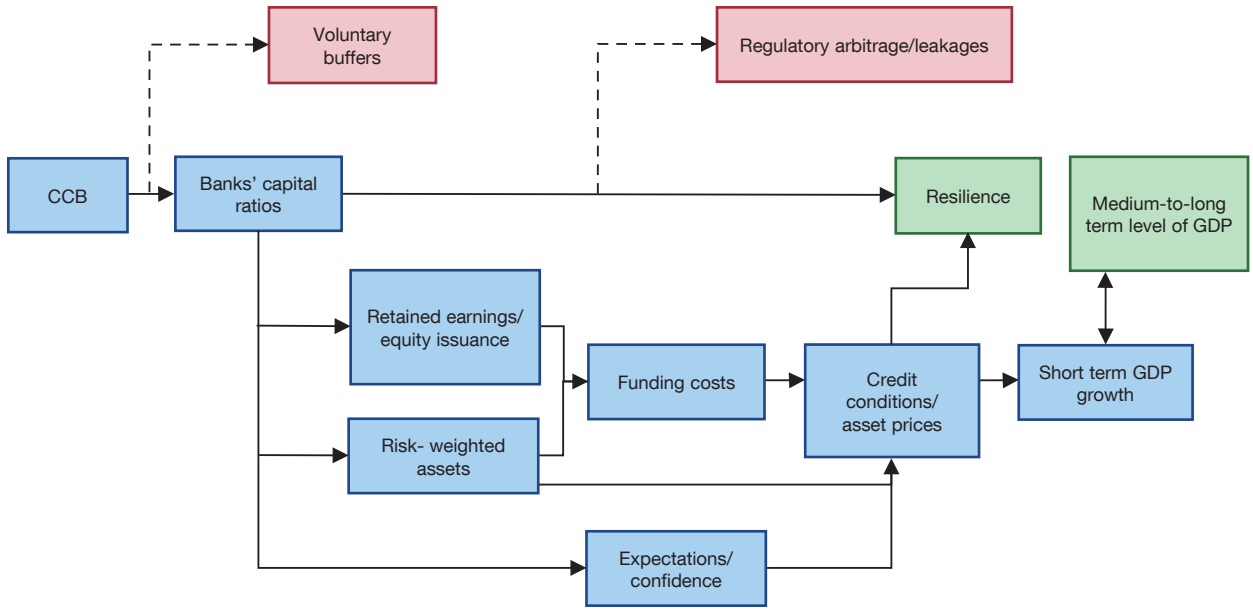
The objectives of the FPC in setting the CCB are to ensure resilience of the UK financial system and, subject to that, to support the government's objectives for employment and output. To understand whether policy actions are consistent with these objectives requires a view on how CCB decisions are likely to affect financial stability and growth. The key links in the transmission mechanism are illustrated in Figure 1.

A decision to apply the CCB when threats to resilience are increasing will enhance financial stability in two ways. First, capital provides a cushion to absorb losses. So, holding fixed

31 Under the forthcoming CRD4/CRR, banks whose capital ratio falls within the upper quartile of the combined conservation buffer and CCB will be required to retain 40% of their profits. Banks then face a sliding scale of restrictions, whereby as a bank's capital ratio falls further from the target, it is required to conserve capital by paying out smaller dividends and bonuses to shareholders and employees. Specifically, these distribution restrictions increase to 60%, 80% and 100% as banks' capital ratios fall to the third, second and first quartiles respectively.

THE IMPACT OF THE COUNTERCYCLICAL CAPITAL BUTTER ON RESILIENCE AND GROWTH

FIGURE 1



SOURCE: Bank of England (2013).

banks' asset and liability positions, a change in the CCB will have the direct effect of increasing the loss absorbing capacity of the banking system, reducing the likelihood and severity of financial crises. This effect is shown in Figure 1 by the central arrows linking capital ratios to resilience and medium-to-long term GDP. While the precise magnitude of this channel is uncertain, there are strong *a priori* grounds for expecting the sign to be positive – greater capital reduces the likelihood of crisis.[32]

Second, the CCB will also affect financial stability through its impact on credit conditions. This size of this channel will depend on various factors including the sensitivity of risk premia on bank debt and equity to banks' leverage,[33] the ease with which banks are able to raise fresh equity in capital markets or adjust retained earnings, the stickiness of loan interest rates and the degree of competition in the banking sector.

For example, if capital buffers are increased in the midst of a credit boom, then the tighter credit conditions that follow may boost financial stability by helping to arrest the build-up of vulnerabilities created by the over-extension of credit. Similarly, if previously accumulated capital buffers are reduced in the midst of a contraction, then that may help to loosen credit conditions, so boosting the economy and thereby helping to reduce borrower defaults. This channel is shown by the arrow in Figure 1, linking credit conditions to short-term GDP growth. Of course, the strength of these effects may vary depending on whether policy is being tightened or loosened – we come on to discuss such asymmetries in the transmission mechanism in Section 5.1.

The effect of these tools on risk-taking behaviour is likely to be more powerful if financial markets anticipate that the policy change will be reinforced by further policy changes in these measures. As in other areas of public policy, there could be an important role for expectations in shaping this collective behaviour. This "signalling channel" of macroprudential policy is depicted in Figure 1 by the arrows running from capital ratios through to credit conditions, via the box marked "expectations", and then on to resilience.

There are as yet no published estimates of the likely impact of changes in the CCB on credit conditions. But some recent studies have analysed the quantitative impact of an increase in capital requirements on banks' lending behaviour (Table 3). While the results differ according to the methodologies employed, and whether permanent or temporary shocks are being analysed, most find that an increase in regulatory capital requirements generates only a modest tightening in credit conditions. For example, based on existing studies, a 1 percentage point increase in capital requirements is estimated to lead to an increase in the interest rate on bank loans of between 4.5 and 25 basis points and a decline in the quantity of lending of between 0 % and 3.6 % relative to baseline. These effects also operate with long and variable lags, often of a couple of years.

A study by the Financial Stability Board and the Basel Committee on Banking Supervision used a similar methodology to estimate the impact of a change in capital requirements on

32 A deeper justification for capital to enhance banks' survival probability is provided by incentive-based theories like Holmstrom and Tirole (1997), where capital strengthens banks' incentives to monitor borrowers. Gale (2010) sounds a note of caution however in his review of the theoretical literature on bank capital and risk taking: general equilibrium effects in these models can sometimes lead to the relationship flipping sign.

33 This is the Modigliani-Miller effect. Banks' cost of equity tends to exceed the rate at which they can borrow. This reflects the preferential treatment of debt in the tax system, market perceptions that the debt-holders of large banks are unlikely to suffer losses because such banks will not be allowed to fail (the so-called "too-big-to-fail" problem), and greater uncertainty over the future earnings that will accrue to shareholders compared to debt-holders who have more certainty over interest payments. These frictions may also make the cost of debt insensitive to banks" leverage and hence their solvency risk.

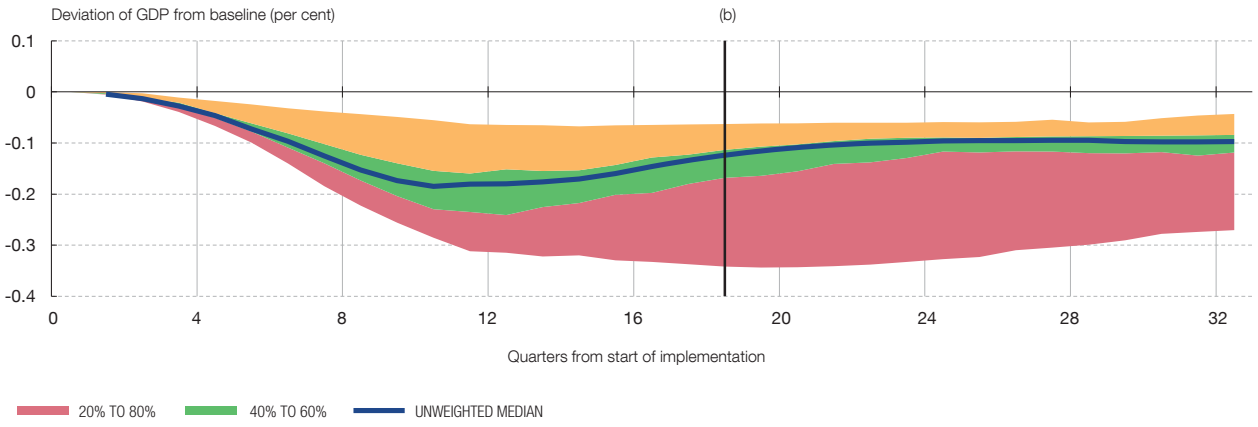
ILLUSTRATIVE ESTIMATES OF THE IMPACT OF A 100 BASIS POINT INCREASE IN BANKS HEADLINE CAPITAL TABLE 3

	Loan rates (basis points)	Loan volumes (per cent)
Permanent change in required capital		
MAG (2010) (a)	17.3 [5.1, 25.0]	-1.4 [-0.7, -3.6]
Elliot (2009) (b)	[4.5, 19.0]	—
Temporary change in required capital		
Aiyar *et al.* (2012) c)	—	[-6.8, -9.0]
Francis and Osborne (2012) (d)	—	0.0

SOURCE: Bank of England (2013).

a The Macroeconomic Assessment Group (MAG) analysed the impact of the transition to Basel III across a range of alternative models, calibrated across a wide variety of jurisdictions (including the UK). The reported figures in the table refer to the median impact across a range of estimated models (see Annex 2.2 in MAG (2010)), with the maximum and minimum reported in square brackets. Estimation assumes implementation of permanently higher capital requirements over two years. Results are for the 18th quarter of the simulation. Monetary policy is held constant.
b Results based on a loan pricing equation calibrated for US banks linking capital requirements to lending rates. The maximum effect refers to the case where banks are able to pass through in full the costs of higher capital requirements on to their customers. The minimum effect assumes a modest decline in banks' funding and administrative costs. Results are calculated from Tables 1 and 2 in Elliott (2009). The exercise assumes no response of monetary policy to the shock
c Results based on an econometric analysis of the impact of the UK Financial Services Authority's microprudential Pillar 2 requirements over the period 1998-2007. Reported results show the cumulative impact, excluding the potential for leakages via the foreign branch lending.Monetary policy is held constant.
d Taken from Francis and Osborne (2012), Table 5. Results based on an econometric analysis of the impact of microprudential Pillar 2 requirements imposed by the UK Financial Services Authority over the period 1996-2007. Results assume a 44 per cent pass-through from regulatory capital requirements to banks' capital ratios. Monetary policy is held constant.

ESTIMATED IMPACT ON GDP OF DATA A 100 BASIS POINT CREASE IN CAPITAL REQUIREMENTS IMPLEMENTED OVER TWO YEARS (a) CHART 6



SOURCE: Macroeconomic Assessment Group (2010).

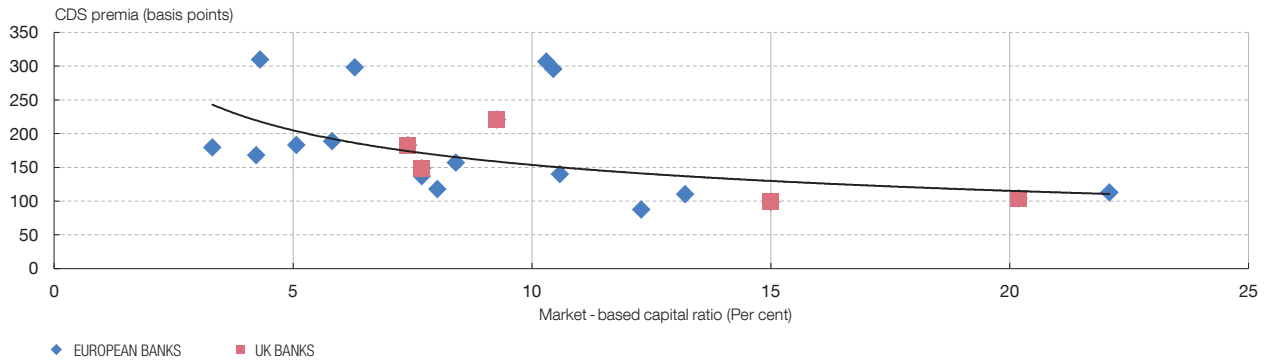
a The shaded areas indicate the 20-80th percentile and 40-60th percentile ranges respectively. The yellow line shows the unweighted median. The distribution of outcomes is computed across 89 models, discussed in MAG (2010). The results do not include the impact of international spillovers.
b The vertical line indicates the 18th quarter.

economic growth.[34] It estimated that GDP will contract by between 0.05 % and 0.35 % relative to baseline in the short run following a 100 basis point increase in headline capital requirements. The largest average impact on GDP across these models was around -0.2 % relative to baseline, occurring after around ten quarters (Chart 6).

These are the best quantitative estimates currently available to guide the setting of the CCB. But the uncertainty is sufficiently large that they need to be treated with caution. One reason for this is that the results in both Table 3 and Chart 6 pertain to a change in headline capital requirements, whereas the CCB will apply only to banks' domestic exposures. Also, some of the studies assume a permanent increase in capital requirements rather than a cyclical regime.

34 See Macroeconomic Assessment Group (2010).

RELATIONSHIP BETWEEN MARKET-BASED CAPITAL RATIOS AND FUNDING COST IN NOVEMBER 2012 (a) (b) (c) (d) CHART 7



SOURCES: Capital IQ, Markit Group Limited, published accounts, Bank of England and Bank calculations.

a Market-based capital ratios are banks' market capitalisation as a percentage of published risk-weighted assets.
b The sample shown is the largest 20 European banks by assets.
c Funding costs are proxied by 5-year senior CDS premia. The 'line of best fit' shown above illustrates their relationship with market-based capital ratios.
d Where possible, Capital IQ data has been used to calculate the market-based capital ratio, but for some banks it was necessary to use published accounts data.

More fundamentally, all such estimates reflect average relationships between banks' capital ratios and credit conditions in the past. It is well known that past relationships can be a poor guide to the future, particularly when there are large structural changes in the economy. The creation of a macroprudential regime might be one such structural change. For example, if financial markets come to expect the CCB to be raised in a sequence of steps when exuberant lending threatens financial stability, then the initial impact of policy actions might be larger than past relationships would suggest.

The relationship between capital requirements and credit conditions is also likely to vary in important ways depending on economic circumstances. For example, in a situation of acute uncertainty about banks' solvency, their borrowing costs may be highly sensitive to their capital adequacy (Chart 7). In these circumstances, a decision to increase capital adequacy may improve confidence to such an extent that overall funding costs fall. That, in turn, might be expected to relax credit conditions. The recapitalisation of UK banks in 2008 and the US stress tests and consequent capital raising of 2009 may have had precisely such an effect.

5 Open issues

While considerable progress has been made in making macroprudential regimes operational over the past few years, a large number of practical challenges remain. From a potentially long list, we discuss three such open issues: how to improve macroprudential policy effectiveness in a downturn; how to make macroprudential decisions when there is uncertainty about the impact of decisions and magnitude of threats; and how to foster policy coordination between macroprudential, microprudential and monetary policies.

5.1 MACROPRUDENTIAL POLICY IN A DOWNTURN

Macroprudential regimes will be at their most effective when policies are set in a broadly symmetric fashion. In practice, that means tightening macroprudential policy tools when lending practices are exuberant but, just as importantly, loosening those tools either when risks recede or when credit conditions need a boost. Achieving this balance will be a major policy challenge.

It is often felt that, in situations of stress, many of the arms of macroeconomic policy are constrained – that policy risks "pushing on a string". Macroprudential policy is no exception. For example, the market might demand higher (than regulatory) capital

requirements in a downswing because they fear the risk of insolvency. That would potentially reduce the potency of a macroprudential loosening of policy, for example in stimulating credit and growth.

But recent empirical research by Jiménez *et al.* (2012) has reached a more optimistic conclusion on the effects of macroprudential policy loosening. The authors analyse the economic impact of the Bank of Spain's dynamic provisioning framework – a close cousin of the Basel III countercyclical capital buffer. In particular, they ask whether its impact differed in good times (when buffers were being built up) from the downswing (when the buffers were being released).

In the upswing, they find that the banks that had to provision more cut their credit supply by most, as might be expected. But, crucially, this macroprudential policy tightening had relatively little effect on overall credit conditions or the macroeconomy. The reason was that other lenders stepped in and picked up the slack created by constrained banks exiting. In other words, credit was highly substitutable during the boom.

By contrast, the release of buffers in 2008 Q4 was found to have had a large positive incremental effect on lending, employment and firm survival in 2009 and 2010, albeit relative to a baseline in which credit conditions were tightening substantially. The reason is that, in a bust, credit supply is not very substitutable, with fewer alternative suppliers of credit to households and customers. So, while the overall level of provisioning turned out to be too small to save Spain from a severe macroeconomic downturn, these results do suggest that macroprudential policy could in fact be more potent in a downswing, not less.

The design of macroprudential tools can also help to foster a symmetric regime. For instance, it may make sense to distinguish between stocks and flows of lending in the application of such tools. Capital requirements are traditionally applied uniformly to both the stock of banks' existing assets and to any new loans created. But suppose capital requirements on *new* loans could be flexed without affecting those applied to the back-book of existing assets. Such an approach could be particularly useful in the downswing as it could stimulate credit supply while reducing the risks associated with release of the buffers. Banks would only benefit from capital relief to the extent they continued to lend, thus stimulating credit supply; while their resilience against legacy assets would still be protected. In the UK, such an approach has recently been put into practice with a lower effective capital charge placed on new loans relative to old to stimulate credit supply.[35]

5.2 MACROPRUDENTIAL POLICY UNDER UNCERTAINTY

Another major challenge in designing macroprudential policies is how to deal with high degrees of (Knightian) uncertainty. This can take many forms: uncertainty over the severity of the threats to financial stability and how these have changed; uncertainty about the structure of the economy and the financial system; uncertainty about the impact of alternative policy tools; and uncertainty about the impact of policy actions on market participants' expectations.

While there is no clear guide from the academic literature on what optimal policy should be in such an environment,[36] some general policy design lessons can be drawn. For example, it is clear that policymakers should not worsen this uncertainty problem through their own actions

35 For details, see http://www.fsa.gov.uk/static/pubs/other/adjustments-capital-planning-buffers.pdf.
36 See Brainard (1969) and Hansen and Sargent (2003, 2004).

and reactions. Among other things, this calls for as clear and transparent a macroprudential decision-making process as possible.

There are several potential dimensions to such a transparent regime. One is having as clear as possible a set of inputs to the policy decision-making process. As discussed in Section 4, the Bank of England's FPC has recently published a list of the core indicators it intends using to set macroprudential policy, for just this reason. The credit-to-GDP ratio guideline path specified as part of Basel III is also intended to serve an indicator role.

A more sophisticated step would be to produce, and potentially publish, information on stress-tests for key macroprudential measures such as liquidity, capital, lending and output. For example, in the United States an annual round of such top-down stress-testing has been in place since 2009, with a high degree of transparency about both inputs and outputs. This is generally felt to have reduced market participants' uncertainty about the true state of health of US banks' balance sheets and thereby supported financial stability.

A third layer of transparency concerns the deliberations of the macroprudential policy committee itself. In the UK, a Record of the meeting of the FPC is published, broadly in line with the practices of the Bank's Monetary Policy Committee. This is intended to make transparent the nature of the FPC's discussion and the reasoning behind its policy stance. Over time, this will help external participants understand the shape and nature of the FPC's "reaction function". Inevitably, this will be a two-way process, as the FPC learn more about how its actions affect the macro-financial environment and market participants learn more about how the FPC intends operating its tools.

One key policy lesson, which is well-illustrated in a wide range of other policy environments, is the need to avoid fine-tuning macroprudential responses when uncertainty is great and past historical evidence limited. Simplicity, both in approach and in action, can be of considerable value in such uncertain environments in avoiding the large errors that otherwise might arise if policy is over-fitted, over-complicated or hyper-active.[37]

5.3 MACROPRUDENTIAL POLICY CO-ORDINATION

A third challenge relates to the co-ordination of macroprudential policies with other policy levers, in particular micro-prudential and monetary policies. In general, these three arms of policy would be expected to be complementary and mutually-supportive. For example, during the pre-crisis credit boom, a macroprudential policy tightening would have helped alleviate strains on micro-prudential regulation of individual firms. It would also potentially have helped reduce the costs of the crisis, thereby alleviating some of the burden subsequently placed on monetary policy.

Nonetheless, because these three arms of policy are, at least to some extent, overlapping in their impact, they do raise new and important issues of co-ordination. Attaching all three arms of policy to a single body – in the UK, the Bank of England – can help in this co-ordination process, as it internalises any policy spillovers, or externalities, which might otherwise arise between them.

Nonetheless, this framework still requires that the three decision-makers consider the impact of each others' actions when making their own policy decisions.[38] For example, monetary policy forecasts for inflation and output will need to include an assumption about

37 Haldane and Madouros (2012); Aikman *et al.* (2013).

38 For a recent discussion, see Stein (2013).

the stance of macroprudential policy. And macroprudential stress-testing will in turn need to make assumptions about the course of monetary policy and the macro-economy.

Co-ordination issues also arise when co-ordinating macroprudential and microprudential policies. By and large, macroprudential tools involve using microprudential tools to address risks to the stability of the financial system as a whole. At some points in the cycle, there may be tensions between the instrument settings appropriate for macro and microprudential purposes. These problems are perhaps most acute during the downswing, when a macroprudential release of buffers could sit awkwardly with a microprudential approach of seeking to bolster firms' resilience.

Potential trade-offs and tensions between policy settings are part and parcel of public policy. The benefits of having a clearly defined policy framework, including for macroprudential policy, is that these trade-offs can be discussed and, ideally, resolved openly. Having distinct policy committees, with distinct statutory remits, ought to make that policy process of openness and resolution no more difficult, and potentially somewhat easier. It certainly ought to make it more transparent and understandable to the wider world.

There is an urgent need for more research on all of these important macroprudential questions – and more besides. If macroprudential policy reduces somewhat the chances or severity of another systemic crisis, the gains to society are potentially enormous.

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