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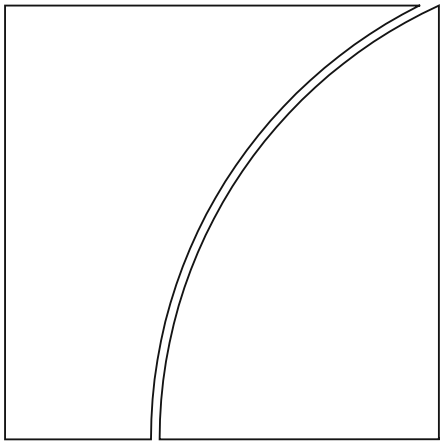

Literature review on integration of regulatory capital and liquidity instruments

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Literature review on integration of regulatory capital and liquidity instruments

1. Executive summary

This working paper aims at reviewing the literature's assessment of recent reforms. It consists of "three essays" on capital (Section 2), on liquidity and its interaction with capital (Section 3) and on other supervisory requirements (Section 4). Although there are many studies on the effects of capital requirements, there are relatively few on the effects of liquidity requirements and other supervisory tools. In part, this is because capital requirements have been in place for a considerable time and over more than one business cycle, while liquidity requirements and other supervisory tools, such as buffers, macroprudential policies and stress tests, have only been implemented since the recent financial crisis.

1.1 Essay on capital

Section 2 reviews a large number of papers that assess the impact of higher capital requirements in terms of the costs and benefits to economic activity and welfare.

As far as costs of capital requirements are concerned, surveying a diverse range of approaches and views allows us to suggest that there are opportunity costs in terms of reduced lending and economic activity as bank capital requirements rise, and that the Modigliani-Miller invariance theorem holds only partially.

There is less focus, at least from an empirical standpoint, on estimating the benefits of capital requirements. The literature is almost unanimously focussed on the benefits of higher capital requirements as reducing risk-taking by banks and, consequently, reducing the likelihood of a future systemic financial crisis. We also have some evidence that benefits arise as better capitalised banks make the provision of credit more stable in a downturn.

The literature focussed on the optimal amount of capital is even sparser and needs careful interpretation.

We note that there are a number of issues with these estimates, many of which are highlighted by the authors themselves. They relate in particular to: (1) the difficulty in separating the influence of supply from demand when estimating costs; (2) the role of the "static-behaviour assumption" (of banks and customers for example) when assessing regulatory changes; (3) the difficulty in inferring the effect of large changes from looking at small ones, or properly taking into account individual firm behaviour by looking at aggregate measures; (4) the frequent lack of a proper distinction between the various types of capital (eg common equity Tier 1 (CET1), additional Tier 1 capital (AT1), total capital); (5) the difficulty in controlling for the macroeconomic environment, notably the very accommodative monetary policy stance for the most recent estimates; and (6) the inability to capture cross border effects and the potential for the costs of global standards to be borne disproportionately by some (particularly emerging) economies. In particular, the impact of a rise in capital requirements on banks' behavioural response is uneven and differs across jurisdictions. In turn, this heterogeneity in banks' behavioural response depends on the structure of their banking system and their degree of institutional development, including differences in regulatory practices.

Furthermore, there is little extant literature on the impact of total loss absorbing capacity. Nevertheless, the literature that is available suggests that total loss-absorbing capacity (TLAC) instruments will have positive net benefits (although the analysis is at a very early stage). In addition, the literature

suggests that (non-capital) TLAC instruments can have an important role in disciplining bank behaviour provided these non-capital instruments fulfil a number of key characteristics.

With these caveats in mind we draw two key conclusions from this review of the literature: First, the overall impact of an appropriate increase in capital requirements seems to be positive, at least from pre-crisis levels, as long-run benefits are large and short-term costs are smaller, although the costs may be borne disproportionately by host countries. Second, the optimal range for capital requirements is not dissimilar to the current calibration of the Basel III requirements once all regulatory buffers have been included and banks' own voluntary surplus above these requirements has been taken into account.

1.2 Essay on liquidity, and its interaction with capital

Because liquidity requirements have not yet been introduced in most jurisdictions, empirical results on the impact of liquidity requirements are sparse. One of the potential benefits of liquidity requirements is the reduced likelihood of bank failure caused by liquidity shocks and smaller contractions of bank credit in reaction to a liquidity shock. While none of the literature directly tests for such benefits, some papers that examine bank behaviour during the most recent financial crisis provide indirect indications of the potential benefits of liquidity requirements. For example, one study of US banks finds that whereas the contraction of bank credit during the 2007–8 crisis was significant, banks that had extended more contingent credit lines and banks with lower proportions of stable funding reduced their lending by more than did other banks. The estimated contraction in bank credit that would have occurred if all of the US banks had had a level of liquidity risk exposure similar to that of the banks in the lowest quartile of the distribution of liquidity risk exposure (based on measures of undrawn credit commitments and wholesale and short-term funding) would have been only around 20% of the amount of the observed credit contraction.

Section 3 identifies a number of potential channels through which liquidity requirements can affect bank behaviour, balance sheets and profitability. While significant gaps exist in the literature in relation to most of these channels, most notably, with respect to the impact of liquidity requirements on funding costs and on net interest income, some literature does examine the question of whether liquidity requirements result in banks' substituting high quality liquid assets (HQLA) for loans on their balance sheets, thereby reducing credit.

Empirical studies based on Quantitative Impact Study (QIS) data and on the impact of liquidity requirements (similar to the Liquidity Coverage Ratio (LCR)) imposed in the UK and the Netherlands offer some tentative findings with respect to the impact of liquidity requirements on credit. None of these studies find that banks substitute HQLA for loans to nonfinancial firms. Rather, banks tend to reduce interbank loans or private bonds in order to increase their holdings of HQLA (which tend to be made up of government bonds). The results of these studies would then suggest that neither lending nor output should be heavily affected by the imposition of the LCR.

At the same time, studies based on simulations do suggest a considerably larger impact of liquidity requirements on loans, with declines in credit ranging from 3% to 26%. However, these results are often driven by very specific assumptions.

With respect to the interactions of capital and liquidity requirements, there is some indication from the literature on stress tests that these interactions can be quite important. For example, estimates based on the Austrian integrated stress tests suggest that overlooking the impact of liquidity shocks on solvency positions can lead to an underestimation of the total solvency stress test losses by as much as 30%, predominantly through the omission of the asset fire-sale channel. This finding suggests that requiring banks to maintain liquidity buffers, such as the LCR, may have an impact that would be similar to that of increasing capital requirements. In other words, liquidity requirements can substitute for capital requirements rather than merely complement them. Interestingly, the estimated losses among Austrian banks due to the liquidity-solvency interactions were actually concentrated in a few institutions with low

resilience to liquidity shocks. The banks with low resilience to liquidity shocks were not necessary those with weak capital positions.

1.3 Essay on other supervisory requirements

Section 4 discusses (1) whether measures other than capital and liquidity requirements adequately complement these regulations in making the banking system more resilient; and (2) whether simpler regulatory rules may be more robust to extreme stress events than the ones in place and whether stress testing can enhance robustness.

In the first part, we concentrate on the concept of regulatory buffers and on macroprudential policy. Buffers represent an innovation of Basel III with respect to both capital (for example, the countercyclical capital buffer or the capital conservation buffer) and liquidity (for example, the liquidity coverage ratio). Their purpose is to guarantee that banks have easy access to capital in bad macroeconomic times: buffers are meant to be "usable" in case of need. However, only if supervisors allow banks to use buffers and banks do not resist their use, can buffers work to protect banks against macroeconomic downturns and taxpayers against bailouts. Supervisory discretion, excessive market discipline, and stigma attached to the use of buffers are some of the hurdles that may undermine their effectiveness.

Macroprudential policies can provide new levers to curb dangerous credit booms and excessive risk-taking by financial intermediaries. Assessing their effectiveness, however, is difficult. For example, it is difficult to create counterfactuals had those policies not been in place or disentangle the independent effects of macroprudential policies from the effects of other policies employed in conjunction with them. Nonetheless, recent research on the effectiveness of macroprudential policies provides some positive evidence (for example, with respect to capital buffers, liquidity buffers, and loan eligibility) that such policies are effective at enhancing bank resilience and some mixed evidence (for example, with respect to tighter capital requirements) on their ability to curb excessive lending.

Both buffers and macroprudential policies can be viewed as an attempt by policymakers to strike a balance between rules and discretion. If rules are less susceptible to forbearance and more likely to deliver consistent decisions, discretion allows policymakers and/or supervisors to adapt to unexpected changes or economic uncertainty. Taking stock of these considerations, the second part of our analysis lists the merits of simple robust regulatory rules and discusses how stress testing can enhance systemic robustness.

- The complexity of the current regulatory framework is, for the most part, the result of rules created ad hoc to address emerging risks that threaten to disrupt financial markets. Recent research suggests that a combination of simple and complex rules is most effective since simple rules can help to contain, and discourage, any arbitrage behaviour that complex rules bring about. Combined capital and leverage rules are, perhaps, the most fitting example of combined complex and simple rules. The leverage ratio (a simple rule) is insensitive to asset risks and, if used alone, it can promote risky credit allocations. However, as a backstop to the risk-based regime, it can help to strengthen overall bank resilience to a wide range of risks.
- To increase resilience to potentially unidentified risks, banks are also stress-tested. Stress tests analyse the effects of low-probability, extreme stress scenarios on banks' assets and functions. Stress tests help banks to increase awareness of internal risks and better monitor them; help supervisors to prevent or, at least, mitigate them; and help markets to assess them. However, stress tests are also vulnerable to model risk related to scenario design, reliance of stress tests outcomes on regulatory risk weights, limitations of modelling techniques, and the treatment of banks' balance sheet. Given the technical challenges of stress tests, they can only be a complement, and never a substitute, for other supervisory tools and processes in properly informing supervision policy.

The academic literature on simple rules and on stress testing is still very recent and tentative.

Box: How do changes in regulation generate costs and benefits to the economy?

To help facilitate the discussion of the costs and benefits of regulatory requirements, Graph 1 shows how banks change their balance sheet in response to changes to capital and liquidity requirements, respectively, and then how these changes influence aggregate economic activity. An indication of the likely direction of change given an increase in regulatory requirements is shown where the literature is (more or less) unambiguous about the direction of the banks' reaction (see discussion in individual sections).

The reaction of individual banks is considered first. Capital and liquidity requirements have a different direct impact on banks' balance sheets which is set out separately at the top of the graph. The changes to requirements then directly influence bank reactions through two key interactions:

- **balance sheet interactions**: changes to a bank's balance sheet in response to changing capital requirements will have implications for liquidity management, and vice versa. For example, banks reduce interbank loans and purchase government bonds in response to an increase in the regulatory liquidity buffer which, in turn, can reduce risk-weighted assets and thereby boost the capital ratio, helping to meet any increase in capital requirements.
- **other interactions**: changes to banks' balance sheet composition will change income earned as well as the quality of both assets (by, for example, reducing the amount of risky assets) and capital (by, for example, requiring more CET1 equity). These changes, in turn, can trigger further changes to banks' balance sheets.

The reaction of individual banks can then have an impact on aggregate capital and liquidity ratios. Changes to aggregate capital and liquidity ratios have implications for aggregate economic activity – both positive (benefits) and negative (costs).

On the benefits side, the literature suggests that higher capital and liquidity ratios improve the resilience to shocks of both individual banks, and the financial system itself. Improved resilience, in turn, lowers both the probability of a financial crisis and reduces the size of the economic loss in the event that a crisis does occur. The benefit, in this sense, is the expected loss that is avoided by having higher capital and liquidity requirements.

On the cost side, higher capital requirements directly increase bank funding costs which, in turn, reduces borrowing by households and non-financial firms. Changes to liquidity requirements reduce interbank lending and maturity transformation, which also has an impact on aggregate borrowing. Lower borrowing reduces aggregate consumption and investment and, eventually, gross domestic product (GDP).

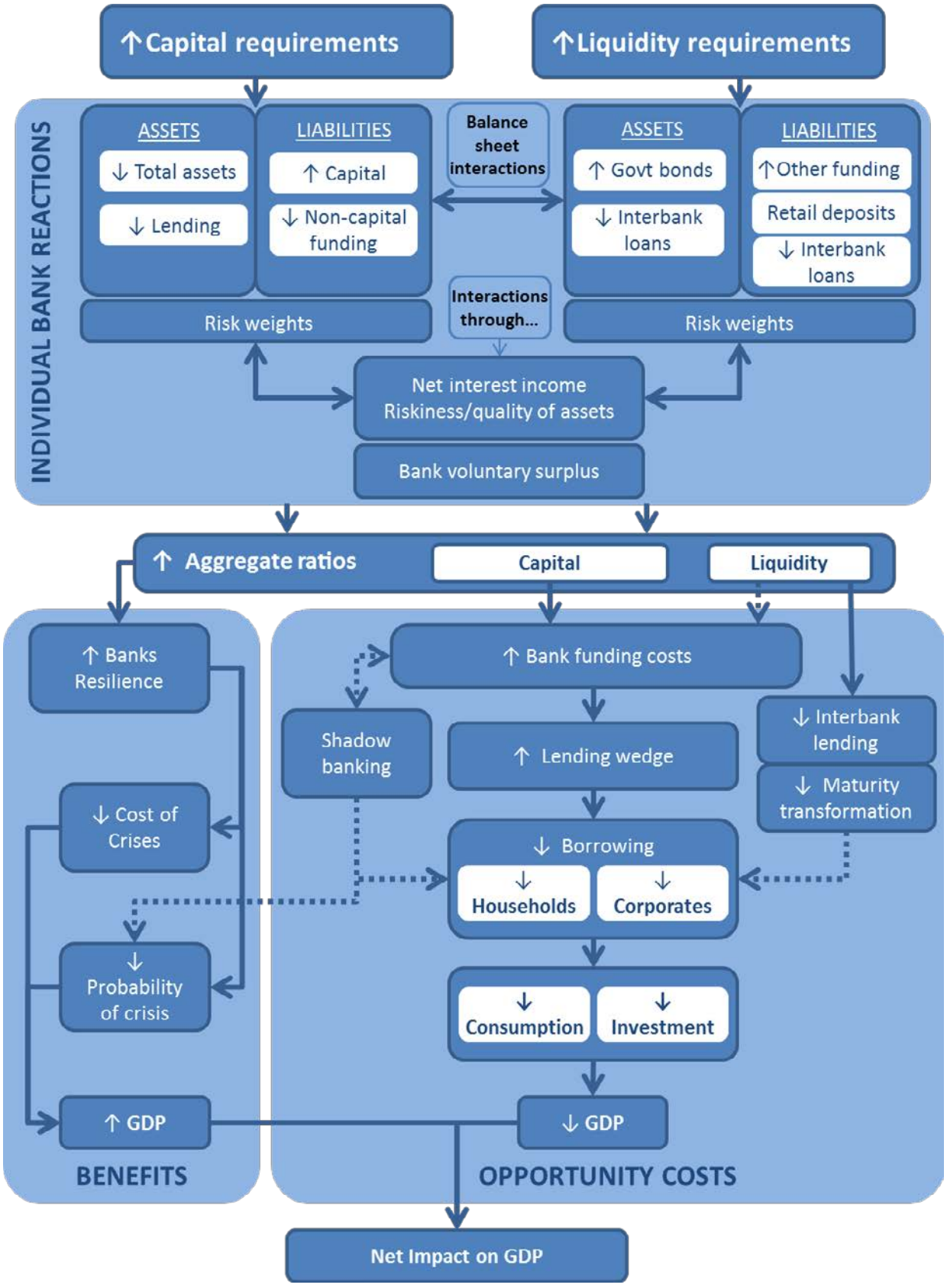
Overall, the net benefits of regulation can be thought of as the expected loss that is avoided in the event that a crisis occurs (the benefit), which is offset by the opportunity cost of reduced economic activity during non-crisis periods.

A key complication in this explanation of the regulatory transmission mechanism is the presence of "shadow banks", which can effect both the benefits and costs. Shadow banks may not be subject to regulatory changes (or affected to a lesser extent). The influence of shadow banks is ambiguous in the literature (where it is considered) and will depend, for example, on the extent to which their activities appropriately consider risks (which could influence the probability of crisis) or on factors such as the extent of competition with banks (which could influence the extent to which borrowing is affected).

Lastly, the differentiation in Graph 1 between microeconomic (bank specific) and macroeconomic (aggregate impacts) is, of course, somewhat artificial. Changes to bank balance sheets cannot be considered in isolation to changes in aggregate demand brought about by changes to the cost of financial intermediation in the economy generally.

Transmission mechanism of regulatory requirements to economic activity

Graph 1



2. Capital requirements

2.1 Summary

We have reviewed papers assessing the impact of higher capital requirements in terms of the costs and benefits to economic activity and welfare. The literature on costs, while presenting a range of approaches and views, suggests that there are opportunity costs in terms of reduced lending and economic activity as bank capital requirements rise, and that the Modigliani-Miller invariance theorem holds only partially.

There is less focus, at least from an empirical standpoint, on estimating benefits. The literature focusses on measuring the reduction in banking sector risk-taking and is unanimous in finding that the benefits of higher capital requirements in line with those of the Basel III regulation are large and that the net benefits are positive (see Section 2.2).

Literature focussed on optimal capital requirements is sparse and needs careful interpretation. For example, there is no consistent definition of capital used to draw conclusions. Nevertheless, the literature suggests an optimal range for capital requirements not dissimilar to the current calibration of the Basel III requirements (see Section 2.4).

Furthermore, literature focussed on the impact of "total loss absorbing capacity" – that is, the requirement for "bail-in-able" instruments and the interaction with existing regulatory capital instruments – is largely non-existent and consequently there is no quantification of the possible costs or benefits. Nevertheless, examination of the literature on the disciplining role of holders of subordinated debt and contingent convertible bonds ("CoCos") suggests that (non-capital) TLAC instruments can have an important role in disciplining bank behaviour, provided these non-capital instruments fulfil a number of key characteristics (see Section 2.5).

Lastly, we note that there are a number of issues with estimates of costs and benefits and any conclusions on optimal capital requirements (see Section 2.7). We highlight, in particular, the potential for significant disparity in costs across national jurisdictions which could lead to large and uneven distribution of costs across the global financial sector, and any conclusions should be treated with caution.

2.2 Impact of capital requirements on the economy

A key aim of capital requirements is to increase banks' resilience to future shocks. Capital requirements enhance financial stability by reducing banks' incentives to take on excessive risks ex ante, and by making banks more able to absorb losses ex post. However, banks may also respond to higher capital requirements by increasing lending rates or reducing credit, which, in turn, may slowdown economic growth or, even worse, deepen an economic recession. Clearly these effects on lending need to be taken into account when considering the calibration of policy.

There are a variety of approaches taken in the literature to analysing the costs and benefits of capital requirements. The most common approach to costs considers the increase in banks' funding costs resulting from higher capital requirements and the transmission of these costs to the real economy via increases in borrowing costs to bank customers. Considered less frequently in the literature, benefits are estimated as the losses to economic activity that are avoided because the banking system is less prone to precipitating financial crises.

This section describes the findings in the literature on estimating economic costs and benefits of capital requirements, net benefit calculations based on general equilibrium models and their welfare implications as well as optimal capital requirements.

It is important to distinguish between a bank's requirements and its resources. Requirements are set by regulators in the form of a minimum risk-based capital ratio or capital buffers (for liquidity the equivalent is the form of an LCR or net stable funding ratio (NSFR)). Banks generally hold resources (capital

instruments) in excess of requirements to prevent unwanted regulatory actions amongst other reasons. For example, restrictions on dividend distribution for banks with capital resources are below the required capital buffer.[1] The difference between a bank's resources and its requirements (the surplus) is chosen strategically by a bank based on a number of factors.[2]

2.2.1 Estimating costs

In line with the analysis undertaken by the Long-term Economic Impact (LEI) Group (BCBS (2010)) and the Macroeconomic Assessment Group (MAG)[3], most studies in the literature since 2010 agree that higher capital requirements impose costs in terms of foregone lending and, ultimately, economic activity. That is, costs as discussed in most papers can be best described as the opportunity cost of higher capital conditional on a "no-crisis" state of the world. However, it is difficult to draw definitive conclusions about the size of the cost based on the most recent literature, given either the limited span of work post-Basel III or any differentiation between the effects during "normal" periods and "crisis" periods (or the likely duration of crisis periods). Many studies continue to use the pre-crisis, Basel I related period and offer limited insight into bank behaviour since then.

2.2.1.1 Impact on the lending channel

The first group of studies focusses on the "pure" lending transmission channel, estimating directly the impact of capital requirements on either lending interest rates (or the spread between lending and deposit interest rates) or on lending growth (or both). For example, de-Ramon et al (2012) estimates the relationship between lending spreads and aggregate bank capital ratios using UK data from 1992 to 2012. They find that, in the long run, UK spreads are increased directly by 9.4 basis points for a one percentage point increase in total capital requirements.[4]

Sutorova and Teply (2013) estimate that lending rates increase by 19 basis points (bps) for a one percentage point increase in capital resources using a sample of 594 European banks for the period 2006 to 2011. Full adoption of the Basel III package is estimated to reduce lending in Europe by 2%. Fraisse et al (2015) find that a one percentage point increase in capital requirements leads to a 1% reduction in lending due to reductions in the size of the loans provided to customers using a sample of French banks. These papers also highlight different transmission channels for the effect of higher capital resources on lending. For example, corporate lending spreads can rise to a greater extent in the short term than household lending spreads (de-Ramon et al (2012)), the impact on the number of loans granted may be much larger than on overall lending values (Fraisse et al (2015)), and substitution between sources of credit at the firm level may be feasible (Fraisse et al (2015); de-Ramon et al (2012)).

Overall, the empirical evidence reported in the literature suggests that an increase in capital requirements by one percentage point forces banks to cut their lending in the long run by 1.4–3.5% or reduce credit growth by 1.2–4.6 percentage points, see Table 1.

1 See Francis and Osborne (2009) for discussion with respect to banks' capital surplus.

2 These factors include the desire to avoid costly interventions stemming from a breach of regulatory requirements, the ability to weather economic downturns and market discipline related to a bank's (discoverable) risk appetite.

3 See MAG (2010).

4 Using Basel II definitions of capital.

Estimates for lending reduction due to an increase in capital requirements Table 1

	Lending reduction (%)	Credit growth reduction (%)	Sample	Estimation period	Period of the accumulated effect (months)
MAG (2010)	1.4		Average 15 countries		24
Fraisse et al (2015)	1–8		France	2008–2011	12
Aiyar et al (2014b)		4.6	UK	1998–2007	<3
Bridges et al (2014)	3.5		UK	1990–2011	36
Messonier and Monks (2014)		1.2	France	2011–2012	9
Noss and Toffano (2014)	1.4		UK	1986–2010	Long run
Meeks (2014)	0.2 (mortgage) 0.5 (corporate)		UK	1989–2008	Long run
Mendicino et al (2015)2	0.15 (mortgage) 0.43 (corporate)		Euro area	2001–2013	Long run
Sutorova and Teply (2013)	1.4–3.5	1.2–4.6	Europe	2006–2011	Long run
De-Ramon et al (2012)	1.6		UK	1992–2010	Long run

[1] 1% at the intensive margin, 8% considering both the intensive and extensive margins. [2] Authors' calculations.

Some studies that consider the lending channel look at how other factors may have differential impacts on lending in different economic environments. Carlson et al (2013) test the influence of the size of banks capital surplus on lending as capital requirements change. They find that change in capital requirements have a bigger impact when a bank's capital surplus is smaller (and therefore the capital regulation is closer to binding) and during crisis periods.[5,6] Moreover, commercial real estate, commercial and industrial lending appear more sensitive to the size of the capital surplus than other lending (consistent with de-Ramon et al (2012)).

Other studies also support the finding that lending is more sensitive to banks' capital resources in times of crisis (eg Gambacorta and Marques-Ibanez (2011), Cornett et al (2011)) and suggest that changing capital requirements when the banking industry is under financial stress might notably affect their lending volumes; however, under more typical financial conditions, such changes are unlikely to greatly influence lending. In addition, there is empirical evidence that better capitalised banks make the provision of credit more stable in a downturn, and preserve long-term lending relationships (Albertazzi and Marchetti (2010), Kapan and Minoiu (2013), Gambacorta and Mistrulli (2004)). These studies have shown that higher capital surpluses lead to a lower reduction in credit supply following a shock. Moreover, well capitalised banks can also shield their lending from monetary shocks as they have easier access to non-insured funding (Jimenez at all (2012)).

The impact on the lending channel was extensively researched in the period before the financial crisis. The results from that period are generally consistent with more recent papers, although the pre-crisis discussion focusses more on the various ways in which banks respond to changes in their capital resources. For example, Peek and Rosengren (1997) find that declines in a parent bank's capital ratio results

[5] Data is taken for banks over the period 2001 to 2011 and the authors focus on the period 2008–2011 to draw conclusions on the impact during a crisis period.

[6] When the capital ratio is below the 25th percentile of its distribution, the authors estimates suggest that a one percentage point increase in the capital ratio raises bank lending by 1.2–2.1% in the next year.

in a large decline in lending at the bank's branches.[7] Bernanke and Lown (1991) show that loan growth is influenced by the capital resources held by small banks, but that there is no such relationship for large banks.[8] Hancock and Wilcox (1994) and Hancock et al (1995) find significant correlations between capital ratios (relative to internal targets) and lending, but the size of the effects varies substantially over time.[9]

Berrospide and Edge (2009) estimate a dynamic model where capital ratios follow a partial adjustment process. They find that banks with a higher capital surplus will experience higher loan growth post-adjustment. Francis and Osborne (2009) estimate a similar model for a set of UK banks and find that banks raise (lower) their capital ratio by raising (lowering) capital and lowering (raising) assets, risk-weights and lending.[10] Other papers also find that capital shocks matter for lending, although the magnitudes of the effects varies (eg Brinkmann and Horovitz (1995), Ediz et al (1998), Hancock et al (1995), Ito and Saaski (2002)).

A second group of studies focuses on the cost of equity transmission channel and the influence of the Modigliani-Miller (M-M) theorem. Modigliani and Miller (1958) demonstrated that, under idealised conditions, raising the proportion of equity funding (at the expense of debt) would leave a firm's total cost of funding unchanged.[11] Many current studies consider the extent to which the M-M theorem holds given the range of divergences from the assumptions underlying the finding of unchanged funding costs.

Admati et al (2013) (re-iterated in Admati and Hellwig (2014)) argue that forcing banks to hold a significantly greater proportion of equity on their balance sheets is not socially expensive (although privately costly for banks). Better capitalised banks are expected to suffer fewer distortions in lending decisions and perform better. Moreover, regulatory approaches based on equity should dominate alternatives (including contingent capital). Although there is some private cost to banks of holding a greater proportion of equity on their balance sheets (eg due to tax reasons, or thanks to the too-big-to-fail subsidy), the authors suggest (CET1) ratios should be up to 50%[12] and argue that banks can raise capital ratios largely without cost to the economy by retaining earnings.

Other papers focus on providing explanations of why higher equity may generate private costs (ie why there may be deviations from the M-M invariance outcome). One strand of the literature points to the inefficiency of the equity market.[13] A second strand of literature points to asymmetric information about banks' net worth (Bolton and Freixas (2006)), especially during a crisis period.

Elliott (2013) and Miles et al (2013) note that the M-M theorem may not hold due to two major distortions: (1) tax advantages for issuing debt, and (2) under-priced guarantees (implicit or explicit) for

7 A one percentage point decline in a Japanese parent's capital ratio leads to a 6% decline in lending at the branch level.

8 The study considered banks' capital resources and lending in New Jersey during the 1990–1991 recession period.

9 For example, during the 1990–1991 recession the sensitivity of lending to capital for large banks was roughly three times higher than in 1991–1992.

10 The adjustment suggests a pecking order for adjusting banks' balance sheets, where the most expensive capital tier is adjusted more slowly than less expensive tiers, and assets with higher risk-weights are adjusted to a greater extent than assets with lower risk-weights.

11 Modigliani and Miller (1958) showed that when a firm increases debt funding (ie it increases leverage), investors can arbitrage away any change to their own leverage position by selling the firm's debt and buying its equity. This raises the firm's cost of debt funding and lowers the cost of equity, such that the average cost of funding for the firm is unchanged.

12 The authors note that equity of 40–50% of total assets were common for banks in the nineteenth century, and that, around 1900, 20–30% ratios were common in many countries, so that it is unclear why such levels would not be appropriate today.

13 Equity may be costly because additional equity reduces returns (increases downside risks) for existing bank shareholders, who require higher compensation (Myers (1977)). Markets also require a higher equity premium for new equity issuance as this can be interpreted as a signal that a firm is under-capitalised (Myers and Majluf (1984)).

debt. Banks can have a preference for debt financing due its lower cost (related to the tax deductibility of debt and incorrect pricing of debt). Miles et al (2013) takes the M-M theorem explicitly into account[14] and find that the M-M effect offsets the cost of higher capital requirements imperfectly, by 45% to 75%. Kashyap et al (2010) also report that the long-run steady-state impact on loan rates to households and corporations is modest, using data for the US and a model-based calibration approach.[15]

The segmentation of the deposit and equity markets also explains why high leverage is attractive for bank. Allen and Carletti (2013) add financial friction in the form of intermediation costs. In equilibrium, the cost of equity financing is equal to that of deposit funding plus intermediation costs. Higher leverage can therefore be justified from a bank perspective. Indeed, many empirical studies find that equity is more expensive than other forms of funding, and any increase in cost of equity can be passed on to borrowers.

Alternatively, many studies take a simple accounting approach to estimating the impact of higher capital requirements, assuming that (1) banks in future target a particular return on equity and (2) raise lending rates (but generally do not change deposit rates and therefore net interest margins) to recover the additional funding costs. The intuition is that higher capital requirements reduce the return on equity (ROE) as (the same) profits must be shared by a larger equity cohort. To keep the ROE unchanged, banks raise lending rates (eg King (2010)) with the risk that higher lending rates may end up in lower lending and, thus, reduced economic activity.

This accounting approach was used for the LEI study[16] and abstracts entirely from the M-M theorem. Slovik and Cornède (2011) also use this approach[17] to show that a one percentage point increase in the ratio of capital to risk-weighted assets will push up bank lending spreads by 14.4 basis points on average, with a higher effect in the US. This result stands in contrast to Cecchetti (2014) where the authors assert that evidence suggests there is little impact on loan volume from the increase in capital stemming from Basel III (except in Europe). Slovik and Cornède (2011) argue that negative effects on credit supply can be offset by accommodative monetary policy in the short run although, in the long run, monetary policy that is too accommodative might lead to excessive risk taking by banks.[18]

Table 2 summarises the main findings and assumptions of the studies noted above. Overall, the literature suggests that there are departures from the irrelevance proposition of the M-M theory and there are no papers that suggest that changes to the capital-debt mix at banks has no impact on bank funding costs. That said, most calculations reveal that the impact is relatively small (around 5–19 basis points, see Table 2) and similar to the results posted in the MAG and LEI reports.

[14] The authors use variations of the CAPM model to estimate directly a relationship between banks equity beta and leverage, and use this relationship to determine the extent to which equity prices adjust as leverage is changed.

[15] The authors estimate a 10 percentage point increase in the capital requirement will increase lending rates by 25–45 bps.

[16] The BCBS (2010) study uses data of 13 OECD countries. It assumes that (1) increase in funding costs are fully passed through to the borrowers (which is a common assumption for similar studies), and (2) the cost of capital does not fall as banks become less risky (in other words, Modigliani-Miller theorem does not hold). The simple mapping shows that one percentage point increase in capital ratio raises loan spreads by 13 basis points.

[17] Based on data from three OECD countries between 2004 and 2006.

[18] Chodorow-Reich (2014) finds limited effects of ex post unconventional monetary policy on risk taking of financial institutions. Stein (2013) finds some evidence of increased flows into risky asset classes, although this may in fact be beneficial, see Repullo (2012)).

Impact on lending spreads (basis points) of increasing ratio of capital to risk-weighted assets by one percentage point

Table 2

	Impact	M-M[1]	Pass-through[2]	Country
LEI (2010)	9–19	No	1	13 OECD
Baker and Wurgler (2015)	6–9	Yes	1	USA
De-Ramon et al (2012)3	9.4 [6.7–19]4	No	Implicit	UK
Cosimano and Hakura (2011)	9–13	No	1	12 OECD
Slovik and Cournède (2011)	16	No	1	3 OECD
Kashyap et al (2010)	2.5–4.5	Yes	1	USA
Mendicino et al (2015)5	2.8 (mortgage) 4.9 (corporate)	No	1	Euro area
King (2010)	15	No	1	13 OECD
Elliott (2009)	5–10	No	25–50%	USA
MAG (2010)	12.2	No	1	17 OECD

[1] M-M refers to the explicit assumption that the Modigliani-Miller invariance proposition holds. [2] Refers to the proportion of the increase in banks' funding costs that is passed through to customer through an increase in lending spreads. [3] De-Ramon et al (2012) estimate directly the relationship between lending spreads and capital requirements and does not provide direct estimates of the pass-through. [4] Short term maximum impacts for the housing sector and corporate sector, respectively. [5] Authors' calculations.

2.2.1.2 Impacts on economic activity (lending / GDP)

The second step in the assessment of the economic costs of higher capital requirements is to evaluate the impact of higher lending spreads on the long-run level of GDP (see the "opportunity costs" section of Graph 1). Rochet (2014) shows the estimated impacts of a one percentage point increase in the ratio of capital on the steady-state GDP level for three directly comparable studies. These studies report similar impacts, which are relatively small.

Impact on steady-state GDP level of increasing the capital ratio of capital[1]

Table 3

	Impact (median)	Range	Country	Size of change in capital ratio
LEI (2010)	0.09%	0.02–0.35%	13 OECD	1 percentage point in ratio of capital to RWAs
MAG (2010)	0.10%	Maximum 0.15% after 8 years	17 OECD	
Slovik and Cournède (2011)	0.20%	Impact achieved after 5 years	3 OECD	
Angelini and Gerali (2012)	0.05%	0–0.36%	Euro area	
Roger and Vitek (2012)	0.11	0.09–0.24	15 advanced and emerging economies	
Mendicino et al (2015)[2]	0.04%		Euro Area	
De-Ramon et al (2012)	0.30		UK	Full Basel III increase in ratio of capital to risk-weighted assets
Miles et al (2013)	0.25		UK	1% increase in cost of capital

[1] Table is taken from Rochet (2014) and augmented with relevant studies shown in the table [2] Authors' calculations.

The estimates in the first part of Table 3 consider the costs across wide geographic areas (OECD and the Euro area) while others note the impacts on individual countries. These estimates are generally more varied in the way in which the regulatory change is specified and the way in which the estimates are calculated. For example, De-Ramon et al (2012) use their modelling framework to estimate the total impact of Basel III on ongoing UK GDP (rather than the impact of a one percentage point increase). The authors estimate the total cost of the Basel III measures (excluding the introduction of liquidity measures) at around £4.7 billion per annum[19] in terms of foregone GDP, or 0.3% of GDP per annum.[20]

Overall, the results from the literature suggest that we cannot realistically ignore costs of higher capital ratios generated via the lending channel. However, when compared to estimates of the benefits discussed below, the costs appear to be small.

2.2.2 Estimating benefits

The main justification for increasing capital requirements on banks is to reduce the likelihood of financial crises driven by the banking sector, while higher capital may also decrease the cost of crises[21] (see Graph 1). Better capitalised banks are less vulnerable to shocks. More bank capital reduces the probability and expected costs of future banking crises. There is evidence in the literature that better capitalised banks make the provision of credit more stable, even in a downturn by preserving long-term lending relationships.[22] Well-capitalised banks can also shield lending from monetary shocks given easier access to non-insured funding. The literature, however, does not have a definitive answer on the extent to which more capital reduces banks' excessive risk-taking ex ante.

The literature notes several potentially offsetting impacts of higher capital requirements for banks. On the positive side, capital strengthening may (1) provide incentives for the bank to reduce its probability of default by monitoring its borrowers (Nguyen (2015)); (2) reduce moral hazard by incentivising banks to invest in less risky assets (Berger and Bowman (2013), de-Ramon et al (2012)); and/or (3) mitigate the incentives to develop risky and complex products. On the negative side, banks may increase risk-taking activities and conceal them from supervisors to restore profitability (Mariathasan and Merrouche (2013)).

Thus, a key issue is to assess to what extent more and better quality capital impacts the probability of survival of banks during normal times and during different types of financial crises (eg crises originating in the banking sector and those originating in capital markets). Berger and Bowman (2013) provides empirical evidence that higher capital resources enhance the probability of individual bank survival and the maintenance of market share for medium- and large-sized banks during banking crises. Small banks with higher capital resources enjoy these benefits at all times. Hence increasing capital requirements is beneficial for the stability of the financial system. The authors also find that higher capital resources improve profitability for medium- and large-sized banks in crises periods and for small-sized banks at all times.

There is a general consensus on benefits around higher capital ratios reducing the probability and costs of crisis (Miles et al (2013), de-Ramon et al (2012), BCBS (2010), de Bandt (2015)), in line with the conclusions drawn by the LEI report. However, de-Ramon et al (2012) note a number of issues with benefits estimates. First, the data to draw conclusions is limited to a small number of relevant crisis events. Second, it is not possible to calculate the benefit of a specific capital requirement as marginal benefits diminish as capital ratios rise, so the benefits of Basel III cannot readily be distinguished from any other capital-raising regulation without imposing some arbitrary order on these regulations. Lastly, decreasing marginal

[19] The cost to GDP is measured in as the net present value of the change in the annual, chained volume measure of 2010 GDP.

[20] RTF estimate. De-Ramon et al (2012) note that annual UK GDP is approximately £1400 billion per annum.

[21] The empirical literature largely ignores the potential reduction in the costs to the economy once a crisis occurs that may also occur. We set out both impacts in Graph 1.

[22] See also Section 4.1.2 for a description of the empirical evidence pertaining to macroprudential supervision.

benefits also means that estimates of total benefits are dependent on which changes in capital are included in the choice of the "counter-factual" benchmark against which outcomes are measured. For example, if banks raise their capital ratios in anticipation of Basel III requirements (but would not have been expected to otherwise), excluding this capital increase from estimates of the expected impact of Basel III will considerably reduce the measured benefits.

2.2.3 Net benefit calculations

Only a small number of the 60 or so surveyed studies make a comparison between the estimated benefits and costs of heightened capital requirements. All of these papers conclude that benefits exceed costs.

BCBS (2010) concludes the net benefits of doubling the capital ratio from 7% to 14% when banking crises may impose large and permanent effects is about 5.8% of the steady-state level of GDP. De-Ramon et al (2012) find that the benefits of Basel III are nearly three times as large as the costs. Junge and Kugler (2013) argue that the impact of doubling the capital ratio is large for the Swiss banking sector, and that the net benefit will be in the order of 12% of GDP. Yan and Turner (2015) estimate that a 10% Tier 1 ratio would lead to cumulative GDP gains of 35%.[23] If the Tier 1 ratio increases only to 7%, as envisaged under Basel III, they estimate those gains to be half as large.

2.3 General equilibrium models and welfare implications

Most studies discussed above use partial equilibrium models to assess the macroeconomic implications of bank capital requirements. More recently, papers have looked to introduce financial intermediation directly into dynamic stochastic general equilibrium (DSGE) models, although we have limited examples. Financial frictions included in these models are typically found to increase the persistence of shocks and their impact.

In this section, we look at papers using general equilibrium models to generate both economic impacts and broader welfare implications. General equilibrium models consider more broadly the interactions set out in the "opportunity cost" box in Graph 1, although some consider both benefits and costs simultaneously.

2.3.1 General equilibrium models

Angelini and Gerali (2012) use a dynamic general equilibrium model of the euro area to study banks' possible responses to the Basel III framework. The effects of tighter capital requirements on output depend on the strategy banks adopt in response to the reform (ie reducing dividends by accumulating capital through retained earnings, raising lending margins, or adjusting banks assets). Overall, the study finds that the economic impact of tighter capital requirements is modest, with the long run reduction in GDP ranging from zero to 36 basis points. They also find that the undesired macroeconomic effects of the reform during the transition phase are significantly mitigated if the reform is announced well ahead of its actual implementation.

Corbae and D'Erasmo (2014) develop a model of banking industry dynamics[24] to study the quantitative impact of capital requirements on bank risk-taking, commercial bank failure, and market structure. The authors find that a rise in capital requirements from 4% to 6% leads to a substantial exit of small banks and a more concentrated industry. Aggregate loan supply falls by 8.7% and interest rates rise by 50 basis points. In turn, higher interest rates induce higher loan delinquencies as well as a lower level of intermediated output.

[23] The authors use data from 1997 to 2010, across the most recent crisis period.

[24] The authors' model is calibrated to US data and market structures.

2.3.2 Welfare implications

Most DSGE models generate a broadly consistent picture of the long term (steady-state) impact of an increase in capital requirements on bank lending, real activity and welfare. These models also suggest the existence of an inverted-U shaped relationship between welfare and capital requirements: beyond some capital ratio threshold, higher capital ratios produce negative marginal net benefits and, eventually, net costs.

Clerc et al (2014) develops a DSGE model with multiple financial frictions where bankers allocate their equity together with funds raised from saving households across two lending activities: mortgage lending to households and corporate lending. The authors find that capital requirements produce welfare gains to the extent they reduce bank leverage, bank default risk as well as the implicit subsidies associated with deposit insurance. Higher capital requirements, however, may unduly restrict credit availability.

Following Clerc et al (2014), Mendicino et al (2015) calibrate the same DSGE model to the euro area economy and find an optimal minimum capital requirement between 8% and 11% of risk-weighted assets.[25] The authors also find that the optimal size of the capital conservation buffer and the countercyclical capital buffer together should be between 4% and 5% of risk-weighted assets. So, the optimal total capital ratio (consisting of the minimum capital ratio plus the fully loaded capital conservation buffer) should be between 12% and 16% of risk-weighted assets. Such levels of bank capitalisation stabilise the economy in the face of large shocks and prevent fragile banks from becoming a source of shock amplification, while the probability of bank failure becomes small (but non-zero). The model also implies large welfare gains from ensuring bank resilience through substantial capital buffers[26] (buffers are discussed in Section 4.1.1). The countercyclical adjustment is also beneficial but its impact on welfare is limited.

In Martinez-Miera and Suarez (2014), banks trade-off higher returns from systemic lending with the risk of losing their charter value in case of unfavourable return realisations on such systemic exposures. Their calibration delivers an optimal capital ratio of 14%. When the capital ratio increases from 7% to the optimal 14% level, loan rates increase less and aggregate consumption, GDP and bank credit decline less in the year that follows a systemic shock, compared to smaller increases in capital ratios. Hence, welfare improves. However, these gains come at the cost of reducing credit and output in "normal" times, generating a welfare trade-off.

Nguyễn (2014) considers the optimal capital ratio by analysing directly the impact of bank prudential policies on welfare. Welfare is measured as gains in permanent (lifetime) consumption for households. Lifetime consumption is higher as banks raise their Tier 1 capital ratios above the Basel II 4% requirement, but not indefinitely. The intuition behind this result is that, at low levels of capital, banks exploit the implicit government guarantee by lending more to high-risk firms. Subsequent losses by banks and reduced economic productivity reduce overall lifetime consumption. The author's model suggests an optimal level for the Tier 1 capital requirement of 8%.

Welfare is also considered in Gersbach et al (2015). Like Nguyễn (2014), the model is highly stylised, expanding the Solow macroeconomic model to include banks. In this formulation, banks fulfil the role of improving information on credit quality when lending to firms vis-à-vis direct firm loans from households. Consequently, bank-funded firms are more productive than household-funded firms. Moreover, banks are leverage-constrained, so a negative shock to bank equity ratios substantially lowers funding flows to more productive firms which leads to large output losses.

[25] See Annex 2 for further discussion.

[26] The authors estimate that, in a scenario of heightened uncertainty about the loan portfolio performance, capital requirements higher by one percentage-point mitigate the increase in the probability of bank default by about 0.2 percentage points and reduce the fiscal cost of bank default (as a percentage of GDP) by 0.06 percentage points.

2.4 Optimal capital requirements

The literature on optimal capital requirements generally seeks to tie together benefits and costs (as shown in the lower half of Graph 1) to find the level of capital requirements that maximises the net gain to GDP, while not explicitly taking welfare into account.

Miles et al (2011) compute the level of capital where the extra benefits of having more capital equal the extra costs. Their estimate of the optimal Tier 1 capital ratio is around 16–20% of risk-weighted assets, a figure substantially higher than current capital ratios.

Repullo and Suarez (2013) build a model to analyse the optimal degree of cyclicality in capital regulation. They find that risk-sensitive capital requirements such as those in Basel III can be optimal, as long as macroprudential concerns are primarily determined by a high social cost of bank failure.

De-Ramon et al (2012) suggest that total capital requirements (measured on a consistent Basel II basis) can rise by a further 22 percentage points before net benefits are exhausted. However, the error around these estimates is large and there is decreasing statistical confidence that net benefits would be positive for capital levels much above those suggested by Basel III.

Table 4 summarises the estimates of optimal capital ratios. The optimal capital requirements range from a CET1 to risk-weighted assets ratio of 10%, to a Tier 1 to risk-weighted assets ratio of around 20%. These estimates are not inconsistent with the existing Basel III requirements *plus* buffers for systemically important firms, which require a CET1 to risk-weighted assets ratio of around 10%, with Tier 1 and total capital ratios set above it.

Optimal capital requirements — Table 4

	LEI (2010)	Miles et al (2013)	Yan et al (2012)	Martinez-Miera and Suarez (2014)	Nguyễn (2014)	Mendicino et al (2015)
Definition of capital	Tier 1	Tier 1	CET1	Tier 1	Tier 1	Total capital ratio
Optimal capital requirement (% of RWAs)	13	16–20	10	14	8	12–16

2.5 The influence of total loss absorbing capacity

The extant literature on the impact of total loss absorbing capacity (TLAC) regulation is limited, especially because the definition and standards for (non-capital) total loss absorbing capacity instruments have only recently been finalised (BCBS (2015a)). Nevertheless, the agreed features of TLAC are similar to subordinated debt that converts into equity to fund the resolution of troubled banks. We have therefore looked for insights from the literature on the disciplining role of holders of subordinated debt and contingent convertible bonds ("CoCos").

The focus of the relevant literature is on the obligation of subordinated debt and CoCo holders to share losses with equity holders in the event of bank failure. The holders of these instruments, at least in theory, have strong incentives to monitor and mitigate the banks' risk-taking behaviours. The literature generally suggests that the efficacy of this discipline depends on a number of prerequisites for aligning incentives: (1) transparent disclosures (Belkhirl (2013)); (2) appropriate level of bank regulation (Nguyen (2013)); (3) elimination of the perception that a bank is "too big to fail" (Nguyen (2013)); and (4) credible conversion mechanism, especially for CoCos (Sundaresan et al (2011), Prescott (2012), Hilscher et al (2014)).

The literature dealing with CoCos focuses mostly on pricing the securities and on the design of conversion mechanisms. While there is no general consensus, most studies point out that the design of the conversion triggers and conversion ratios is crucial for aligning the risk-taking incentives of equity holders and debt holders. Sundaresan et al (2011) and Prescott (2012) show that a "market-based trigger," which automatically converts CoCos when the market price of the equity hits a predetermined level, may lead to a situation where no unique equilibrium exists. Conversion errors would weaken the punishment of equity holders' excessive risk-taking and, in turn, any market discipline by debt holders. Hilscher et al (2014) suggest that appropriate design of CoCos, in particular capital-based triggers and conversion ratios, can neutralise equity holder's incentives to increase risk. For pricing CoCos, Glasserman et al (2012) and Berg et al (2015) pointed out that CoCos have much higher price volatility than straight (non-convertible) bonds due to the complexity of their structures, which could curb the demand from investors needed for widespread issuance of the securities. This may limit CoCos use in satisfying TLAC requirements going forward.

The empirical literature provides some evidence on the effectiveness of market discipline. Nguyen (2013) shows that the presence of subordinated debt mitigates excessive risk-taking by banks that are not too big to fail.[27] Belkhir (2013) documents that subordinated debt strengthens risk management at banks affiliated with bank holding companies if subordinated debt holders have better access to the information needed for monitoring. Danisewicz et al (2015) show that monitoring efforts by debt holders are asymmetric depending on whether a creditor class moves up or down the priority ladder. In particular, the authors suggest that junior debt holders have greater incentives to exert monitoring effort. This last finding is most relevant, since TLAC is lower in the creditor hierarchy compared with non-eligible debt for TLAC.

Although there is no quantification of the costs or benefits of TLAC directly, the literature suggests that TLAC instruments can have an important role in disciplining the behaviour of banks and especially risk-taking, provided the instruments fulfil a number of key characteristics.

2.6 Key issues in the literature

In this section, we set out a number of key issues with the estimates of costs and benefits, many of which are noted in the literature itself, but are often ignored. First, we discuss some of the key limitations of those papers that estimate the impact on national economic activity, including the generally limited attention paid to the multinational presence of banks. We then discuss some broader practical issues that arise when estimating costs and benefits. Finally, we look briefly at issues that arise by focussing on banks in aggregate, rather than at a firm level.

2.6.1 Key issues with estimates of impacts on activity

A key issue with the estimates presented in Section 2.2 is generally banks are considered within a single national market or a limited range of countries (see detail in Table 2 and Table 3) and wider spillovers into the global economy are not considered. This raises a number of problems, including the inability to capture (1) the effect on global banking activity by considering the impact on cross-border activity within a financial network; (2) the degree of institutional development in different countries, including differences in regulatory practices; and (3) the level of harmonisation with the global regulatory framework set out in Basel III.

Some studies acknowledge these problems and show that there are unintended effects of regulation applied to global banks that impact both domestic and cross-border activities, with negative

[27] Study uses global bank data for the period 2002–2008.

spillovers to some emerging markets. Increases in capital requirements under current consolidation and risk management practices may exert a disproportionate impact on the operations of subsidiaries in emerging countries, particularly those where foreign banks have a large share of the banking system. In turn this could lead to a significant (but as yet unconsidered) underestimation of the size of the costs for emerging countries.[28]

Cohen and Scatigna (2014) show that there are significant differences in the adjustment of banks in emerging markets relative to banks in developed countries. Bank of International Settlements (BIS (2014)) finds considerable heterogeneity across advanced and emerging economies in terms of pre-tax profits, net interest margins and operating costs. FSB (2014) notes that, while consolidated supervision and risk management practices have many benefits, too great a focus on home authority regulatory practices vis-à-vis host authorities can generate some problems. For example, when international banks, consolidating risks on a global basis, book exposures in an entity (or entities) that are inappropriate for the risks inherent for that entity's host country, risks are not transparent. In a similar vein, BIS (2015) looks at the spillover effects of the implementation of TLAC on home and host jurisdictions and find that the peak macroeconomic costs across these jurisdictions vary widely. On average the median peak output loss for home countries of globally systemically important banks (G-SIBs) is estimated at 3–4 bps from annual GDP, although losses to host and other countries range from less than 1 bps (eg New Zealand, Philippines) to more than 5 bps (eg Mexico).

A further problem in these studies is the difficulty in controlling for the current macroeconomic environment and, in particular, the very accommodative monetary policy stance at present which could distort outcomes. We did not find any studies that specifically address this issue.

2.6.2 Issues with cost estimates

A first issue with cost estimates to note is the definition of capital that is used. Some studies follow the LEI and MAG approach and use "total common equity," the closest in definition to common equity Tier 1 (CET1) in Basel III (Cohen (2013), Berrospide and Edge (2010), Roger and Vitek (2012)). Most theoretical papers consider a definition of capital that represents the interests of the owners of the bank, also closest in concept to CET1. Other papers use the Tier 1 definition of capital (eg Miles et al (2013)), perhaps in part because, unlike CET1, Tier 1 equity was more clearly defined in both Basel II and Basel III.

In addition, a small number of papers attempt to consider multiple tiers of regulatory capital simultaneously. For example, De-Ramon et al (2012) looks at adjustments to CET1, Tier 1 and total capital. The authors use the existing price of each tier of capital to derive a "quality-adjusted" capital ratio in an attempt to provide a consistent measure of total capital across both the Basel II and Basel III definitions. While somewhat appealing, such measures make it difficult to compare outcomes with "headline" definitions of CET1, Tier 1 and total capital used for the Basel III reforms.

A second issue relates to the Lucas Critique. In this context, the Lucas Critique notes that the optimal decisions of economic agents may change in response to policy changes, hence "reduced-form" models based on estimates of past behaviour are not suitable for analysing regulatory changes. The vast majority of empirical papers – whether based on microeconomic or macroeconomic data – use reduced-form models, which necessarily assume that individual bank behaviour can be approximated in aggregate (eg de Bandt et al (2014), Kashyap et al (2010), Brun et al (2013), Aiyar et al (2014a), De Nicoló (2015), Noss and Toffano (2014), Miles et al (2013)). De-Ramon et al (2012) cite the Lucas Critique as a shortcoming of macroeconomic models used to estimate costs and benefits; they use a satellite banking sector model to derive aggregate capital ratios to address the "fallacy of composition" that arises from treating the banking sector as a single representative agent. Nevertheless, this approach does not completely address the Lucas Critique.

[28] See also Jakovlejević et al (2015).

Third, many papers look at the impact of relatively small, irregularly timed, changes to capital requirements on individual banks to calculate the impact of much larger changes (eg BCBS (2010), MAG (2010), de Bandt et al (2015), Brun et al (2013), Miles et al (2013)). However, this approach may underestimate impacts if banks are able to absorb at least some small changes in regulation within their capital surplus. For example, Francis and Osborne (2012) find that a change in capital requirements would, on average, raise banks' capital ratios (ie their capital resources) by around 40% of the change in requirements. However, a large enough increase in capital requirements implies that banks end up with very low capital surplus, leading banks to potentially raise their capital resources to an even greater extent. It is not clear how a coordinated and more substantial increase in capital requirements across all banks will affect aggregate capital resources.

Moreover, micro-founded econometric studies (and most macroeconomic models) often overlook the general equilibrium effects associated with borrowers who cannot receive bank loans seeking alternative sources of funding. Additionally, higher lending rates may attract lower quality borrowers who are willing to pay higher prices for their loans. This effect increases bank loan risk and reduces financial stability. Furthermore, most papers acknowledge problems in disentangling credit supply side effects, which arise from capital pressure on banks, from demand side effects, which are related to changes in the external environment.

Lastly, only a limited number of models consider differentiation between short-run and long-run outcomes. Many papers focus only on the long-run outcomes (eg Miles et al (2013), Noss and Toffano (2014)). However if short-run adjustment costs for banks are large, then overall costs of higher capital requirements may be considerably larger than what long-run equilibrium outcomes might suggest (eg de-Ramon et al (2012), MAG (2010)). That said, long transition periods (as in the case of the Basel III regime) suggest that short-run costs are unlikely to affect outcomes considerably.

2.6.3 Issues with impacts of capital requirements on banks behaviour

Increasing capital requirements is not inconsequential at the bank-level as such requirements may affect banks' profitability, business models and balance sheet structures. Regulators should be cognisant of the possibility that the impact of regulation may differ from initial expectations if bank behaviour is different than assumed. That is, the aggregate behaviour assumed in many of the papers discussed above may not be representative of actual outcomes (ie the Lucas Critique applies). In this section, we set out briefly the literature that looks more closely at individual bank reactions, rather than at the aggregate behaviour of the financial sector.

The literature looking at determinants of banks' capital resources is limited as most theoretical models assume that banks operate at the regulatory minimum, while most empirical papers assume that banks' capital surplus remains unchanged.[29] However, some literature (most of which was written before the crisis) sets out a number of complex and interlinked factors that should be considered in determining how banks respond to capital shocks.

First, the literature notes a number of factors that describe banks' capital structures. Alfon et al (2004) note that the capital held by banks depends on three key factors: (1) risk management (eg internal factors including as management's attitude towards risk); (2) market discipline (eg credit ratings, market expectations of government bailouts etc); and (3) the regulatory environment. Moreover, there are several factors that may affect the type of capital banks choose to adjust, including the focus of equity markets on Tier 1 capital, the relative price difference between different tiers of capital, and regulatory requirements that specify different types of capital.

[29] See Section 2.2.2 for discussion of the distinction between banks' requirements, resources and surplus.

Second, we note the extent to which capital requirements are directly binding on banks' capital levels. Ediz et al (1998) assess whether higher capital requirements change banks behaviour over and above the influence of the banks' own internally generated capital targets.[30] They find that capital requirements prompt banks to increase their capital ratios by directly boosting their capital levels. This result is in contrast to Hancock and Wilcox (1993) which shows that in the case of the US, banks' internal capital targets explain declines in private sector lending better than capital requirements.

Third, in response to an increase in (risk-based) capital requirements, the literature suggests that banks have four strategies: (1) raise capital by issuing new equity; (2) raise equity by retaining earnings; (3) change asset composition (ie by changing risk-weighted assets); and (4) reduce asset size (Cohen (2013), Francis and Osborne (2009, 2012), de-Ramon et al (2012)). As noted above, some studies find that banks do not keep their capital surplus constant and can absorb some of the increase in capital requirements although there is also evidence that the smaller the capital surplus, the more responsive banks are to changes in capital requirements (Alfon (2004), Francis and Osborne (2009)).

In addition, there is evidence that banks adjust more extensively the less costly forms of capital (Myer and Majluf (1984), Francis and Osborne (2009))[31] and higher risk-weighted assets (Francis and Osborne (2009); de-Ramon et al (2012)) to move to a new capital ratio. The outcome of these strategies will shape the structure of the banking system under the new regulatory framework and this, in turn, will determine the macroeconomic impact (see Graph 1). More recently, Cohen (2013) provides evidence that most of the adjustment to higher capital ratios by large banks was achieved by the accumulation of retained earnings, rather than through sharp adjustments in lending or asset growth.[32]

Finally, de-Ramon et al (2012) look at how banks adjust lending and deposit rates to different sectors of the economy as they adjust their capital resources. They find that banks widen the lending wedge (the difference between lending and deposit rates) charged to the corporate sector to a greater extent than charged to the household sector in the short term, but in the long run the increase in the wedge is the same for both sectors. This adjustment is efficient for banks in the short term as corporate lending has a much higher average risk weight than household lending (which is dominated by secured mortgages), and consistent with the strategy of changing asset composition described above. While the long term outcome for both sectors is the same, non-bank corporates face a higher financing constraint in the short term.

These factors suggestion that banks may not respond to regulatory requirement in the manner assumed in many models and that we should be cautious about any conclusions drawn from models that ignore these issues.

3. Impact of liquidity requirements and their interaction with solvency requirements

This section reviews the existing literature relating to the potential impacts of liquidity requirements, as well as the interactions between liquidity and capital requirements, both at the individual bank level and at the market (macroeconomic) level.[33] First, we identify conceptual channels through which liquidity

[30] The study uses confidential UK, bank-specific data for the period 1989–1995.

[31] Myers and Majluf (1984) discuss the "pecking order" of capital adjustment, whereby banks adjust cheaper and more flexible types of capital more aggressively than more expensive and less flexible common equity to manage total capital levels.

[32] Cohen (2013) uses a sample of 82 large global banks from advanced and emerging economies for the period 2007–12. In particular, for the period 2009–2012, retained earnings accounted for 1.9 out of the 2.9 percentage point increase in capital.

[33] The discussion in this section has in part been based on the literature review on the liquidity risk factors in BCBS (2013a; 2013b), which were drafted by an earlier RTF work stream on liquidity stress testing.

requirements are expected to exert impacts. Then, this conceptual framework is used to identify potential costs and benefits of liquidity regulation. The literature on various costs and benefits is discussed as it currently exists.

Before discussing the literature and drawing any tentative conclusions, a few caveats should be mentioned.

First, as for any regulatory reform, the long-term expected benefits potentially trade-off with short-term costs of meeting new requirements, which are directly measurable. In the case of liquidity requirements, the constraints imposed by the regulation on institutions in "normal times" may be viewed as insurance against the negative impact of liquidity shocks in crisis periods.

Second, the actual liquidity regulation included in the Basel III framework is currently not fully in place (eg the LCR is partially implemented, and the NSFR has yet to be implemented). This implies that only putative conclusions can be drawn at this stage. In addition, while it may be possible to make estimates of the impacts of liquidity requirements that have been imposed by some countries in recent years, it is nevertheless necessary to adequately control for several important environmental factors, including monetary policy conditions and the level of interest rates. To the extent that these factors are not sufficiently controlled for, any conclusions regarding the impact of liquidity requirements must be viewed as potentially fragile.

Third, the empirical, and some of the simulation, studies do not take into account the full welfare impacts of liquidity regulation. In effect, the literature studying the social benefits of liquidity regulation remains almost entirely theoretical. None of the empirical papers reviewed below attempts to weigh both the potential social costs and benefits simultaneously. For example, a reduction in credit growth may be socially beneficial if it is accompanied by a lowering of the likelihood of state or central bank interventions. Similarly, even if regulations hamper the provision of credit by non-compliant banks, the remaining compliant banks may simultaneously be able to take over and substitute for the non-compliant banks. These shortcomings, which in many cases are data-driven, render a balanced assessment of the impact of liquidity regulation difficult.

Finally, although the distinction between transitional and steady-state periods was made in the MAG and LEI reports, subsequent studies sometimes fail to separate the impacts of the transition associated with the introduction of liquidity regulation from the steady state outcomes.

3.1 Channels through which liquidity requirements have impacts

Liquidity requirements can affect banks through several channels, which depend upon whether the liquidity requirement takes the form of the LCR or the NSFR. Whereas much of the theoretical literature relating to the liquidity risk of banks pertains to withdrawals of demand deposits, liquidity risk of modern banks is more likely to materialise in the form of withdrawals of wholesale funding or other short-term finance, drawing by borrowers on unused credit lines, or margin calls on collateral.

The effects of liquidity requirements are first realised at the bank level and then may translate into market (macroeconomic) level impacts. Table 5 describes the potential channels, at both bank- and market-levels, through which liquidity requirements may have impacts. Relevant references are made to the (mostly theoretical) academic literature identifying these channels.

Channels of impacts of liquidity regulation — Table 5

Effect	Description	Effect due to LCR or NSFR?	Benefits	Costs
Bank level channels				
Bank level: asset-side				
Replacement of non-HQLA with HQLA	Reduced loans & increased holding of securities – Covas-Driscoll (2014) Reduced private bonds & increased holdings of government bonds – Bonner (2014) Lower credit risk	LCR	Lower credit risk – Lower capital requirements – Higher excess capital – Higher ratings Lower funding costs due to higher ratings Reduced vulnerability due to funding shocks Reduced vulnerability due to unexpected increases in collateral	Lower interest income due to less risky assets
Increased holdings of securitisations/covered bonds		LCR	Reduced vulnerability due to increased ability to borrow from the central bank	
Shortening of maturity of assets		NSFR		
Bank level: liability side				
Replacement of non-stable funding with stable funding through less wholesale funding or through covered bond issuance	– Shin (2009) – Birn et al (2015)	LCR/NSFR	Reduced risk of funding shocks – Modern view of Diamond/Dybvig – Ennis-Keister (2006) – Bowman (2014) – Diamond-Kashyap (2015) – Hong et al (2014)	Higher interest expenses on stable funding Higher interest rates on unsecured interbank funding if close to LCR – Bonner-Eijfinger (2012)
Lengthening of maturity of liabilities (lower short-term wholesale funding)		NSFR		
Reduction in contingent credit and liquidity facilities	Cornett et al (2011)	LCR		
Market (macroeconomic) level impacts				
Lower costs of bank failures	Higher HQLA reduces cost of bank failures – Calomiris et al (2011)		Lower social costs of banking crises	
Reduced negative externalities due to bank failures	Reduce system-wide externalities of bank reliance on common sources of short-term funding – Perotti-Suarez (2011)		Lower probability of simultaneous bank failures	

Greater impact on market prices of liquidity shocks	Due to greater commonality of banks' asset holdings and herding behaviour – Bonfim-Kim (2012) – Allen et al (2012)			Large, correlated sales by one or a few banks can significantly impact the asset values of other banks
Banking system less vulnerable to liquidity shocks due to increased absorption capacity	Central bank becomes lender of last resort, rather than lender of first resort – Goodhart (2011) – Farhi-Tirole (2012)		Less moral hazard among banks (ie safer banks)	
Bank credit may diminish in normal times	Due to substitution of HQLA for non-HQLA – Acharya-Vishwanathan (2010)			Less credit to the economy – Covas-Driscoll (2014)
Bank credit may contract less in reaction to funding shocks	Due to the existence of a liquidity buffer – Acharya-Vishwanathan (2010)		Less contraction of credit in stress period – Cornett et al (2011)	
Less overnight and other short-term funding				Lower effectiveness of monetary policy – Bech-Keister (2013)
Less short-term funding may increase bank fragility	Due to lower discipline of banks by wholesale investors – Calomiris-Kahn (1991) – Diamond-Rajan (2001a, b)			May increase the likelihood of bank failure

In addition to describing the channels through which liquidity requirements affect bank behaviour, the bank level panels of the table also indicate whether the channel would be associated with the LCR and/or the NSFR. The costs and benefits pertaining to each channel are also identified. At the market (macroeconomic) level, effects are more difficult to attribute specifically to the LCR or the NSFR. Whereas the costs and benefits cited for the impacts at the bank level are private to the bank, the costs and benefits indicated for the market (macroeconomic) impacts are social costs and benefits.

Bank level asset-side channels of the LCR include replacement of non-HQLA with HQLA, which may result in a substitution away from loans towards holding government bonds. The NSFR potentially shortens the maturity of banks' assets. Both of these adjustments may be expected to lower banks' credit risk. However, the substitution of non-HQLA with lower yielding HQLA and the shortening of asset maturities is expected to lower banks' interest income.

On the liabilities side of banks' balance sheets, both the NSFR and the LCR are expected to result in stable funding replacing non-stable funding. This likely reduces wholesale funding and potentially increases covered bond issuance. The NSFR is expected to lengthen the maturity of liabilities. Together these liability adjustments may increase interest expenses, because more stable and longer maturity funding sources are associated with larger spreads and are, thus, more costly. Regarding off-balance sheet items, the LCR is expected to result in a reduction in contingent credit lines or liquidity facilities granted by the bank.

In order to assess the actual impacts of liquidity requirements, empirical hypotheses (or outcomes) need to be identified. This is especially important given that in certain cases, differing

conceptual channels may lead to the same observed outcome. In practice, it may be possible only to observe the outcome and not the specific underlying channels that generated the outcome. In addition, whereas the potential channels may have been identified on the basis of theory, the impacts of regulatory requirements can only be evaluated on the basis of empirical testing, or at minimum, quantitative simulations. The potential empirically observable outcomes associated with the costs and with benefits of liquidity regulation are identified and discussed in the following sections.

3.2 Costs of liquidity requirements

The bank level channels described in the previous subsection can translate into market (macroeconomic) outcomes. Greater impacts of liquidity shocks on asset prices (due to increased common exposures in banks' asset holdings) and less credit in normal times (due to the substitution of non-HQLA for HQLA) are among the outcomes representing potential social costs of liquidity requirements.

We first state the outcomes associated with the potential costs of liquidity regulation and then discuss the empirical results pertaining these outcomes when available.

- Outcome 1: Introduction of the LCR may reduce aggregate bank credit in normal times lowering aggregate output (Section 3.2.1) through the following channels:
  - (a) Introduction of the LCR may increase the opportunity cost of holding illiquid assets, which may translate into higher loan rates.
  - (b) Introduction of the LCR may reduce the proportion of loans on bank balance sheets (as well as contingent credit and liquidity facilities).
  - (c) Liquidity requirements may reduce the average maturity of bank loans.
  - (d) Liquidity regulation may lead banks to increase lending costs to cover higher funding costs.
- Outcome 2: Introduction of the LCR may reduce the proportion of private bonds and increase the proportion of government debt held by banks.
- Outcome 3: Liquidity requirements may reduce net interest income (NII) (Section 3.2.2). NII may decrease due to the fact that banks hold more HQLA (typically lower yielding assets), or due to the increase in stable funding (typically more costly).
- Outcome 4: Due to increased common asset holdings by banks, liquidity requirements may increase the impact of liquidity shocks on asset prices.
- Outcome 5: Introduction of the LCR may result in less interbank lending in normal times (Section 3.2.3).

3.2.1 Credit and composition of assets

The current empirical evidence on the impact of liquidity requirements on the composition of assets is based on the liquidity requirements (similar to the LCR) imposed in the UK and Netherlands prior to Basel III. There are currently no empirical studies of the potential impact of the NSFR on credit.

The Financial Service Authority (FSA) imposed an individual bank liquidity regulation in the UK in 2010. This "individual liquidity guidance" (ILG) required banks to hold HQLA to withstand both an acute bank-specific shock lasting for 2 weeks as well as a general funding shock lasting for 3 months. The FSA excluded some banks from the liquidity requirements, which created a natural control group against which Banerjee and Mio (2015) were able to study the causal effects of the ILG on bank balance sheets. Using a "local projection method" (which allows the sample to be divided into pre-crisis and post-crisis periods), these authors find that the ILG induced a substitution of short-term intra-financial loans with HQLA, whereas lending remained nearly unchanged. As banks under the ILG increased the share of HQLA on

average by 12 percentage points compared with banks that were exempted from the requirements, banks' credit risk declined and, thus, eased their ability to fulfil regulatory capital requirements. However, the authors emphasise that the latter result may have been driven by the UK's Quantitative Easing programme, which may have led to a perfectly elastic HQLA supply curve.

In 2003, the Dutch National Bank (DNB) introduced a quantitative liquidity coverage ratio for Dutch banks (hereafter referred to as DLCR). According to this rule, banks' liquidity must exceed certain minimum requirements at horizons of both one week and one month. The amount of required liquidity is determined according to assumptions related to deposit withdrawals, calls on contingent credit lines, and runoffs for wholesale and derivative funding. Bonner (2015) studies the effects of both capital and liquidity requirements in the Netherlands and identifies a similar substitution effect as was observed in the UK for liquidity requirements. Due to the preferential regulatory treatment of government bonds in capital and liquidity requirements, banks substituted Dutch government bonds for other bonds (eg financial bonds, covered bonds and asset-backed securities), which had a significant effect on capital requirements.

In contrast to the findings for the UK, Bonner identifies an impact of liquidity requirements on private lending. With the revision of the DLCR in May 2011, liquidity requirements became stricter, as haircuts for all securities increased. Government bonds, however, became relatively more attractive, as the haircut for this asset class had increased by merely 5% whereas the haircuts for most other bonds had increased by 30%. In response, banks increased government bond holdings, and bank lending to the private sector declined by 3.1%.

The findings of these two studies (ie imposition of liquidity requirements does not appear to reduce aggregate output) is consistent with the conclusions of three European Banking Authority (EBA) reports (2013, 2014 and forthcoming) based on QIS data. These reports find that the LCR and the NSFR do not negatively affect lending to the real economy or GDP growth. In particular, banks have adjusted their LCR by reducing their intra-bank lending and increasing their HQLA holding, with no or very little impact on lending to non-financial corporates, retail and small- and medium-sized enterprise (SME) customers. These results appear to be due, at least in part, to the substantial "softening" of both ratios during the course of the Basel negotiations and to the relatively low opportunity costs of compliance.

Whereas the existing empirical analyses find no significant impacts of liquidity regulation on credit, papers using simulations suggest a larger impact of liquidity requirements on lending. Analysing bank behaviour in a dynamic partial equilibrium model, de Nicolò et al (2014) find that adding liquidity requirements on top of capital requirements may severely hamper maturity transformation. In order to fulfil the additional requirements, banks are forced to use retained earnings to increase bond holdings (rather than using these funds for extending loans) or to reduce liabilities. Low capital requirements rather than no capital requirements at all can result in more lending, because it can be beneficial for banks to use the higher revenues from risky loans to build capital. However, for higher capital requirements this alternative becomes too costly, due to the assumption of decreasing returns to scale in lending, which then leads to a U-shaped impact of capital requirements on bank lending. In contrast, liquidity requirements lead to an increase in capital ratios by an inefficient increase in bond holdings. Although these actions increase the safety of banks, loans decline by 26%, due to a high elasticity of loan demand with respect to loan spreads. However, this result may be driven by the assumption that both deposits and prices are exogenous, ie by the usage of a dynamic partial equilibrium model.

Covas and Driscoll (2014) argue that partial equilibrium models are not well suited to identify the magnitude of the impact of different regulatory requirements as such models do not take into account price effects. Using a non-linear DSGE model, they show that taking price adjustments into account significantly diminishes the estimates of impacts made through partial equilibrium models. In particular, imposing an LCR requirement on top of a capital requirement of 6% decreases bank lending by 3%, whereas neglecting the price effects would indicate a decline in lending by 6%. This effect also remains identical when the LCR is added to a capital requirement of 12%. In both cases, banks hold more securities and equity in response to the LCR and, as a result, their capital ratio increases by one percentage point. Doubling capital requirements from 6 to 12% instead of imposing an LCR would reduce lending by less

than 1%. However, these higher capital requirements have a strong impact on banks' holdings of securities and their equity ratios, which then leads to an increase in banks' capital ratio of nearly 5%. The extent of the dampening effect depends on firms' characteristics and the design of the financial system. In fact the private sector might have a number of alternatives to bank loans at the margin (eg equity funding, supplier loans, issuance of corporate debt, and factoring/leasing).

Using a broader DSGE model that distinguishes between SME customers, large corporates, and investment in sovereign bonds, de Bandt and Chahad (2015) stress that liquidity requirements lead to an increase in households' deposits. When the LCR moves from 60% to 85% of its target in four years, loans to SME customers decrease by 1%, while loans to large corporates, which also rely on bond funding, decrease by only 0.5%. The overall impact on GDP is in the same range as in the previous studies (see Table 6).

Impact of capital and liquidity requirements from various macroeconomic models

Table 6

Paper	Increase in capital and liquidity requirement	Loan growth	GDP growth
De Nicolo et al (2014) Partial equilibrium	Leverage ratio at 4% and LCR at 50%	-26%	
Covas and Driscol (2014) DSGE	LCR (of 100%) on top of 6% capital requirement	-3%	-0.3% (from one steady state to another)
De Bandt and Chahad (2015) DSGE	LCR from 60% to 85% in four years	-3% for SME customers, -2% for large corporates	-0.15% first-year -0.08% after 4 years

3.2.2 Funding and net interest income

With respect to the impact of liquidity regulation on net interest income (NII), as identified by Outcome 3, interest income and interest expenses should be distinguished as well as transactions with different counterparties (eg wholesale vs. non-financial sectors). However, these distinctions are not always feasible in empirical studies due to lack of data, even if some papers provide evidence on lending rates to households and companies. Overall, the conclusion that can be drawn at this point from the literature is that that the effects on NII are not very significant.

King (2013) estimates that the implementation of the NSFR (or rather its proxy as developed by the author) could mean that the most cost effective strategies to meet the regulatory minimum would be to increase the maturities of wholesale funding and increase holdings of higher-rated assets, which together would reduce NII. Using a sample of 15 countries based on Bankscope data and assuming banks increase liquid assets by 25%, King estimates that the interest margin would decrease by 70–80 bps (ie 40% based on 2013 data as compared to the 2009 level).[34]

Turning to the DLCR rule in the Netherlands (described above), Bonner and Eijfinger (2012) find that constrained banks (ie those close to the liquidity requirement) pay and charge higher interest rates for unsecured interbank loans, especially for loans with maturities above 30 days. Even though the results are consistent with lengthening funding maturity, the evidence provided by the authors is inconclusive because several channels would be consistent with this outcome.

[34] King makes various assumptions regarding the opportunity cost of the different investments, which may be different from the costs in the current low interest rate environment.

Increased funding costs might also impose an indirect cost on bank lending. Using a fixed-effects panel regression for 26 Dutch banks between January 2008 and December 2011, Bonner (2012) analyses whether banks pass on increased funding costs to the corporate sector. He finds that banks close to the liquidity requirement face higher funding costs in the interbank market, but these banks do not charge higher interest rates for corporate lending. The reason for this finding is a lack of pricing power that may result from either high competition among banks or close relationships between banks and corporates in the Netherlands. Banerjee and Mio (2015) also do not find evidence that banks increased the average interest rates on loans to the non-financial sector.

3.2.3 Interbank markets and interconnectedness

With respect to the impact of liquidity regulation on interbank lending (Outcome 5), Banerjee and Mio (2015) find that UK banks subject to tighter liquidity rules reduced interbank loans, reducing the interconnectedness of the banking sector. The EBA reports (EBA 2013, 2014) also find that the progressive implementation of the LCR resulted in reduced interbank loans.

3.3 Benefits of liquidity requirements

The literature has identified a number of social benefits of liquidity regulation: (1) lower incidence and costs of bank failures; (2) lower probability of systemic crises due to lower degree of interconnectedness, less reliance on short-term bank funding, or lower likelihood of asset fire-sales; and (3) reduced sensitivity of credit supply to underlying liquidity conditions facing banks. There may also be lower moral hazard among banks due to the fact that the central bank will become the lender of last resort rather than the lender of first resort.

Continuing with the numbering scheme from the previous section, we state the following outcomes associated with the potential benefits of liquidity regulation:

- Outcome 6: Liquidity regulation may reduce the contraction of bank credit in response to liquidity shocks, thereby resulting in a lower reduction in aggregate output associated with banking crises than in its absence (Section 3.3.1).
- Outcome 7: Liquidity requirements may reduce the proportion of wholesale funding of banks or increase the share of stable funding (Section 3.3.2).
- Outcome 8: Liquidity requirements may increase net interest income (NII). An increase would occur due to lower funding costs attributable to a perceived reduced risk profile and lower probability of default (Section 3.3.2).
- Outcome 9: Introduction of liquidity regulation may lower the use of central bank funding, either through regular operations or via emergency lending assistance.
- Outcome 10: Liquidity requirements may reduce the incidence of asset fire-sales.
- Outcome 11: Introduction of the LCR may result in less contraction of interbank liquidity in stressed periods.
- Outcome 12: Introduction of the LCR may reduce correlations in banks' exposures to shocks in short-term funding.

As liquidity requirements have not been implemented yet, empirical evidence on social benefits is scarce.

3.3.1 Credit and composition of assets

An indication of the benefit described by Outcome 6 is given by Cornett et al (2011), who estimate quarterly changes in new credit provision by US banks during the financial crisis relative to the pre-crisis period. They find that banks that had more contingent credit lines and banks with lower proportions of

stable funding reduced their lending more during the crisis. These authors estimate that new credit fell by about US$ 500 billion in Q4 2008 and they find that this reduction would have only been around US$ 87 billion if all of the banks had had the same level of liquidity risk exposure as the lowest quartile of the distribution of US banks. Hence, a binding liquidity requirement would have enhanced the ability of capital requirements to reduce the vulnerability of banks to this type of crisis.

Pessarossi and Vinas (2015) find similar results for France. Controlling for demand effects, they take advantage of the exogenous international interbank market freeze in 2007–2008 to assess the causal relation between French banks' liquidity risk and their lending. They provide evidence that banks with lower funding risk and a lower ratio of long-term loans-to-(long-term funding and deposits) provide more loans after the shock. This difference in lending only exists for long-term loan supply.

3.3.2 Funding and net interest income

With respect to the potential funding benefits identified by Outcome 7, Banerjee and Mio (2015) find that UK banks subject to higher liquidity requirements reduced interbank loans, reduced short-term wholesale funding, and turned to more stable deposits from their corporate and retail clients.

Likewise, the analysis of EBA (2013) shows that European Union (EU) banks seemed to have increased their Basel LCR ratios mostly by reducing their interbank loans and not loans to retail, SME or non-financial clients. The second report (EBA (2014)) on LCR impact assessment also notes that the progressive implementation of the LCR has led EU banks to increase retail deposits rather than to lengthen the maturity of liabilities (based on analysis of QIS data between 2011 and 2014). Banks have been replacing unsecured debt and interbank funding for retail deposits.

DeYoung and Jang (2015) use the loan-to-deposit ratio as a proxy for the NSFR and examine how US banks reacted to shocks to this ratio during the period 1992–2012. They estimate that US banks may respond to NFSR requirements by actively managing their funding and turning to larger amounts of stable funding, more so than actively managing their assets and turning to lower-yield (but higher-quality) assets. They also show that systemically important US banks manage liquidity less actively than community banks, hence the former will have to adjust more to the NSFR.

3.4 Net benefits

As noted in the introduction, a comprehensive empirical assessment of the net welfare benefits of liquidity regulations has not been conducted by any single study. This is especially true because no empirical study has considered the benefits arising from the lower costs and likelihood of bank failures. Thus, a net benefit evaluation can only be qualitatively conjectured, on the basis of the information that is available. But even so, only limited information exists with respect to the potential costs of liquidity regulation.

An assessment of the literature suggests that a significant decline in aggregate lending – one of the leading costs of liquidity regulation cited in public debates – would not be expected to occur. Indeed, the available empirical evidence seems to suggest that national liquidity rules that resemble the LCR have had little, if any, impact on aggregate lending and thus on aggregate growth. While simulation studies tend to generate slightly greater effects, the absolute impacts are nevertheless insignificant. Moreover, recent studies highlight that the costs arising from liquidity regulations in good times should be offset, at least partially, by a reduced contraction of credit during crisis periods.

A second set of cost channels that have received attention relates to the impact of liquidity regulation on the profitability of banks and, perhaps more importantly, on the pricing of loans. While the empirical research is less advanced in this area, the existing studies tend to show that liquidity requirements may indeed lower NII, especially for banks that are close to or below the regulatory minimum. The reduction in NII suggests that these banks are not able to fully pass on the cost of compliance to their customers. One empirical study clearly shows that this is the case for banks that lack market power in the credit markets.

Putting these findings together, one could argue that, on the basis of the information that is currently available, the welfare costs arising from liquidity regulation should be relatively small, even without considering the full set of welfare benefits arising from a lower probability and cost of bank failures. Thus, the net social benefit of liquidity regulation may be expected to be significantly positive. As a caveat to this conclusion, however, the low estimated costs that have been observed for liquidity requirements to date may be partly due to Quantitative Easing programmes by central banks. More experience with implementation of liquidity regulation will have to accumulate before any definitive claims can be made.

3.5 Interactions between capital and liquidity requirements

The interactions between liquidity and capital requirements (risk-weighted and non-risk-weighted) mainly operate through four channels: (1) quality of assets, (2) fire-sales, (3) bank profitability, and (4) bank solvency.

With regard to the first channel, banks may be expected to respond to higher liquidity and risk-weighted capital requirements by improving the quality of their assets. Indeed, lowering risk weights is an effective way to meet the risk-weighted capital requirements. With respect to liquidity requirements, higher quality assets are treated favourably in terms of the regulatory liquidity buffer of the LCR and require less stable funding under the NSFR.

With regard to the second channel, increasing liquidity requirements may reduce the occurrence of asset fire-sales when banks are faced with funding difficulties. Asset fire-sales can be very costly. Indeed, as the developments in the early phases of the recent crisis amply demonstrated, such sales may threaten the solvency of individual banks as well as the banking system as a whole.

With respect to bank profitability (the third channel), the adjustments banks make to meet higher liquidity and capital requirements, all else equal, may impact banks' profits and in particular, their NII. The potential impacts on NII due to liquidity requirements have been discussed in Sections 3.2 and 3.3, which notes that NII may increase or decrease in response to the imposition of liquidity requirements. More specifically, to the extent that NII is a principle component of many banks' earnings, liquidity requirements may have an impact on the ability of a bank to maintain higher capital buffers through retained earnings. In turn, higher capital requirements may lead to higher funding costs. The Modigliani-Miller (M-M) theorem would suggest, however, that well-capitalised banks would find it cheaper to obtain funding. The empirical literature tends to find support for the latter effect, whereby a 100 bps hike in capital requirements leads to a net reduction in the cost of funding of between 26 and 110 bps.[35] Either way, higher capital and liquidity requirements may have an impact on profitability and thereby on the provision and pricing of risky loans.

With respect to bank solvency (the fourth channel), liquidity and capital requirements can both help to protect a bank, its claimholders, and the broader stakeholders from different forms of risks that may threaten the solvency of the bank.[36] Capital requirements (both risk-weighted and unweighted) effectively require banks to hold more "skin in the game," which may reduce banks' incentives to undertake excessive risk in addition to better protecting creditors from losses. Moreover, liquidity requirements lead banks to increase their stable funding. More broadly, both requirements lead to the shoring up of buffers that ensure that banks have adequate absorptive capacity to combat different risks that may threaten them as a "going concern" (eg funding-withdrawal risks for liquidity or asset-quality deterioration risk for capital requirements) and, thus, ease any "gone concern" interventions.

[35] For a recent literature review and accompanying empirical analysis on the impact of solvency positions on bank funding costs, see BCBS (2015b, Section 3).

[36] See Morris and Shin (2010) for a theoretical discussion of how the default risk of a bank may be decomposed into risks originating from illiquidity and asset quality deterioration.

The four channels through which capital and liquidity requirements operate suggest that these two types of requirements have elements of substitutability but also of complementarity. For the first and second channels identified above (quality of assets and fire-sales channels), liquidity and capital requirements can be seen as substitutes as far as the social net benefits are concerned. Indeed, both capital requirements and liquidity requirements may cause banks to hold HQLA translating into lower risk weights.

With regard to substitutability, the first two channels give rise to the testable hypothesis that higher liquidity (capital) requirements may lower the need for higher capital (liquidity) requirements. The EBA analyses of QIS data (2013, 2014, and forthcoming) suggest that the low costs of compliance associated with the Basel III liquidity requirements are due, in part, to the fact that HQLA have lower risk weights than non-HQLA. Thus, the opportunity costs of the lower returns to HQLA are partially offset by the lower capital requirements for these assets.

At the same time, the last two channels (bank profitability and bank solvency channels) highlight that the two requirements may be more complements than substitutes. The bank solvency channel implies a clear degree of complementarity between capital and liquidity requirements, as each type of requirement protects the bank and its creditors from different types of shocks (eg capital requirements protect against asset deterioration and liquidity requirements protect against asset fire-sales). Together, these channels would then give rise to the testable hypothesis that higher solvency (liquidity) requirements alone are not sufficient to prevent liquidity-driven (insolvency-driven) crises.

Finally, if liquidity requirements reduce NII, then they may actually make it more difficult to maintain excess capital above the regulatory minimum, potentially calling for increased capital requirements. Most of the existing empirical work involves simulations and considers the interactions identified via the NII channel.

3.5.1 Simulations using bank data

Using a number of Vector Error Correction Model (VECM) estimations based on US bank data, Gambacorta (2011) and Angelini et al (2011) show that the impact of a four percentage point increase in the proxy for the tangible equity capital ratio has a similar impact on steady state output as would a 50% increase in the NSFR proxy combined with a two percentage point rise in the proxy for tangible equity. It is important to note that these models only consider the impact of capital and liquidity regulation via its negative impact on NII, which may be mitigated by banks passing through some costs to customers.

Schmaltz et al (2014) simulate the interaction of the risk-weighted capital ratio, the leverage ratio, the LCR, and the NSFR. The authors consider how banks may change their business models to comply with new regulations, effectively covering the first two channels. Assuming that banks have fully adjusted to Basel II regulatory requirements, and that the profit and compliance functions can be represented as linear functions of the volume of activity in different business segments (eg retail, corporate, and wholesale loans or funding) the authors derive implied adjustment costs and product margins. Then, they use these factors to estimate how banks would optimally respond to the new regulatory standards under the Basel III calibration. To illustrate the use of the model, the authors use data for a "typical German universal bank" and find that Basel III requirements would essentially work through the NII channel. The authors show that, optimally, banks turn to stable, cheaper forms of funding rather than investing more into liquid assets. Of course, an analysis with more plausible cost of funding assumptions may lead to different results.

Birn et al (2015) use a similar approach to assess the impact of the four Basel III regulatory requirements, once again considering both the quality of assets and the NII channels. Unlike Schmaltz et al (2014), banks' responses to new requirements are not simulated by taking account of costs but rather by solving a number of accounting and compliance identities, assuming no changes in behaviour by banks. The costs of adjustments are also imposed as exogenous variables, which are used to derive the overall impact of the new requirements. The authors use QIS data of the BCBS on 161 banks in 2011 to model how the implementation of the Basel III rules may change the business models. Then, the authors compare their estimates with actual changes observed for those banks for the years 2011 through 2014. The authors

find that banks facing LCR shortfalls and capital shortfalls tend to increase the share of HQLA, both in the model and the data. They also conclude that the most difficult constraint banks are facing across the world – for both liquidity and capital – is to implement the NSFR.

3.5.2 DSGE models

As discussed in Section 3.2.1, Covas and Driscoll (2014) calibrate a DSGE model with a banking sector to assess the macroeconomic impact of introducing liquidity and capital requirements together. The authors' results highlight the importance of price adjustments for loans and securities as well as the NII channel. When loan and security prices are not allowed to adjust (eg in partial equilibrium), the imposition of liquidity and capital requirements have relatively substantial impacts, leading to a sizeable contraction in credit. However, in a general equilibrium framework, lower loan supply and greater demand for securities imply loan rates increase and returns on securities drop, thereby dampening the results. The authors also draw attention to the fact that liquidity requirements have a much larger impact (0.3% drop in output) since they are assumed to be binding for larger institutions – while the opposite is true for capital requirements (leading only to a 0.1% drop in output).

Paying close attention to the possibility that banks may adjust their solvency and liquidity positions simultaneously, Distinguin et al (2013) examine the interaction between capital and liquidity requirements. Unlike other papers, the empirical analysis does not make any assumptions regarding channels, adjustments, and costs. A bank's liquidity position is measured by an NSFR proxy as well as a "liquidity creation" proxy (which measures the extent to which banks transform liquid liabilities (eg sight deposits) into illiquid assets (eg long-term loans)). The authors' Bankscope dataset includes a large number of US and EU commercial banks over the years 2002 to 2006. The results show that, faced with illiquidity (as measured by the NSFR), banks decrease their regulatory capital. However, using an adjusted illiquidity indicator that focuses more closely on core deposits (for which data only exists for US banks), the authors find that smaller US banks do increase their capital ratios when they face illiquidity. While these adjustments to portfolio occur in the data, they suggest some degree of substitutability between capital and liquidity requirements.

3.5.3 Top-down stress testing models

The emerging literature on stress testing has recently turned to the analysis of solvency and liquidity risks in parallel. Most of the top-down stress testing frameworks that incorporate liquidity as well as solvency risks assume that banks are first hit by solvency shocks, which are then followed by potential withdrawals (non-rollovers) of short-term funding, due to investors' concerns about the future solvency of the bank. The Bank of Canada macro stress testing model takes this approach and contains three modules: (1) a solvency module; (2) a funding liquidity module; and (3) an interbank module. The inclusion of the third module implies that in addition to the impacts of potential withdrawals of short-term funding, the model also considers spillover effects of bank failures in interbank markets.

In order to determine the value of bank assets, which will play a role in short-term creditors' potential decisions regarding withdrawal of funding, haircuts are assigned to the values of banks' illiquid assets. This is implicitly a type of fire-sale effect. Three types of non-highly liquid assets are represented on banks' balance sheets: securities, loans, and other assets (which include derivatives). Separate haircut values are assumed for each of these asset classes.

Interbank exposures in the third module include derivatives as well as traditional interbank loans. Derivative exposures are obtained from data on bilateral derivatives exposures. Bilateral interbank loans have to be estimated on the basis of data for each bank on aggregate interbank lending and borrowing.

The Bank of Canada's stress testing model contains six banks with balance sheets similar to those of the six large Canadian banks, which account for 90% of banking assets. Simulations of this model were undertaken in the course of the 2013 IMF Financial Sector Assessment Program (FSAP) exercise. In these simulations short-term creditors were assumed not to roll over funding when a bank's CET1 ratio falls

below 7%. In addition, when short-term creditors do not roll over funding, the bank is assumed to experience losses equal 2.5% of risk-weighted assets.

Table 7, taken from Anan et al (2014), provides information on the severity of the scenario used for the FSAP simulations.

Key macroeconomic variables in the FSAP stress scenario

Table 7

Macroeconomic variables	2013 FSAP	2007–09 recession	1990s recession	1980s recession
Real GDP contraction (peak to trough, percentage points)	-5.9	-4.2	-3.4	-5.1
Duration of recession (number of cumulative quarters of negative growth)	9	3	4	6
Peak increase in unemployment rate (percentage points)	5.9	2.4	4.1	5.8
House price correction (peak to trough, percentage points)	-33.0	-7.6	-10.1	-4.2

Source: Bank of Canada.

The simulations reveal that when only solvency risk is taken into account, the aggregate (three-year) decline in CET1 ratios is between 170 and 250 bps. When liquidity risk and network effects are also taken into account, there is an additional 40 bps decline in the aggregate CET1 ratio. Hence, adding the liquidity risk and network effects increases the CET1 losses by between 16% and 24%. Liquidity risk accounts for 65% of this additional decline and interbank network effects account for the remaining 35%.

In addition to the 2013 FSAP simulations, Gauthier et al (2014) report the results of simulations of the Bank of Canada stress testing model with bank balance sheet parameters that resemble pre-crisis values. Such simulations can help provide estimates of the benefits of liquidity regulation as well as gauge the importance of taking into account capital and liquidity interactions.

For these pre-crisis simulations, the capital ratios of all banks were first assumed to equal 6%. Then, simulations were then run where all balance sheet parameters were held constant except for short-term funding, which was assumed to range from 25% to 65%. An increase in short-term funding from 25% to 65% increased the probability of simultaneous failure of all six banks from 15% to more than 60%. This change also reduced the probability of no bank in default from 60% to less than 20%.

This same simulation framework was also used to examine the potential substitutability of capital and liquidity requirements. It was found that raising the capital ratio from 6% to 8% would reduce the probability of bank failure to zero for all levels of short-term funding up to 40%. However, this result is quite sensitive to the capital threshold below which funding problems are assumed to arise.

In the Austrian context, Puhr and Schmitz (2014) show that their stress testing model which is calibrated using balance sheet and maturity mismatch data for a large sample of Austrian banks, gives rise to a relatively strong linkage between liquidity and solvency risks. Solvency shocks reduce the stock and pledgeability of liquid assets and they lower liquidity inflows due to increased non-performing loans and credit write-offs. In turn, liquidity shocks imply that certain less well-capitalised banks may get shut out of the funding markets (ie higher cost of funding), causing them to turn to asset fire-sales. Both outcomes imply lower earnings. Using stress test results for a single illustrative scenario (mostly based on one-year IMF World Economic Outlook forecasts), the authors show that not taking into account the various liquidity stress channels in solvency stress testing would lead to an underestimation of the results by around 30%, predominantly due to the asset fire-sale losses. In the opposite direction, not taking account of the solvency stresses in liquidity stress tests could lead to an underestimation of the stand-alone liquidity

stress tests by up to 45%, predominantly due to differences in funding costs between less (and more) capitalised banks.

3.6 Conclusions

Empirical studies relating to the impacts of liquidity requirements, or relating to the interaction of capital and liquidity requirements, are sparse. The only empirical studies on liquidity regulation are based on the UK and Netherlands. These studies suggest that neither lending to the real economy nor output will be significantly affected by the imposition of the LCR. This is consistent with the EBA reports using QIS data.

Simulations suggest a considerably larger impact on output in the range of 3% to 26%. However, these findings are often driven by specific assumptions, which are not in line with the findings of the empirical studies regarding banks adjustment strategies to liquidity regulation.

At the same time, liquidity requirements may have a positive impact on lending in times of distress (in the sense that these requirements may result in a weaker contraction of lending in stress periods). There is some evidence that would suggest that the contraction of bank credit will be less pronounced in the event that a shock materialises if liquidity requirements are in place.

The evidence obtained so far indicates that banks seem to meet the liquidity requirements also by adjusting their liabilities. An initial finding suggests that banks may increase their share of stable funding by reducing interbank loans. Interesting avenues for future research might examine whether liquidity requirements can lead to greater issuance of securitised or covered bonds by banks and/or whether covered bonds (in Europe) or securitisation would replace unsecured wholesale funding. Such findings would tease out whether the share of unstable funding and the interconnectedness of the banking sector would decline with liquidity requirements.

The literature on the impact of liquidity requirements on NII is ambiguous. Up to now, there is no clear identification as to whether NII increases or decreases in response to liquidity requirements.

Finally, macro stress testing models provide an indication of the degree of interaction between liquidity and solvency risks and, in addition, of the potential benefits arising from liquidity regulation. In particular, the literature suggests that not taking into account liquidity and interbank channels in solvency stress tests could understate total losses by as much as 25%. This suggests that a combination of capital and liquidity regulation can reduce the combined costs of adjustments due to nonlinearities in the interaction between both areas of regulation.

4. Other supervisory requirements

In the following section, we first discuss whether other supervisory requirements – both microprudential and macroprudential – adequately complement capital and liquidity requirements. Concentrating on buffers and macroprudential policies introduced in Basel III, we emphasise how these tools may make the banking system more resilient and present evidence on the hurdles that may undermine their effectiveness. Second, we discuss how simpler regulatory rules may complement more complex rules particularly when there are low-probability, extreme stress scenarios. This section concludes by listing the merits of simple robust regulatory rules and discuss how stress testing can enhance robustness.

4.1 Do other supervisory requirements adequately complement capital and liquidity requirements against any residual risks?

4.1.1 Procyclicality, requirements and buffers

Basel I and II only included a capital requirement. The capital requirement was meant to be respected at all times. In sharp contrast, Basel III is associated with multiple requirements (capital ratio, leverage ratio, LCR and NSFR) and includes buffers which are meant to be "used" in certain circumstances. In addition, Basel III added a macroprudential focus to (1) limit interconnectedness (ie large exposure limits), (2) address systemic importance (ie G-SIB buffers), and (3) deal with cyclical movements (ie countercyclical capital buffers).

While only the countercyclical capital buffer seems explicitly meant to address procyclicality, robustness against macroeconomic shocks is being addressed much more generally in Basel III through this concept of "buffers." Indeed, buffers appear at multiple places and represent a significant innovation of Basel III: they are a key feature of the capital ratio (not only in the countercyclical capital buffer, but also in the capital conservation buffer and in the G-SIB buffers) and the LCR is also intended to be a buffer.

The academic literature not only allows us to rationalise this use of buffers, but also to formulate caveats as far as their use is concerned. For example, Dewatripont and Tirole (1994a, 1994b, 2012) analyse banking regulation starting from a model of the optimal capital structure of firms. In this model, when firm performance is bad, managers risk facing a control switch from equity holders (who are relatively nice to managers) to debt holders (who are relatively tough on managers). Turning to banks, their debt holders (ie depositors) are often unable to exert control, so that bank regulation is seen as a way to replicate the role of capital structure in non-financial corporations (this is called the "representation hypothesis").

In a sense, Basel regulation is consistent with the representation hypothesis: control is meant to shift from shareholders to a resolution authority if capital falls below the regulatory requirement. Of course, shareholders can avoid this if they decide to recapitalise the bank, but they will be reluctant to do it if previous performance was too mediocre.

Dewatripont and Tirole stress two issues with the forgoing positive assessment of the Basel framework: (1) the control switch following poor performance has to be credible (this concerns the whole debate about resolution); and (2) the notion of poor performance has to be defined. Indeed, if the goal of regulation is to incentivise bank managers to perform adequately, classical incentive theory (eg Holmstrom (1979)) tells us that we should look at idiosyncratic performance, which can be influenced by managerial effort, and not performance linked to aggregate shocks.

This distinction between idiosyncratic and aggregate performance was ignored by Basel I and II. In Basel I, a bank may have had to be resolved after a big recession just as after poor individual performance. Indeed, shareholders will be unwilling to recapitalise a bank if the size of the hole to be filled is too big, even if managers can claim they have suffered bad macroeconomic luck. Basel II made this problem even bigger, since a recession naturally tightens the capital requirement by raising risk weights (external ratings downgrades, potential internal model revisions).

As discussed by Dewatripont and Tirole, while Basel I and II are too harsh with bank managers in the case of recessions, it would also be suboptimal to "give them a break" by allowing them to function with too low a capital level in a recession, since doing so (which has unfortunately happened in a number of crises; think for example of the "regulatory accounting practices" introduced during the S&L crisis in the US in the 1980's) will naturally lead to "gambling for resurrection."

Instead, what is needed is to make sure the bank does manage to have easy-enough access to a sufficient level of capital in bad macroeconomic times. One way to achieve this is "capital insurance," a device suggested by Kashyap et al (2008). This would naturally have to be nationally provided in order to withstand macroeconomic shocks (remember AIG). Dewatripont and Tirole (1994a) suggest another form of automatic stabilisers, namely procyclical deposit insurance premia.

Basel III has moved in that direction using other instruments: (1) it asks banks to complement a 4.5% CET1 requirement with a 2.5% capital conservation buffer, (2) it adds a G-SIB buffer and, (3) in overheated times, it adds a countercyclical capital buffer (this latter one being similar to earlier Spanish dynamic provisions). All these buffers are meant to be "usable" in case of need, in contrast to the 4.5% minimum, which is meant to trigger resolution. The same is true with the LCR, seen explicitly as a buffer to be used in case of stress.

This widespread use of buffers in Basel III is a significant innovation. It has the potential of making the system more resilient in case of bad macroeconomic times, not only in terms of protecting taxpayers against the risk of potential bailouts but also in terms of incentivising bank managers, and therefore protecting the banking system against macroeconomic downturns.

Let us end this section with two caveats:

1. *Buffers will only "work" provided they are used when needed*. This requires that (1) supervisors allow banks to use them, and (2) banks do not resist using them. The first condition requires the proper use of supervisory discretion. The second condition raises the issue of "excessive market discipline," alluded to by banks who claim "markets do not care about transitional paths towards new capital standards and immediately request fully-loaded capital levels," and/or "the LCR buffer will never be used because there will be a stigma attached to such use." If one believes these claims, one could also be equally sceptical about the use of capital buffers and argue for stabilisers that are more automatic (eg capital insurance linked to the business cycle or procyclical deposit insurance premia). These automatic stabilisers could be introduced as complements to Basel III buffers.
2. *Risk-based capital versus leverage buffers*. Since the leverage ratio is meant to act as a backstop that prevents underestimation of risk weights, it would be natural to introduce in the leverage ratio constraint the same flexibility as is now present in the capital ratio in Basel III. Especially since individual banks will typically face either a binding capital ratio or a binding leverage ratio depending on their business model. In this sense, if a buffer component is desirable on one constraint, one can naturally argue it is desirable on the other constraint too. Note that the same logic is being followed for TLAC, whose additional loss-absorbency over CET1 is now expressed both in terms of the capital ratio and in terms of the leverage ratio.

4.1.2 Macroprudential policy

The need for macroprudential policies is in part a reflection of the view that monetary policy "is clearly not the ideal tool for dealing with the kind of imbalances that led to the crisis. Its reach is too broad to be cost effective" (Blanchard et al (2013)). More specifically, higher monetary policy rates – not supported by higher inflationary expectations – may reduce aggregate output when not all sectors suffer the build-up of financial imbalances. Moreover, the policy rate may have too small and uncertain of an effect on the probability and/or severity of a financial crisis to match the substantial costs of tighter policy (Svensson (2015)), particularly since monetary policy may have limited power in affecting credit supply (Romer and Romer (1990)) and lower policy rates may actually reduce asset price bubbles, rather than create or inflate them (Gali (2014)).

A consensus is emerging that macroprudential policies are necessary for financial stability and can provide new levers to curb dangerous credit booms and excessive risk-taking by financial

intermediaries (Paries et al (2011); Freixas et al (2015)).[37] Examples of powerful macroprudential policies at authorities' disposal include: targeted increases in capital requirements, countercyclical capital requirements, liquidity and reserve requirements, as well as measures that affect loan eligibility (eg a cap on the loan-to-value ratio for home mortgages).[38] In principle, such policies (which may vary over time and across sectors) can be utilised independently or in conjunction with each other to (1) alter the composition and risk profile of financial institutions, (2) influence the cost or composition of the liabilities of financial institutions, and (3) improve the average quality of borrowers (Graph 1). Ideally, the levers for macroprudential policies would be managed to both reduce the probability of the crisis and the costs for the economy at large (ie the net impact on GDP) should a crisis occur.

The empirical identification of the net benefits associated with macroprudential policies is, however, quite difficult for two reasons. First, one or more of such are policies are typically implemented in response to signs of growing risks and imbalances in the financial system. Therefore, it is difficult to create the counterfactual on how the build-up of imbalances would have played out in their absence. Second, macroprudential policies are typically employed not only in conjunction with each other, but also in conjunction with more traditional macroeconomic policies (eg monetary or fiscal policies), thereby making it difficult to disentangle the independent effect of each macroprudential policy on systemic risk (see Freixas et al (2015)). That said, there is a growing literature that provides mixed to somewhat positive evidence that macroprudential policies are beneficial.

The recent empirical research pertaining to the effects of the most common macroprudential policies is briefly summarised in Table 8. Starting at the top of the table, policies designed to build capital buffers have generally been found to make a banking system more resilient. Evidence on whether tighter capital requirements restrict lending growth, however, is mixed. In Poland, there is some evidence that tighter capital requirements curbed lending growth (Kruszka and Kowalczyk (2011)). In Croatia, however, tighter capital requirements do not appear to have reined in credit growth (Kraft and Galac (2011)). Interestingly, in the UK, increased capital requirements on UK regulated banks reduced their lending, but that reduction in lending was partially offset by an increase in lending by resident foreign branches that were not subject to the tightened capital requirements. This evidence affirms the importance of the comprehensiveness of macroprudential policies across all levered institutions in a country and also the need for cross-country cooperation on macroprudential policies as such policies can be partly arbitraged.

Because dynamic loss provisioning rules, which build capital buffers in good times and release them in bad times, were introduced in Spain in 2000, there has been a full credit cycle to observe their effects. Moreover, authorities modified such rules in 2005 and in 2008. These policy changes coupled with comprehensive bank-level, firm-level, loan-level and loan-application-level data (over Q1 1999–Q4 2010) facilitated the identification of the effectiveness of such rules by Jimenez et al (2014). They found evidence that dynamic loss provisioning rules upheld firm financing during the credit bust (see Table 8 for specific estimates on credit availability, employment growth and firm survival probability). This finding is consistent with this macroprudential policy increasing the resiliency of the banking system, but not curtailing lending sufficiently to prevent a credit bust.

[37] Paries et al provide a dynamic stochastic general equilibrium (DSGE) model that demonstrates that optimal monetary policy responses are different under alternative regulatory frameworks that include higher and risk-based capital requirements and/or macroprudential policies.

[38] An appendix in Freixas et al (2015) provides data for more than 50 countries on whether different types of macroprudential policies are in effect.

Empirical evidence on the effects of macroprudential policies — Table 8

Type of macroprudential policy implemented	Country/ time period	Evidence on effectiveness	Study
Capital standards			
Increase in capital requirements during a "normal" or a "boom" period	Poland / 2006	Effective in curbing growth of foreign currency denominated loans to households – Made banking system more resilient during global financial crisis in 2007 to 2008	Kruszka and Kowalczyk (2011)
	Croatia / 2003	Effective in helping weather global financial crisis – Not effective at slowing credit growth and capital inflows	Kraft and Galac (2011)
	UK / 1998–2007	Effective in reducing lending of UK regulated banks, but not effective in reducing lending at resident foreign branches (not UK-regulated) – Foreign branches increased their lending in the UK – This "leakage" was material, but did not make up for the reduced lending by UK regulated banks	Aiyar, Calomiris and Wieladek (2014)
Countercyclical capital requirements; buffers built using dynamic loss provisioning	Spain / 2000–2013 (modified in 2005 and 2008)	Effective in smoothing cycles in the supply of credit – Upholds firm financing and performance – Firms with banks with a 1 percentage point higher dynamic provision (over loans) prior to crisis had a 6 percentage point higher credit availability growth, a 2.5 percentage point asset growth, a 2.7% higher employment growth and a one percentage point higher likelihood of survival	Jimenez, Ongenal, Peydro and Saurina (2013)
Liquidity/reserve requirements			
Cyclical variation in LCR	Simulation based on 50 banks	Effective at postponing breach of LCR requirement and the development of negative feedback spirals	Van den End and Kruidhof (2012)
Increase in reserve requirements on demand deposits	Brazil/ 1998–2010	Effective at reducing bank credit, exchange rate depreciation and an improvement in the trade balance – Increases inflation	Glocker and Towbin (2011)
	Latin America/ 1999–2002	Effective at decreasing bank credit supply – An increase in reserve requirements on deposits of 10 percentage points increases net interest margins by about 0.4 to 0.7 percentage points	Gelos (2009)

Loan eligibility criteria			
Increase in risk weight on high LTV car loans	Brazil/2010	Effective at raising interest rates on high LTV car loans, thereby slowing supply of such credit	Freixas, Laeven and Peydro (2015)
	Brazil/2010	Effective at raising loan spreads (27bps) for every additional capital charge of 1%.	Martins and Schechtman (2013)
LTV and DTI Restrictions	Korea/ 2001–2009	Effective at reducing transaction activity in the three-month period – Price appreciation slows down in a six-month window rather than a three-month window – Price dynamics appear to be reined in more after LTV tightening rather than DTI tightening	Igan and Kang (2011)
LTV and DTI Restrictions	Hong Kong/ 1997	Effective at reducing the sensitivity of mortgage default risk to property price shocks – Simulation results suggest that if the maximum LTV ratio were to have been relaxed from 70% to 90% before 1997, the delinquency ratio right after the 40% decline in property prices in 1997–8 would have been 1.7%, compared to the actual level of 0.84% at the end of 1998	Wong, Fong, Ka-fai and Choi (2011)

The nascent empirical literature on liquidity buffers has mainly focused on increases in reserve requirements on demand deposits in Latin America; such macroprudential policies appear to have curbed bank credit supply (Glocker and Towbin (2011)) and also boosted bank net interest margins (Gelos (2009)). In addition, a simulation for the cyclical variation in the LCR requirement suggests that such variation could potentially reduce the consequences of negative feedback spirals (Van den End and Kruidhof (2012)).

Empirical evidence also suggests that suitably-timed changes in loan eligibility criteria can be helpful macroprudential policies. For example, the resiliency of the Hong Kong banking system during the Asian financial crisis in 1998 has been attributed to actively managed loan-to-value (LTV) restrictions, which were introduced in 1991 and lowered from 90% to 70% in 1995 (Wong et al (2011)). With the 40% reduction in property prices that occurred in 1997–98, it is estimated that the delinquency ratio in 1998 would have been 1.7% compared to the actual delinquency rate of 0.84% without the changes in the maximum allowable LTV. Moreover, LTV restrictions in Korea and Singapore have been shown to reduce household sector leverage (Wong et al (2011) and Igan and Kang (2011)). It should be noted, however, that only in Korea is there evidence that these type of restrictions reduced property price appreciation (Igan and Kang (2011)). Interestingly, a different approach was taken in Brazil where the risk weight in the risk-based capital ratio was increased on high LTV car loans; Friexas et al (2015) indicate that this approach was effective at raising interest rates on such loans and also slowed the growth in the supply of such credit. Moreover, Martins and Schechtman (2013) report that this approach resulted in significantly higher loan spreads only on the targeted auto loans with high LTVs and long maturities. This evidence suggests that stress test scenarios that result in higher capital requirements for certain types of loans could result in higher rates and less credit to a specific sector.

Taking stock of the empirical evidence to date, macroprudential policies show promise in reining in systemic risk to prevent systemic crises, especially given their targeted nature as compared to traditional macroeconomic policies. Moreover, such policies have been shown to be important for increasing the resiliency of the banking system once a crisis occurs. More empirical analysis is needed, however, for a full

assessment of their net effects on systemic risk and their net benefits more generally, particularly since the targeted nature of such policies may make them easier to circumvent and also more difficult to implement.

Looking forward, researchers have begun to consider the advantages and disadvantages associated with macroprudential policies that are rule-based, rather than based on discretion (eg Bank of England (2009); Quagliariello and Libertucci (2010); Agur and Sharma (2013)). On the one hand, rule-based policies are less susceptible to forbearance or to regulatory capture, and are more likely to deliver policymaker decisions that are viewed to be consistent and systematic. On the other hand, it is difficult to measure the build-up of systemic risk in real time and a discretionary approach would allow policymakers to adapt to unexpected structural changes and/or uncertainty as well as to observe the interaction of relevant stakeholders after a particular policy, or subset of macroprudential policies, has been applied.[39] Striking the right balance between rules versus discretion will likely depend not only on the risk that regulatory measures, by limiting systemic risk in one segment of the market, increase systemic risk for the market as a whole because displaced activities are transferred to less tightly regulated sectors, but also on the costs associated with any reduction in credit supply, including the potential for banks to compensate for lost profits by taking on greater risk.

4.2 Would simpler regulatory rules complement more complex rules particularly when there are low-probability, extreme stress scenarios?

4.2.1 Reasons for simple regulatory rules

By its nature, regulation advances intermittently as rules are created to address new risks that threaten to disrupt financial markets. The resulting regulatory framework is thus complex and institutions are often subject to multiple requirements (eg capital requirements, liquidity requirements and additional buffers that depend on an institution's systemic importance).

In light of the fact that the ultimate goal of regulation is to create a safer financial system, robust regulatory rules are essential. For example, as internal risk-based models are discretionary in nature – and necessarily omit factors that might be crucial in determining how much capital or liquidity an institution should hold – simpler and more flexible rules could be a desirable tool to ensure an institution's safety.

This is not to say, however, that simple rules ought to replace complex rules. Instead, simple rules are most effective if they can help to contain or discourage any arbitrage behaviour that complex rules inevitably bring about (ie simple rules can complement complex rules).

Consider the definition of various capital ratios versus the definition of the leverage ratio. Capital ratios "tax" activities by assigning higher risk weights to asset classes that increase an institution's default risk. Over time, banks and other financial institutions have found loopholes to avoid the scope of such capital regulations without directly violating them. On the contrary, the leverage ratio "taxes" all asset classes equally and it does not allow for loopholes: it is a simple rule.

Of course, the leverage ratio is insensitive to asset risks and might promote risky or inefficient credit allocations. It is only when supplemented with capital ratios that the leverage ratio is most beneficial to limit unsound bank behaviour. Stefan Ingves (Governor, Sveriges Riksbank and Chairman, Basel Committee on Banking Supervision) recently suggested that combined capital and leverage rules may strengthen overall bank resilience to a wide range of risks within a bank's business. Mr Ingves likened the combined approach of Basel III to a "belt and suspenders" approach, where the leverage ratio serves as a

[39] For example, Peek et al (2015) and Aikman et al (2015) provide two strikingly different methodologies for measuring systemic risk.

backstop to the risk-based regime. The idea is "not to rely on either risk-based or non-risk-based measures alone, but to have each reinforcing the other."[40]

Recent research on this topic has highlighted two distinctive features of simple rule:

1. *The costs of uncovering violations to simple rules are often low* (Glaeser and Shleifer (2001)). Since law enforcement is not free (Becker and Stigler (1974)), the degree of complexity of a given rule determines how costly it may be for regulators to enforce it. Low costs, in turn, may change the incentives for enforcement by regulators as well as by other market participants.

2. *Simple rules are robust to changes in the incentives of regulated institutions*. As institutions change in scope and structure over time, models estimated on internal past data have no validity going forward, regardless of their complexity (Rajan et al (2015)). With insurance companies and asset managers increasingly performing traditional banking functions, rules that monitor the functions of institutions are indispensable complements to rules that monitor the institutions themselves (Gray et al (2010)).

Concerns that complex rules might grossly underestimate default risk are also gaining traction among regulators. For example, Andrew G Haldane (Chief Economist and Executive Director of Monetary Analysis and Statistics, Bank of England) warned against policies that "should respond to every raindrop." Instead, he spoke favourably of more coarse-tuned policies that "may only respond to every thunderstorm" (Haldane (2012)).

In a thunderstorm, simple rules may be the only accessible supervisory instrument. Risks that may be calculable in normal times might not be during a crisis, as foreseeing all future states of the world becomes unfeasible (ie the economic environment is more uncertain). Then, greater complexity may give at best an opaque account of a financial system's health. The consensus among academics and regulators (eg Hansen and Sargent (2007), BCBS (2013) and BoE (2014)) is that an appropriate balance between simplicity and complexity may be desirable as simple rules can improve both the objective and the strength of more complex rules.

4.2.2 Does stress testing adequately complement capital and liquidity requirements against any residual risks?

4.2.2.1 Purpose(s) of stress testing

Stress testing methods evolved from banks' internal risk management tools and grew in importance with the increase in complexity and diversity of banks' activities (CGFS (2000)). BCBS (2006) provides comprehensive guidance for internal stress testing by large banks. During the recent financial crisis, as part of a broader effort to restore confidence in the financial system, stress testing has become the cornerstone of a new approach for regulating and supervising the largest financial institutions (Tarullo (2014)). By providing a dynamic assessment of the capital positions of large financial firms, stress testing has made the supervision framework more macroprudential and data-driven than it was pre-crisis. In its essence, stress testing has supplemented the existing toolboxes in identifying gaps between the capital and liquidity banks had and what they needed to support their business activities (Schuermann (2014)).

Supervisory stress testing is a flexible tool which can address a broad range of risks not captured in Pillar 1 requirements. It was adopted by regulators (as reflected in the Basel II and Basel III frameworks) as a tool supporting and supplementing the Pillar 2 and Pillar 3 measures. The ability of stress tests to identify key vulnerabilities of an institution, independently of the degree of its intricacy, has been explored in the calibration of Pillar 2 instruments (Peura and Jokivuolle (2004)). But the opportunity stress testing

[40] "Basel III is simpler and stronger: The new rules will make taxpayer bailouts less likely", in *The Wall Street Journal Europe*, 14 October 2012.

provides to incorporate macroprudential elements (eg by focusing on significant exposures to common shocks) makes it an important advance in prudential regulation after the crisis.

The public disclosure of stress test outcomes (eg the number of failing institutions, additional capital needed) fosters the use of stress tests to influence investors' confidence and enhance market discipline. The latter use has been put upfront in the most recent regulatory stress tests in both the United States (Comprehensive Capital Analysis and Review (CCAR)) and Europe (EBA EU-wide stress tests). The impact on investors' confidence is likely to be stronger in times of market turbulence (eg 2009 US CCAR (Candelon and Sy (2015)) then in calmer times (eg Comprehensive Assessment in Europe (Sahin and de Haan (2015)).

The choice to grant greater transparency to supervisory stress tests prompted healthy discussions on the merits of disclosing regulatory information. Since banks' portfolios are often opaque and difficult for outsiders to value, higher transparency would reduce asymmetric information and bank opacity by promoting effective market discipline (Ellahie (2012), Petrella and Resti (2013)). It also increases awareness of risks by all stakeholders involved (banks, supervisors and market investors) and provides an incentive to reduce risk exposure (Bischof and Daske (2012)). Higher transparency also subjects supervisors to greater outside scrutiny and analyses, by increasing their accountability (Tarullo (2014)).

Alternatively, disclosing banks' weaknesses might cause financial instability (Angeloni (2014)) and induce market overreaction and deleveraging. Increased disclosure might also reduce the ability of regulators to obtain information from banks (Leitner (2012)) or adversely affect the ex ante incentives of bank managers, as emphasised in the traditional corporate governance literature (eg Burkart, Gromb and Panunzi (1997)). Thus, in good times no disclosure would be optimal, while in bad times disclosing some information may be necessary to prevent a market breakdown. Disclosing too much information however would destroy risk-sharing opportunities (Goldstein and Leitnerz (2015)). In sum, in bad times partial disclosures would be optimal.

Challenges for supervisory stress tests remain high as changes in the real economy, financial innovations, and shifts in correlations across firms and sectors occur. Recently, there is significant pressure to develop stress testing methods aimed to inform the calibration of macroprudential tools under Pillar I.

4.2.2.2 Stress testing analyses

Stress testing comes in two forms of "what-if" analysis: sensitivity analysis and scenario analysis. Sensitivity analysis tests the resilience of banks to a single factor shock (eg a change in a financial risk factor or a change in an asset's price). Generally, no indication is provided about the driver of the shock and the shock is assumed to occur instantaneously (or within a short horizon, ie less than one year).

In scenario analysis, the emphasis is on drivers of multiple shocks materialising at once (ie the narrative). The horizon of these exercises is usually longer, from one to five years, and the dynamic aspects of vulnerabilities and risk triggers are more thoroughly explored.

Regulatory stress tests have been mostly developed using scenario analysis. This approach delivers robust results that integrate different types of risks and limit the degree of double-counting them (Alessandri and Drehmann (2010)). Most importantly, scenario analysis is more easily understood by the public; stress tests based on a narrative are more accessible than stress tests involving a shift in single balance sheet, or financial risk, parameter.

Yet, scenario analysis poses some challenges, especially with respect to the definition of sufficiently severe but plausible scenarios – a key component of stress tests. Too lenient scenarios were one of the reasons why pre-crisis stress tests failed to predict the financial crisis (Alfaro and Drehmann (2009), Haldane (2009), IMF (2012)). Gauging the severity of stress test scenarios is a common topic of debate among supervisors, financial stability authorities and financial institutions subject to stress tests. The scenario selection is often discretionary and based on historical experience. The deviation of key macro-financial parameters from a baseline scenario is often the metric for benchmarking severity.

To address the concerns expressed above, various approaches have been suggested to design adverse scenarios (Bunn (2005)):

1. The historical approach calibrates shocks or macroeconomic outcomes for key variables to a specific adverse past event.
2. The probabilistic approach uses the distribution of past shocks or macroeconomic outcomes (eg conditional variances).
3. The hypothetical approach considers a set of plausible risks not necessarily linked to past experience (eg risks based on information gathered in the context of surveillance of the financial sector).
4. The reverse engineering approach considers how adverse macroeconomic outcomes would need to be in order to generate bank losses above a certain threshold.

There is a clear link between historical and probabilistic approaches (Borio et al (2012)), as both rely on historical experience (eg past events or the distribution of past recessions). A downside of these approaches is the reflection of regularities in the data, and thus, a failure to test the resilience of the system in a forward-looking manner. For this reason, IMF (2012) emphasises the merits of the hypothetical approach and both United States' CCAR and Europe's EBA EU-wide stress tests have been hypothetical in nature.

4.2.2.3 Operationalising regulatory stress testing

Regulatory stress tests can be conducted in two ways: top-down (eg CCAR) and bottom-up (eg EBA EU-wide stress tests). Both approaches have strengths and weaknesses (IMF (2012)). In the former case, the supervisor develops a scenario and then applies it based on its own modelling techniques to the reported bank-level data. Expected bank-level losses are derived and the results aggregated. In a bottom-up exercise, the supervisor defines a scenario (or scenarios) and provides additional benchmarks for balance sheet parameters. Expected losses are derived by banks and then aggregated by the supervisor.

The top-down approach to regulatory stress testing has a number of advantages: it allows for greater comparability of results across institutions, it is generally less resource-intensive and it is more time-efficient. Top-down stress tests can capture different types of systemic risks including contagion, funding and market risks related to fire-sales. The main weaknesses in applying this approach is the lack of granular bank-level data.

In contrast, the bottom-up approach to regulatory stress tests can provide better insights into the internal risk assessment methodologies of banks. It is also a better option if there are legal obstacles to sharing regulatory data (as is the case for the EBA EU-wide stress test or for a few IMF FSAP exercises). The main limitation of bottom-up stress tests is that they can capture systemic risks only partially and indirectly. Moreover, comparing stress test results across banks is very difficult and, often, impossible. Banks' models are, by definition, institution-specific: two banks with identical balance sheets and income statements may respond quite differently to a common stress scenario.

Both approaches are vulnerable to model risk. Some of the factors that result in model risk are stress scenario design, the reliance of stress tests outcomes on regulatory risk weights, model misspecification, forecast horizon and treatment of future business. Each of these factors may result in a severe underestimation of losses and associated capital needs (Frame, Gerardi and Willen (2015), Acharya, Engle and Pierret (2013)). Technical limitations of stress test modelling techniques (ie the "model" used to simulate financial distress) call for conservative estimates of losses resulting from shocks and for severe scenarios as devices to overcome those limitations (Borio et al (2012)).

The European choice for a "constrained bottom-up approach" combines the bottom-up and top-down approaches. It is based on a methodology designed by supervisors whereby banks assess the impact of consistent, common macro-financial scenarios on their portfolios. A Quality Assurance (QA) process is established to ensure (1) the robustness and credibility of results and (2) a level playing field among

institutions operating in different countries. QA typically consists of contrasting banks' results with some common benchmarks, usually derived at an aggregate level through econometric models developed by central banks or other supervisory authorities. Moreover, to keep the exercise manageable, the constrained bottom up approach includes a number of common hypotheses and judgment-based rules. A typical assumption is that banks' balance sheet are "static" (ie they do not react to macroeconomic and macro-financial developments). This assumption can, however, represent a significant departure from reality when the stress test time horizon extends beyond the short run: indeed, banks will react to adverse economic and financial shocks by adjusting their business plans so as to mitigate the impact of those shocks on their balance sheets.

Unfortunately, there is no easy solution to the tension between robustness and realism of a stress test. A single exercise cannot be enough to properly assess banks' capital adequacy and should be complemented with other supervisory tools. Building on the lessons learned from previous exercises, the 2016 EU-wide stress test will be more closely aligned with the cycle of the annual supervisory review and evaluation process (SREP), to ensure that the results of the stress test are incorporated as inputs to SREP.

4.2.2.4 Making supervisory stress test more macroprudential

Regulatory stress tests are complex and costly processes (especially bottom-up exercises), in terms of resources and time. Scenario design, for example, is a rather lengthy process in the EU context, where scenarios consider cross-country spillover effects among the almost 30 member nations. Despite the complexity of this process, stress test results can become predictable over time if banks' portfolios, methodologies and scenarios remain reasonably consistent (Glasserman and Tangirala (2015)).

Two elements decide the credibility of a regulatory stress test exercise: (1) the design of the scenario (its severity and relevance) and (2) the disclosure of its results (Candelon and Sy (2015)). Developing multiple scenarios would limit reliance on a specific set of results. Moreover, multiple scenarios would make the stress test outcomes more informative and less predictable (Glasserman and G. Tangirala (2015)). Calibrating shocks to the state of the economy – with severe stresses in "good" times, when the risk of a downturn may be larger, and smaller shocks in "bad" times – may also improve current stress tests. In fact, failure to include economic cycles in the calibration of stress tests could reinforce the inherent pro-cyclicality in the banking sector (Hoggarth et al (2013)).

Making stress tests more macroprudential requires (1) incorporating general equilibrium considerations, so that the outcome of the test depends not only on the size of the shock and the buffers of individual institutions but also on the interactions among their behavioural responses and those with the responses of other economic agents; and (2) focusing on the resilience of the system as a whole. Looking forward, macroprudential stress tests would entail using a variety of analytical approaches and scenarios, integrating non-bank financial entities, and exploring the use of agent-based models.[41] Moreover, macroprudential stress tests should not be used in isolation but treated as complements to other tools and – crucially – be combined with microprudential stress tests (Demekis (2015)).

The two most important elements in the development of future regulatory stress tests are the introduction of macro-financial and intrasectoral feedback effects (including contagion and fire-sales) and bridging solvency and liquidity risks. Contemporary stress tests rarely incorporate these linkages (eg the EBA stress test is conducted under the assumption of "static balance sheets"). Incorporating systemic risks in stress testing methodologies should not only pave the way for better communication to investors, but also increase the use of stress testing in the calibration of macroprudential instruments.

[41] Agent-based modelling (ABM) offer insights into the ways banks (and other financial system agents) interact and the ways shocks can propagate in the financial system. ABMs can simplify the modelling of complex systems by including a set of individual agents, a topology (ie is the mechanism through which agents can interact with one another in the model) and an environment (ie exogenous shocks that occur to the model) (BCBS (2015b)).

Annex 1: Summary of the LEI and MAG estimates

The Committee undertook two complementary exercises in 2010 to establish (1) the costs and benefits in steady state of an increase in bank capital ratios (BCBS (2010)); and (2) the transition costs of moving to higher capital requirements (MAG (2010)).

The Long-term Economic Impact report (LEI) focussed on determining the net costs and benefits of different steady-state levels of capital for an "average" advanced economy, incorporating analysis from a number of Basel member organisations. Benefits were derived from the reduction in the probability of crisis arising from higher capital requirements while costs were driven by the reduction in output due to higher lending spreads driven by higher bank funding costs.

The LEI report emphasised that the results represent the likely costs and benefits once banks have completed the transition to new capital (and liquidity) levels. It leaves the transition costs to the MAG report and notes that benefits over the transition period have not been estimated. The results suggest[42] that long-run, expected annual net economic benefits are maximised with the ratio of total common equity to risk-weighted assets of around 10–11% where a crisis has no permanent effects on output (and therefore the net present cost of a crisis in the equation above is small) and between 13 and 14% where a crisis has moderate permanent effects.[43]

The headline results of the LEI are presented in Table 9.

LEI results

Table 9

	Assuming financial crises have no permanent effect	Assuming financial crises have a "moderate" permanent effect
Capital ratio at which maximum net benefits are achieved (% of RWA)	10% Tier 1	13% Tier 1
Long-run net economic benefits relative to pre-Basel III capital ratios	0.3% of GDP per annum	2.0% of GDP per annum

The MAG estimated the transition costs of moving to higher capital ratios in terms of the reduction in lending and impact on GDP for an "average" advanced economy. In summary, the MAG found that the impact on lending to the economy and GDP were not only larger in the short-term than in the long-run, but that a shorter implementation period exaggerated this effect. These effects on growth and GDP can be ameliorated by easier monetary policy, but are (marginally) higher when international linkages are included in the analysis.[44]

The headline results of the MAG are reproduced in Table 10.

[42] The LEI report notes that it should not be viewed as indicating a particular calibration level. However, Table 8 of the report notes calculations of net benefits over a range of values for the total common equity to risk-weighted assets ratio, which suggests optimal levels of capital given the underlying assumptions in the analysis.

[43] The LEI also report results that include a liquidity requirement. While the level of net benefits is different, the inclusion of liquidity requirements in this analysis does not materially change the optimal level of capital implied in the analysis.

[44] The IMF estimated the likely "spillover" effects that would arise when bank capital requirements are raised simultaneously across all countries. The overall effect was estimated to be small, resulting in an additional 0.02% fall in GDP below the median results from country specific implementation after 35 quarters, and a less than 0.01% fall by the end of the simulation period (48 quarters).

Estimated deviations of lending spreads, volumes and GDP from baseline forecasts for a one percentage point increase in the target capital ratio implemented over eight years[1]

Table 10

	Lending volume[2] (in percent)		Lending spreads[3] (in basis points)		GDP[4] (in percent)	
	Q35	Q48	Q35	Q48	Q35	Q48
Unweighted median	–1.38	–1.47	15.5	12.2	–0.15	–0.10
GDP weighted median	–1.11	–1.11	16.6	12.8	–0.21	–0.18
Unweighted mean	–1.29	–1.46	18.6	17.6	–0.20	–0.16
GDP weighted mean	–1.85	–1.89	17.9	16.7	–0.26	–0.22

[1] Table reproduced from MAG (2010) [2] Results reported for 38 models. [3] Results reported for 53 models. [4] Results reported for 97 models. Not including international spillover effects.

Annex 2: Summary of the "3D" model

The model in Clerc et al (2015) (the "3D" model) introduces financial intermediation and three layers of default into an otherwise standard dynamic stochastic general equilibrium (DSGE) model.[45] A distinctive feature of the model is that it provides a clear rationale for capital regulation, which arises as a welfare improving response to two types of distortions: undesired side effects of safety net guarantees and bank funding cost externalities (bank funding costs depend on system-wide bank behaviour). Both lead to excessive risk taking by banks.

Higher capital ratios, from one side reduce incentives to lever up excessively and, other things equal, tighten the supply of loans; from the other, reduce bank defaults and thus the cost of uninsured funds, that, other things equal, reduce the cost of credit. Thus, the impact of changes in capital requirements on lending, activity and welfare depends on which of the two channels dominate.

In order to provide quantitative results, Mendicino et al (2015) fit the model to Euro Area (EA) data and match the first and second moments of a number of key aggregate macroeconomic and financial variables for the Euro Area economy, with a particular emphasis on matching the empirical properties of a number of banking variables such as bank capital ratios, loan write offs, bank lending spreads and quantities, etc.

Macroeconomic impact of increasing ratio of capital to RWAs by one percentage point

Table 11

Lending reduction (%)	Impact on lending spreads (bps)	Impact on steady-state GDP (%)	Mitigation in bank default prob. (pp)[1]	Mitigation in fiscal cost bank default (pp)[1]
0.15 (mortgage) 0.43 (corporate)	2.8 (mortgage) 4.9 (corporate)	0.04	0.2	0.06

[1] Conditional on an adverse scenario of heightened uncertainty about loan portfolio performance

The quantitative model in Mendicino et al (2015) provides a unified framework to assess the impact of higher capital requirements in terms of the costs and benefits to economic activity and welfare. Using the model, the authors evaluate the impact of a one percentage point increase in the capital requirement. This is shown in Table 11 above. Lending spreads for loans to households and non-financial corporations in the Euro Area increase by 2.8 and 4.9 basis points, respectively. These estimates are very similar to what Kashyap et al (2010) report for the US.[46] Lending to households and non-financial corporations declines by 0.15% and 0.43%, respectively. There is a small negative impact on GDP (0.04%).

The framework also allows for an explicit quantification of the benefits of heightened capital requirements. The authors estimate that, in a scenario of heightened uncertainty about the loan portfolio performance, capital requirements higher by one percentage point mitigate the increase in the probability of bank default by about 0.2 percentage points and reduce the fiscal cost of bank default (as a percentage of GDP) by 0.06 percentage points.

[45] The model in Clerc et al (2015) was developed in the context of macroprudential research network (MaRS) of the European System of Central Banks with the goal of building a decision-support tool that provides analytical feedback to policymakers regarding the positive and normative analysis of macroprudential policy, with a specific focus on capital requirements.

[46] Kashyap et al (2010) report the impact of a 10 percentage point increase in capital requirements. Our numbers scale up to theirs.

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